The Implementation Dynamics of Continuous Improvement throughout the Corporate
Hierarchy based on Lean Six Sigma at DTE Energy

by

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Submitted to the Alfred P. Sloan School of Management
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy in Management
at the
Massachusetts Institute of Technology

June 2011

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ABSTRACT

This dissertation comprises a case study and formal simulation model of DTE Energy's Lean Six Sigma continuous-improvement (CI) program from its inception in 1998 through the end of 2009. The case history is based on qualitative fieldwork involving interviews, direct observation, and collection of company documents and records. DTE Energy is one of the top 20 largest electricity and natural gas utilities in the U.S. It adopted CI from its automotive industrial customers in southeast Michigan. During the 12-year period I studied, DTE Energy's CI initiative was stressed by three organizational crises. Typical of other companies' CI initiatives, DTE Energy's success with CI was variable, prompting experiments and revisions to its CI training and methods, to its tactics for garnering managers' attention and support, and to its methods for orchestrating improvement work. Several leaders of the CI initiative were graduates of MIT's Leaders for Manufacturing program and were heavily influenced by research on the Toyota Production System (TPS) by Steven Spear (e.g., Spear and Bowen 1999) and Jeffrey Liker (e.g., Liker 2004). About halfway through this history, DTE Energy added Six Sigma tools and practices to its CI initiative, creating a Lean Six Sigma program.

I formulated a System Dynamics (SD) simulation model based on this case study. In this dissertation, I elaborate and extend previous work in the SD literature on the implementation dynamics of CI initiatives, especially Sterman and colleagues' (1997) model of the Total Quality Management (TQM) program at Analog Devices. My model represents explicitly the corporate hierarchy, which I divided into three levels: senior executives, middle managers, and front-line employees. I also examined the interactions between front-line employees engaging in their own Lean-style CI activities and Six Sigma Black Belts doing CI projects.

Based on my simulation analysis, I find that managers' and Black Belts' support and coaching required by front-line employees is usually chronically inadequate. I also find that Black Belts or industrial engineers, as full-time experts for process redesign and improvement, are crucial to the growth and long-term sustainability of a company's CI initiative.

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Chapter 1: Introduction

"Change is like heaven: We all want to get there, but you have to die to accomplish it."

— DTE Energy manager

In this thesis, I address a chicken-or-egg problem faced by companies like DTE Energy trying to implement a continuous improvement (CI) initiative. Employees at all levels of the company hierarchy must be convinced that learning and using CI methods and tools would be worthwhile. But they are convinced primarily by a track record of CI successes in their own company. These successes are not possible without the right degree of support on the part of the company's managers and without the right degree of skill with CI methods on the part of the company's employees. Such management support and employee skill development are not enacted without managers and employees being convinced that CI would be worthwhile. My case study of DTE Energy's experiences with its CI initiative examines how DTE Energy overcame this vicious circle.

1.1. Contributions

In this thesis, I make three contributions that elaborate and extend previous work in the System Dynamics literature on the implementation dynamics of CI initiatives, which includes Sterman and colleagues' model of Analog Devices (Repenning & Sterman, 1994b; Sterman, Repenning, & Kofman, 1997c), Repenning and Sterman's study of Ford Electronics (2002), Oliva and colleagues' study of National Semiconductor (1998), Keating and Oliva' study of AT&T's Transmission System Business Unit (2000a), and Morrison's study of Harley Davidson (2003).

First, I disaggregate the Commitment construct from the formal simulation model of Analog Devices (Repenning & Sterman, 1994b; Sterman, Repenning, et al., 1997c) into its constituent parts of (1) belief in the general effectiveness of CI tools and methods, and (2)

effort earnestness, which represents the translation of employees' belief into action but also incorporates the (de)motivating effects of other factors. Such disaggregation enables me to analyze changes in employee behavior, which happen rapidly in response to prevailing effects, separately from changes in employee belief, which exhibit significant inertia.

My second contribution is to represent explicitly the corporate hierarchy, which I divide into three levels: senior executives, middle managers, and front-line employees. Except for a few differences, these levels share a common model structure, which I implement using subscripts in most model equations. These few differences, coupled with the handful of equations that link the three levels together, have important ramifications. My simulation scenarios in Chapter 6 demonstrate how the dynamics that unfold at each level can lead, lag, or even run counter to the dynamics of the others. I discuss the implications of these level-specific behaviors in Chapter 8.

My third contribution is to examine a CI initiative that includes both the TQM approach of front-line employees engaging in their own CI activities and the Six Sigma approach of Black Belts, as specialized CI experts, working to deliver CI savings and coaching the front-line employees. I demonstrate that Black Belts, dedicated to process improvement full-time, are a crucial part of a CI initiative's success and sustainability.

1.2. Methods

Case Study

For my qualitative case study in Chapters 2-4 (and in the appendices), I designed my data-collection plan to follow Robert Yin's three recommendations: (1) use multiple sources of evidence, (2) create and maintain a case-study database, and (3) maintain a chain of evidence (Yin, 2003, pp. 97-106).

I collected and analyzed archival, interview, and observation data as multiple sources of evidence. I identified interviewees via the snowball method. My first interviews were of employees who had been involved with DTE Energy's CI initiative

since its inception. I asked each interviewee for the names of other employees who might have useful perspectives on the CI initiative, both positive and negative. I conducted 37 interviews, recording and transcribing them when permitted by my interviewees. Most of my interviews were about 90 minutes in duration, although two were 60 minutes and four were between 100 and 120 minutes in duration. I attended 19 meetings, six of which were quarterly all-day retreats for DTE Energy's CI personnel. A few of these meetings included site visits to several of DTE Energy's power plants and service stations. I took copious notes by hand at all meetings and retyped them immediately after each meeting. I also collected 196 company documents, 6 spreadsheet databases, and 12 publications (none of which contained confidential information).

I created a database to organize and track these various sources. For each data source, I assigned it a unique identifier and categorized it as one of the following: interview, meeting minutes, document, spreadsheet database, or publication. For interviews, I recorded the date, interviewee's name, job title, and department. For documents, spreadsheet databases, and publications, I recorded the date I collected it, a short description, from whom I obtained it, its format (e.g., hardcopy, spreadsheet, PDF file), how many pages it contained, and where I stored it. I imported all of my interview transcripts, meeting notes, and text documents into Scrivener (Blount, 2010), a software application designed to assemble and organize research materials for writing manuscript drafts. Within Scrivener, I wrote summary memos for the major documents that I could not import. To each of my documents in Scrivener, I assigned the following metadata: the document's unique identifier from my project database, the date I obtained (or created) the document, from whom I obtained the document, and the document's type (e.g., interview transcript, meeting minutes, corporate newsletter).

Yin's third recommendation — maintain a chain of evidence — pertains to analysis more than to data collection. Scrivener provides the researcher with the ability to work with chunks of text (called "scrivenings") as short or as long as the researcher desires — like flexible 3x5 index cards. I divided my source documents into scrivenings, each one retaining its parent document's unique identifier, and reorganized them into groups. I created a folder for each year from 1997 to 2009. Each year folder contained the

following main groups: (1) senior executives, (2) middle managers, (3) front-line employees, and (4) the CI initiative. I used these chronologically organized scrivenings to write the case study in Chapters 2-4.

In addition to my chronological groupings, I also created thematic groups. I used these thematic groups to provide additional detail in my chronology, when warranted, and to write the non-chronological sections in the appendices. These thematic groups included the following: leadership, DTE Energy's culture, 4G9S, Operating Systems, CI at Chrysler, CI at GM, CI at Johnson Controls, CI at Ford, Fos Gen CI examples, MichCon CI examples, front-line engagement, project selection, measurement and tracking, and communication.

I made extensive use of another useful feature of Scrivener to maintain my chain of evidence. Scrivener provides the ability to make annotations in one's manuscript that Scrivener removes when the researcher exports the manuscript to another format (like Microsoft Word). In my case-study manuscript, I annotated each quote, paraphrase, or other datum with the unique identifier of its source document.

Simulation Model

I used an iterative approach to construct the formal simulation model presented in Chapter 5. My first step was to construct a series of 20 "brainstorming" stock–flow diagrams that represented what I perceived to be the structural features of each section of my DTE Energy case study. In this stage, I sought to be comprehensive by including in my diagrams all the concepts (variables) that I could identify in my case study. I noted on these diagrams where the variables' causal relationships formed feedback loops. My second step was to clarify the feedback-loop structure by constructing a series of 14 causal-loop diagrams (CLDs) based on my 20 stock–flow diagrams and on the text of my case study. In this step, I included only those concepts (variables) necessary to complete these loops. My third step was to build a formal simulation model specific to DTE Energy's experiences with its CI initiative, based on my CLDs, stock–flow diagrams, and my case study text. In general, I sought to include all the feedback loops from my second step, but I excluded the variables from my first step whose effects seemed marginal. My

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fourth step was to build a second formal simulation model in which I removed all DTE Energy-specific formulations in favor of a generic structure that could be applied to other companies (by changing model parameters). In constructing both my DTE Energy-specific model and my generalizable model, I used standard formulations from the System Dynamics literature where possible and appropriate (see Chapter 5) using Vensim DSS version 5 (Eberlein, 2010). My fifth step was to formulate the six simulation scenarios presented in Chapter 6. This step required simulating the model, comparing its output to my DTE Energy case study, and revising either the model parameters or the model's equations to achieve a good fit.

1.3. CI Definitions

In this section, I provide definitions for the most important concepts in my analysis of DTE Energy's CI iniative.

Continuous Improvement (CI)

While I was conducting this research project, I discussed possible definitions of *continuous improvement* with many people at DTE Energy. Opinions differed, of course, but we settled on one main criterion: problem solving that is structured with the scientific method — analyzing data to understand root causes, not just symptoms — instead of acting on presumptions. At its core, CI means following a rigorous process to ensure that your countermeasures address the right problem, that they are likely to be effective, and that they are likely to stay in place.

CI necessarily involves improving an organization's capabilities by increasing the rational design of its work processes to boost their efficiency, reliability, consistency, and/or output quality. An organization achieves such capability improvement by boosting the problem-solving and project-management skills of its employees. By this definition, an organization that cuts the size of its workforce or the scope of its work and then tries to figure out how to live with those cuts is *not* doing CI because its capability remains unchanged. (The one exception: CI is accomplished if the organization redesigns its processes to produce the same output with fewer people.) Lean consultant and former

Harley-Davidson vice president Don Kieffer recommends that CI be implemented as follows: Design the organization's processes first such that they function well, then improve those processes incrementally and continually.

CI Initiative and Operating System

I found it easier to define a *CI initiative*. I assert that any "flavor" of CI — TQM, Lean, Six Sigma — comprises elements from all four of the following categories:

1. **Technical tools** — histogram, control chart, Pareto chart, cause-and-effect diagram, analysis of variance, multivariate analysis

2. **CI procedures** — PDSA, DMAIC, 5S, phase-gate project management, benchmarking, flowcharting, value-stream mapping

3. **Organizational practices** — QC circles, improvement project teams, rapid problem solving, learning lines, *kaizen* events, employee-suggestion systems

4. **Management principles** — employment security, supplier partnerships, waste elimination, reduction of variation, explicit process (re)design, work standardization, just-in-time, leaders as CI coaches, employee involvement

Technical tools are very specific and usually involve the analysis of data. CI procedures are roadmaps or recipes that tell employees how to use the technical tools. In other words, CI procedures define ways to approach problem solving. Organizational practices are the vehicles or forums for organizing and coordinating employees' actions. Management principles are the background conditions or underlying assumptions that managers put in place as the "ground rules".

Companies trying to "implement" a CI initiative typically pick from what amounts to an amorphous grab bag of elements. Some companies try to stay denominational. They might adopt Lean, focused on orchestrating the pace of production, or Six Sigma, emphasizing defect elimination and reduction of variation. Other companies eschew the religious war between competing CI "schools" and adopt a hybrid approach (e.g., "Lean Six Sigma"). I claim that Lean and Six Sigma, in essence, differ only in organizational practices and in management principles, not in technical tools or in CI procedures. The

Operating System fad, I suspect, was an attempt to bring more order and clarity to this grab bag of elements. A company's Operating System typically specifies what elements from all four categories constitute its CI initiative (see Appendix C for DTE Energy's Operating System).

DTE Energy began its CI initiative in 1998 with a Lean-only orientation and added Six Sigma elements later. The distinction between Lean and Six Sigma that I claim matters most is whether DTE Energy's CI activities were projects conducted almost solely by CI experts (Six Sigma) or workshops (like *kaizen* or swarm events) and projects conducted mostly by front-line employees (Lean). Even though DTE Energy did not label its CI initiative as Lean Six Sigma until 2004, its CI personnel had introduced CI-expert-run "demonstration" projects two years earlier. DTE Energy's Lean organizational practices and management principles included *kaizen* events, swarm events, UMP teams, learning lines, C1-C4, and OPCA (see Glossary for definitions). DTE Energy's Six Sigma organizational practices included Black Belt projects, Black Belt certification, and statistics training. DTE Energy's CI tools and procedures included problem-solving processes (4G9S and DMAIC) and tools like flowcharts and fishbone diagrams.

Belief in CI

The seminal System Dynamics study of CI implementation was Sterman and Repenning's model of Analog Devices (Repenning & Sterman, 1994b; Sterman, Repenning, et al., 1997c). The Analog Devices model contained a construct of employee Commitment to the CI initiative that commingled employees' belief in the usefulness of CI tools and methods with all other factors that would affect employees' behaviors with respect to the CI initiative. These factors included upper management's push for CI work, positive and negative word of mouth about the initiative, employees' perception of their job security, and the amount of support they receive from upper management for engaging in CI activities. The Analog Devices formulation for Commitment was parsimonious, but prevented separate analyses of employees' belief in CI and their CI behaviors. In my model, therefore, I separate employees' belief from a separate construct of their CI

behavior, which I call effort earnestness (see sections 5.1, p.137, and 5.7, p.172).

To define my construct of belief in CI, I borrow the useful distinction between *efficacy* and *effectiveness* from the medical literature (e.g., Glasgow, Lichtenstein, & Marcus, 2003). Flay defines an efficiacy trial as a test of whether a "program does more good than harm when delivered under optimum conditions" (Flay, 1986, p. 451). Clinical trials typically test whether drugs are efficacious; that is, whether they produce the desired physiological effect in the human body. An effectiveness trial, on the other hand, tests whether a "program does more good than harm when delivered under real-world conditions" (Flay, 1986, p. 451). Whether a patient benefits from a treatment regimen with a drug depends on its efficacy and on all other moderating factors, such as how compliant is the patient with the treatment regimen.

When defining belief in CI for my simulation model in Chapter 5, I decided that such belief would refer to the efficacy of CI in general, not to the effectiveness of CI at DTE Energy specifically. This choice was arbitrary, so I selected the alternative that made my model equations easier to define. In my model, employees become convinced or disillusioned with CI from their results only (see sections 5.10, p.189, and 5.11, p.195). All other prevailing factors – job security, support from upper management, coaching from Black Belts, financial stress and distractions – affect effort earnestness and thereby results downstream (see section 5.7, p.172).

In my simulation model, I represent the belief construct by dividing all employees into three mutually exclusive and collectively exhaustive states: believers, neutrals, and skeptics (see section 5.1, p.137).

CI Skill

The simulation model presented in Chapter 5 includes a construct that I call CI Skill. This construct represents an employee's ability to achieve real improvement results from his or her hours of work time expended on CI activities. As I explain in section 5.3 (p.149), I use a version of the classic learning-curve formulation as my mathematical expression for CI Skill. An employee's CI Skill increases nonlinearly as he or she

accumulates relevant experience with CI tools and methods. I define empirically the substantive content of this CI Skill construct, however, from my case study of DTE Energy's CI initiative. The specific behaviors that I include in CI Skill are listed in Table 1 below.

Managers and CI Experts	Front-Line Employees
Collect, evaluate, prioritize, and select improvement ideas to implement	Monitor one's own work processes for abnormalities, problems, and inefficiencies
Manage project sizes, scopes, and financial payoffs	Constantly question the design of one's own work processes
Organize CI activities	Constantly learn about one's own work processes
Reinforce CI principles	Always report improvement ideas to one's managers
Coordinate among groups	Initiate fixes if possible
Lobby for needed resources	Proper CI tool use, especially the scentific methods (DMAIC, PDSA, 4G9S)
Insist on proper CI tool use	Refine countermeasures
Ensure changes stick	Work to make changes stick
Encourage skill development	Seek training and assistance when needed
Resist the check-the-box mentality	Resist the check-the-box mentality

Table 1. Definition of CI Skill

Managerial Push and Employee Pull for CI

The potential for divergence of beliefs about CI, and of actions based on those beliefs, between bosses and their subordinates was an important finding from my case study of DTE Energy. I encountered historical examples where apathetic managers stymied the efforts of pro-CI employees. But I also encountered historial examples where enthusiastic managers coerced anti-CI employees to reluctantly "go through the motions" on CI projects that, consequently, couldn't possibly deliver what those managers hoped

for. This latter phenomenon recalls Oliver Williamson's distinction between consummate and perfunctory cooperation (Williamson, 1975, p. 69). I observed that employees did what their bosses mandated, but their cooperation was only perfunctory when they disliked or disagreed with the mandate.

Keating and Oliva (2000a) categorized manager-initiated and employee-centered motives for engaging in CI according to Shiba, Graham, and Walden's (1993) constructs of managerial push and employee pull, respectively. Managerial push is formed primarily from incentives imposed by a manager on his or her subordinate for certain behaviors, and includes expectations and beliefs, communication of goals and priorities, and other means of providing direction. Employee pull is formed primarily from someone's own mental models, perceptions and beliefs about all the various costs and benefits associated with enacting the new behaviors. Employee pull is also bolstered by one's own capabilities. I assume people want to exercise skills that they've worked to acquire, especially if such exercise reinforces certain individual or group identities.

Motivating employees to improve their work processes has always been a central concern in managing organizational change. In his 14 Points for Management, Deming (1986) insisted on fostering pride of workmanship (Point 12), driving out fear in the workplace (Point 8), and eliminating management by objectives (Point 11). In his later work, Deming said that these Points follow naturally from the application of his "system of profound knowledge" (1994, p. xv), which includes (managerial) psychology. Specifically, he believed that his own observations in many companies as a quality improvement consultant confirmed the overjustification effect (Deci, 1971), that extrinsic motivation, used extensively in traditional styles of management, destroys employees' intrinsic motivation — an innate desire and joy to learn and innovate (Deming, 1994, p. 122). (Deming wrote before empirical support for this effect became controversial (see Deci, Koestner, & Ryan, 2001).)

Unfortunately, where psychologists draw the line between intrinsic and extrinsic sources of motivation does not match lay conceptions. Edward Deci and Richard Ryan (1985) include in extrinsic motivation those types of self-regulation that originate from one's social context: introjected, identified, and integrated regulation (see Ryan & Deci,

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2000, p. 72). They restrict intrinsic motivation to the pleasure derived from self-determined knowing, acting, or being stimulated. Their definition of intrinsic motivation excludes acting from internalized values or norms.

The Deci-Ryan distinction between intrinsic and extrinsic motivation is not helpful for theories of CI implementation because it is not congruent with how managers think about the sources of motivation that influence organizational change and whether these sources constitute policy "levers" or not. For example, a manager will take a particular approach if she is intent on behaviorist reinforcement with rewards and punishments. Another manager will take a different approach if he wants to foster taking pride in one's work. For this reason, I intentionally avoid the intrinsic-extrinsic dichotomy.

I posit that each individual has his or her own orientation toward CI, as determined by managerial-push and employee-pull influences. For simplicity, I have dichotomized the effects of each influence into positive and non-positive (neutral and negative) orientations. Two possible levels for each dimension yields the four possible orientations summarized in Figure 1 below. I intend a person's orientation to be revealed through his or her actions such that categorization is possible by examining what people choose to do in a given circumstance.

Managerial-Push Dimension (vertical axis, from 0 to +)

Ceremonially Conforming	Committed
Complacent	Constrained

Employee-Pull Dimension (horizontal axis, from 0 to +)
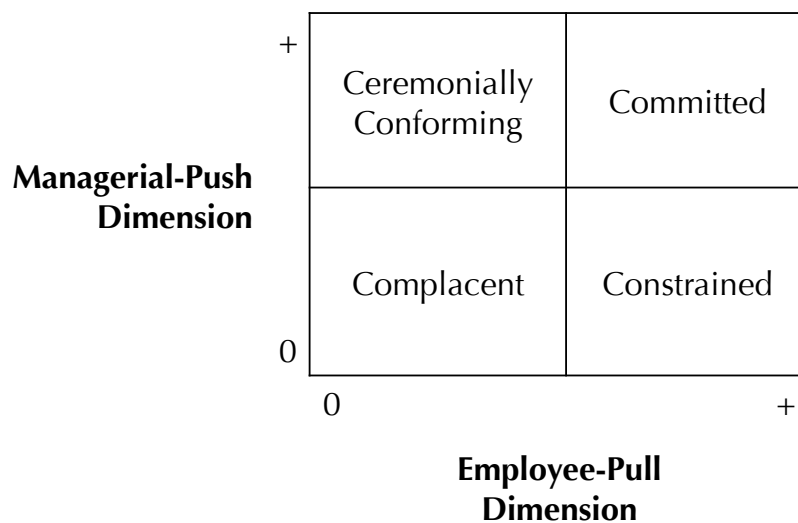
Figure 1. 4C Grid of CI Orientations

I define *complacent* as not positively disposed toward CI. An individual of this

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orientation would not enact CI behaviors. An individual is *committed* if his or her positive beliefs in CI are aligned with managers' incentives for it. If someone does not believe in CI but is compelled by managers to participate, then he or she will *ceremonially conform*, but his or her effort will be half-hearted and the outcome less beneficial than a committed individual would produce. Oliver Williamson calls such behavior *perfunctory cooperation* (Williamson, 1975, p. 69). An individual may strive to enact CI in an apathetic organization, but his or her ability to act will be *constrained* by a lack of managerial support.

1.4. Overview of DTE Energy

DTE Energy Corporation (NYSE: DTE) has assets of $24.2 billion, annual revenues of $8.0 billion, net income of $535 million, and almost 10,300 employees (2009 figures). DTE Energy is a holding company that was established in January 1996. Its two main subsidiaries are Detroit Edison, an electric utility, and Michigan Consolidated Gas Company (MichCon), a natural gas utility. The operations of these two regulated utilities produce 75 percent of DTE Energy's earnings. DTE Energy's other, non-regulated businesses include coal and rail services, natural gas pipelines and storage, industrial energy projects, and energy trading.

Detroit Edison, founded in 1903, generates and distributes electricity to 2.1 million customers in southeastern Michigan (see Figure 2 below). Detroit Edison's total generation capacity is approximately 11 gigawatts. About 10 percent, or 1.1 gigawatts, of this capacity is represented by its nuclear power plant, called Fermi 2. Detroit Edison's nine coal-fired power plants — Monroe, St. Clair, Belle River, Trenton Channel, River Rouge, Marysville, Harbor Beach, Greenwood, and Conners Creek — make up about 72 percent of its generation capacity. The remaining 18 percent consists of gas, oil, and pumped-water storage. Historically, Detroit Edison operated the entire chain from generation to retail, but it sold its high-voltage transmission subsidiary, International Transmission Company (ITC), in December 2002. (Transmission is the link between generation and distribution.)

Detroit Edison has been a member of the Midwest Independent Transmission System Operator (MISO) organization since it was created in December 2001. (MISO operates and monitors the electrical transmission system for 13 Midwestern states and the Canadian province of Manitoba.) Detroit Edison constitutes about 8 percent of MISO's total generation capacity and typically serves about 11 percent of its peak demand.

MichCon is engaged in the purchase, storage, transmission, distribution, and sale of natural gas to 1.2 million customers in Michigan. MichCon was founded in 1849 as the Detroit Gaslight Company and was acquired by DTE Energy in 2001.
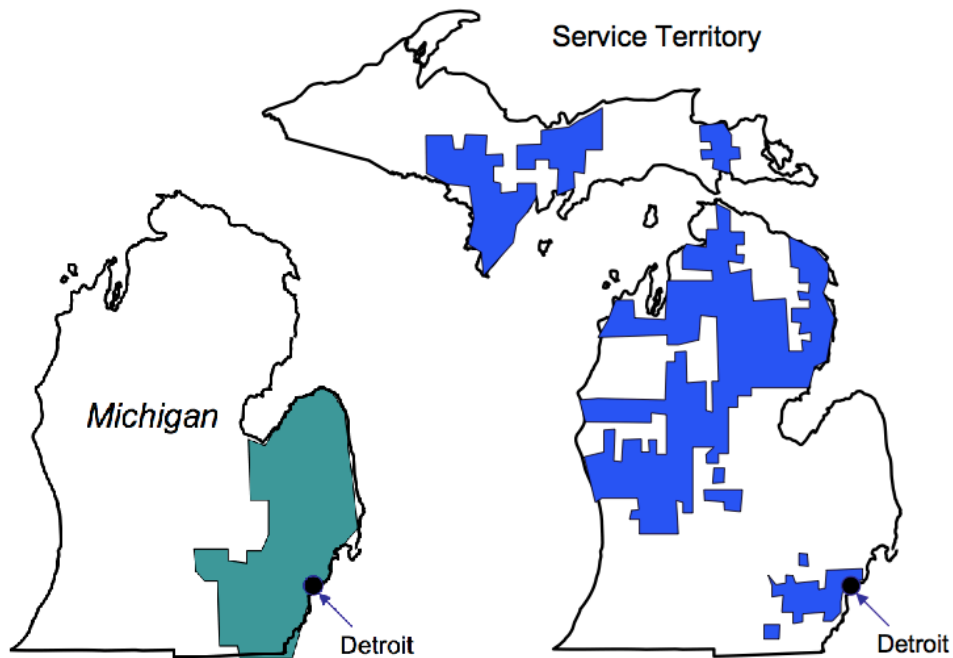
Figure 2. Detroit Edison and MichCon Service Areas

The main labor unions represented at DTE Energy are the Utility Workers Union of America (UWUA) and the International Brotherhood of Electrical Workers (IBEW). UWUA Local 223 is the largest union chapter at DTE Energy with about 4500 members. It is organized into eleven divisions. IBEW Local 17 is the second-largest union chapter at DTE Energy with about 500 members. After DTE Energy acquired MichCon, its 1000 members of Service Employees International Union (SEIU) Local 80 voted to become members of UWUA Local 223 to eliminate wage and benefits disparities between the two union chapters.

Both Detroit Edison and MichCon are regulated by the Michigan Public Service

Commission (MPSC), which reviews and approves the setting of rates. As subsidiaries of publicly traded DTE Energy, Detroit Edison and MichCon are each allowed a maximum return on equity of 11 percent (close to the national average) by the MPSC.

1.5. Case Study Overview

For my study of DTE Energy's continuous improvement (CI) initiative, I examined its six main business units: Fossil Generation (Fos Gen) and Distribution Operations (DO) of Detroit Edison, MichCon's gas distribution operations (MichCon), Customer Service (which handles retail operations for both Detroit Edison and MichCon), Corporate Services (which includes supply chain, warehousing, and fleet operations), and the Corporate Support operations at DTE Energy's Detroit headquarters (finance, IT, HR, and the senior executives). I did not examine any of DTE Energy's non-regulated businesses or, for reasons of security, DTE Energy's nuclear power plant.

Looking back over DTE Energy's 12 years of history with CI (1998-2009), I perceive three distinct implementation "waves". In this context, I define a *wave* as my unit of analysis comprising two sequential phases of events: an unstressed phase of relative calm in which DTE Energy's CI proponents sought to grow the initiative mostly unencumbered by outside pressures, followed by a second stressed phase in which the company and the CI initiative were subjected to considerable pressure. I define these waves as a useful device for compactly describing the ups and downs of DTE Energy's CI initiative through the years.

The three waves of DTE Energy's history constitute three cases, which I then compare. My criterion for defining the boundaries of each wave and its two constituent phases was the prevailing agenda of DTE Energy's senior executives at the time. I defined a wave as the period during which an extraordinary agenda like cutting costs or completing a merger was in effect, plus the previous period of business as usual. It is important to note that these implementation waves do not correspond to any CI implementation plans formulated and used by DTE Energy's CI personnel. For example, the second wave spans two of the OSSG's CI implementation plans.

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The three waves that I identify in DTE Energy's chronology are as follows. The first wave consisted of the start of the CI initiative in 1998-1999 with *kaizen* events and the subsequent stress of the MichCon merger in 2000-2001. The second wave consisted of the OSSG's emphasis on demonstration projects by CI experts (Black Belts) in 2002-2004 followed by the cost-cutting pressure of McKinsey's PEP initiative in 2005-2006. The third wave comprised the OSSG's strategy of promoting both Black Belt projects and CI workshops (CILWs, swarm events) in 2007-2008, which were put to the test responding to the economic crisis in 2009. I devote the next three chapters to each of these three waves. In all three chapters, I present DTE Energy's story via journalistic exposition, keeping my own interpretations to a minimum, except for the last section of each chapter in which I summarize its wave.

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Chapter 2: Wave One — 1997-2001

2.1. Start of the CI Initiative — 1997-2000

In the late 1990s, the federal and state governments began to push for deregulation of utilities. DTE Energy's senior executives were worried that financial-performance pressures arising from such deregulation would trigger consolidation in the industry. In 1996, the Federal Energy Regulatory Commission (FERC) issued Order 888, requiring utilities to open their transmission lines to competitors. Subsequently in mid-2000, the Michigan legislature passed Public Act 141 into law, requiring Detroit Edison to allow its customers to purchase electricity generated by other suppliers beginning on January 1, 2002. (Under this program, called Electric Choice, Detroit Edison would still distribute the purchased electricity.)

Tony Earley, DTE Energy's CEO, wanted the company to control its destiny instead of being a potential acquisition target. In response, DTE Energy began diversifying its business and concentrating on improving its cost structure and operations. Over several years following FERC's Order 888, DTE Energy started several non-regulated energy businesses, acquired Michigan Consolidated Gas Company (MichCon), and began seeking people and ideas from outside the utility industry.

DTE Energy has always had close ties to the U.S. automotive industry. The "Big Three" car companies — GM, Ford, and Chrysler — constitute 10 percent of Detroit Edison's load, and their first- and second-tier suppliers make up another 10 percent. DTE Energy's executives knew and were influenced by their peers at the Big Three. Understandably, they were particularly interested in the car companies' 10-year efforts to adopt Lean production techniques from Toyota.

Chrysler's adoption of Lean had the most direct influence on DTE Energy. Chrysler employees had developed the Chrysler Operating System, a coherent and holistic framework comprising Lean tools, practices, and principles, packaged for easy

dissemination throughout the company. Three employees who contributed to this development were graduates of MIT's Leaders for Manufacturing (LFM) program — Steve Nagy, Jamie Flinchbaugh, and Jamie Bonini. As we shall see, all three of these former Chrysler employees were influential in DTE Energy's development of its own 'operating system'.

The idea of forming a Lean improvement initiative was brought to DTE Energy by David Meador in 1997. Meador was one of the founding trustees of the Society for Organizational Learning and had been strongly influenced by the Chrysler Operating System. After a successful 14-year career in Chrysler's finance organization, Meador joined DTE Energy as controller and treasurer. CFO Larry Garberding groomed Meador as his successor — a position Meador assumed when Garberding retired in December 2001.

Meador's arrival was significant because he already believed in CI from his experiences at Chrysler and he was placed high enough at DTE Energy to influence his peers and nurture a CI effort. Meador hired Steve Nagy from Chrysler in 1997 to run a new supply-chain department, and to think about creating a CI initiative and a group to run it. One of the first members of that group, Gary Lemont, recalled, "[Meador] had this Operating System vision and wanted to bring somebody in to lead that charge." Nagy, one of the Chrysler Operating System's architects, seemed a perfect choice. Another of the group's first members said, "Dave [Meador] had seen the Chrysler Operating System work and he liked it, but he didn't really know what it was. He just liked the idea. Steve [Nagy] was the first one to show up who really knew what the game looked like and what it was going to take."

It took Nagy almost two years to lobby DTE Energy's senior executives for the resources necessary to create a CI group with full-time employees. Eventually, he would hire his LFM classmate Shawn Patterson from GM in 1999 to be the manager of the new Center for Continuous Improvement (CCI). But to reach that point, Nagy and Meador had to sell the idea to DTE Energy's other senior executives.

Nagy and Meador used two tactics, leveraging their Chrysler connections for both. One tactic was to influence DTE Energy's senior executives by having them meet — sometimes informally over dinner — with Dennis Pawley, Chrysler's executive vice

president of manufacturing and labor relations, who oversaw the development and implementation of the Chrysler Operating System. The second tactic was to demonstrate to the senior executives what could be accomplished with Lean techniques at DTE Energy. Nagy hired Lean consulting firm Achievement Dynamics, which had assisted Chrysler since 1995, to run a few demonstration *kaizen* events in 1998. Shawn Patterson recounted, "Dave [Meador] and Steve [Nagy] were trying to get anything to stick. They brought [Achievement Dynamics] down here to do a couple *kaizens*. It was interesting, but didn't really go anywhere. A couple *kaizens*, a couple dinners, just a lot of talk until [the senior executives] said, 'You know, we've got to get a group, some people solely dedicated to this.'"

Even though Meador secured the money needed to create CCI, Patterson explained that the rest of the senior executives regarded it as an experiment: "There was very little understanding. There were a couple people who had a vision for what we were trying to create:...people working on continuous improvement all the time. The vision was...the right things would be taking place anywhere you go in the company. But beyond that, it was a pretty fuzzy picture. And, frankly, there were a lot of people who thought, 'Who cares?'"

When Shawn Patterson joined DTE Energy to lead the nascent CCI, it consisting of only a handful of members from inside the company. Patterson soon hired Jamie Flinchbaugh, another contributor to the Chrysler Operating System, to assist him with designing the CI initiative and, eventually, an operating system for DTE Energy.

Patterson expanded the scale of Nagy's *kaizen* tactic into a formal program. He recalled, "Steve [Nagy] and I strategized and decided that just launching this Operating System was going to lose people. We first needed to get some quick wins around continuous improvement and teach some basic Lean-type tools, so we decided to launch a *kaizen* program to do exactly that." Gary Lemont, Jamie Flinchbaugh, and Achievement Dynamics founder Andy Carlino continued to run *kaizen* events and, within four months, began training business-unit personnel to run their own. Lemont said, "Eventually, we had quite a core group of people that were capable and were running their own. We had some real successes — and we had some [*kaizens*] that were less successful — but it

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really had some legs for a couple years. ...There were enough successes to keep interest in it." About 50 business-unit employees trained as facilitators eventually conducted approximately 50 *kaizen* events per year in 1999 and in 2000.

A *kaizen* event was typically a week-long workshop, ideally attended by everyone who was affected by the problem being addressed: front-line employees, other subject-matter experts, and decision makers. Lemont explained, "We would bring the people together and teach them some basic concepts around waste, teach them problem-solving skills. ...We tried to make them on-site, so that we could actually go out throughout the week and implement solutions."

The consensus among DTE Energy's employees was only 50 percent of the approximately 100 *kaizens* conducted in 1999 and 2000 were considered successful. A CI manager summarized bluntly: "Fifty of them were good and fifty of them were bad." Some managers were reluctant to allow *kaizen* teams to make changes without their approval. A *kaizen* facilitator explained how he tried to overcome this resistance by insisting managers attend the events, arguing, "If you need to be part of the decision process, then you need to be there during the week. We don't want to come and spend the whole week and then have you say no."

Lemont said that some *kaizen* teams worked on problems that were too big to be fixed in one week. *Kaizen* participants would take away to-do lists that were too big and, in many cases, were never completed. Many *kaizen* teams would convene to flowchart new "ideal-state" process designs — sometimes at an off-site retreat — yet never examine the current process or try to change it. Another facilitator said, "The more successful ones were where they had done a current state and an ideal state and they had time in the workshop to actually get the things done."

Gradually, CCI's members realized that the *kaizen* program "was not the silver bullet," according to Lemont. And front-line employees began to take notice of the *kaizen* program's poor track record. When one of the facilitators asked a new *kaizen* group what they hoped to achieve, they answered, "We just don't want another failed *kaizen*." Jamie Flinchbaugh experienced many DTE Energy employees resisting what they perceived to be an inappropriate automotive fad foisted on them by what they called "the Chrysler mafia"

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(Flinchbaugh, Nagy, and Meador). A CCI member said, "We needed to have a different way of thinking, not just throw a bunch of tools at things."

Patterson also continued Nagy's tactic of executive influence and education, at least until DTE Energy announced its plan to acquire MichCon in October 1999:

> While we were working on [*kaizen* events], we were working on the executive-development piece in parallel. Whatever we could do to get our executives synced in with other executives, or people they had a lot of respect for, whom they could learn from.
>
> We brought in [Harvard Business School professor] Kent Bowen to hold some executive sessions. We had some of our executives...go out to Alcoa to meet with [CEO] Paul O'Neill to learn about the Alcoa Business System. We had some more follow-up dinners with Denny Pawley. We did a benchmarking trip down to Mackie [Automotive Systems], a supplier...who was well-known for its outstanding operations.
>
> We really worked hard at whatever we could put in front of our executives [to help] get them to a clearer vision. We were rolling along and starting to get some momentum towards creating this Operating System. Then the merger, or acquisition, was announced. ...When the merger came, we were just getting ready. We had the executives ready to go, realizing that we need to move beyond *kaizen*. It was useful for quick wins and early adoption, but not the big game changer that an Operating System could be.

2.2. The Union Management Partnership Initiative — 1999-2000

A related initiative arose in the late 1990s from DTE Energy's labor relations. The 1992 contract negotiations between DTE Energy and UWUA Local 223 failed, prompting them to adopt a new interest-based bargaining process[1] for the next round of negotiations in 1995. This process was so successful that DTE Energy and Local 223 created an initiative to foster collaboration and greater union involvement in decision making. This initiative, called the Union Management Partnership (UMP), was launched as part of Local 223's next contract in 1999.

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[1] When they first introduced interest-based bargaining, Fisher & Ury (1981) called it "principled negotiation".

UMP's goals were similar to those of a CI initiative: Institutionalize a set of principles that would increase front-line employee participation in decision making and process redesign, thereby expanding their skills, improving their work conditions and safety, and boosting productivity.

The structure of the UMP initiative was similar to Nagy's *kaizen* program. DTE Energy's executives and Local 223 leaders created a department, the Office of Labor Management Partnership (OLMP), to oversee the UMP initiative. OLMP hired Restructuring Associates Inc. (RAI) to train "partnership consultants" who would facilitate Partnership teams in DTE Energy's power plants and service centers. These teams typically met once per month and (those that were successful) concentrated on small projects that could yield quick results.

One of Nagy's supply-chain employees remembered some Partnership teams requesting assistance from the CCI group to facilitate improvement work in some of DO's service centers. She said the service centers' budgets weren't cut as a result of that improvement work. Instead, they were allowed to put the money they saved to other uses.

One area of overlap between the UMP and CI initiatives in 1999 was an assurance of no layoffs. The compromise between the unions, wanting to ensure their members stayed employed, and DTE Energy's executives, wanting to retain flexibility, was an agreement on *employment* security instead of *job* security (see Glossary). CEO Tony Earley explicitly transferred that assurance from the UMP initiative to the *kaizen* program, announcing, "You will not lose employment due to participation in *kaizen*."

The UMP initiative had its share of problems too. First, its focus on labor relations created a perception among non-represented employees that it was a union-only initiative. Second, like some *kaizen* teams, some Partnership teams clashed with managers who were unwilling to relinquish their traditional command-and-control style. An employee observed that Partnership teams worked best when they had UMP facilitators and managers who were committed to the initiative.

A third problem was some Partnership teams simply didn't know what they were supposed to do to achieve "partnership". One of the UMP facilitators said, "That was the

biggest struggle: We sat in rooms, talked about things we should do. We all agreed that the Partnership Principles said all of the right things but without the CI tools we struggled to get sustainability in the workplace. Principles alone were not going to get us there." Without such tools, many Partnership teams got bogged down or sidetracked. A facilitator described a team he was on that took six months to determine "the different levels of decision making: what they should be, who should be involved, and stuff like that."

2.3. The MichCon Merger — 1999-2001

DTE Energy issued a press release in October 1999 announcing its plan to acquire MCN Energy, the parent company of MichCon, in a deal estimated at $2.6 billion in cash and stock. (Despite being an acquisition, all employees referred to it as a merger.) The senior executives created a temporary strategic-planning department to orchestrate the merger activities. The CCI group was moved under this new department because, as Patterson said, "the goal was to use this *kaizen* methodology to integrate processes in six months." Patterson's CCI group began this work, collaborating with MichCon's counterpart, the Business Process Improvement group.

Planning and negotiations proceeded well for six months until the merger became mired in regulatory hurdles, legal hurdles, and arguments over MichCon's purchase price that lasted through the next 13 months. Executives at both companies became frustrated and — each at different points — almost abandoned the deal.

Unsurprisingly, this outcome uncertainty in mid-2000 killed the planning that middle managers and front-line employees were doing for combining the two companies. Employees did not want to waste effort doing work that would not be used. Patterson recalled the situation at DTE Energy: "Operating units' guys were like: 'Puh! We may or may not merge. What am I going to go tinker with my processes for? It just means I've got to go through another 'do' loop.'" A MichCon employee reported that the same abandonment happened at his company: "When you look back...you do find some very good continuous-improvement efforts had been done at the company right around merger time. Lots of process mapping was done. Lots of documentation was written. It was

right, it was great, the metrics were good. What happened to it all? There was no upkeep."

Wrangling over the merger dominated DTE Energy's senior executives' attention. But they had several other demands on their attention as well. One demand was negotiating Local 17's new 5-year contract, which — unlike recent negotiations with Local 223 — a union member euphemistically said involved "tension and struggle" between the two parties. Another demand was a 12-month phasing in of the MPSC-mandated Electric Choice program, to begin on January 1, 2001. Not only was DTE Energy compelled to create expensive new processes to enable Electric Choice, but its senior executives were rightly worried about this program's effect on sales. Because DTE Energy's residential customers were subsidized by its commercial customers, those commercial customers had an incentive to switch to cheaper electricity suppliers — which they did, cutting DTE Energy's sales by about 20 percent in 2002. (This "rate skewing" was not abolished until Michigan energy legislation was passed in September 2008.)

With senior executives' attention thus diverted, Patterson, Nagy, and Meador could not proceed with their plan of influencing them in favor of a large-scale CI initiative. However, Patterson said, "The merger put *kaizen* on the back burner, but it didn't disappear entirely." They had to wait until the merger turmoil subsided before renewing their efforts.

2.4. Wave One Summary

Unstressed First Phase — 1997-2000

An important aspect of understanding diffusion — of diseases, of ideas, of trends or fads — is understanding how it begins in the first place. In many ways, DTE Energy was best positioned for its CI initiative to diffuse throughout the company. At the outset in 1997, DTE Energy's cadre of senior executives was primed with a few CI believers — CEO Tony Earley and CFO Dave Meador — who authorized some initial experimentation with

CI. These pro-CI executives, later joined by Bob Richard in 2003, defended the fledgling CI initiative from its detractors.

DTE Energy was fortunate in other ways. Its employees learned from the experiences of southeast Michigan's automotive companies, who had already introduced Lean and Six Sigma. It was able to hire well-trained engineers away from those companies. Some of those engineers, like Patterson, Flinchbaugh, and Schulist, had personal connections to leading CI researchers in academia and practitioners in industry.

These early CI proponents convinced DTE Energy's neutral senior executives with two tactics. First, they used social means, such as meeting with Dennis Pawley from Chrysler and Paul O'Neill from Alcoa, to explain CI and its potential benefits. Second, they conducted small-scale CI experiments in the form of *kaizen* events to demonstrate what improvements could be made with CI techniques at DTE Energy. Eventually, enough of the senior executives were convinced that they allocated money to hire Lean consultants and, later, employees dedicated to the CI initiative full time.

The primary purpose of *kaizen* events was to convince DTE Energy's senior executives of CI's potential so they would invest in it further. While *kaizen* events, if executed well, could also convince DTE Energy's middle managers and front-line employees, this purpose was not emphasized. The *kaizen*-event participants faced a chicken-or-egg problem: Nobody at DTE Energy had much experience or skill using CI techniques to achieve successful *kaizen* events, but employees were unwilling to participate and build their CI skills without perceiving a high probability of success beforehand.

Kaizen teams, especially those of the UMP initiative, also faced another related chicken-or-egg problem. Success of a front-line *kaizen* team partially depended on the support and, in some cases, the involvement of that team's middle managers. Without a strong push for *kaizen* events from DTE Energy's senior executives, these middle managers had little incentive to increase their workload by participating in *kaizen* events. Their lack of involvement decreased the success rate of *kaizen* events, thereby creating a self-fulfilling belief that their participation in CI activities was not worthwhile.

The CI initiative was kept alive during this period with forcing. The CCI personnel

kept up their executive-development push to convince the senior executives. The *kaizen* facilitators compelled the participation of front-line employees (but not their middle managers).

Stressed Second Phase — 2000-2001

It is not surprising that the CI initiative was suspended when the merger's problems consumed the senior executives' attention. But CCI's strategy was working; executives were being convinced — slowly — that CI had merit (even if the lower levels of the company hierarchy were not being convinced). Two observations support this conclusion. First, before the merger negotiations ran into trouble, DTE Energy's senior executives wanted their subordinates to use *kaizen* events for post-merger integration. Second, as we shall see in the next chapter, the CI initiative resumed apace after the merger closed.

It is unlikely that DTE Energy's early CI proponents could have done much better. Their targeting the senior executives was a necessary first step for securing money to grow the CI initiative. The distraction of the merger was unfortunate, but could hardly have been avoided. Perhaps DTE Energy's CI proponents could have prevented some disillusionment among front-line employees and middle managers if *kaizen* events had been run with even greater care in project selection, facilitator skill, and management politics. CCI's limited budget, however, constrained what was possible.

Chapter 3: Wave Two — 2001-2006

3.1. Creation of DTE Energy's Operating System — 2001-2002

The merger of DTE Energy and MCN Energy was officially completed in May 2001. CEO Tony Earley created an Operating Council, comprising the three presidents and their operations vice presidents, to oversee the work of consolidating duplicate processes, like those for customer service, and reducing the sudden surplus of facilities, vehicles, and equipment.

Even if the pre-merger *kaizen* events were forgotten, the vision of achieving operational excellence with CI was still alive. Earley was convinced that DTE Energy would be making future acquisitions and he believed that CI was the way to make them successful — a strategy used best by Danaher Corporation for hundreds of acquisitions (Hindo, 2007; Pethokoukis, 2006). Patterson recalled Earley announcing to Wall Street analysts in 2001: "We are going to be the first utility to adopt Toyota Production System concepts." Earley spoke about DTE Energy emulating Alcoa and other companies that benefitted from Lean. According to one manager, "Tony Earley was still hot-to-trot on creating an Operating System."

With senior-executive support for a corporate-level CI department, Shawn Patterson and his counterpart at MichCon, Marcia Jackson, held a 5-day workshop to combine DTE Energy's CCI group, MichCon's Business Process Improvement group, and any other personnel judged to be CI related. CCI employee Gary Lemont described the process:

> ...[S]ince we were going to have a corporate effort, we needed to look throughout the organization and see...who belonged where. ...We invited people from the business units to be part of the workshop. There was a staff group that was supporting both Customer Service and Distribution Operations. They were primarily a continuous-improvement group supporting that side of the business, so we absorbed the analysts — three or four [people]. We did not absorb the administrative people. ...We didn't identify anybody at Fermi. On the Fossil Gen side of the house, there were some people.... It was decided at the workshop that they were primarily business-unit people that were just doing

continuous-improvement stuff, so they were left in the organization; we didn't absorb any of that complement. ...The next combination came from the Partnership. ...They had a separate organization, the Union Management Partnership...that was determined to be enough about continuous improvement that it was absorbed into our group. That was about four people. ...We went from a group of four or five people to a group of twelve now to support [the OS]. It was a combination of Gas, Shawn's group, DO, and the Union Management Partnership. That was the creation of the central group, with that overall corporate support [and] philosophy.

Patterson became director of this new Operating System Strategy Group (OSSG). Jackson explained that they expected to need a large group for the CI initiative at the start, but over time they could shrink to a smaller, strategic group — CI experts who would concentrate on improving the CI initiative's tools, methods, and strategies for culture change.

The UMP initiative ended when its facilitators were transferred to the OSSG. One manager claimed that UMP "totally lacked leadership, so it was having a hard time becoming mainstream." Patterson said that the senior executives "didn't know what to do with it," but perceived it similar enough to the CI initiative to combine the two. "Honestly," Patterson added, "not a lot of thought was put into it." The UMP steering committee solicited comment from the initiative's facilitators only ceremonially. One facilitator recalled, "They brought us into a room and said, 'We are thinking of merging the two groups and would like your input.' [But] it was clear their minds were already made up."

Many union members felt disappointed and even betrayed by UMP's demise. An OSSG employee recalled, "The unions, especially 223, were really big on [UMP]. It was one of their ideas. They saw it as *the* way of transforming the business and the culture of the organization. ...They said, 'Management, this is what you bought into. This is the way to go. Why are you paying so much attention over here to this Operating System thing?' Those Toyota ideals and principles obviously didn't sit well with the unions, so they saw us as a threat." And one of the transferred UMP facilitators concluded, "To some people, 'Partnership' is a dirty word because we never did do what we said we were going to do."

Despite these feelings, Patterson believed the CI initiative benefitted from the gain of

these labor-relations people. He said, "I was glad to have [the UMP initiative], because I thought there were some really good things. I saw it was a chance to leverage our relationship with the union in a different way than we had before, so I was happy to take it. I had pretty good relationships with the union guys, [Local 223 president] Mike Langford and Kevin Shaffer, [president] at Local 17. They were a lot less concerned about it and the executives were happy to...not have two things to worry about. It cut through a lot of confusion...."

The Operating Council members agreed in November 2001 to create a DTE Energy operating system. Patterson assembled a team of 10 people to collect and study the operating systems of Chrysler, Alcoa, Danaher, Visteon, and others. They studied the Toyota Production System and visited TMMK in Georgetown, Kentucky, where Jamie Bonini, another contributor to the Chrysler Operating System, had recently taken a job (Spear, 2004a). They visited a Chrysler factory and another manufacturer to see how those companies used Lean on the front lines.

The Operating Council hired organizational-development consulting firm Maxcomm to assist with the change-management aspects of the CI initiative. Maxcomm consultants helped Patterson design and conduct workshops for the senior executives. "There was a lot of prep getting them on board again, a lot of re-teaching," Patterson said. "[Harvard Business School professors and TPS researchers] Kent Bowen and Steve Spear showed up to talk about what they were doing and with whom. ...[W]ithout [the workshops], I don't think they would have really got it." Lemont said, "We had stuff for the executives to look at. We had trouble explaining to them what the heck an operating system was because we were tool-focused in the company. We would bring in tools, we would do problem solving. That was our history. ...We brought in these different examples and used that to get them to think about what do we want to do, who do we want to be, and how do we define that." An employee who had worked previously as a CI expert for Johnson Controls said that it was common for companies to think of CI as nothing but learning and applying specific tools to problems: "I have this tool belt. I have all these tools. If you use these tools, you'll be Lean. Errrnt, wrong answer! That wasn't it. We didn't understand process. We didn't understand the production-system side of it:...using them all in

conjunction [and] getting everybody everywhere using them, not just in pockets."

Because many of the senior executives had worked for DTE Energy for decades, it was important to acknowledge their previous improvement efforts. An Operating Council executive said, "Detroit Edison has dabbled in lots of improvement programs over the years." The fads mentioned by employees included Management By Objectives (Drucker, 1954), the Complex Change model (Ambrose, 1987; Knoster, Villa, & Thousand, 2000), the Kepner-Tregoe method (Kepner & Tregoe, 1965), and Business Process Reengineering (Hammer & Champy, 1993) (see the Glossary for more information on each of these fads). Maxcomm CEO Bill Adams told the Operating Council, "You've got to honor the past of what has been here. Let's not just race to something new, let's understand how we got here." Ensuring that past improvement programs were echoed in the new operating system was a shrewd way of overcoming the Not-Invented-Here syndrome, especially because so much of its design was copied from other companies' operating systems.

The team also conducted workshops with managers and union members to solicit their opinions. Everyone agreed that the most important part of DTE Energy's operating system was a set of twelve principles (see *Operating Principles* in the Glossary). The team verified that these principles encapsulated the UMP initiative's principles, such that they could claim continuity. One of the team members said, "The story became that it's like [Prego's advertising slogan]: 'It's in there.'" A former UMP facilitator said combining these principles with CI's tools into a single operating-system framework was the best thing he has seen in his 30 years with DTE Energy. The workshop attendees agreed that new behaviors require thinking differently about how to approach one's work, and that this new thinking is stimulated by an explicit statement of guiding principles. Jamie Flinchbaugh explained, "What decision gets made at 2:00 A.M. on the loading dock? You can't tell the guy what to do specifically, but you *can* tell him what principle to follow."

Creating DTE Energy's operating system took about four months. It was a 1-page diagram depicting the intended elements of the CI initiative (see Appendix C). OSSG personnel used it primarily for communicating what elements constituted the CI initiative. They disseminated laminated posters of the Operating System diagram as broadly as they could throughout the company. OSSG personnel also used it as a framework for

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organizing new training courses.

3.2. The CI Initiative's First Plan — 2002-2004

As Patterson's OSSG team was developing the DTE Energy Operating System, they were also developing a 2-year CI implementation plan. OSSG team member Gary Lemont described the underlying logic of this plan as a campaign to convince all employees — not just the senior executives — of CI's value:

> At this point in time, we're trying to get a foothold for something that's sustainable, instead of just doing projects. ...The philosophy of this whole thing was we can't go out and sell this to people as a theory. They're not going to buy it — it's the program of the month, blah-blah-blah. What we have to do is show them some results. The concept was we'll do some demonstration projects and then, as we're spreading the word, we can point to these things and say, "In your organization, for instance, we did this. And look at how neat that was! Not only do we want to do this, but these are the kinds of results that we think we can get by doing this." That was the strategy. ...We said we're going to do demonstration projects, then...as we're teaching people, we're going to be able to point back to the demonstration projects.

Early in the plan-formulation process, the team confronted two questions. The first question was about the initiative's initial breadth. Lemont explained: "There was a big discussion: Do we go a mile deep and not very wide, or do we go to ten thousand employees and an inch deep? The mile deep won. ...So we weren't telling anybody else about it, other than the executives. That was the mile-deep thing: We're going to teach people who can go out and use it...show[ing] them the demonstration projects that have results. Then they'll go out and do their own [projects] and it'll just grow."

The second question was whether to incorporate Six Sigma — already well underway at Motorola, GE, and Allied Signal — into the CI initiative. Several OSSG members remembered the idea being considered, but ultimately the team settled on a Lean-only approach. When I asked about the team's reason for dismissing Six Sigma, one member answered, "They just didn't want to do it. They didn't think they needed it." One ramification of this decision was the development and adoption of a phase-gate problem-solving and project-management model called 4-Gate 9-Step (4G9S) as an

alternative to Six Sigma's DMAIC model (see both *4G9S* and *DMAIC* in the Glossary).

This first CI implementation plan comprised four 6-month phases, running from mid-2002 until mid-2004, with gradually increasing targets in each phase for the number of employees trained, for the number of demonstration projects completed, and for the amount of savings gained. Patterson explained the plan's design:

> We created this implementation plan. ...We had envisioned that this was a two-year thing to create full engagement in the organization. We would go through these different phases. You could break this down into how we were going to train, what was going to be the executive-development piece, what kinds of projects we were going to work on, how would we measure. And it would grow as you go through these different phases. We defined how that would look at each phase.

The plan called for the OSSG personnel to train 25 OS Experts during each 6-month phase. These OS Experts were expected to complete demonstration projects. External consultants would assist at the beginning, but this assistance was expected to taper off as the OS Experts gained experience. The goal was to train directors first because they were in positions to promote CI both up and down the management hierarchy. One OSSG member said the directors selected to become OS Experts were "good problem solvers to begin with, or engineers who liked to analyze things." Twelve of the OSSG's 17 employees also became OS Experts to act like an internal consulting group, many of whom would work on projects in their former business units leveraging their subject-matter expertise.

Shawn Patterson hired a Lean expert in early 2002 after OSSG personnel had difficulty creating the OS Expert training course. An OSSG manager recalled, "When we first started designing it...it was not well integrated. We all had little sections, based on our [OS] framework that we were going to teach. That's okay; when you're starting out, you don't know what the hell you're doing. But it became apparent that we needed a Lean expert. That's when Michele came in." Michele Hieber was previously a Lean consultant at RWD, with a certification from Masaaki Imai's Kaizen Institute of America, past experience at Johnson Controls, and a Master's degree in adult education. She assumed responsibility for the OS Expert training:

Jamie [Flinchbaugh] had already put together the training package. These [OS] Experts were the directors of the organization. They were going to put them through these long classes, over a long period of time. There was a humongous body of knowledge that was put together for them. The first day I came, they were starting module one. Jamie left to start the Lean Learning Center, so I picked that piece up.

...There were twenty-five directors and managers in the class, it was twenty-six days long, and it was parsed out over an eight-month period. ...It was full of applications, games, and simulations — all kinds of stuff. It was all Lean. ...There were twenty-six things listed [on the Operating System Framework]. I had to have a module for all twenty-six of those things. There were things like corporate governance. ...I had the corporate secretary come down and talk for two hours about what governance meant to the vice presidents and the board of directors. I never understood what corporate governance had to do with teaching Lean concepts.

For the second class, I took it from twenty-six to twenty-four [days]. We got through that and then we made the determination that there was no way we were going to be able to [train everybody as an OS Expert]. At that time, we had about eleven thousand people in the organization. I had just spent a year and a half and got fifty trained [by the end of 2003]. ...We were able to get the organization to [agree that] you don't need to know about governance, you don't need to know this, you don't need to know that. We moved to this [second OS version], so I didn't have to do those twenty-six things anymore.

After designing the OS Expert course, Hieber developed a 6-day introductory course for front-line employees called OS Specialist training in 2003. She said, "I quickly took from [the OS Expert course] the stuff that I thought [employees] needed to know and what other corporations had done — Johnson Controls and Ford." OS Specialist training was intended to introduce employees to CI and the Operating System, providing enough background for them to contribute to demonstration projects if they were called upon to do so. The OSSG personnel trained about 250 OS Specialists in the course's first twelve months, but the implementation plan's emphasis was on training OS Experts to complete demonstration projects.

The CI implementation plan specified targets in each phase for demonstration-project savings. Patterson said that these demonstration projects were "*kaizens* on steriods, taking on meatier things, longer-term projects." Another manager explained:

When we first started with these demo projects in 2002, we didn't have any Black Belts or any of these statistical methods. The reason they were called demo projects was because the vice presidents were requesting proof that the methodology worked. ...[A]n [OS] Expert and a [Project] Lead would go out and take a large project that would take, say, three months to six months to fix. They would use the 4-Gate 9-Step process to prove that that methodology worked. They would go through the gates with the various vice presidents and produce a report at the end. ...After a while, they believed.

The plan assumed the OS Experts would complete 91 demonstration projects, saving an average of $2 million per project, for a 2-year savings target of $182 million. Shawn Patterson reported progress toward these targets monthly to the Operating Council. By the end of 2004, the OSSG had trained the expected 125 OS Experts, who completed over 150 projects, reportedly saving approximately $175 million (see Figure 3 below).
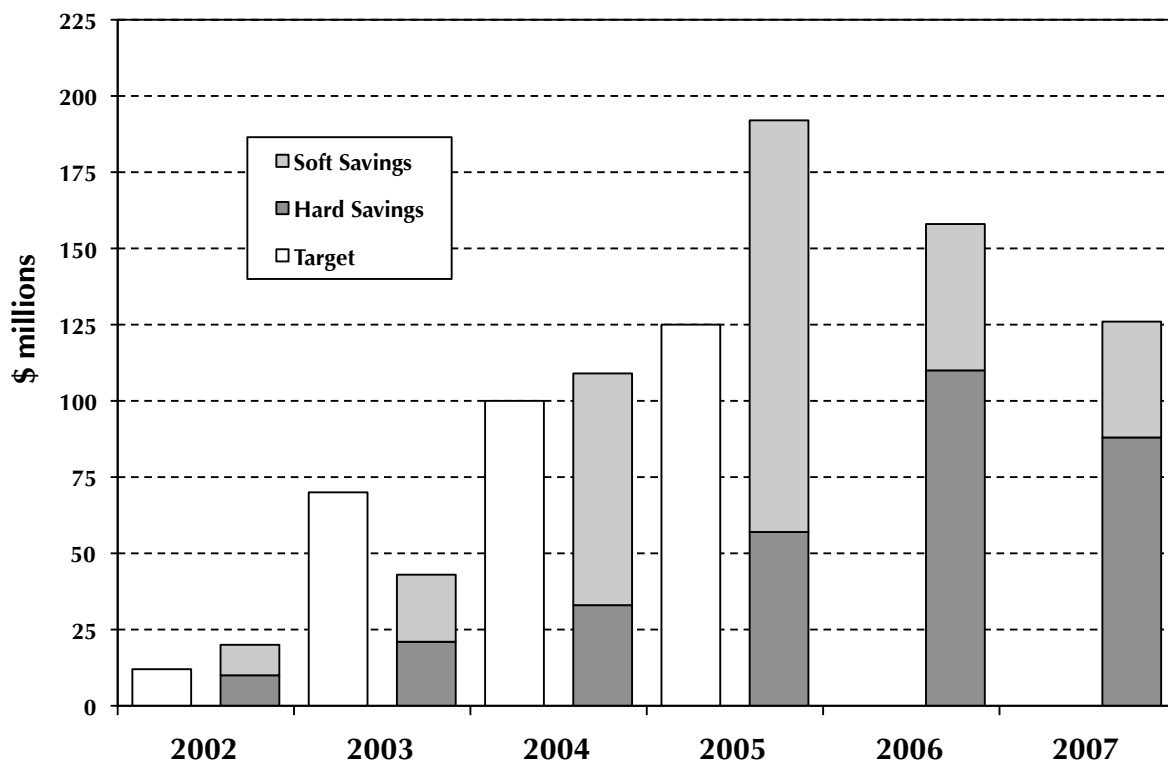
Figure 3. CI Initiative Targets and Reported Savings

One OSSG employee believed that Patterson's plan to convince the senior executives of CI's value succeeded with these results. He said, "I think we got some

people's attention [for] the potential of what we were talking about." Another perceived that they weren't sure at the outset what CI was or what the initiative was going to be, "but they figured it was a good thing to have." He also perceived that the senior executives, in 2002, did not consider CI to be part of their core strategy to improve the company's performance at that point, despite CEO Tony Earley's public statements to the contrary.

The CI initiative's results at the end of 2004 were not all positive. One employee observed that the business-unit managers began resisting the CI initiative because they didn't want their budgets reduced. (As we shall see, their budgets would be cut a few years later anyway.) A management report circulated in December noted a few other failures. First, about 60 percent of the reported savings were considered "soft" — avoided costs that did not directly reduce expenses from one quarter to the next. Second, the OSSG failed to engage union members in the CI initiative, training only about 50 represented employees (5 percent of all employees trained). Third, the plan's authors naively assumed that the CI initiative would be "fully implemented" throughout DTE Energy in only two years. In 2008, Shawn Patterson reflected on how unrealistic, yet necessary, was this timetable:

> I thought it was a cool plan, but totally flawed in a number of ways. When we created the plan, we had a big to-do over at the DAC to bring everyone on board. A lot of the executives had contributed pieces to it, so we brought them all in to explain this is what we're going to do. I remember sitting [there] and I honestly thought that two years was long. Man, that's a long time. If we don't get there, we really screwed up.

> I look back [in 2008] and, honestly, we're probably somewhere in this [second] phase now. What I've learned, as I look at other companies and read about Danaher and see what Chrysler and GM struggled with, there's a period of five years of, What is this thing and exactly how do I engage around it? Then, once the rules are understood and the principles behind it are somewhat understood, there's the [question], Now how do I really link it into where I'm trying to take the organization strategically?

> At best, these are probably two-year phases. More realistically, [they are] probably three- to four-year phases that you need to move through. Problem is, going back to 2002, if we had put a ten-year plan together, [people would have said], "Whatever! We've got forever to get this thing going." So you almost

need to force it. It's totally unrealistic to think that in two years you can have full engagement around this work.

If you think we really got going by 2002 — by the time we did all our pre-work and everything — you're looking at 2012. It will be interesting to see where we are then. I think there isn't a lot of questioning of [CI]: Are we going back? Are we not doing this? But I think there's still a lot of skills to build in the organization. It's ten years, it is.

3.3. Addition of Six Sigma — 2003-2004

In 2003, the OSSG's plan for demonstration projects was well underway and was succeeding at convincing the senior executives. With the CI initiative thus established, employees familiar with Six Sigma began to question its Lean-only orientation. These employees knew that both Ford and Johnson Controls had parallel but separate Lean and Six Sigma initiatives. Then, a new CI manager and a new vice president, both of whom were enthusiastic proponents of Six Sigma, joined DTE Energy and lobbied their peers for its adoption. I believe that the OSSG yielded to this influence because, with the hype of introducing DTE Energy's Operating System subsiding, adding a Black Belt program would keep the executives' attention on the CI initiative. One OSSG manager, perhaps with a little historical revisionism, said, "Our initial Operating System framework and the 2002 strategic plan was getting stale. ...It needed to continue to grow. It had probably gotten too rooted in Lean concepts."

Shawn Patterson hired John Weiss[2] from Florida Power & Light (FPL) in April 2003 to replace one of the OSSG's outgoing CI managers. The OSSG personnel were interested in FPL because, in 1989, it was the first non-Japanese company to win the Deming Prize, awarded by the Union of Japanese Scientists and Engineers (Bacon, 1990; Hudiburg, 1991). Weiss had worked for Qualtec Quality Services, the division FPL created in 1986 to provide what would become Six Sigma consulting services to other companies and government agencies. (FPL later spun off Qualtec.) Several of DTE Energy's managers reported being unimpressed with FPL's CI program 13 years after winning the Deming

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[2] a pseudonym.

Prize, but they were eager to learn from Weiss' Six Sigma experience in a utility. One manager said, "Even though people had been talking to Shawn about [Six Sigma] all along, [Weiss] came in and he was able to convince Shawn it was the right thing to do."

A few months later, Bob Richard joined DTE Energy as vice president for Fossil Generation. Richard had become a Six Sigma Black Belt during a 13-year tenure at GE. He was hired by Bethlehem Steel as vice president of operations and process improvement to attempt a turnaround following the company's 2001 bankruptcy. Ultimately, Bethlehem Steel's assets were sold to International Steel Group in 2003, so Richard left for DTE Energy.

Richard created the impression among his executive peers that DTE Energy needed a Six Sigma program. He wanted a Black Belt training program and he was able to articulate how he wanted to use Black Belts. A union employee observed, "John's whole background was Six Sigma. When Bob Richard came in, it was very easy to see where we were going as an organization. I think Shawn was kind of going there before John [Weiss] came in, but that's what brought the whole Black Belt model as we have today."

According to Patterson, DTE Energy adopted Six Sigma smoothly. He said, "Two years into the strategic plan seemed like the perfect time to freshen things up, bring some new tools. ...A lot of people liked the whole Six Sigma thing, being a strong engineering company as we are." He said Six Sigma was easy to adopt because "it was well packaged": The role of Black Belts was clear and the set of tools was well defined. "[T]here was a lot of discussion around, does this change our whole thinking? Or is it just new tools? The new-tools [argument] won out," recalled an OSSG employee. "Lean is not an Operating System. Six Sigma is not an Operating System. They are tools, and the Operating System and the principles can incorporate both. So that's when the Lean Six Sigma thing got born."

Bob Richard, like Dave Meador before him, joined DTE Energy already a CI believer and convinced of its potential value to the company. They both acted upon their beliefs by trying to introduce to DTE Energy what they had learned elsewhere. They both used their positions to promote their ideas among their senior-executive peers. Patterson said Richard was particularly influential in showing how to use Six Sigma Black Belts:

"Importantly, he really knew what he was looking for, so he was awesome in terms of connecting with his peers, other vice presidents, and showing them good models of how you'd use this. He did a great job of linking continuous-improvement work to the strategic plan, getting his Black Belts plugged into the most important things. He really did a great job, I think. He intimidated some of his peers in some ways with how skilled he was at this. He was great. That was huge. We needed someone at his level who really, really knew how to play and act in this world, and he was good at it." Emmett Romine, a former CI manager, described Richard's intentions: "The only guy that was doing it for real in those days was Bob Richard. ...He wanted Black Belts everywhere. He wanted to inundate the system, which is probably what you had to do to change the culture. Inundate the system to the point where you can't get anywhere without running into a Black Belt doing a project."

The OSSG personnel debated how to reconcile Six Sigma Black Belts with DTE Energy's Lean-oriented OS Experts. They discussed the possibility of keeping them separate, but decided in the end to have Black Belts replace OS Experts. (By that time, the OSSG had trained about 150 OS Experts.) Weiss and Michele Hieber, therefore, began to transform the OS Expert course into a Black Belt certification program. A plant manager said that Weiss "was able to put a power-plant twist on it, which was nice." After a few months, however, Weiss took the newly vacant position of CI manager for Fos Gen. The Black Belt course development was taken over by Paul Mullenhour, an Achievement Dynamics consultant who earned his Master Black Belt certification at GE.

The OSSG made a good start training the first cadre of Black Belts. In 2004, the first year of the program, about 26 Black Belts were trained and certified internally, and 11 externally trained Black Belts were hired. A similar number were trained and certified in 2005, bringing the total to 56 but falling short of the CI initiative plan's target of 75 (see Figure 4, p.91).

Patterson and Weiss, at first, followed the common Six Sigma prescription that employees selected to become Black Belts should be promising candidates for advancement. These future managers would be change agents (Bennis, 1963). Hieber said, "We started up the Six Sigma program as quickly as we could and started graduating

Black Belts internally." Richard announced that being a certified Black Belt would factor in his promotion decisions (but he stopped short of making it a requirement). The first cohort of Black Belts were eight Fos Gen employees whom Richard wanted to work on improving specific metrics. A certified Black Belt recalled, "We did it right the first time: We picked the best of the best, the select few who were really good at their jobs and really smart. They went to a bad training class and we made them Black Belts. They went out and did a bunch of good stuff, because they were really good people, influential, and kicked butt."

Many employees felt that Richard's push for Six Sigma successfully changed Fos Gen's culture. By 2008, the plant managers of four of DTE Energy's five biggest power plants were Black Belts. One of these plant managers said: "When the Black Belts first came out, it was one of those, 'Okay, what's Bob Richard trying to do? What's he trying to create with us here?' It was a lot of math, a lot of statistics. There's going to be resistance to some of that, trying to understand where it was coming from. I think, because he stayed pretty strong in making sure that was a process he wanted to have used, ...we have an institution here that looks at always continually improving."

After Weiss became CI manager for Fos Gen, Patterson had to hire a corporate Master Black Belt to lead the training and certification program. The Master Black Belt position proved difficult to keep filled over the next five years. The first Master Black Belt, hired from Ford, turned out to be a poor teacher, so he only mentored Black Belt candidates while consultant Paul Mullenhour continued to teach the Black Belt course. This first Master Black Belt left about a year later, in 2005, and was succeeded by a survey statistician from DTE Energy's marketing department who, surprisingly, was not a Black Belt. The statistician left after a few months when her husband, also a DTE Energy employee, took a job in another state. The statistician's replacement, a Black Belt this time, lasted from late 2005 until November 2007. The position was then vacant for six months until a Master Black Belt was hired from EDS in May 2008.

Several managers thought that the Black Belt program suffered from this lack of leadership continuity. They voiced three main complaints (see also Appendix B). First, each Black Belt program leader revised the course to emphasize his or her preferred tools

and methods. As a result, Black Belts trained at different times had highly variable expertise. Second, the Black Belt program languished in the gaps between leaders; most importantly, Black Belt candidates' progress toward their certifications was suspended during these gaps. Third, the criteria for Black Belt certification, especially for acceptable projects, were variable and inconsistent over time. Consequently, one Black Belt said that the program "lost its momentum, got messed up...and watered down...." These problems stand in contrast to the approach taken by many of Michigan's automotive companies. Several Black Belts, who earned their certification at other companies before joining DTE Energy, reported that Ford and Johnson Controls hired Six Sigma Academy (SSA) to design their Green Belt, Black Belt, and Master Black Belt training courses and to train their future instructors. (SSA was the original Six Sigma consulting company started by Mikel Harry, who developed Six Sigma at Motorola in the late 1980s with Bill Smith.) Once installed, these companies' Six Sigma programs were consistent, stable, and commensurable with each other.

3.4. Learning Lines — 2004-2005

In addition to starting a new Six Sigma Black Belt program, the OSSG personnel also decided to attempt a learning line. Manufacturing companies adopting Lean typically experiment with the new techniques on a smaller line separate from the main production line. OSSG members were encouraged to try a utility analog of this practice by Steve Spear, who had used learning lines successfully at the University of Pittsburgh Medical Center (UPMC) (Thompson, Wolf, & Spear, 2003). (UPMC had adopted Lean from Alcoa in 2000.)

I present this story of DTE Energy's first learning line in detail because of its importance to the CI initiative — it was still discussed as a paragon four years later — and because it shows necessary elements of CI that DTE Energy struggled to replicate later and elsewhere in the company.

MichCon personnel had been trying to improve the field employees' service-call productivity (service calls per hour). OSSG member Gary Lemont said, "I think it was two

or three years they were tracking it, trying to improve it. They had done different things and it hadn't been giving them any results, so they generated a project for it." MichCon's frustrated vice president came to the OSSG for help. Marcia Jackson, MichCon's CI manager, assembled a team, which included Lemont and two other OSSG employees, to meet with the MichCon executives. "When we sat down with them," Lemont recalled, "we said, 'Well, this is a pretty big thing. Why don't we go to one service center and we'll do some work around there?'" Jackson said that their objective was "to see what type of improvements we could make and possibly sustain over a ninety-day period."

The learning line took place from February to April 2004. Of MichCon's four service stations in Detroit, Jackson's team selected Coolidge Service Center for the learning line because it had the worst productivity, and because the station manager was willing to let them in.

The OSSG team knew that they were going to focus on making improvements at Coolidge over a 90-day period (this was perceived to be a long duration), but they otherwise didn't know what they were going to do. Their first step was to understand the work being done, so the OSSG personnel and Coolidge leaders accompanied the front-line employees on their service calls for a few days. The team sought to understand the timing and duration of customer service calls and, especially, what barriers hindered MichCon's employees. Jackson recalled:

> Basically, the approach was to first observe work. We assigned a [team member] to each person [whom] we selected to be on the learning line. The learning line was ten employees: They were union employees, a supervisor, and a leader. We did ride-withs for a couple of days. I asked each team to look at the timing of every single thing that was done, from seven thirty until the end of the shift, ...to really understanding what happens [and] primarily what gets in their way — how many times they had to go back and forth to the truck because they forgot something, or they didn't bring what was needed with them.

> Once that was completed, we invited everyone to a meeting. I facilitated the session to look at what was observed and the timings.... Then we started talking about what were some things that we could do to remove those obstacles or barriers. Part of it was an elementary kind of [CI] workshop: We taught them about Lean and what we were doing, that is, to increase the

number of jobs completed per day. It was a little bit of teaching and an exercise about observing work....

Based on that meeting, we defined a scope. We decided that those ten people whom we rode with would be part of the learning line. They would be taken out of their sections to experiment and implement small changes. They were a combination of seasoned and new employees.

Jackson's team immediately encountered resistance. One of the employees selected for the learning line was a union steward who said, "I can't work any harder than I'm already working right now. We're always getting used. People are always wanting to look at Coolidge. They always want to improve Coolidge." Another union steward tried to have the station manager throw Jackson's team out of Coolidge. Their second step, therefore, was to try to engage the learning-line employees as willing participants. Lemont explained, "There was skepticism at first because most of the time when this happens, the vice presidents come down and say, 'This is what I want you to work on, because this is the problem.' And quite honestly, they haven't got a clue." Instead, he told the learning-line participants, "You're going to drive this. We don't want to know what the vice presidents think is wrong; we want to know what *you* think is wrong. ...[W]e're going to talk to you and try to build an initial list of things to work on. ...We want to try to fix the things that are getting in the way of you being productive." Lemont added, "They appreciated the words and when we followed it up with action, that's when they got engaged. They said, 'Oh, they're going to work on what I think is important? They're going to let me try different things to fix it?' That was it: They were sold!"

The team also found it necessary to demonstrate to the union employees that their improvements would not lead to layoffs. Lemont explained:

The other thing that sealed the deal was a commitment to not reduce complement. ...We warned management up front that that would be a push-back [otherwise]. They were talking about productivity and a big backlog. ...We told them up front: "If you're going to improve productivity and lay people off, this is not going to go off." ...We brought the union management and the corporate management in to do the orientation and the roll-out, so [union members] knew we had upper management support and union support. ...They said, "Okay, so they're supporting it. They're not going to whack us. The union is involved; they're supporting it. They are actually going to listen to

me." Very quickly — over a period of two or three weeks — there wasn't any problem with engagement anymore because things were going very well.

Jackson used a few other tactics to overcome resistance. She held all of her team meetings at Coolidge, even the ones that did not involve the Coolidge employees, to make their seriousness and persistence apparent. She also invited MichCon's executives to attend progress-report meetings to emphasize upper management's support for the learning line.

The OSSG team's third step was to help the learning-line participants iteratively experiment with different ways of organizing their work processes or with possible countermeasures to workflow barriers. The OSSG team gave each employee only one task per day, such as recording how frequently a problem occurred or assessing whether a countermeasure fixed a problem as expected. Lemont said that they didn't use rigorous root-cause analyses or statistics, but used simple tools like 5S or after-action reviews, "whatever we needed to keep the ball rolling." They helped the employees brainstorm potential fixes and "play[ed] around with two or three different things until [they] found something that worked a little bit better." Jackson told the story of this experimentation:

> We didn't know what we were doing. We were just trying to actualize Steven Spear's work of doing learning lines. We were just having a ball. ...We looked at where they worked — their area, their environment — and we looked at how they did their work too, and tried to agree on what are we going to improve. A lot of fits and stops. ...But the point was we were just trying different experiments, some my team suggested and others that the learning-line team suggested. Sometimes it was hard because it was an approach that they weren't used to. If the night before we said, "Let's try this tomorrow," the next day you try it. And while you're trying it, by the way, we're going to be calling you to see if it's working. We may not be out in the field with you, but we're going to call you, the leader's going to be on the conversation.
>
> I found that, the more we experimented with our process as we went along, we started structuring and improving how we were doing things. We had a top-of-the-day call, this is what we're going to implement, and an end-of-the-day call, how did it work? Well, even when we first started doing that, it was kind of all over the place because there wasn't a real agenda. We moved from not having an agenda to an agenda in the morning and an agenda in the afternoon. We moved to a cadence of weekly meetings where the director or the vice president would come to see how we were doing.

Then we started using tools. We created a master schedule once we determined what it was we were going to work on and who was assigned to it. And we got a little smarter: Because we wanted to use union employees, my team split up. I worked with the union employees to 5S the station. Curtis Wilson worked with the leaders to make sure that they were changing how they were looking at work. We told the employees, "You should never be at a job more than thirty minutes before you diagnose it. If you can't diagnose it within thirty minutes, then you must call your leader." That was our *andon* cord. Because we were supposed to be all open and honest, a senior field person who had been with the company for years said, "You know what? You all expect me to know everything and how to do everything, but I don't always know how." Which was great. "Okay, you diagnose the problem. You can't figure it out? You call the leader." The leaders should be monitoring the work load, looking at their watches to see how long they've been at a job and call them to see if they need assistance, because it should be a two-way street. We tried that. Well, this is what tended to happen: You're going into a home that's not in the best condition and when you go downstairs there's cobwebs, or stuff in the way, whatever. You get involved in what you have to do to get to the furnace, moving stuff, the homeowner's talking to you, and then you're trying to figure out what's going on. Thirty minutes goes very quickly. We said, "How do they know when they're at the thirty minutes?" So we went out and bought some egg timers. That was one they didn't like! ...We tried that. We just tried simple fixes.

...Another situation was when everybody's supposed to be gone from the station, but there are always these people left. I asked them, "Why are you still here?" They said, "I don't know where my truck is." So we decided to time [how long it took for] the dispatcher to get the truck to them. We gave them ten or fifteen minutes. We also gave them a visual to know where the trucks were in the yard and who they were attached to, if it was in repair or somebody else had been assigned to it or whatever the case may be at that time.

I think that there was a lot of tension at the beginning. Once we didn't leave, when we kept coming back, kept coming back, even though they didn't want us to be there, after a while they got used to us being there. Then they started suggesting: "You know, what if we tried this?" or "What if we do this?"

We used visual management to make it clear to the employees what's going on or how long it takes them to do their job. We had the employees in all four sections displayed as either green or red depending on whether they got there [to their first job] within the thirty minutes or not. You were red if you didn't. There were a couple of people in our learning line who were really good employees but who got marked red. It caused them to say, "Marcia, why did I

get marked red?" I said, "Let's look at what you did that day for you to be red." Well, she would take her [job list], go outside, turn on her computer, determine what her jobs were going to be, and start calling while she was sitting in the parking lot. She was setting up her day as opposed to calling one, going to that job, [and proceeding in sequence]. Our metric was to be at the first job within thirty minutes and to get everything out of the way of doing that. ...We had a huge metric board and part of the huddle was to see how we were doing. Now they would just look up and see: "Oh, we're green here, we're red there, we're yellow there."

...One of the problems in the morning was the employees needing to calibrate their gas meters. The room to recalibrate your gas meter was probably about [the size of a conference table], and there were about sixty people across the four sections. Give or take, on any given day, maybe forty-five were there. They were all going in and lining up to calibrate their gas meters. So, easy enough, we just had somebody on the midnight shift have those ten gas meters ready when they came in and communicated to the employees where their meters were going to be placed. And it was clearly marked. That [idea] was such a good one, we did it for the whole station. ...One day you come in and everybody's labeled and everybody has a gas meter. "We have assigned seats?" Well, it wasn't a matter of having assigned seats. It was a matter of [ensuring the] equipment you need for your truck will be there at that place.

...Then we looked at parts being left behind: Why are they being left behind? Who are they for? And why didn't they pick them up? There were various reasons: I didn't know, I forgot. So we started putting up parts. Once everything is marked, you can put the parts there too. You can sweep every day and you can problem solve when there are parts left. We measured the number of parts left in an effort to decrease the number. Making sure the right person had the right part at the right time to complete the job. We measured how long it took to get out to the field and we started doing that across the station. What else did we measure? Anything that walked, we measured it.

...I think the 5S helped too, because they knew what stuff was in the lazy susan and what wasn't going to be there. And the environment changed and began to look better; we cleaned it up and threw out a lot of old documents and other waste that no longer belonged in the station. We sorted, set up, and standardized areas where you could retrieve equipment, tools, and documents, or where you could check to see your schedule and other important information pertaining to the work.

The learning line was a success. The employees boosted Coolidge's productivity from an average of 1.2 to 1.7 service calls per hour, an increase of 42 percent. (The

OSSG team had to demonstrate that this improvement was statistically significant, via *t*-test, before DTE Energy's Six Sigma enthusiasts were satisfied.) "During the three months, they worked off the entire backlog," Lemont said. "They started loaning people out to other service centers because they didn't have enough work for them to do. It was a very dramatic impact."

The Coolidge employees' experiences with the learning line convinced them of CI's value in two ways. The first way was being able to improve their jobs by exercising their own volition. Lemont said:

> It was received tremendously by the employees because of their involvement, their ability to tackle the things that they thought were wrong, to implement the things that they thought would work, and the support that they got in terms of doing things differently. A couple times we got into trouble because the union people were suggesting things that the union leadership didn't want them to do! One of the [problems] was starting time. They said, "Why don't we take trucks home and just drive to the [first] job?" We said, "Okay, why don't we try it?" Well, there's something in the union contract about not being able to do that. They got in trouble with their own union, but they were very engaged.

These front-line employees were won over also by seeing managers demonstrate the importance of CI work by participating themselves — not just exercising close oversight, but literally getting their hands dirty too. Jackson related this anecdote:

> You know what else happened? This was kind of interesting. I brought the team in, I explained to them what the 5S tool was, we started doing the work. ...I saw they wanted to be a part of it. ...[W]hen we did 5S, they were saying, "Wow, they really care! Wow, things are changing! Wow, they're painting that? Wow, they're throwing out all that old stuff? Wow, we've wanted to change that! We've wanted to move that desk and it got moved!" ...I had rags! I was cleaning! [laughs] They saw a manager with rags and cleaning, really trying to make it better. There was stuff that had been there for years. It wasn't used anymore, so it was gone: We made room for other things. As they saw that coming together, the environment changing, that's what engaged them more, I think.

The success of this learning line was widely publicized throughout the company. The Coolidge employees presented the results of their work to the senior executives. Jackson concluded this story by describing the rewards that the employees' requested, countering a prevailing assumption that union employees insist on more money for doing

"extra" work:

> The attitude of the line — what I saw was they began to feel special. They were part of the report out to the executives! Some people had probably never presented in their lives and, to be honest with you, the day before we had to do that, I didn't know what was going to happen! [laughs] There were still times that they were mad at me, so I didn't know what was going to happen. They did the report out.

> When teams naturally come together, (a) you see the skill sets, and (b) you see the things that they are passionate about, and they're drawn to those things. So they reported out those things. That worked really well. And the [union steward] guy that I said told me, "You're not going to make me work any harder; I'm not busting my duh-duh-duh..."? He got up and said, "I didn't work not one day harder. And in fact, it's easier!" And it *was* easier.

> ...They became a shining star. [CEO] Tony Earley came to see them. All the execs were there at that report-out. [Energy distribution president] Bob Buckler was there. They were just so pleased with what they heard in their voices and what they saw in terms of their own ownership. It was a happy meeting! It really was.

> What I thought was the most interesting thing:...They asked them, "What do you want?" You know what they said? A baseball game. They wanted to go to a baseball game and they wanted to see Fermi nuclear power plant. That's what they wanted. It taught me something about what is really rewarding to people, and it's not money. Money is only a reward for a few minutes, because then you get used to it. A memory is more rewarding. The great thing was Bill O'Conner, who was the vice president for Fermi (he's retired now), personally took them on the tour, so that was real special. They welcomed us with small tokens and provided us breakfast. And then for the baseball game, Bob Buckler said, "Marcia, call so-and-so and get the suite." So we had a well-stocked suite for the entire game! That was very rewarding. That's probably why they still like me, because we partied! [laughs] ...That was a wonderful experience.

After the learning line concluded, Jackson's team wanted to spread Coolidge's 50-60 countermeasures to the other service stations. They called a meeting of representatives from the other stations to ask them which of the learning-line countermeasures could be broadly adopted. Those representatives resisted adopting countermeasures that had not been tested at their respective stations. Lemont remembers telling them, "Okay, instead of trying to guess about that, why don't we go to another site? We'll take this [list] with us. As we review and start getting [problems] from the new location, if we can pull a solution

off the shelf and try it, we'll do that. If there are completely new issues that come up, then we'll address those in the same way we did [at Coolidge]."

Lemont led a second learning line at the Broadway Service Center in Ann Arbor. The team worked to improve service calls per hour, as at Coolidge. As expected, they were able to use some of Coolidge's countermeasures with some tweaking, and other problems required new countermeasures. They boosted Broadway's productivity by about 20 percent.

This second learning-line team felt that it was harder to engage Broadway's station employees. An OSSG member said, "They made improvements, but it wasn't the same feeling, the same comfort level, the same [outcome of] the people being engaged to the point that they wanted to do it. ...The culture was a little different there. They were a little less accepting, I think, because they were further out and usually people don't bother them." Lemont agreed that these difficulties arose from the Not-Invented-Here syndrome:

> Our culture says, "We're different than everybody else." That's why we couldn't take the solutions from one [station] and implement [them elsewhere] because, even if they were appropriate, the people there have to admit that they're appropriate before you cram them down their throat. "I'm different than everybody else." That's the mentality that we've got. So we brought them along: When a problem came up, we'd say, "You know, over at Coolidge, we tried this and it worked. Why don't you guys at least try it?" They were willing to do that, try it and see if it worked. If it did then they were willing to sign off on it. But saying, "Here's the solution" — that wasn't our culture.

By late 2004, a few MichCon employees were earning their Black Belt certifications, so they took over MichCon's CI activities from the corporate OSSG group. Several OSSG members reported that these MichCon Black Belts called a few of their improvement projects at other service stations "learning lines," but they were not proper learning lines.

Eventually, such misuse of the term 'learning line' poisoned it among DTE Energy's front-line employees. A project was undertaken at Pontiac Service Center in November 2005, which was called a learning line for lack of a better name. But it included plans for eliminating positions. The front-line employees, particularly union members, linked the name 'learning line' to the planned layoffs.

The OSSG personnel regarded the learning-line approach as the most effective way

to engage front-line employees in CI activities, although they admitted that it requires a lot of time, attention, and coaching expertise. As we shall see, the OSSG directors wanted to reintroduce the learning-line approach in 2009, albeit under a new name, to experimentally develop specific ways of enacting CI in each of DTE Energy's business units.

3.5. The CI Initiative's Second Plan — 2004-2005

The first CI implementation plan came to an end in mid-2004, triggering several changes to the OSSG. A new plan was needed to guide the CI initiative forward, especially because it had not reached Patterson's anticipated company-wide "full implementation" after two years. The new plan also needed to reflect the 2004 switch from OS Experts to Black Belts. Furthermore, after being the CI initiative's driving force for five years, Patterson was ready to hand that responsibility to someone else. Patterson was part of DTE Energy's talent-planning program, which required candidates for upper-management positions to rotate through the major business units of the company. He moved to Distribution Operations (DO), running DTE Energy's north area operations for a while before becoming DO's director of resource management.

John Weiss succeeded Shawn Patterson as OSSG director. Several managers thought that Weiss was not the CI visionary and cheerleader that Patterson was, but he was chosen to lead the CI initiative for several reasons. First, managers considered Weiss' utility background an asset. Second, he benefitted from several senior executives' enthusiasm for the new Six Sigma Black Belt program, which he championed. Third, many pro-CI managers thought that the CI initiative had matured such that it no longer required Patterson's entrepreneurialism. Patterson had always viewed his OSSG-director role as a teacher and mentor to the senior executives. He felt that the CI initiative was so fragile at its beginning that he had to prevent the senior executives from making mistakes. He said, "Things were always so tenuous that if they were going to do something stupid, I had to somehow do something to counteract it." By mid-2004, however, Patterson believed that such nurturing of the initiative was no longer required. "We had the delusional belief that

we were farther along than we really were," said Patterson, "and that anyone could have stepped in. That was the feeling with John [Weiss]: Things are good enough; we can't push backwards, everyone gets it. But that proved not to be the case."

The transition from Patterson to Weiss was gradual, lasting the latter half of 2004 as they collaborated on a second CI implementation plan. Jason Schulist, another graduate of MIT's LFM program, also contributed to the plan. (Schulist had joined DTE Energy from GM in March 2004 as the new CI manager for DO.) The second plan retained the essential features of the first one: Train a specified number of CI experts (now Black Belts) who would complete projects to reach annual savings targets. The plan's authors expected that improvement projects would save $125 million each year in 2005 and 2006, and would reduce operations and maintenance (O&M) costs by three to five percent annually thereafter. They also hoped for improvements in non-financial measures like customer satisfaction, safety, and absenteeism, but the details of these objectives remained vague. The plan also called for all 100 directors and senior executives to attend a CI "champion" course. The plan specified a training rate of 25 people every 6 months. The OSSG personnel began designing this CI Champion course but, for reasons explained in the next section, never launched it.

According to one member, the OSSG personnel reconsidered their 2002 decision to follow a "mile-deep/inch-wide" approach. They felt that the front line's lack of understanding was hurting the CI initiative. One front-line employee recalled, "There was a big push...saying everybody needed to have OS training." The OSSG trainers subsequently achieved the second plan's target of training 600 OS Specialists by the end of 2005. Judging this number to be insufficient still, the OSSG personnel began planning a large push to train 4000 front-line employees on the Operating Principles (see Glossary) and five basic CI tools. No one mentioned that the second plan, like the first, did not specify exactly how these front-line employees would become involved in CI work after they were trained. One employee observed that the front line didn't take the OS Specialist course seriously: "[For] most people in an office, unless you were busy, wasting three days in training was usually a good proposition. [It] gets you to meet different people. It was fun...I think we got to go up to Big Rapids [Michigan] or something, golfing afterwards."

The second implementation plan was clearer about the Black Belt program. Weiss wanted to train and certify at least one to two percent of DTE Energy's total workforce as Black Belts, between 100 and 200 people, by the end of 2006. An OSSG manager said, "We've never met that, never got close to that. Most of the vice presidents will say they know they need more, but they can't see how to fund it. ...Most companies have a hard time figuring out how to fund that, because it's always about, What have you done for me lately?" DTE Energy certified 56 Black Belts by the end of 2005 and 75 by the end of 2007.

The OSSG personnel debated whether these Black Belts should be members of the OSSG and assigned to business-unit projects as needed, or owned by and embedded in DTE Energy's business units. They decided to decentralize the Black Belts, placing them closer to where problems arise. Weiss also wanted the OSSG to have a Master Black Belt mentor for each of DTE Energy's four major business units, but the senior executives never approved this staffing plan.

The plan included no overall project targets, but each Black Belt candidate was required to complete two projects to earn his or her certification. These candidates were required to use DTE Energy's 4G9S project-management process for their projects (see *4G9S* in the Glossary). Emmett Romine, a former CI manager, said that this requirement caused many employees to believe that "if [a project] is not four-gate nine-step, it's not CI."

With large annual savings targets and a continual need to convince CI skeptics, it is unsurprising that Weiss maneuvered to count the benefits of successful improvement projects toward the CI initiative's targets even if those projects were not undertaken as part of the CI initiative. For example, Weiss permitted Frank Wszelaki, the director of Monroe power plant, to count his periodic outage handbook project toward his Black Belt certification, even though most of the work was done before the Black Belt program was established. Wszelaki said, "I think [the OSSG] wanted to highlight that [project] because it was so much savings — in the millions of dollars. We wanted to have something up there that showed if you take a big project — we're talking megawatt-weeks now — you can save so much. You're talking twenty-five, thirty-five millions of dollars that you can

save by just making sure these units are available sooner, by doing the right planning up front."

Every power plant unit must be taken out of service every couple of years for periodic maintenance. In 2001, Fos Gen personnel used to 'guesstimate' how long a major periodic outage would take (usually between 4 and 15 weeks) and did not control each one with rigorous project management. Wszelaki said, "We didn't have a structured approach to doing outages. When I was in Fossil Gen [before 1991] at Monroe, we had developed very good rigor around how we managed periodics. Over time, for whatever reasons, there was no format, policy, procedures around managing outages." He assembled a team that, over the next 18 months, developed a standardized process after studying the procedures used internally at Fermi and Monroe, and externally at TVA in Tennessee and at Progress Energy in North Carolina. The team also solicited contributions from union members and from upper management. They published a periodic outage handbook in 2003.

The handbook was a success, and Wszelaki and others kept improving it. The new procedure saved DTE Energy about $11 million in its first two years of use. Wszelaki and another outage manager revised the handbook for their Black Belt certifications: "One of the things that we observed when we wrote the outage handbook was we didn't have a good understanding of when the outages would occur, so we couldn't sequence who needed to do what when and we didn't communicate it well. So we tried to improve our ability to show...how many outage weeks can we do." One of the first outages to occur after the revision was scheduled at Monroe, where Wszelaki had become plant director. He insisted his staff follow the handbook to the letter. "We learned quite a bit from doing it," he said. Those learnings became the basis for the next revision. Wszelaki and his team presented it to other utilities, at conferences, and at industry-group meetings like the Electric Power Research Institute (EPRI), receiving "a lot of kudos on it."

Another project given retroactive credit was led by one of the few union members to pursue a Black Belt certification. He explained that prior to the 2001 merger, neither MichCon nor Detroit Edison managed their vehicle fleets well. As an example, he said one could go to a service center in the middle of a work day and see 50 idle vehicles in

the yard. He said, "There were stories of linemen who had two or three bucket trucks!" After the merger, DTE Energy therefore sought to trim its fleet of over 7000 pieces of mobile equipment. The union Black Belt's fleet project enabled DTE Energy to auction off 50 bucket trucks for a financial gain of $8 million. (In 2002, a bucket truck cost about $125,000 and had a 7-year expected life. DTE Energy's truck-maintenance reputation was so good that bidding utilities offered high prices.) The union Black Belt recalled presenting his results to a group of senior executives that included CEO Tony Earley: "When we rang the cash register, they were very happy."

The union Black Belt's other certification project is an example of the large benefits obtainable with better design and control of neglected processes. He instituted new policies and procedures for approving and reporting overtime in DO. He explained that when a circuit is out from a down wire, for example, the overhead linemen may have to work overtime to get the lines back up. But the dispatchers would sometimes grant the linemen, who wanted extra pay, their requested overtime even if their relief shift was sitting in the service station yard with nothing to do. The Black Belt said, "It was a free-for-all, and it was [costing] millions and millions of dollars."

Gerry Anderson, the executive vice president for Fos Gen, was promoted to DTE Energy president in mid-2004 and to COO about a year later. Many managers believed that he was being groomed to succeed Tony Earley as CEO. At the time, Anderson knew little about CI, but he continued other executives' expectation for its use. At an upper-management retreat in early 2005, Anderson reportedly told DTE Energy's directors, "I want you to do CI and work it hard." But because Anderson did not believe in CI himself at that point, he did not specify a method for working CI hard and, furthermore, delegated oversight of the OSSG to senior vice presidents Steve Kurmas (DO) and Bob Richard (Fos Gen). Patterson explained that Anderson's family owns a large agriculture-related business. His siblings, who run the company, had been unsuccessful with CI experiments of their own, so Anderson "has always been a bit of a skeptic from day one." As a former McKinsey consultant, however, Anderson brought a stronger focus to the mounting pressures on DTE Energy's financial health.

Some senior executives, including Anderson, had begun to doubt the veracity of the

savings attributed to the CI initiative. From 2002 through 2005, the OSSG's reported savings approximately doubled each year, but the savings classified as "soft" made up progressively larger proportions of the annual amounts (see Figure 3, p.48). These "soft" savings constituted 67 percent of the 4-year total. Even the so-called "hard" savings had not necessarily produced visible changes to DTE Energy's financial statements. Patterson recalled, "I think Gerry [Anderson] got frustrated with where the [CI] program was going. That's where the [cost-cutting] came from. He didn't feel like the Operating System was catching hold the way that he had expected it to. He didn't feel like it was delivering the kind of results that it should have. And he was right. ...Gerry [Anderson] saw the statistics about our soft versus hard savings [and said], 'I'm not driving the structural change to this business that I'd expected.'"

The OSSG personnel felt strongly that the Operating Council should have decided how the CI savings would be put to use from 2002 forward, whether funding extra projects, increasing shareholder earnings, or reinvesting the gains in more improvement work. Instead, the senior executives, not wanting to imperil the restarted CI initiative, let the business units keep their savings. (The executives did so by not reducing the business units' budgets.) An OSSG employee characterized the business units' argument as follows: "If I save a million dollars and you take it away from me, I'm not going to save any more money for you. So if I save a million dollars, you've got to let me do what I need to do with it." But these uses for CI savings were not necessarily the best for DTE Energy's strategic objectives or for the health of the CI initiative. The business units typically used their CI savings to fund over-budget projects, to fund desired projects that upper management had rejected previously in the budgeting process, or — as one disapproving employee put it — "to go waste the money elsewhere." One of DTE Energy's CI experts said, "We went along for a while, doing a lot of good work and not seeing anything fall out on the bottom line. When Gerry Anderson talks about not getting any results, he's not talking these [savings] numbers not being big. He's saying, 'I don't see them anyplace.'"

DTE Energy's managers and Black Belts cited several reasons for the CI initiative's failure to affect DTE Energy's bottom line through 2005. Two big problems were poor

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project selection and poor project management. Several managers complained that the demonstration projects and the Black Belt projects of the two CI implementation plans tended to be ill-defined, too broad in scope, and not selected strategically (see also Appendix B). One Black Belt thought that DTE Energy's CI initiative compared unfavorably to the Six Sigma initiative at GE, where he had worked previously. He said, "It was like we weren't taking it seriously. It was frustrating." An OSSG manager recalled, "[W]e were advocating that [the business units] needed a portfolio of projects. They needed a PMO [project management office]. They needed a way to prioritize. We didn't have that in many of the business units. People just did stuff. (That time was still a little early on in the Black Belt [program], so there wasn't a huge pipeline of people.) They just worked on things. A director would tell you what to work on. We were trying to build that structure, but we had no functional power. We were [telling] them: 'You need to get your act together.' ...It's a lot better now in the areas that have [CI] managers." For example, DO's CI manager Schulist was responsible for auditing a line-restoration improvement project in DO. He recalled that the project was so big, it was really 13 projects. He refused to let the team close the project when the 13th sub-project ran into trouble. He said, "I didn't count it as a successful project because it was scoped wrong." These project-management problems persisted despite the OSSG personnel designing the 4G9S process to avert these difficulties suffered by the *kaizen* events prior to the MichCon merger. Another manager summarized his perception of the Black Belt program's deficiencies:

> The training itself was not well crafted. When you went to the class, right out of the chute it felt like a waste of time, in some cases. ...You came out of what was called a Black Belt program with what is probably the equivalent of a Green Belt in other companies. Having seen other programs, I knew that. ...Why are you calling this a Black Belt? It's not a Black Belt.
>
> ...Secondly, the projects:...there wasn't good tracking, there wasn't enforcement, there wasn't a good connection with the budgeting process. People were getting to call it "savings" and there was no interaction with the finance guys to say, "Okay, this is a good project and we will take this out of the budget for next year."

Do the Black Belt projects always have to focus on financials? No. They could focus on other things. But...they weren't going in and saying, "We're doing a project on reliability. We're going to increase our forecast for reliability from now on because we think we've affected it with this program."

...It felt like a toy, like a program of the month, so people didn't take it seriously.

A few managers with strong consulting and finance backgrounds believed that the CI initiative, until 2005, failed to improve DTE Energy's cost structure because it did not counteract a culture of "gaming the system" with a strong emphasis on executives holding their subordinate managers accountable for verifiable results. One such manager said:

When John Weiss was running [CI], it was demonstration projects. All of a sudden, you had a whole bunch of little toy projects out there that somehow managed to stack up to a hundred and twenty million dollars or whatever he was promoting. Nobody believed it. There was very little buy-in that that was actually happening, because one of the cultures we have here, as a company, is we love to game the system. We love to [claim] that we saved money when we really didn't. There was a huge culture behind that. ...[CI] didn't change the culture such that...we were accountable, and honest, and had high integrity with these things. It was not mainstream. It wasn't part of core operations. You put a Black Belt...on a project, keep him busy — politically, you're covered. There's still some of that today. ...There were a few projects that were highlighted that did get into core operations, but far and few between.

...For a long time, I looked at Fossil as being a leader until I...got close to them, and looked under the covers. ...In this case, I would say that the finance guys were somewhat [complicit]. What they would do is say, "I've got an O&M budget of four hundred and twenty million dollars. I asked for four hundred and fifty, so my CI gap is thirty million dollars." They would work supposed expenditures down to where they hit the four hundred and twenty. ...They had all these people out there doing these little projects, and they had weekly calls, and it was cadenced, and it was worked hard.... Some projects probably had merit, but the approach didn't appear from the outside [to be] making a real impact.

Patterson, looking back on the performance of the initiative he cultivated, noted its successes and failures. DTE Energy had progressively built its capability for improvement projects, from the early *kaizen* events, through the post-merger demonstration projects, to the Black Belt program. But he thought that the firm foundation for cultural change — CI

leadership from the senior executives and broad participation by front-line employees — had yet to be laid:

> [With] *kaizens*, we started getting lots of people involved, early wins, teaching some things. Get twenty people in a workshop? Awesome, they're going to learn something. But we were really working on very isolated processes, like how do I get this type of an accounts receivable from ninety days to thirty days. Really small, low-level kind of stuff.
>
> Then we got into the [post-merger] integration work, so it got a little more high-level. Early on [with] the Operating System, we tried to nail some very major, strategic problems in organizations that we wanted to close gaps with.
>
> But then we got so focused on this cadre of Black Belts that that almost became the program. It was like these fifty people were the ones, the disciples, [who] make everything happen. We weren't letting everyone else into the game. The projects almost collapsed under their own weight, because it did require lots of other people to have skills to understand [for example] why you're putting *kanban* in this place. The fifty Black Belts were the only ones who were working on anything.
>
> We [were] working on some nice stuff, but lost a lot of the development of the organization. Now Jason's tried to steer it back: How do we get to the masses again? How do we not turn this into, "Black Belt project? I can track it!" but a cultural change? You know, really understand that.
>
> Another thing: When we went out of the gate, there were some things in [the 2002 plan] on how we were going to develop our executives, but it wasn't the same type of focus that we had before we created that plan. [Previously,] we were getting them out with Alcoa and bringing in Steve Spear. We really did not do enough on the executive-development piece. You had an organization [that] was starting to out-pace the leaders of the organization in terms of what they were capable of doing. When you needed that executive presence, executive backstop on some projects — "No, we're going to go *this* way and these changes *are* going to happen" — they collapsed because they didn't get it. That was a miss too, early on.
>
> Plus, I think hearing from other leaders — to be patient with it and keep growing your skills and keep building — would have been really helpful. We missed that one.
>
> We had our two-year plan that we were working on and, in terms of checking the dots, we had done it, but whether it was true to the intention of what was supposed to happen was questionable.

Senior vice president Bob Richard agreed with Patterson. The CI initiative was still led primarily by the OSSG, which consisted mostly of training a few experts to do projects. Richard was looking for a broader transformation in work practices. "Like most companies," he said, "we spent a lot of time on education and tools, and not as much time on implementation and execution and employee engagement. We were implementing a lot of tools, developing a lot of change leaders, a lot of Black Belts. They were doing projects and getting some things done, but we weren't fundamentally changing the company" (Wilhelm, 2009, p. 37).

3.6. The Performance Excellence Process — 2005-2006

In Chapter 2, we saw that DTE Energy's senior executives were nervous about the consequences of utility-industry deregulation. It was this apprehension that prompted DTE Energy's executives to start the CI initiative in 1998. These fears were rekindled when MISO's day-ahead and real-time trading system went live in April 2005, decoupling customers' price of electricity from their utilities' cost to generate it. A 40-year veteran of DTE Energy said, "I personally thought this was never going to work. The model we've had for electricity was developed in the 1800s [and has] worked well for over a hundred years. ...I said, 'They're never going to deregulate.' I was very much wrong." About the launch of MISO's trading system, he said, "When they got to the summer, it was a disaster. By September, it was like a well-oiled machine."

DTE Energy's operating costs were high, putting it at a disadvantage in a deregulated market. One manager recalled: "Gerry Anderson pushed benchmarking. [He] wanted to see where we were relative to the rest of the utilities industry. ...[W]hen you did an overall and honest-to-God look at the cost structure of the company, it was pretty bad. We had the highest administrative cost. We were third or fourth quartile [relative to our peers] in a lot of other places from a cost-structure point of view." Also in 2005, DTE Energy anticipated making large capital investments at its power plants to comply with stricter environmental regulations in the coming years. Several managers said that DTE

Energy's "cost structure was going to be unsustainable with all these investments coming." Consequently, DTE Energy's senior executives were "fully aligned" in their agreement that something needed to be done, so COO Gerry Anderson hired McKinsey, his former employer, to design a cost-cutting and consolidation initiative called Performance Excellence Process (PEP).

The McKinsey consultants began their analyses in August 2005, assisted by two other consulting firms. They scrutinized every aspect of DTE Energy's operations, looking for opportunities to trim costs, consolidate or eliminate services, and divest where strategically appropriate. Patterson, having moved to an operations role in DO, explained, "The idea was we're going to do benchmarking [against other utilities], we're going to see where the gaps are. [Gerry Anderson] expected plans from all operating executives for how they're going to close from wherever they are to first-quartile performance — and we're going to use the Operating System to do that. Well, the leaders didn't know how to use the Operating System to do that. They had some Black Belts who could work on some projects, but Gerry was very demanding on how quickly it was going to happen. Some of these projects, to really do them right, were longer-term projects. So it became your traditional [cost cutting]: outsource things, stop doing certain services." Power plant director Frank Wszelaki related the story of when McKinsey's consultants came to Monroe:

> It was August of '05. They came in and showed us that our business model was not efficient. That's what they said.
>
> They came here [to Monroe power plant], they went to St Clair [power plant], they went through our records, they went through how the [coal-fired] units operated, they looked at my financials, they looked at my organizational charts. They brought in a team of three to four people and we inundated them with data for weeks. Then they studied it.
>
> They got back to us. They had different areas where they told us we were having issues. They benchmarked us against what they thought was the industry best, the top quartile, and made suggestions. They worked with us.
>
> I got to admit, from a standpoint of telling you your baby's ugly, it made you look at yourself in a different context. Plus, the way they presented the stuff, you could tell it was PhD professional. They were able to show us charts and

graphs that made good sense really fast. ...Taught me a lot on the presentation of data, more than even my Black Belt training. They had a way to present information so it made sense.

I thought they also did an okay assessment of us. It got us to move toward trying to improve and trying to learn. [But] sometimes you've got to move on your own and keep going. That's what we did.

...They were pushing huge change. They did an Activity Value Analysis for engineering and they did a process evaluation for Monroe and St Clair [power plants]. We went through and did [an employee] headcount walk. We had five hundred and twenty-four employees, a hundred and seventy-five full-time contractors, and close to two hundred [Detroit Edison] foreign labor [see Glossary for definition].

...If we did certain things, what improvements could we make in what areas? They pushed you to put a plan together. We presented that plan in front of Gerry [Anderson]. I can remember doing it here.

...My only problem with that whole [employee] numbers thing was we were told it was to maintain and operate [the plant]. We never looked at [staffing requirements] for periodic outages, forced outages, [and] capital-modification work. We were told what it would take to maintain and operate the site and somehow those numbers got twisted.

When I told people we would have an outage where I needed extra operators, or if I had a forced outage where I had to put an extra operator to [shut down] a unit, [they asked:] "Why do you need to do that?" [I said,] "If it's a periodic outage, I got five hundred people standing around. I don't think one guy's enough to [shut down] the unit, do you?"

...[McKinsey's consultants] told me I could run a unit side with one [system operator]. [If] we have a unit trip, we almost have to have three [operators] to bring it down.... They were good MBAs, they took their data, but sometimes plants aren't created equal. In some ways, we had to take it with a grain of salt....

We reduced our patrols [see Glossary for definition], which were very heavy. Dunlap has probably had the biggest reduction in fuel supply: He went from nine patrols to five. He's cut probably fifty people out of fuel supply. He doesn't have a general foreman out there anymore, he doesn't have a maintenance foreman on nights. ...I've only got two foremen out there now. I had seven or eight [previously]. We've made some major changes in how we do the business out there in the plant that are just huge.

Then we got beat over the head with the [employee headcount] numbers. Instead of us making a budget, you [also] had to make your [head]count, which didn't make a whole hell of a lot of sense to me. If you tell me a budget you want me to make and I make it...? Here is what we ended up with in 2007: three hundred and one plant employees, one hundred full-time contractors, and seventy-five [Detroit Edison] foreign labor — prior to the scrubber plant [installation]. The scrubber plant [is expected] to add seventy-five employees for two units (or a hundred and fifty for all four [units]).

Headcount became such an emotional event — and sometimes still is, to this day. I'll tell you, the troops' morale was down in the dumps because we would do a process improvement and eliminate a person. So everybody checked out. [Upper management] are wondering why: "You gotta keep going, you gotta keep doing." I'm thinking to myself, "You got to come to the front lines! Get out of wherever you're thinking and come to the site and look at what's going on here." ...[I]t's taken time to get out of that sting. The engineers went through it. It was ugly.

I whittled Ops down pretty low. I got pretty nervous there for a while. We had to build [staffing levels] back up — not to the levels we had before, but to a level where you can maintain the units.

We just looked at the headcount number, we didn't look at the criticalness of [each] position. Some people didn't understand that. I mean, I only have twelve operators in the plant running a thirty-two hundred megawatt station. Sometimes I have nine.

The McKinsey consultants determined budget cuts from their own analyses and by estimating the likely savings from ideas that they had obtained — sometimes assisted by CI personnel — from front-line employees and middle managers in brainstorming sessions. In total, McKinsey's consultants projected a $200-300 million reduction in costs from the PEP initiative. But whenever the McKinsey consultants' analyses did not make sense, DTE Energy's employees were afraid to challenge them. For example, one manager reported how McKinsey tried to apply FTE-per-megawatt staffing ratios from other utilities like TVA to DTE Energy's power plants, ignoring important differences in coal-fired unit technologies and practices, such as TVA's use of contractors instead of employees for ash removal.

DTE Energy's employees did not protest against McKinsey's unrealistic

recommendations for two reasons. First, there was a lot of fear in the organization.
Employees reported that the "PEP" acronym was ubiquitous at the time — it could be
heard often and everywhere, uttered with trepidation. McKinsey's engagement was the
first time DTE Energy's front-line employees had endured such scrutiny and interaction
with outside consultants. "People were afraid to disagree with anything McKinsey said for
fear of being fired or something," said one employee. Second, employees didn't believe
that DTE Energy's senior executives were going to follow through and implement
McKinsey's recommendations. "A lot of people thought McKinsey would make their
presentation, DTE Energy would put it on a shelf, and that would be it," said a manager.
Instead, when the senior executives asked their subordinate managers to formulate
detailed cost-reduction plans, "everyone panicked." Senior executives holding managers
responsible for rapidly improving DTE Energy's poor operating costs would have
precipitated stress in any case, but the tension in the company was even higher because
those targets were unrealistic.

DTE Energy's senior executives created a new Enterprise Performance Management
(EPM) group to track the PEP initiative. Members of the EPM group were former
consultants and high-potential employees who would later become managers and
directors of strategic planning, quality assurance, and power plant operations. The EPM
members viewed their group's approach as philosophically different from the CI initiative.
"I felt it was a political struggle between CI ruling the roost and the financial/McKinsey
approach," said one member. "It was a bake-off, in my mind: Which one works better?"
Another EPM member agreed, "It was certainly a bake-off. The prevailing belief at the
time with the EPM group was that CI was not working and needed to be replaced with a
better system that would hold leaders accountable for savings goals." He continued, "We
put some of the better thinkers in the company on the team.... We focused solely on
savings. We crafted a strategy to track savings and assured that all progress would be
rigorously tracked to plan."

The EPM group was responsible for tracking business units' progress against the three
main components of the PEP plan: (1) meeting reduced budgets, (2) achieving savings
from specific projects, and (3) meeting targets for reducing headcount. EPM personnel

reported the company's progress toward these targets to DTE Energy's senior executives every month. The business units' budgets were cut for the 2006 fiscal year. Savings from projects expected to take longer than one year were reflected in the budgets for 2007 and, in a few cases, for 2008. Oddly, contract labor was not part of McKinsey's headcount scrutiny. (As we shall see, DTE Energy did not scrutinize contract labor until late 2008.) Consequently, many business-unit managers used the following tactic to meet their targets for budget and headcount: Replace employees with contractors and then attempt to cut costs elsewhere to compensate for their higher contract-labor expense. One employee said, "It worked. Our budgets were slashed and people did whatever they needed to do to come in as close to budget as they could."

DTE Energy's CI personnel were co-opted by the PEP initiative, helping the business units meet these targets. Michele Hieber explained how the McKinsey consultants used the OSSG personnel: "The way the PEP process worked was the McKinsey person took the department into the room and asked them for improvement ideas. They brainstormed and wrote them all down. Then for the next couple of weeks...they looked at the organization and said if they thought the department was too big or too small. They also looked at what the efforts were. Then they would call us in, as OSSG'ers, to say, 'Okay, can you do a *kaizen* on this area to try to get this money out here? And can you help there?' They saw us as the hands and the feet of McKinsey...the people to help them drive this."

It is remarkable that the OSSG — an expensive corporate department of uncertain benefit — was not eliminated during the PEP initiative. An OSSG member recalled some senior executives challenging the OSSG: "What have you guys been doing? Do we even need you? We brought in a consulting company to do the work that you guys should have done. We're not even sure that we even need a continuous improvement group. If we can bring in consultants to do the work you should be doing, then we're not so sure you belong." Employees cited several reasons for the CI initiative's persistence. Many employees throughout the company believed in CI's value, despite its dubious savings numbers. Former CI manager Emmett Romine said, "The people who were involved with it, at the time, had a deep belief that it was the right thing to do, so they didn't let go. I don't think they would have let go of it." Many employees thought that pro-CI executives

Dave Meador and Bob Richard defended the CI initiative. Second, the CI initiative had enough CI proponents and institutionalized practices to acquire its own inertia. "You can't call the initial [CI] efforts a failure because there was momentum there," said one manager. "[The] momentum that was there had a culture behind it." Third, various senior executives had their own reasons for keeping the initiative going. "I don't think you had complete consensus at the senior levels that [CI] was a bad thing. I think there were some people that saw value in it...as a tool that they could use to keep their career moving," said a former CI manager. It would have been a gamble for senior executives to eliminate the CI initiative and support the PEP initiative exclusively. "There would be risks to doing that: [What] if I cut one off and I chose the wrong one? This way, I could still play both sides," another manager said.

For their part, OSSG members defended the CI approach by saying that the aim of PEP's "improvement" projects was only to reduce costs, rather than improving any dimension of organizational capability. An OSSG member said, "If you look at the two ways to do savings, you either do the process work, you define what potential savings there are, and you take it out, or you take it out and then make people scramble around to do the job without it. ...Unfortunately, when people are scrambling around trying to operate in crisis mode, there's not a lot of continuous improvement going on. There's just survival going on. ...[C]hanging your process so you can operate without those resources doesn't happen very much."

When the PEP initiative put about 1200 positions on the chopping block, the unions mobilized to fight the layoffs. Reportedly, Local 223 president Jim Harrison told Gerry Anderson, "You're getting exactly the union you're asking for. I believe in continuous improvement and all the other stuff, but when you do these sorts of things, I have to react." In June 2006, the unions sought to interfere with DTE Energy's open case with the MPSC, compelling DTE Energy's senior executives to negotiate a settlement. They agreed to workforce reductions through "voluntary separations" only and postponed discussion of all other issues until they negotiated Local 223's next contract in 2007. About 400 employees took buy-out packages to leave the company. Over the 2-year period 2006-2007, DTE Energy reduced its number of employees by 11 percent (Wilhelm, 2009, p.

37).

PEP's proposed layoffs and buy-outs were shocking to DTE Energy employees accustomed to job security. "It was like they saw the company as Uncle DTE — he's always going to be there, he's always going to take care of me," described one manager. "People were shocked that they were being given packages to leave. ...It went against the culture big time. People couldn't believe it." Consequently, the PEP initiative damaged employee morale and commitment to the company. An EPM employee said, "[PEP] was a hard program to go through. People didn't like it because it was headcount-oriented. Culturally, it was a difficult way of doing business — in terms of morale and tension with the unions. It was difficult from that point of view." One manager recalled Anderson's reaction to Gallup's employee-survey results: "Our Gallup scores went down dramatically and he was surprised. It was rumored that he said, 'I can't believe this hurt our Gallup scores this bad.' We [thought], 'You don't understand people felt their jobs were threatened?'"

The fight over layoffs also hurt the struggling CI initiative. Lemont explained how DTE Energy's employees implicitly carried over Tony Earley's commitment of employment security from the *kaizen* program to the Operating System: "That thinking was all part of the whole continuous-improvement evolution that we were able to piggy-back on and tell people, 'This is not about cutting your job. This is about making your job better and making the company better.' Nobody got laid off, so people started believing it." Because the PEP initiative co-opted CI personnel, however, that trust was undermined. An OSSG member recalled, "John [Weiss] was trying to sidestep the layoffs and not have that get any mud on us. We didn't want them to say that they lost their jobs because they were continuously improved out of their jobs."

Many front-line employees thought PEP was the next incarnation of CI, because McKinsey's brainstorming sessions for cost-reduction ideas seemed similar to the early *kaizen* workshops facilitated by Achievement Dynamics in 1998. This association was strengthened when Black Belts participated. A Black Belt working in DO during PEP said, "I went to the locations and did activity-value analysis workshops with people. ...[P]eople came back to me and said, 'Boy, you asked us for how I spend my day. What happens to

that data is it gets bubbled up and now, all of a sudden, three of my peers get let go and we don't do this piece of the work anymore.'"

Opinions among OSSG members differed on whether employees believed the CI initiative was guilty by association. On one hand, an OSSG manager thought that the CI initiative was not blamed, "because everybody knew that McKinsey had done the cuts." He said, "We were there to try to help them live after the ax had fallen. We were first aid, first responders sent in to help them." On the other hand, he acknowledged that front-line employees at the plants "hated Black Belts because they were tied to the PEP stuff." Ultimately, the OSSG personnel could not overcome front-line employees' confusion and inability to tell PEP and CI apart. "What PEP did was put that element of doubt in their minds [because] of buy-out programs and all the stuff that went on during PEP for the sake of saving dollars. They linked that saving of dollars and continuous improvement together and said, 'This must be the new phase of the Operating System: to cut people's heads.' There was some damage there," said Lemont. "I think we're still trying to come out of that." A pro-CI director described how PEP created disincentives for front-line employees to participate in CI: "Employee morale was shot and people started tagging the Operating System: 'Well, if this is all it is — it's just a big outsourcing drive or a big layoff drive and I'm going to lose my job — why should I get engaged in this?'"

John Weiss found it difficult to lead the CI initiative during this period. Patterson said, "John [Weiss] wasn't doing a good job of playing well with the McKinsey guys. He had an opportunity he didn't seize. He let McKinsey run this thing and he tried to distance himself from it. It was a really tough year and a half." By trying to keep a low profile, however, Weiss hurt himself and the CI initiative in the eyes of the senior executives. An OSSG manager said, "John [Weiss] was a really smart guy, but something happened and he got on the bad side of the vice presidents. We didn't know what had happened. All we knew was, over the next two years [2005-2006], they stopped inviting him to meetings, they stopped including him in the strategic thinking. ...We felt like [CI] things were slowly grinding to a halt. ...All of us [in the OSSG said], 'This [initiative] could die on the vine here.'"

The OSSG continued to train during the PEP initiative, but suffered high attrition.

"We kept the Black Belt program going, because it was now corporate wide. People were still being asked to go through it," said a plant director. "You've got to have people trained to be the experts. You can't do [CI] without someone having a very intimate knowledge of what they're working on or what they're talking about. I think having that class and that accreditation is a good thing. They kept that going." However, only a handful (18) of over 130 Black Belt candidates earned their certification during PEP. Similarly, OSSG personnel trained 600 OS Specialists in 2005 but only 370 in 2006 (see Figure 4, p.91). About 450 employees — 25 percent of all enrollees — who started the OS Specialist course never finished it. Due to PEP, the OSSG personnel canceled their planned train-the-trainer endeavor for training 4000 front-line employees on CI basics.

Whatever difficulties the CI initiative may have experienced, employees had no trouble using CI tools to make improvements under PEP. For example, Monroe power plant director Frank Wszelaki said that his employees brainstormed projects and visually tracked their progress by posting 4-Block summaries on walls. They made soot-blower improvements and reduced the size of their coal piles, reducing inventory from its previous level of 150-180 days. Another project was to reduce fuel costs by blending more expensive eastern coal with less expensive western coal. (Eastern coal has higher heat content than western coal, but also has higher ash and sulfur content.)

Reported savings associated with these projects were approximately $160 million in 2006 and $125 million in 2007, with "soft" savings accounting for only 30 percent of these totals (see Figure 3, p.48). However, the EPM group did not differentiate between PEP savings and CI savings when they compiled and presented results to the senior executives. Hieber said, "The problem that we were having during PEP was we were keeping track of what our Black Belts were doing and the money that we were saving, but it was the same money that the business units were claiming. There was overlap. When we said, 'We did this project and we saved a million and a half,' they would roll their eyes and say, 'Yeah, where? It doesn't affect the bottom line.' They had already claimed it and taken it out of their budget, or whatever. We've had that problem for a while."

Opinions about PEP differed among DTE Energy's employees. Front-line employees evaluated PEP's outcomes harshly. One employee said, "Everybody finally figured out

PEP was a very bad idea — very misdirected and poorly implemented. ...A lot of the projects were great, but a lot of the projects were bad. Lost a lot of good people. It was just slash and burn, cut the cost. Very painful. ...Messed up a lot of processes." As painful as DTE Energy's front-line employees found PEP, however, some managers with prior experience at other companies thought that PEP was "a very soft-handed approach" compared to similar initiatives in other industries. Contrary to the ill feelings on the front line, several managers felt PEP was successful: It had a consistent message and it fixed many of DTE Energy's cost-structure problems by holding everyone accountable to clear targets.

In the end, state governments did not deregulate the utility industry as much as the utilities had feared. However, DTE Energy's relationship with the state regulators at the MPSC was not business as usual. One director observed, "[Utility commissions] got a lot smarter. The MPSC got better at scrutinizing DTE's books." In October 2005, for example, the MPSC ordered DTE Energy to explain why its administrative and general expenses were so much higher, per customer and per megawatt-hour, than those of the other major Michigan utility, Consumers Energy (MPSC Case No. U-14666). DTE Energy was compelled to hire accounting firm PricewaterhouseCoopers (PwC) to conduct an analysis, which DTE Energy submitted to the MPSC on February 1, 2006. Following that filing, the MPSC ordered DTE Energy, in March 2006, to "show cause why its retail electric rates should not be reduced," particularly given the anticipated savings from the PEP initiative (MPSC Case No. U-14838). An employee summarized the change of focus these events made on everyone: "We're kind of on the same page now: We want to get cheaper, [the MPSC] want us to get cheaper, and we need to get cheaper because we're not competitive. ...Before, there was no incentive. The big thing was maximizing our earnings. ...Now we're not thinking about earnings anymore because the cost-competitiveness thing has really taken front seat in terms of our goals."

3.7. Wave Two Summary

Unstressed First Phase — 2001-2005

As I stated in Chapter 1, the meaningful difference I draw between a Lean approach and a Six Sigma approach to CI is whether a company trains its front-line employees or its dedicated experts as the main perpetrators of CI activities. The OSSG did not formally adopt Six Sigma until after John Weiss and Bob Richard joined DTE Energy in 2003, but I consider its 2002 CI implementation plan to have been already "Six Sigma" because it specified demonstration projects by trained CI experts. Conspicuous by its absence in these plans was any concrete practice like *kaizen* events for involving front-line employees and middle managers in their own CI activities.

Whether a company wants its regular employees to allocate a fraction of their workweeks to CI activities, instead of consigning CI to specialists like internal consultants or industrial engineers, is a valid strategic question with pros and cons specific to each case. I find no evidence in DTE Energy's history, however, to indicate that the switch from front-line *kaizen* events in the first wave to CI expert-run projects in the second wave was made strategically on the basis of such trade-offs. Instead, the OSSG's leaders seemed to emphasize demonstration projects by CI experts because they were the best way to achieve large gains most convincing to DTE Energy's senior executives (and to everyone else). The OSSG's first CI plan anticipated "full implementation" after two years, but provided no details for how regular employees, the non-experts, would become involved. I think the OSSG's leaders hoped that DTE Energy's regular employees would naturally want to replicate the perceived project successes of the CI experts or, at least, that DTE Energy's enthusiastic middle managers would coerce their subordinates to attempt such replication.

Learning lines were an important exception to what I claim was the OSSG's Six Sigma focus during this wave. Each learning line was led by a team of CI experts, but they also involved heavy participation by front-line employees. The initial learning lines were successful, but they were resource intensive. Each learning line required a few CI experts for an extended duration and a high degree of involvement and support from managers

and executives. The later learning lines were less successful because they lacked the necessary managerial involvement and support. I believe that the OSSG could not replicate learning lines as a standard CI activity because DTE Energy's executives were not willing to support a whole team of CI experts disrupting operations at a service center or power plant for an extended period of time. This unwillingness persisted, I believe, through the rest of DTE Energy's history. Schulist's attempts to reintroduce learning lines as "beachheads" in 2008-2009 (see section 4.5) met the same resistance.

The CI experts' projects in the second wave were more successful than the first wave's *kaizen* events at convincing DTE Energy's senior executives and middle managers — at first. Unfortunately, these CI experts undermined their own credibility by reporting a lot of CI "savings" that could not be verified or believed.

I claim this erosion of credibility was caused by two factors. First, DTE Energy's CI experts were narrowly focused initially on achieving the OSSG's targets for projects and savings as specified by the 2002 plan. This behavior was understandable; the OSSG had to justify its existence and budget. By 2004, however, I believe the OSSG personnel felt that their department had become a permanent fixture in DTE Energy's corporate structure. In its 2004 plan, the role of the OSSG was primarily a department for training Black Belts, rather than for fostering organizational change. The 2004 plan's lack of specific targets for projects and savings per project supports this hypothesis.

The second factor for the CI initiative's erosion of credibility was the relative poor quality of DTE Energy's Black Belt program (see Appendix B for an assessment). As the GE-trained Black Belt in section 3.5 complained, "It was like we weren't taking it seriously." The direction and content of DTE Energy's Black Belt program was determined mostly by the OSSG's single Master Black Belt. As we saw in section 3.5, however, the Master Black Belt position was a revolving door and not always filled with the best-qualified candidates. The OSSG's leaders or DTE Energy's senior executives decided that hiring a consulting firm like Six Sigma Academy to design and start its Black Belt program was unnecessary. Perhaps they believed that they could start the program adequately themselves, or that the expense of a firm like SSA was unjustified, or both.

The OSSG personnel failed to advance the CI initiative to its next logical stage after

they had convinced the senior executives — with *kaizen* events and demonstration projects — to invest in it. That next stage should have been training employees at all levels of the company hierarchy to employ CI methods to improve DTE Energy's core processes. The OSSG personnel advanced to this next stage in the third wave.

Stressed Second Phase — 2005-2006

The cost pressures faced by DTE Energy, peaking in 2005 when Gerry Anderson became the new COO, raised expectations for the CI initiative. It is possible that DTE Energy's senior executives would have been more forgiving of the CI initiative's shortcomings if the CI personnel had not been reporting large CI "savings" at a time when the company needed those savings to improve its financial performance quickly and directly.

The PEP initiative both damaged and helped DTE Energy's CI initiative. On the negative side, the PEP initiative reinforced the Black Belts' role as internal consultants, working alongside (or under) the McKinsey consultants, who were not focused on developing the skills of front-line employees by coaching them. Many front-line employees — perhaps those who had never participated in any CI activities — could not tell the difference between the Black Belts and the McKinsey consultants. All nonroutine work being done for the PEP initiative was aimed at cutting costs in a forced-survival manner, pushing the focus away from sound process design and employees' problem-solving capabilities. Furthermore, PEP's downsizing lowered front-line employees' morale, making them resistant to anything outside of their normal routine work.

On the positive side, PEP was a wake-up call for the CI initiative. PEP's focus on verifiable results forced the OSSG personnel to confront the CI initiative's shortcomings. As an OSSG member said (in section 4.1), they needed to think like the Operating System, but achieve results like PEP. They made good progress toward that goal in the third wave, as described in Chapter 4.

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Chapter 4: Wave Three — 2007-2009

4.1. CI Initiative Revival — 2007-2008

The aftermath of the PEP initiative created an opportunity for the CI initiative. Because it wasn't eliminated, the CI initiative remained in DTE Energy's repertoire of organizational practices. Consequently, Gerry Anderson reconsidered it. "Quite honestly, we wouldn't have needed [PEP] if we were much further along with the Operating System work," said Patterson "Toyota doesn't need to do a big spring cleaning; they look for incremental improvement." He continued, "The silver lining in that story is Gerry [Anderson] came out of it shaken up around what occurred. I don't think he expected this incredible backlash from the organization around how PEP went, around the morale being torpedoed in the organization. I think he came out of it a different person around commitment to continuous improvement and the Operating System. 'This is not going to be my legacy — that every five years we're going to clean this organization up in some massive hack-and-slash sort of a move.'" Stories circulated among employees about Anderson's change of mind. One employee said, "Local myths are that he hired McKinsey to do [cost-cutting] because he had done it before when he was a consultant,...but this was the first time that he had to stay behind and see what happens to the organization in the aftermath, once McKinsey goes home — and it was ugly." Several employees thought that Anderson did not want to be remembered as "the PEP guy."

At an upper-management retreat in mid-2007, Anderson publicly acknowledged PEP's negative ramifications to his peers. He argued that it had been necessary, however, because "the Operating System failed" to address DTE Energy's financial problems. Dave Meador had interjected, "It didn't actually fail, it was too slow. *We* failed *it*, not it failed us." Anderson said that he could hire consultants periodically for corporate housecleaning, if necessary, but he admitted that another approach might be preferable. Anderson was interested in fostering a "culture of excellence" at DTE Energy, so in

preparation for this retreat, Anderson, CEO Tony Earley, and DTE Energy's vice president for human resources met with Edgar Schein in Boston to discuss his research on corporate culture (Schein, 1999) and on New York utility Con Edison. According to Patterson:

> When we were up at Traverse City at our big leadership conference, he spoke very candidly around how wrong he was, how he hadn't been the type of leader he should have been in promoting the Operating System, that this is going to be part of the legacy of who he is as a leader in this company, that continuous improvement – having an Operating System – is critically important to us, and was really clear on why it needed to be done.
>
> He has always been on the Operating Council. He wants it. He definitely wants it. I think he's skeptical about how to do it. I don't think he knows what his role exactly is. [In mid-2008], I think he's still searching. And I think he's open. If you sat down with him, he'd say, "Yeah, I'm still learning how to be the kind of leader that I need to be to really make this happen."
>
> Problem is, he probably doesn't dedicate enough time to that pursuit. I look at Koenigsaecker and [Ford CEO] Alan Mulally and how much time they spend. ...George Koenigsaecker was the guy who led the Danaher Business System. If you read his story, his account, about how much time he personally spent learning and studying, [he] became such a zealot around this that [Danaher] had no choice. Gerry still hasn't gotten to that point. The question is, does he need to?

Managers were impressed with Anderson's forthrightness. "Gerry was humble enough to step back, look at PEP, and say, 'You know what? I did it, I had to do it, but we can't continue to go on like this. This isn't a sustainable model.' He was humble enough to do that," said one manager. "I give him a lot of respect for listening to the system and realizing that he couldn't continue to operate that way. It was something they had to do in the short-term, but they couldn't continue to operate that way."

The senior executives agreed to recommit to the CI initiative. During the first three quarters of 2008, the EPM group continued to track the business units' progress toward the $204 million in residual cost cuts specified by PEP. The CI initiative did not have its own targets; everyone assumed that all CI activity would be aimed at helping achieve these cost reductions. DTE Energy's managers carried this assumption over into 2009. An OSSG member explained: "The concept is we need to think like [the OS framework], but achieve like [PEP]. That's where we are now. Whether we're able to do that or not is still

up for grabs. ...They're trying to merge these two things together. [They] say, 'There's good things about both of them; let's see if we can't make that work.' ...In fact, one of the slides in the [CILW] presentation talks about continuous improvement moving forward, taking PEP and Operating System and merging the best of the two things together."

Jason Schulist, who had collaborated on the second CI implementation plan in 2004, replaced John Weiss as OSSG director. Schulist, an adherent of Jeffrey Liker's research on the Toyota Production System (Liker, 2004; Liker & Meier, 2006), wanted to revitalize the CI initiative by reemphasizing Lean concepts and tools. He believed that Lean's emphasis on what he called "problem solving at the point of activity" was needed to engage front-line employees in CI work, instead of leaving that work to a select cadre of Black Belts. To do so, Schulist sought the advice of Jeffrey Liker at the University of Michigan; his fellow LFM alumnus Jamie Bonini, who was working at Toyota Motor Manufacturing Kentucky (TMMK); and Steve Spear, who was developing Lean courses for the Bluegrass Automotive Manufacturing Association (BAMA), a consortium of suppliers for TMMK. Reportedly, Anderson told the OSSG group, "Show me that CI is the way we need to go." When Schulist asked Anderson why he thought that the Operating System had "failed", Anderson enumerated the following reasons:

1. It was not implemented top down. There was no tension.
2. Leaders were not committed.
3. It wasn't focused properly on quality and cost.
4. All the improvement work was done on the fringe, not "in the belly of the beast."
5. DTE Energy did not have a culture of honest self-appraisal.
6. Employees did not understand it or know how to deploy it. The language used by the OSSG personnel was "too fancy."

One of Schulist's first hurdles was dispelling the belief, even among some of his CI managers, that 4G9S projects were the only way to do CI properly. Schulist and a few other CI managers argued for many other types of CI activity — such as 5S and Just Do It (JDI) work (see Glossary for definitions) — as long as these other approaches were managed as rigorously as 4G9S projects. In early 2007, Schulist asked one of his few union CI experts to lead a year-long project to establish 5S practices in all of DTE Energy's

68 garages. This expert told Schulist that he wouldn't mind the 5S project, but he was more interested in doing a project requiring statistics because he had recently earned his Black Belt certification. Schulist reassured him that the project would be worthwhile: "Here's the deal: I think we're going to be leaning mostly towards Lean in the next couple of years anyway."

In 2007, Schulist addressed the union fallout from PEP by meeting with Local 223 president Jim Harrison. Harrison agreed, in principle at least, that involvement in CI would provide union members with opportunities to expand their skills, making them more valuable employees. By 2008, however, Local 223's leaders were resisting the CI initiative. They prohibited OSSG personnel from surveying their members about ways to improve how they engage front-line employees in CI activities. They told Schulist, in August 2008, that they were resisting the CI initiative because it helped only "management's agenda". By the end of the year, after Local 223's elections, president Jim Harrison's position on CI was neutral, "not resistant, but not engaged either," according to Schulist.

Schulist inherited the CI initiative without an implementation plan; the previous one for 2005-2006 had been forestalled by the PEP initiative. Through 2007, he followed the core of Patterson's original design: Training Black Belts and OS Specialists to do improvement projects in their business units. The rate at which the OSSG trained and certified Black Belts slowed during the period 2006-2007 (see Figure 4 below). One reason for this slowdown was the disruption and diversion of attention away from CI caused by the PEP initiative. More important for the CI initiative, however, was a tightening of the requirements for Black Belt certification. An OSSG manager claimed that Weiss, eager to get the Black Belt program started quickly, had lax criteria for certification at the beginning. She said, "John Weiss okayed some Black Belt projects that no one else would have okayed." When a new Master Black Belt was hired in late 2005, she "put a stake in the ground" and imposed stricter certification-project criteria. By the time that Master Black Belt left DTE Energy in November 2007, she had certified fewer than 20 new Black Belts (bringing the total to 75), but had accumulated a large number of Black Belt candidates struggling to complete their projects. The number of uncertified candidates at

90

the end of 2007 is uncertain, but there were at least 130 and possibly as many as 250. Black Belt candidates earning their certifications rebounded to 45 in 2008. Similarly, only about 160 OS Specialists were training in 2007, but the 2008 total reached about 400. OSSG personnel had developed a draft CI Champion course for leaders, as specified by the 2005 implementation plan, but it wasn't used. Schulist admitted, "We've always espoused the Champion training, but never really systematically introduced it."
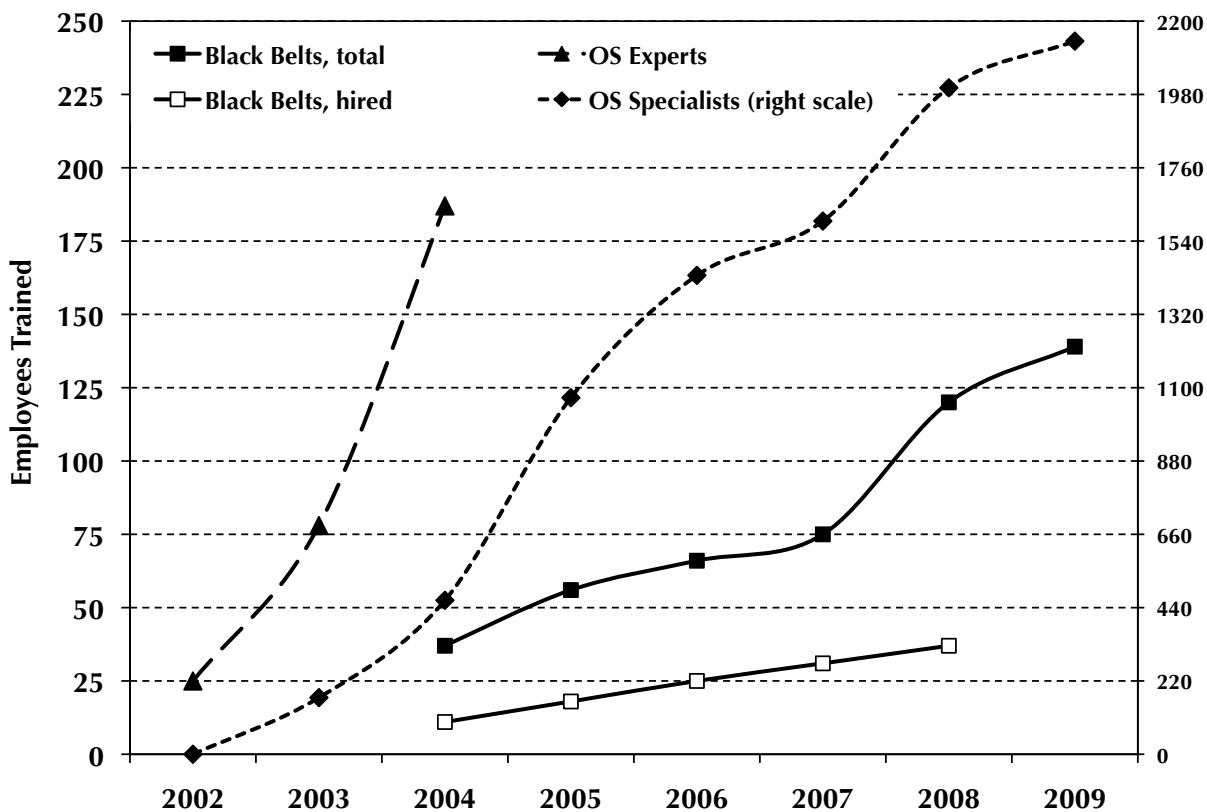
Figure 4. DTE Energy Employees Trained in CI Courses

Schulist believed that a major defect of the CI initiative was that responsibility for it was not shared broadly. "Historically," Schulist said, "everyone called on Shawn's group of about 10 FTEs for OS expertise." He set about correcting this defect in 2007 with three tactics. First, he convinced DTE Energy's leaders to experiment with Business Plan Deployment (BPD) — GM's version of *hoshin kanri* (Akao, 1991), or policy deployment (see Glossary) — to link CI activities to DTE Energy's strategic objectives. The business-unit managers resisted the experiment and Schulist later admitted that it had been too early to attempt it. Without a culture that supports learning from failures, "we would use

[BPD] as a way to beat people down," Schulist said. Second, he decentralized the CI managers, situating them within their assigned business units with only a "dotted line" reporting relationship to himself. This structural change coincided with personnel changes: All four of DTE Energy's major business units — Fos Gen, DO, MichCon, and Customer Service — got new CI managers soon after Schulist took over as OSSG director. One of MichCon's Black Belts said, "We got CI managers. That was a big thing, starting to consolidate and reorganize it. That was a big help." However, DO's newly decentralized CI manager, Emmett Romine, said he had difficulty getting DO's directors involved in CI projects, a problem also reported in DTE Energy's other business units. They kept "trying to outsource...CI to the CI person."

For his third tactic, Schulist felt it was crucial to mimic Patterson's personal efforts to influence and teach the senior executives about CI. His goal was to get the senior executives to own the CI initiative, instead of delegating it to the OSSG. About Schulist's efforts, Patterson observed: "He operates well from the principle that it needs to be owned by the leaders. He doesn't do anything foolish to take that jurisdiction from them: 'I can tell you what's going to happen if you decide to behave that way, but at the end of the day it's your choice. I'm not going to jump in. ...You've got to own it. I'll advise you on what I think you need to do, but here's what you're going to have to do to do it.' Which is good. He also operates from the principle that [CI] has to look like this for business reasons. This isn't just an interesting little culture thing so we can all feel good; this is so we can be a viable business and all that that means." An OSSG manager agreed: "He worked hard to mesh well with the various vice presidents: met them in many different ways, sold it in different ways to the different people, tried to match [their styles]."

After becoming the new OSSG director, Schulist met with Gerry Anderson and Guy Harris, the new director of the EPM group, to convey his perception of how DTE Energy's executives had been handling the CI initiative. For the CI initiative to be financially worthwhile, Schulist believed that certain ingredients, enumerated by Jeffrey Liker and others, were required in addition to simply pushing employees through CI training courses. Without those ingredients, DTE Energy's CI personnel were at risk of failing to save more money than their salaries cost the company.

When I started my job, I had a meeting with him [Gerry Anderson] and Guy [Harris]. I asked Gerry if he played Texas Hold 'em poker. He said yeah. Okay, if you take the ninety-some (maybe it's less than [that]) people who are a dotted-line or a straight-line [subordinate of] my org [the OSSG], it's about an eighteen million dollar bet every year. So I said, "Are you all in?" I call it the poker analogy. We're basically placing an eighteen million dollar ante, not looking at our cards, and folding every year. And then doing the same thing again [the following year]. So we're not serious about playing the cards, we're just *kind of* playing.

He asks, "Well, what cards do I have?"

I said, "Well Gerry, you kind of own the deck. You can pick whatever cards you want and play them in whatever order you want. In some ways, you can stack the deck. You own it. It's just a matter of whether or not you want to play." That's how I set the context.

He said, "Okay, then how would I play?"

So then we started talking about [it]. Here is the aspiration: Every person is a problem solver at the point of activity. I took a lot of Jeff Liker's *Toyota Way* work and said, "Here are the things they consider when they want to do something sustainable. These are things we might want to consider too. It's not misaligned with our Operating System at all. It's very aligned to it. As you can see, all these things are related. But this is how they would do it, so we should consider and think about these types of things."

He said, "Okay, let's proceed. I'll get back to you and talk some more about how we might deploy it."

Schulist's way of convincing the senior executives was to persuade them to attend 5-day executive courses on Lean conducted by the Toyota Production System Support Center (TSSC). Steve Spear and Jamie Bonini developed these executive courses for TSSC based on Spear's prior work at Alcoa and the University of Pittsburgh Medical Center (as part of the Pittsburgh Regional Health Initiative for improving health care safety and quality). The aim of these courses was to train executives to be Lean coaches in their respective organizations. In 2007, Schulist took Steve Kurmas, senior vice president for Fos Gen, and Vince Dow, vice president for DO, to a course at one of Autoliv's airbag manufacturing facilities in Utah. Next, he took CFO Dave Meador and MichCon president Jerry Norcia to a course at one of TMMK's suppliers in Georgetown, Kentucky.

Schulist recalled:

> We went to some courses. Steve Kurmas, Vince [Dow], and I all went out to the airbag course in Utah. We all went through it together. Steve and Vince came back on fire saying, "We can do this! We can get our people engaged!" Their boss, Bob Buckler, said, "Wow, they're on fire! I've never seen them on fire like this about anything continuous improvement before!"

> Bob is very interested in Toyota's methodologies. He's a University of Michigan alum. He's on the [School of Engineering's advisory] board. He knows Jeff Liker's *Toyota Way* work. We had Liker in once, and [Bob] was all excited, an advocate: "Finally, we're doing the right thing in this CI stuff. I want to get involved and go to [it]."

> ...The two of them [Steve Kurmas and Vince Dow] were on fire. Dave [Meador] sees that and he says, "Wow, this is good! We're on fire!" ...Then we sent Dave [Meador] and Jerry Norcia to an external class in Kentucky, and *they* both come back on fire. So this class is doing something good for our leadership.

Schulist had convinced Gerry Anderson and Detroit Edison president Bob Buckler to attend such a training course in San Antonio, Texas, in February 2008. Unfortunately, both executives had to cancel. Instead, Schulist took Paul Fessler, who was later promoted to Fos Gen vice president, and Heather Koenders, DO's operations director for all of DTE Energy's geographically scattered service centers.

These TSSC-run courses were successful at converting DTE Energy's senior executives to a Toyota-style CI vision, as Schulist had hoped. They returned from these courses convinced of the need for a mile-wide approach (in contrast to the OSSG's "mile-deep" plan in 2002). Steve Kurmas, who later succeeded Bob Buckler as president of Detroit Edison in December 2008, said: "It was eye-opening. Seeing what they were doing with CI compared to what we were doing — it fundamentally changed my perspective. We came back and wanted to instill that mindset and culture in our employees. We began to implement what we learned, and to engage people at the front line. We could see that continuous improvement is not a project or a process, it's a culture. It's about looking for smaller incremental changes in every element of every process, and getting the employees actively involved in that" (Wilhelm, 2009, p. 33). A union member said, "I'm seeing a fundamental change in the senior leadership of this

company that's unbelievable. ...I'm seeing things happen [since] last year, from a senior leadership standpoint, that I didn't see happen in the first nine."

BAMA-member companies, working with Steve Spear, began developing their own TSSC-style workshops for their executives, called CI Leadership Workshops (CILW), in late 2007. One of the leaders of this experiment was Bob Hemrick at Dana Corporation, one of BAMA's member companies. Hemrick had been the instructor for the TSSC-sponsored workshops that Schulist and several of DTE Energy's executives had attended in San Antonio and in Georgetown, Kentucky. Schulist cold-called Hemrick at Dana for his workshop materials so he could create CILWs for DTE Energy. DTE Energy's CILW is a 5-day workshop consisting of 8-12 hours of teaching CI concepts and tools, and two participant teams each attempting to identify, implement, and assess 50 countermeasures for an operations problem (see *CILW* in the Glossary). DTE Energy's employees completed about 21 CILWs in 2008, a completion rate exceeding that of any BAMA company. In September 2008, Schulist and Meador hired Hemrick to be (in effect) co-director of the OSSG; Schulist said that they "poached" him for his CI expertise.

Schulist's target audience for CILWs comprised DTE Energy's 40 senior executives and 100 directors, those both responsible for and able to coordinate process redesign. He intended each CILW to be led by a trained senior executive with assistance from a CI expert. In this way, DTE Energy's leaders would jointly learn and practice CI skills with their subordinates. Schulist described the CILW approach as "a way to introduce leadership to their role in engaging employees in problem solving at the point of activity. It [creates] a top-down awareness, because the top needs to engage the bottom in making this happen. That's the way I think of it." In early 2008, Schulist held an off-site meeting with his OSSG staff at which they assessed each senior executive's understanding of and willingness to support the CI initiative. They wanted the pro-CI executives to be the teachers in the early CILWs so they could convince their peers. Fos Gen was the most aggressive business unit at training its leaders: All of its leaders had attended a CILW by mid-2008. Bob Richard set a goal for all of MichCon's leaders to attend a CILW by the end of the year (MichCon's year-end percentage was 77). Throughout 2008, about 25 senior executives attended a CILW each quarter, prompting Schulist to estimate that

CILWs would be needed through mid-2009 to train everyone. (The OSSG extended its CILW-completion goal to October 2009, however, after DTE Energy's senior executives added middle managers to the CILWs' target audience.) Schulist also worked to convince the contenders for Buckler's soon-to-be-open position of Detroit Edison president that supporting the CI initiative could only help one's prospects for promotion.

Unsurprisingly, some executives and middle managers were reluctant to embrace the CILW approach. One business-unit manager observed, "For the first half of the year, there were a lot of people, in leadership as well, that just kept their head down, waiting for this thing to blow over, because they've seen it in the past. Keep your head low, this wave is going to blow over, then you can slip back into your coma and not worry about it." Eventually, however, the CILWs successfully convinced senior executives of CI's potential value by creating forums in which improvements to DTE Energy's processes could be made and seen first hand. CILWs got senior executives out of their offices and conference rooms and onto the front line. (As we shall see, however, Anderson wasn't completely converted until mid-December 2008.) MichCon senior vice president Richard said, "This reminds me of back when I started as a frontline engineer, where I actually could solve problems, and here I am — I can see what's going on, I'm starting to understand my problems, and I'm helping to unleash people to solve them. We all got into operations and manufacturing because we love to build things and make things and solve problems — solve customers' problems. When you get a chance to do that, it's energizing. And it's good for leaders to see what their folks contend with every day" (Wilhelm, 2009, p. 35).

Unlike *kaizen* events and Black Belt projects, CILWs defined a clear CI role for executives, which they could not delegate without undermining the purpose of the workshop. MichCon president Jerry Norcia said, "When you go and observe and see what's happening, you quickly realize all the obstacles that are in our employees' way of doing their job. It's easy to sit in your executive office and say, 'We've got to drive productivity,' but unless you get down to where the work is actually done by the hands that do it, it's very difficult to discern why you're not getting the productivity you desire" (Wilhelm, 2009, p. 38). Similarly, DO vice president Vince Dow said, "Spending five whole days at one location is great. Although it's a huge time commitment, you really start

understanding the operation and the barriers that get in the way of us being as efficient and customer friendly as we want to. You start seeing barriers and eliminating them. It's valuable for executives to get there on the shop floor, with the shop floor people, working on the issues with them and freeing them up" (Wilhelm, 2009, p. 36). An employee remarked how beneficial it was for DO's vice president to run the CILW that he attended: "Having Vince [Dow] come and spend a week at a service center — that's very big. [The employees] appreciated it and it changed some viewpoints, I think, right off the bat."

Many CI personnel credit Schulist's political skill with shaping senior executives' perceptions of what CI can accomplish and what is needed to realize its potential. One manager said, "I give [Jason] most of the credit. [He] sold the concept that we're in now really well. [He] got the ear of Dave Meador and Gerry Anderson, who have been the primary backers of the whole [CI] effort." An OSSG member thought Schulist's and Patterson's political skills were similar: "A lot of this stuff has to do with who you know, how you can stroke their egos and help them see the vision, such that they can see how it's going to help them or help their organization. Jason is really good at that. ...He's very credible with them; they believe in him. Shawn did that also.... Shawn is a great salesman; he has that enthusiasm. There's a little bit of charisma about both of them that is similar."

The CILWs were intended to train DTE Energy's leaders only, so the CI initiative needed a similar workshop for front-line employees. The OSSG personnel reintroduced *kaizen* events to fill this need, but with a few important differences. Their guiding vision was a utility analog of Toyota's on-the-spot problem solving by assembly-line employees and their team leaders after someone pulls an *andon* cord, signaling a problem. These so-called *swarm events* (see Glossary) were to be led by middle managers and to include a few hours of instruction on CI concepts and tools. Mirroring the CILWs, front-line employees and middle managers were expected to learn and practice CI skills together, thereby promoting CI down the hierarchy. Schulist explained: "The model is to train leaders who will then train the employees in their respective areas." Even though the OSSG introduced swarm events in 2008, they were used infrequently until 2009 for two main reasons. First, DTE Energy's processes were not designed with what Schulist called

embedded tests, the mechanisms that would signal abnormal conditions and trigger swarm events. Second, DTE Energy's senior executives were slowly being exposed to CI through the CILWs, but it took a while before they started requiring their subordinate managers to use swarm events.

Approximately 120 of DTE Energy's directors and senior executives attended an upper-management retreat in Traverse City in July 2008, just as they had done the previous year. Schulist surveyed the attendees — anonymously and on-the-spot with electronic clickers — about their perceptions of the CI initiative. Anderson was surprised that 62 percent believed CI would be displaced by a new initiative within five years. (One CI manager believed this result reflected the fraction of directors who were still unfamiliar with CI.) Anderson announced: "I take it on as a personal challenge that CI is not a flavor of the month." He said DTE Energy needs to be able to cut costs sustainably, not episodically — a conviction that would be reflected four months later in his 2009 strategic plan. In late August, Schulist discussed the retreat's survey with Local 223's leaders. Seventy-five percent of these leaders were skeptical about the value of the CI initiative and they were unanimous in their belief that DTE Energy will have moved to a new initiative within five years.

It became clear to all retreat attendees that the CI initiative's lack of a documented implementation plan was causing confusion. Some managers believed that the CI initiative now consisted only of CILWs, but Anderson corrected this misconception: "The CI workshop is an *education* strategy, not a deployment strategy. We haven't defined the way to do CI yet. ...We don't have a deployment strategy right now and, to some extent, we shouldn't have one yet — but we'll have one soon." Despite their conversion to the CI philosophy, DTE Energy's senior executives still looked to Schulist and the OSSG to formulate the CI initiative's implementation plan, just as they had Patterson and his colleagues do in 2002 and again in 2004. Schulist said, "My motto has been that this is not Jason's CI deployment plan; this is Gerry & Company's CI deployment plan. But they're waiting for the answer from the OSSG versus exploring it and attacking it themselves. I don't think I'm going to get what I want...so I'm going to have to develop this [plan] that I can give to them and say, 'This is what we want to do. This is what I

need you to advocate and own.'"

Schulist presented a draft implementation plan to the CI managers at a staff meeting in late July. It enumerated the OSSG-sanctioned CI practices already in use, as well as a few that Schulist wanted to reintroduce. CILWs and swarm events were designed to simultaneously train and influence down the hierarchy while fixing process problems along the way. CI personnel embedded in the business units were assumed to initiate or facilitate projects of either the 4G9S or JDI variety. The OSSG expected other CI tools to be used as needed, such as 5S or AARs. To this portfolio of practices, Schulist also wanted to reintroduce practices that had previously failed to catch on: learning lines (renamed 'beachheads' to avoid the prior name's stigma) and BPD (see Glossary). One of the CI managers objected to this draft plan because it did not feature value-stream mapping (VSM) prominently as a way to concentrate CI efforts on DTE Energy's core processes. Schulist defended the omission of VSM from his list of main "methods" — 4G9S projects, JDI projects, swarm events, and DNA building — by saying he didn't want to further complicate the CI initiative for the senior executives.

Schulist held a meeting with Anderson and other senior executives in late August to discuss the CI initiative's implementation plan. Rather than discuss these details, Anderson — still not completely sold on CI — wanted to hear about Fos Gen's recent work on a "leadership model" (specific leader behaviors) for motivating employees. As I discuss in section 4.3, Fos Gen had created its own training program called Performance Leadership, which was getting more attention than the CI initiative in the power plants. Anderson did not take a leading role in defining a CI-related plan until the economic crisis reached a critical point in October 2008.

Decentralizing the CI managers and Black Belts made it more difficult for the OSSG to control and monitor the CI initiative. After the business units began running CILWs and swarm events in 2008, Schulist repeatedly begged the CI managers to share any beneficial changes that they made to the OSSG's training materials and to submit project summaries for posting on the OSSG website (as a way to share knowledge) — requests that were more often ignored than heeded. During PEP, the EPM group had appropriated the OSSG's previous accounting of projects and savings reported by DTE Energy's business-

unit managers. Since 2005, the OSSG had neither consistently nor rigorously measured the CI initiative's performance other than tracking the numbers of trained Black Belts and OS Specialists.

4.2. CI Activities at MichCon — 2007-2008

Unsurprisingly, MichCon employees retained their own culture and sense of independence from the DTE Energy corporate parent after the merger. One of MichCon's station managers told me that DTE Energy's senior executives had originally intended to reduce overhead by consolidating MichCon's and DO's service stations, but they abandoned that plan in the face of daunting logistical and political barriers. Even though MichCon's senior vice president had requested help from Marcia Jackson, a MichCon veteran, for the service station learning lines in 2004, he otherwise resisted interference from the OSSG at corporate headquarters. This senior vice president used PEP's headcount reductions as a way to eliminate MichCon's OSSG-based CI manager. In October 2006, DTE Energy's executive-development scheme prompted a shuffling of senior executives among its business units. Bob Richard moved from Fos Gen to become senior vice president of MichCon. He was the first outsider to hold the position, so MichCon's employees were understandably apprehensive, not knowing what to expect. Richard immediately reversed his predecessor's purge of CI personnel. He requested 40 CI positions and was granted 12 Black Belts and a new CI manager.

A station manager reported that, until 2007, MichCon did not feel the need to improve, despite returning three or four percent on equity — far below the MPSC-authorized 11 percent. He said, "Even when their stock was down, even when they were dragging DTE Energy down shortly after the merger — because their return was a third or less of what it should be — they didn't feel the tension and the need to get better. That's something that Bob [Richard] brought with him and said: 'Come on, guys. There's money lying around on the ground out there. Let's go pick it up.'" One of MichCon's few Black Belts at the time recalled Richard's arrival:

Celebrated that day quite a bit, actually. That was a good day for continuous improvement. We knew about him from Fos Gen: being trained from GE and the steel industry, and being a Black Belt himself. It was refreshing to say, "Ah! Now we've got a guy at the top that might have a different idea of continuous improvement, accept us for who we are, and let us do our job in a different way." And he did. He certainly made it easier for us.

I would say continuous improvement was on the decline in Gas. The Black Belt four-gate nine-step was definitely on the outs in Gas, 'cuz it wasn't working. ...When he came in, he reenergized it and said, "We're doing this." ...He started fixing the problems, taking out roadblocks, and in short order, the Black Belts were meeting with Bob on a regular basis. Once a month, alone — Black Belts and the vice president. That was huge. That gave them a wide breadth of exposure, responsibility, and encouragement.

Schulist hired Mike Baum from Johnson Controls in mid-2007 to be MichCon's new CI manager. Baum had to address many of the Black Belt program's shortcomings: lack of clear goals and expectations, poor project selection, poor measurement of results, and skepticism by finance personnel (see also Appendix B). Baum urged his Black Belts with director-assigned, non-financial projects (like improving customer satisfaction) to collaborate with Black Belts working on projects with large potential savings. By the end of 2008, Baum's 12 Black Belts had exceeded Richard's $12 million goal by $2 million. Baum related the story:

When I came here to DTE, Jason said, "Here's the org chart. Here are your twelve Black Belts. Go continuously improve." Once I got into the mix and saw what was going on, we weren't doing *anything*. We had a bunch of people working on a bunch of different projects, who continually allowed the scope to creep and creep and creep to where all of the projects were this big behemoth thing. We had a lot of people who were doing a lot of work and they were netting zero results from a cost-structure standpoint. They were fixing some process things along the way, but it was extremely ineffective.

You had the naysayers and the stone-throwers on the outside saying, "We're making this investment in Black Belts. It's a big waste of money. They're not yielding any results. Their numbers are just fictional. It's just happy talk; it's not real." So I tried to focus on that aspect to start: (1) to show people what we were capable of, and (2) actually to achieve some results.

...January of '08 was my first crack at establishing goals for my group. I put in [my CI plan] that they had a minimum task of five hundred thousand dollars

hard savings in O&M each. A minimum expectation. I let them know. I said, "The waste is just dripping off the vines here. That's not a stretch goal."

Of course, they were shocked: What is this insurmountable thing that you've just thrown around my shoulders? They knew there was opportunity there, but they weren't held to any kind of expectations. They didn't excel in quantifying their efforts: what is the impact, what am I saving, how do I prove it.

...Some of the biggest stone-throwers were the finance community, so we implemented a system where we had finance sign off on individual projects prior to the Black Belts being able to claim that savings and get credit for it on their EAS [annual performance review]. The lead financial analyst at the time was [hired from] Ford Motor Company. She was in tune with the controllers signing off on Black Belt projects before you can claim it because the automotive industry worked through the fictitious CI [savings] numbers years ago. They got wise to the fact that I'm reporting twenty-two million dollars in savings, but my costs went up this year. She was in tune with that and she was very supportive of it. It took us a few months to work together through a system with the Black Belts, to get them comfortable with sitting down and reviewing their projects: their assumptions, their fixes, their results, the data before and after. [They] had to show correlation — that what they implemented was why the numbers moved. Then finance felt comfortable and they would sign off on a form, as would the Black Belt and their ops director.

...I arrived at the five hundred thousand dollar hard minimum as three times their annual wage (loaded). [I] wanted to demonstrate to the organization — and wanted the [Black Belts] to demonstrate — that they were more than paying for themselves and they were reaping additional savings. With twelve CI folks...there's six million dollars — which I thought was a good start. Bob Richard said, "Sounds great, but I need twelve million from you...." We took our orders and charged up the hill smartly. We actually ended up exceeding that by a bit. I think we came in at about fourteen million dollars for 2008, so that was good. That really quieted the naysayers a bit because we had finance sign-off, we had a 4-Block that included all of the savings, and we had all the back-up detail to go along with that.

One of MichCon's Black Belts described how their CI efforts began slowly as they acquired data and worked to engage the front-line employees who had the expertise they needed. After this early groundwork, the Black Belts were able to accelerate their progress:

It was so much stuff to do, all you can do is just take a bite and start fixing. Fixing and fixing — everything. You can't even quantify it because it was so

much. You just say: people have more time, it wastes less, there is less over-processing, there is less repetitive work. It started to rapidly eliminate waste. Then the real improvements started coming up, system fixes.

It took us a while to dig through the quagmire of understanding data, getting to the people who understood the data, getting them to understand what we're talking about, getting on the same page. Then we got a rapid succession of improvements, because we got through all the low-hanging fruit.

We were writing Crystal reports and getting databases organized differently. Now IT is in tune with the way we want to see data in Gas Ops. They started...asking questions of clients the right way. They're proliferating some ideas to other parts of the organization that don't know them: "If I'm going to write that report, should we try it this way? Because I think you'll want it this way in the end." Then light bulbs start kicking on. Think of that throughout the organization. ...We've still got tons of things to do today.

An example of a Black Belt project requiring such involvement from IT was a home-start program initiated in 2008. A Black Belt sought to reduce MichCon's non-productive time by shortening field workers' first-arrival times. (First-arrival time is the time it takes for a service truck to arrive at the first customer job each day.) He was able to introduce a practice that had been rejected by union members when Marcia Jackson's team first proposed it during the learning line in 2004: By taking their trucks home at night, field workers could leave directly for their first job the next day without first having to commute to their respective service stations. Presenting this project at an OSSG off-site meeting, the Black Belt quipped, "Bob Richard is very supportive. Some people might say he's *too* supportive!" Improvements in first-arrival times from 2007 to 2008 were as follows: 62 to 30 minutes in southeast Michigan, and 74 to 44 minutes in greater Michigan. The Black Belt tracked first-arrival times on control charts, but finance personnel required statistically significant *t*-tests before they would certify these gains.

After Schulist started CILWs in February 2008, Richard enthusiastically latched onto CILWs as a way of pushing for improvements. He wanted to hold one in MichCon every six weeks. Additionally, he wanted to run all the initial workshops at Michigan Avenue Service Center in Ypsilanti to establish a "model station" whose CI successes could be copied elsewhere. MichCon's executives and CI personnel ran four CILWs at Michigan

Avenue in 2008. These CILWs at Michigan Avenue were highlighted in an article on DTE Energy's CI initiative in the Association for Manufacturing Excellence's *Target* magazine (Wilhelm, 2009). The article quotes a union member's summary of their countermeasures that dramatically improved getting each service truck to its first job as quickly as possible: "Some guys can now go to their first job in the morning right from their house, so that eliminated some of the vans that were here, and we got more parking. We moved all our heavy equipment down to the far end, so that's out of the way. Everyone has assigned parking now, so the stock guys know exactly where your truck is and they bring your stock right out and put it on the back of the truck. The stock guys working the 4 p.m. to midnight shift fuel all the equipment when it comes in. Everything is more efficient now" (Wilhelm, 2009, p. 39). In early 2009, Michigan Avenue reported a 40 percent reduction in operating costs, although some executives outside of MichCon were a little skeptical of this claim.

Schulist, for his part, was looking for a culture change such that station employees would engage in CI activity routinely. He did not see such change happening:

It's been used as a poster child, but it's not really working the way we think: We're not building this new culture, we're just running courses there. How do we change that approach?

[MichCon president] Jerry Norcia is supposed to go and spend a week there to figure out what's really going on — see if we're holding countermeasures and making sure things are sustaining — because every time I go there, I can see they're not. It's episodic.

Then Bob Richard gets upset with my assessment because I am not seeing the culture change and he *is* seeing the metrics improve. All I'm trying to do is say, "It's not you, it's not Michigan Avenue, it's not anybody. We just haven't figured out how to change the culture and engage everyone at the point of activity, every day, to make things better. We haven't cracked the nut on this."

Baum was promoted to station manager at Michigan Avenue in late December 2008. He shared Richard, Schulist, and Hemrick's desire to have his employees experiment with various CI activities to make Michigan Avenue a "model station". However, he felt that he needed the help of OSSG personnel to construct a structure to respond adequately to front-line employees' improvement requests. He was afraid that inadequate responses to

such requests would disappoint his front-line employees, causing them to disengage from the CI initiative. (Baum's fear was well-founded: Morrison (2003) documented these dynamics at a vehicle manufacturer trying to implement Lean.) With the OSSG personnel busy with DTE Energy's organizational response to the 2008 economic crisis, plans for a model station were put on hold in 2009.

> We are beginning to draw information out of the field as far as defects and things like that. What I would like the OSSG group to help with is a good infrastructure in place to effectively deal with the defects that are coming out of the field. I've been hesitant. I don't want to ask the field, "Send me your problems," because I'm going to get a wave. Whoosh! If I don't have an effective way to deal with that then I'm going to lose credibility with the folks, we're going to flounder. We'll make some improvements, but it certainly won't be as good as if we go into it in a bit more organized fashion. That's what I would like to have as the first focus.

> Jamie Bonini came out here and met with us. We got the chance to sit and chat with him for a few hours, which was good. He even sort of reiterated that. He said, "You need to begin pulling all this information out of the field. And when you start that, be ready because you're going to get more than what you are able to handle." He said, "Working hard, knocking down these issues — it levels off over time. Then it's more manageable, sustainable." He said, "But the initial rush could be impressive." ...And that's exactly what I fear will happen, so I haven't asked them to open the floodgates up yet.

4.3. CI Activities at Fossil Generation — 2008-2009

Patti Poppe, director over the Belle River and St. Clair power plants, launched an initiative in August 2008 to address Fos Gen's culture. In designing this new initiative, Poppe was heavily influenced by Rayona Sharpnack, a consultant and founder of the Institute for Women's Leadership. DTE Energy's plant leaders — all of whom were Black Belts because of Bob Richard's earlier influence — held an off-site managers' meeting for each of Fos Gen's two geographic areas. A plant manager at Monroe had come to DTE Energy from AES Corporation where CEO Dennis Bakke was a strong proponent of Douglas McGregor's (1960) Theory Y style of management (see *Theory X* and *Theory Y* in the Glossary). Fos Gen's culture-change efforts therefore became a blend of Sharpnack's (2007) "Trade Up!" and Bakke's (2005) "Joy at Work" philosophies. The meeting

attendees worked to articulate their perceptions of Fos Gen's prevailing culture and what kind of culture they desired (which they called their "Trade Up Culture"). These culture descriptions, with clear parallels to McGregor's Theories X and Y, are presented in Table 2 below.

Prevailing Culture	Trade Up Culture
We do not trust each other to do what is good for the whole organization.	We are trusted to make decisions every day.
Too many and constantly changing priorities results in lack of progress in any direction.	Based on a clearly communicated business plan, we know what to do because we understand how our work supports our organizational priorities.
We have been given limited resources, therefore we can only provide limited results.	We generate value by using our resources efficiently and creatively in our alignment with our goals.
Everyone focuses on today's crisis so no one is looking forward.	We look ahead and prepare to serve the future energy needs of our region by aligning our daily decisions with our long-term goals.
We don't feel respected and valued because management does not ask for my input nor explain their decisions.	All employees are respected and appreciated for their contribution to our success through ownership, pride, and innovation.
I just do what I'm told because no one listens.	We enjoy an environment where shared learning is encouraged and open communication creates common understanding to achieve desired results.

Table 2. Descriptions of Fos Gen's Prevailing and Desired Cultures

Fos Gen's managers held similar meetings with their respective plant personnel. Monroe power plant director Frank Wszelaki said, "We brought in people from the plants and we did the same sort of thing — did the same kind of exercise — and came up with the same answers, so we knew it was real. Now that you know it's real, how do you

change it?" The core of Fos Gen's culture-change strategy was for its managers to teach their employees and coach them in their CI activities.

Managers at DTE Energy's nuclear power plant, Fermi 2, had taught their employees in a series of sessions called "Leading and Learning." When vice president Paul Fessler joined Fos Gen from Fermi before PEP, he brought Fermi's training program with him. In 2004, it comprised 11 sessions on conflict resolution and collaboration, on the Operating System and CI, and on "Business 101" for Fos Gen's power plants. The training program was suspended during the PEP initiative, but Fos Gen's managers and union leaders restarted a shorter, 7-session version in October 2007 called "Performance Leadership." A Training Advisory Group (TAG) was formed to manage the program. Fos Gen's vice presidents and directors were trained first. The TAG reorganized the program into four modules, incorporating Poppe's culture-change work: (1) roles and responsibilities, (2) goals and metrics, (3) Trade Up Culture, and (4) C1-C4. Performance Leadership training was attended by plant managers and supervisors in 2008, and by staff personnel and other business-units' employees in 2009.

Power plant managers developed different forums at their respective plants for expanding the scope of Performance Leadership. At Riven Rouge power plant, for example, a voluntary Performance Leadership advisory group met monthly at to develop training sessions for the plant employees. River Rouge's managers conducted the session three times each month to ensure that employees on all shifts had a chance to attend. At the smaller Greenwood power plant, in contrast, managers held town-hall-style meetings to build trust with front-line employees by soliciting and discussing their improvement ideas.

By late 2008, CI activities at Fos Gen's power plants exhibited many of the features that the OSSG personnel wanted to foster across the company, yet these activities were somewhat disconnected from the corporate CI initiative. Fos Gen's middle managers encouraged CI work that the Black Belts and front-line employees did not always do as part of OSSG-sanctioned 4G9S projects, CILWs, or swarm events. Such experimentation — like the Coolidge learning line or the intended "model station" work at Michigan Avenue (presented in the next section) — was beneficial for figuring out how to adapt CI

to a particular context. But the OSSG's leaders were worried about their ability to develop a company-wide approach to CI because they did not have systematic (and enforceable) ways of collecting, evaluating, and disseminating the results of Fos Gen's CI experiments.

Below, I provide examples of CI activities at Fos Gen's power plants that illustrate the OSSG's goal of instilling "problem solving at the point of activity."

1. CI coaching by middle managers

Poppe, hired from GM during the PEP initiative, was unafraid of experimenting with new ways of managing her power plants. Schulist said that she took his advice in early 2008 to "consider realigning and reorganizing her power plant along value streams, instead of around the organizational functions that she has." Patterson, promoted to director of Corporate Services in late 2008, admired her efforts to give her employees the "vehicles" to figure out how to work smarter:

> She has rallied around this Operating System principle of driving decision making closest to the point of activity: How do I create systems and structures for that to happen? She's doing some awesome work.

> She creates a daily checkbook for her plant, breaks it out to the lowest level she possibly can. "Here's our everyday run rate. We can't spend any more than this. Now, you make the decisions — purchasing, materials, overtime, what have you — but this is all we have to spend." She has a variance on it on a daily basis. I haven't seen it yet, but she talks about how it has totally driven people's mindset around paying attention to what things cost and how [they] can do things differently. She's given them an infrastructure and a vehicle to bring some creativity to work.

> She has set up a conference room as their new war room. Before, Central Engineering would tell them what work orders they're going to work on to keep [up] their plant availability. The idea was we can look across all the units and decide [how] we'll deploy our capital to the most costly stuff. She said, "But you guys are missing a big thing: You've got workers out here executing these projects mindlessly. You don't know everything that they know. They probably don't know everything that you know. How do we bridge that?" So she created this war room. It prioritizes things based on what Central Engineering says, but then [the front-line employees] get the chance to make the final decision: I agree, I disagree, or here is something that was number ten on the list that I really think should be number one because it's going to cause this kind of a problem. She has broken the teams up into responsibilities around the units. This is where she has given them some vehicles to start

bringing some continuous-improvement thinking to the organization, so you don't have to wait for a [CILW]. Every day they can see how they're contributing and get some feedback on how they're contributing, which I think is pretty awesome work.

Employees at River Rouge power plant created and maintained a whiteboard summary list of their CI activities without management coercion. A surprised OSSG member asked one of River Rouge's Black Belts how the plant's managers fostered such a climate, something that the OSSG personnel had not been able to do. Fos Gen's employees credit plant manager Brian Rice, a charismatic and well-respected Black Belt with over 30 years of experience in Fos Gen operations. One of the managers explained that he is adept at teaching and reinforcing CI concepts to front-line employees subtly — "in the moment" — and he does so at every opportunity.

After the OSSG's laminated posters of the DTE Energy Operating System disappeared from the company's walls about 2004, front-line employees at Trenton Channel power plant had trouble understanding what the CI initiative was all about. Plant manager Dan Braker, a Black Belt from GE Plastics, worked with his employees to create posters explaining how the pieces of the CI initiative fit together. Their diagrams visually demonstrated how Braker expected his front-line employees to use the OSSG's problem solving methods — 4G9S projects, JDI projects, swarm events, AARs, and root-cause analyses — to address the following CI opportunities: (1) process improvement "quick hits", (2) performance shortfalls relative to budget, (3) external pressures, and (4) problems uncovered by process audits.

2. Improvement of core processes

Fos Gen's managers had little trouble applying CI to certain core processes within the power plants, like outages and planned equipment maintenance. "The critical path is always going to get CI'ed," said Monroe's Wszelaki. After each improvement, he said, "we're going to go after the next critical path, which may be somebody else." For example, Monroe's employees were persistently trying to streamline the scheduling and management of the outage process. The Northeast Blackout on August 14, 2003, prompted Fos Gen's personnel to create a standardized procedure for handling forced

outages, modeled after Wszelaki's periodic outage handbook. Wszelaki recalled:

> If we have a forced outage, we're not making megawatts, we're not making money, so you've got to spin these around as quick as you can.
>
> We were sitting in the command center. We were trying to get the units back on. The plants would talk to each other on a daily basis about when we would run. After we had the blackout, there were certain things you would need to know, because we had never started up our [power-plant] fleet in a blackout situation. ...I don't know what time it was — we had been working some ungodly amount of hours. We were trying to get ready for our next call with the plants. The SOC [System Operations Center] and those people were trying to [determine] what [coal-fired] units were coming on. How could we tell you what units would be available at what periods of time? What we came up with was kind of neat. It was really simple, too. It was just a set of milestones that were consistent, up and down the fleet, for what we would look at for bringing back a unit. ...Like first air release. Every unit's got to do it. ...When do you think your first established coal fire is going to be? When will you have your hydro performed? All those sequenced steps. ...It had never dawned on us, in a way, because we had never had to start up X amount of units at one time. ...We said, "Man, we do it every day with each unit, if we have to start it up or shut it down. So what's the sequence that you use? How do you share it?" So we came up with some major milestones,...developed the way we structured the call, and built this template.
>
> After we got into it, we started expanding it. If you look at the handbook and the template, it talks about manpower. It's simplified, but it gets into that level of detail.... We put in cost, we put in safety, and other things that they have to look at to make sure they're staying on track. Kind of neat.
>
> I think we've become a leader in forced-outage reduction. We have a very good forced-outage process now within our group. It's pretty much consistently done up and down the river, if you talk to the guys. They have an approach that they make. Each plant, each unit, and all the plants are not created equal when it comes to material and how the designs are, but the basics are there. It's another project-management tool that they're using. It hones their skill and they become very good at it.

With standardized project-management templates in place for both periodic and forced outages, Fos Gen's Black Belts had a base from which they could work with front-line employees to make incremental improvements. Wszelaki described how their outage planning was more rigorous than in the past, thanks to such improvements:

I think maybe we're getting spoiled, because we have Black Belts now. I have one here at the plant. There's also one in the south projects group and one in the north. [These] Black Belts' assignment is to reduce time in an outage.... They're the professionals who can take you through the [improvement] process. We ended up taking the turbine guys to sit in a room for a couple days to [brainstorm countermeasures for improving] their area. ...We tell the guys: "...Make it practical. Make it real. Don't just throw stuff out there to throw it out there." I think the acceptance has been pretty good. Now it's part of our DNA, it's part of our [improvement] process. We do it.

Five years ago, you would get this rolling of the eyes and "I can't talk about it." And: "I don't know what you're talking about, kid. Just give me the money, tell me I got four weeks. You'll be happy in four weeks. Come back in the fifth [week] and you'll see the units [running]." ...I think guys had done so many outages [that] planning was more like, "Outage is in three weeks? Okay. The day before the outage, I'll walk out there and take a look around and whatever." It wasn't planned as well as it could have been. I'm not saying we changed that when I came — 'cuz there were people planning outages. Don't get me wrong. It's [a question of] how much rigor was around it.

Wszelaki also described how the PEP initiative's focus on cost reduction prompted the personnel at Monroe to innovate new ways of making work assignments within the plant. He said, "Maybe you don't have to have a dedicated person for that [outage]. They can multitask. [That's] the next thing we've been looking at. Periodics is just a piece of the daily operation: day-to-day operation, forced outage, and periodics. With our workforce, you want to have the workforce be flexible: You might have to go from forced, daily, to periodic — wearing all three hats — but know where you're priorities are. You can have three resources on each major task, [but] if you can cut it down to two, then go to one, now you're going after additional labor cost and not costing yourself time.... We're having foremen and other individuals get outage assignments in line with their daily assignments. That's been somewhat of a challenge, but it reduces headcount."

3. Collaboration between Black Belts and front-line employees

Black Belts and front-line employees used value-stream mapping (VSM) to identify ways of shortening durations of periodic outages for planned maintenance. Employees at one power plant used VSM to cut the time needed to replace a main-unit transformer from 30 days to 17 days. Another example was the coal-mill group at Monroe requesting a

Black Belt to help them improve their process for rebuilding the coal mills. Monroe's plant manager recounted the story:

> Our coal-mill group call themselves "The Elite Force". If you go into the coal-mill shop, they have it on their door. They have some pretty aggressive supervisors and they have a very onerous group of people that work in there. They take care of our coal mills. There's twenty to twenty-four guys in there. They work well together.
>
> They took on themselves how to improve rebuilds of coal mills. We had put a CI person in there a few years ago. They went through and mapped it out, tried to understand how do they get better.
>
> One of the reasons they were fearful: Rumor got out that we were looking at contracting coal mills out. They don't want to lose coal-mill work. Sometimes it's not a bad idea to see what your competitor can do. They took it on: "Wait a minute! There is nobody better than us! You could bring B&W [Babcock & Wilcox] or whoever you think you want to bring in here and they ain't going to do it faster, they ain't going to do it better, and the quality's not going to be there."
>
> I said, "Okay, let's prove some of this stuff out, 'cuz you guys don't make your dates. Sometimes the quality isn't there. Every time it's Friday at three o'clock, it won't be till Saturday, so we got to work Saturday. Why is that?" It was like: "Okay, prove it."
>
> Over time — things take time — they developed a pretty good team down there. They did it pretty good. We had a CI person [who] got with them, sat down, went through the process so that they could see it. A year or two later, we had an engineer planner go back through it, kind of re-look at it, see how their plans and schedules go. Now I rarely worry about their plans or schedules — knock on wood. They do pretty good.

4. Collaboration between managers and front-line union employees

Even though the Union Management Partnership was folded into the CI initiative in 2002, Fos Gen's managers could not improve their outage cycle times without engaging the union employees in the process. One plant manager explained that only the union employees could properly evaluate their work packages and identify impediments:

> We bring in a number of building trades to work during a periodic [outage]. We have a host of maintenance folks that work the outage — they're full-time [Local] 223 guys. We're trying to build on our union partnership. If I brought

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in an ironworker, a welder, a pipefitter, an electrician, and an INC [instrument controls] guy, then we're going to talk about areas of work. We won't get into the details of the job, but we'll start by saying: "Okay, what do you think when you're in an outage and you're working on an FD [forced-draft] fan?" Or, "You have to go out and repair these valves on the turbine, what's been your experience?" "What should be our cadence of direction that you think you need in the field? Not planning the work package for you, but when you go out there?"

We did a lot of work on 'what's in it for me'. I remember having what's-a-good-day-look-like meetings up and down the river. ...That's when we [realized] certain [work] packages need to be walked down by the craft [employees]. We'd have a unit team take the work packages and they'd walk down to work. They'd make sure the sequence was there. We'd take one almost from start to finish, unwind the whole package, look at it, and say, "Okay, it's a major job. Do they have all the right step text in there? If I have a maintenance procedure I have to use, is it correct? Are the parts the best parts?" ...That's why I wanted to get the union involved. They're the hands-on guys. "Look, we're not worried about you trying to understand what a schedule hammock is, or how a level-one schedule compares to a level-three.... We want you to look at our sequence. When we give you the job, are the hand-offs there when you go to the warehouse and get the part? Do we set up staging areas for you? If we do, where do we set them up?"

A lot of groups were doing that, but we honed our skills by having those kinds of discussions. At the end of the day, no one wants to be frustrated, you want to get your job done, and you want to do it correctly.

Many CI projects would not have been successful without the expertise of the front-line union employees. For example, managers at St. Clair power plant attempted biomass cofiring — burning wood chips with coal — but did not succeed until they included front-line employees in the project. In another example, several union employees designed a process for sending out the power plant's circulation water-pump motors for maintenance. Their manager recalled, "These circ' water-pump motors are huge and they need to get sent out every five or six years. We have to take the roof off and bring in a Laramie truck. It used to take us weeks to do it. We used to just fiddle around with it, didn't have a good sequence. The parking lot would be all messed up. You hardly don't even hear about it now. An iron worker and a good rigger got together with the foreman who enjoys doing the work and they followed the [CI] process. In a few days, those guys can have the roof

off, the pump and the motor removed, decoupled, on trucks to go to where they need to be repaired. You wouldn't get that if you didn't have the union involvement."

At one plant, the managers held a swarm event in early 2009 to resolve discrepancies between their engineers' and their coal-mill employees' recommendations for coal mill rebuilds. Coal mills were typically rebuilt — replacing the motor and grinding zone — after 100 thousand hours of run time. But the swarm team discovered that they might be able to run a coal mill for 120-150 thousand hours before needing to rebuild it, depending on how and how often routine inspections were done. Based on the team's findings, the plant's managers increased the frequency of inspections from every five thousand running hours to every four thousand. One of the managers said, "They were able to define what things they look at for recommending — and it's done with the group now, not just the engineer. You drive it down that way; you get some camaraderie and it works out."

5. Collaboration with contractors

In addition to fostering effective collaboration with front-line union employees, some plant managers also solicited the help of their contracted suppliers. Fos Gen had a partnership with Washington Group International (WGI[3]) as its major constructor. Employees at one of Fos Gen's plants, with assistance from WGI, replaced 2000 square feet of waterwall tubes in 8 weeks. But WGI reported that a plant at another utility did the same replacement in 6 weeks. With that competitive benchmark, WGI and Fos Gen's employees worked to reduce their waterwall-tube replacement time to 3.5 weeks. The plant's manager remarked, "You can only go so far with certain things because physics — heat and pressure — will affect you sometimes. But the drive to be better is out there."

WGI also assisted a plant team improving their cycle time for replacing reheater pendants. Their first replacement took 77 days. For the next replacement, the team set a goal of 67 days and actually completed the job in 59 days. "Now they know that they can do it even better," said their plant manager. "They'll look at their areas, like how much

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[3] WGI was acquired by URS Corporation in November 2007.

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fetal weld do you have to provide and are you doing it automatically or a person manually doing it."

6. Improvements initiated by front-line employees

The Holy Grail of any organization's CI initiative is to create a culture in which all front-line employees monitor their (already well-designed) work processes and take the initiative to fix problems that arise. I present a few examples that demonstrate Fos Gen's movement toward that ideal.

Example 1: Pendant Tube Replacement

A periodic-outage team took 13 weeks to replace a secondary superheated outlet pendant tube. After deciding to improve this cycle time, they used CI tools to improve their process during the plant's next three periodic outages. The team was able to cut the cycle time to 8.5 weeks.

Example 2: Precipitator Circuit Board

A plant had a problem with its precipitator controller overheating. A young electrician discovered the controller's circuit board would fail every 18-24 months. "He decided he was going to try to figure out how the board functioned," said the plant manager. "He did. There's a fifty-cent resistor on there that would fail. I think it was something like that. He can repair these boards now. He did his own process review, looked at the thing, taught his electrician buddies how to do it." The electrician's repairs saved the plant $1600 for each circuit board and the labor needed to replace them.

Example 3: Weld Sheets

Welders at one plant were frustrated because they never seemed to receive the weld sheets they needed on time, so they asked their manager to help them flowchart the process. "They pushed us to do a process map of how many people touch a weld sheet," said the manager. "We were shocked: twelve people! Why are twelve people touching a weld sheet, from the start to the finish, by the time it goes out to the welder who's signing his name on the weld?! They got it down to just a handful, the right information, modernized it. There was a process improvement. They got frustrated and then they

[fixed it]. That's the kind of stuff we want."

Example 4: Coal Conveyor

The fuel supply area at Monroe power plant needed to replace the large conveyor belt they used for unloading coal trains. The belt was a mile long and 6-feet wide. Wszelaki explained their approach when it was replaced 12 years prior: "Okay, we need to do the belt. Hire the contractor. What do you think we gotta do? It's going to take twelve to fourteen days. Someone SWAG'ed it. ...Come to work; it's going to be fourteen days. They do it in fourteen days." The fuel supply team were confident they could beat the contractor's past performance: "What do you think you can do it in? How quickly can it be done? If you've got some roadblocks out there, what are they? Let's figure them out." They researched how the contractor had replaced the belt and what it cost in 1997 and they were able to replace the conveyor belt faster and cheaper themselves in 2009.

4.4. Response to the Economic Crisis — 2008-2009

The U.S. economy sharply deteriorated in the fourth quarter of 2008 after a speculative bubble in subprime mortgages popped. A critical point was reached in September when investment bank Lehman Brothers collapsed and the U.S. Federal Reserve extended about $123 billion in credit to American International Group to prevent its collapse. On October 3, the U.S. Congress passed the Emergency Economic Stabilization Act of 2008, authorizing the U.S. Treasury to spend up to $700 billion to purchase mortgage-backed securities and to prop up banks' beleaguered balance sheets by giving them cash. As measures of the stock market's performance during the quarter, the S&P 500 index fell about 22 percent and the broadly representative Wilshire 5000 index fell about 9 percent. (These indexes finished the year 37 percent and 19 percent lower, respectively.) Companies found it increasingly difficult to borrow money as banks drastically reduced their lending.

This economic crisis affected DTE Energy primarily through its effects on DTE Energy's industrial customers. Detroit's car companies and their first- and second-tier

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suppliers comprise 20 percent of DTE Energy's sales. Detroit Edison's annual electricity generation dropped 2.5 percent in 2008 and 5.8 percent in 2009. By the end of 2008, half of DTE Energy's industrial customer accounts were 60 days or more past due. For Detroit Edison, these unpaid bills totaled $239 million, $87 million of which DTE Energy's executives believed was uncollectible. For the whole company, uncollectible bills were $213 million in 2008 and $171 million in 2009. Chrysler filed for Chapter 11 bankruptcy protection in April 2009 and GM followed two months later.

DTE Energy's senior executives began formulating what they called an economic-crisis response (ECR) in October 2008. Like PEP, the ECR plan was a cost-cutting initiative. Since PEP, one of the senior executives' long-term goals for the company was to reduce DTE Energy's operating and maintenance (O&M) expenses to within the 25th percentile of its (self-defined) peer group of utilities (see Appendix E). The senior executives referred to this goal as "first-quartile performance". The ECR plan was their chance to push the company toward this goal rapidly. One of DTE Energy's board members told the executives, "Don't waste this crisis." At an off-site meeting for CI personnel in September 2009, DTE Energy's vice president for regulatory affairs said that DTE Energy's senior executives expected continued consolidation in the utility industry, but not until corporate borrowing becomes easier — perhaps in three to five years.

DTE Energy's executives had already formulated their 2009 budgets, with reductions from their 2008 levels, when the economic crisis became apparent. They determined that they needed to save an additional $130 million in 2009 and to boost DTE Energy's cash reserves by $20 million. (DTE Energy's front-line employees viewed these goals as a single $150 million target.) Overall cost reductions from 2008 levels totaled about $250 million. The $130 million ECR cost-reduction target was allocated among DTE Energy's entities to close a portion of each entity's gap to first-quartile operating-cost performance. These allocations were as follows: $63 million to Detroit Edison (40 percent of its gap), $13 million to MichCon (68 percent of its gap), and $54 million to Corporate Services (76 percent of its gap). MichCon's 2009 goal was increased to $20 million to account for a cost-reduction shortfall of $7 million in 2008.

It was a fortunate coincidence that Anderson led the formulation of DTE Energy's

ECR plan in October 2008 concurrent with his personalized CI training (which had been scheduled months before the economic crisis occurred). In late September, Schulist had said, "Gerry [Anderson] has never been to a class. He's been to one or two report-outs. In October, I have him for five days, so I'm going to take him through his *Karate Kid*[4] journey over those five days and hopefully convert him. I believe that the result of that [journey] doesn't make or break but changes the future path of continuous improvement in the company. If he gets it and he's converted like most, we go one way. If he thinks it's a crock," he said laughing, "we are doomed forever!"

Schulist taught Anderson's individually tailored CI course one-on-one, spread out between October and mid-December 2008. They discussed the Jack Smith (Spear, 2004b, 2004c; Spear & Purrington, 2004) and TMMK (Mishina, 1995) Harvard Business School case studies, and Anderson completed a practicum — implementing 20 improvement ideas in six days — at Trombly cable plant. Schulist reported that Anderson didn't find CI compelling at first because he didn't understand how all its pieces fit together. It took a few weeks before Anderson told Schulist that "the pieces are coming together" in his head. Steve Kurmas, Detroit Edison's new pro-CI president, also influenced Anderson's thinking. An OSSG manager observed, "Jason [Schulist] has had this tremendous boost because of the downturn in the economy and that feeling of a burning platform."

By mid-December, Anderson and Kurmas were promoting CI themselves. Kurmas said, "When it was done successfully, it was our job to congratulate and reward them. The mindset we have now is that it's our responsibility to lead that effort, by hands-on demonstration" (Wilhelm, 2009, p. 33). By February 2009, Anderson had "drunk the Kool-Aid," according to Schulist, and was "charging ahead with the CI strategy." One manager noticed the senior executives talking about CI a lot more, which she said "sends signals to middle management that this stuff is important." A MichCon employee said, "Bob Richard, still to this day, is out doing swarm events — which is huge. That's probably the biggest help of all: to have a vice president that will put on a darn hard hat,

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[4] Schulist is referring to the 1984 film starring Ralph Macchio and Pat Morita; see Glossary.

go out in the trenches, and walk around with you...." Richard explained, "All the directors, managers, and supervisors have to go through a swarm event with me. They spend a week with me, listening to me talking about how important it is, but they can see it's not just me telling them to do it. It's me teaching them how to do it" (Wilhelm, 2009, p. 39).

DTE Energy's senior executives did not want the ECR plan to create the same employee backlash that the PEP initiative did, so COO Gerry Anderson announced that they would guarantee employment security for employees. He said, "We will lead from the front and with heart." Consequently, employees would have to make the $130 million in cost cuts to DTE Energy's $778 million of overtime and non-labor O&M expenditure (see Table 3 below for a breakdown by category). In this respect, DTE Energy and Toyota used the same strategy: Employ a large number of "temporary" contractors who can be cut easily in an economic downturn without damaging regular employees' morale. One director said, "The ECR plan was the first time that DTE went after contractors." Nevertheless, several managers believed that the employment guarantee would have been impossible without the PEP initiative's downsizing and cost cutting in 2006. As we saw in section 3.6, many managers had trimmed their employee ranks to meet PEP's headcount target, shifting their work to contractors who had no employment guarantee.

Expense Category	Category Reduction ($ millions)	Category Reduction (%)
Overtime	18	25
Contractors and consultants	50	21
Outside services	23	14
Materials	4	5
Other	26	12
Global items	9	-
Total:	130	17

Table 3. ECR Cost-Reduction Targets by Expense Category

The ECR plan's employment-security guarantee restored a necessary component for engaging union employees in CI activities. Throughout 2008, employment security had continued to be a problem for union members. Schulist had proposed several strategies to avoid future layoffs:

1. Attrition — not replacing people who leave the company.
2. Reassignment, or "redeployment" — moving people to new jobs, which might require retraining.
3. Insource — having employees make products instead of purchasing them and provide services themselves instead of hiring contractors.
4. *Kaizen* float team[5] — create a roving team of CI experts who can be deployed where needed.

Labor relations and union participation in CI improved when DTE Energy's senior executives agreed that attrition and redeployment of employees would be used to handle

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[5] Schulist noted that a kaizen float team would require close oversight to ensure that managers looking for ways to get rid of low-performing employees do not use this team as a convenient dumping ground.

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excess labor created by CI improvements in 2009. One senior executive said, "We've told people that, while we'll all be doing different jobs in the future and work will continue to change, we have plenty of work for our employees to do. Jobs may change, but I think employment will be enhanced by these kinds of activities" (Wilhelm, 2009, p. 40). DTE Energy's 2009 budget estimated excess labor of 50-100 people only. One manager felt that front-line union members' participation in swarm events in 2009 was their first serious engagement in CI work since the UMP teams of 1999.

To reach first-quartile performance, the senior executives wanted to ensure that DTE Energy's business units didn't just reduce expenses temporarily. When at risk of going over budget, for example, DO employees would reduce their clearing of power lines and Fos Gen's employees would defer planned and preventive maintenance. DTE Energy's senior executives therefore insisted that cost reductions in 2009 not reduce service levels or what they called "core business" processes (like preventive maintenance). Instead, they wanted all employees to use CI to eliminate waste and "challenge our ways of doing business." A manager in Fos Gen said, "There's an easier way to cut budgets: Whatever you had last year, now you got ninety percent, you got eighty-five. That's a horrible way. It's better to do it smart and try to leverage the [CI] tools." One senior executive said, "We need to go after some DNA." A middle manager perceived this approach as the only alternative in the face of the GM and Chrysler bankruptcies:

> With major companies filing for bankruptcy — these are our biggest customers — boy, you'd better have a whole bag of tricks. They're all CI tricks — that's all we have.

> We can't change our plants. They're between thirty and fifty years old. They're not getting any newer. We can't change our rates — that takes legislation. ...If you threaten to leave me, I can't say, "Woah! What's your best price? I'll undercut [it]." I can't; my rates are locked. I'm capped by the Public Service Commission. I don't have that flexibility. We can't change our customer base — and it's eroding. There's no doubt about it. We're locked in to the price of coal, we're locked in to the price of gas. You start running out [of alternatives]. What do you got left? You got people. Okay, can I get rid of people? I'm going to try — eventually. But can I maybe be smarter about how I do things? Can I improve all my processes? Absolutely. It's the only thing left when you look at our company.

The ECR plan prompted Anderson and the other senior executives to make a few structural changes that reflected a different emphasis from PEP. They appointed a new director of the EPM group and shuffled the group's personnel. Anderson wanted greater attention paid to non-financial metrics, so EPM's new director began working on a company-wide Balanced Scorecard (Kaplan & Norton, 1992). DTE Energy's finance controller said, "The plan is not to have fifty thousand projects tracked centrally, but to track KPI's [key performance indicators] only." Schulist explained that the senior executives called this approach "trust and verify." The CI initiative gained prominence when Anderson brought the OSSG out from under the EPM group and assumed direct oversight of it himself.

The senior executives wanted all employees' use of CI to be serious and earnest in making cost reductions. Speaking to a group of Detroit Edison's CI personnel about their cost-reduction target, president Steve Kurmas said, "We're not going to 5S our way to sixty-three million dollars." He continued, "You need to get comfortable asking front-line workers for improvement opportunities, and the front-line workers need to get comfortable answering. We've never had the opportunity to use the tools that you've been practicing for the last five years as we do now." Schulist recommended to Anderson that he insist a fraction of the $130 million in cost reductions be "sustainable" — lasting improvements to processes instead of temporary cuts or deferred expenses. Anderson selected a sustainability target of 80 percent, to be achieved gradually by year end (see Figure 5 below). Echoing the skepticism about the CI initiative's savings numbers before PEP, Schulist warned Anderson "about the dangers of other executives snowing him, or even Gerry snowing himself about what's being achieved."
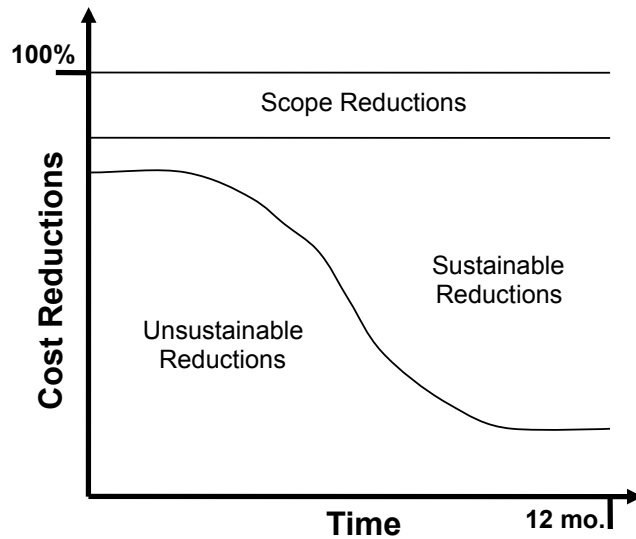
Figure 5. ECR Cost-Reduction Plan

Leading the ECR plan's implementation, the senior executives acknowledged that the company needed to avoid the following possible pitfalls:

1. Lack of leadership commitment.

2. Lack of employee commitment.

3. Not thinking outside the box and challenging assumptions.

4. Unintended consequences from the lag in realizing gains from CI efforts.

5. Coordination problems among business units.

6. Communication problems among business units.

7. Making cost cuts that are unsustainable.

In November 2008, Anderson created a video that was distributed company-wide in which he explained the ECR plan to all employees, including the employment guarantee, a hiring freeze, a freeze of non-union salaries, the 2009 budget cuts, and his expectations for process improvements.

DTE Energy's annual budgeting process was already well underway when the senior executives began formulating their ECR plan. The senior executives had already reviewed the business units' budgets, called S2 plans, but had not closely examined their operational plans intended to "close the performance gaps." Anderson and other executives, therefore, held an all-day review of these S2 plans in December 2008 to

scrutinize the details. Anderson wanted to understand what fraction of the proposed cost-reductions would be permanent.

Fos Gen's CI personnel formed and facilitated small teams at each power plant to brainstorm and assess the feasibility of cost-reduction ideas. To meet Fos Gen's $43 million cost-reduction target, they identified $18.5 million in permanent cuts, $18.2 million in one-time cuts, and $6.2 million in scope reductions. Fos Gen's personnel planned to perform the same amount of preventive maintenance in 2009 as they did in 2008, but they deferred any needed maintenance above that amount. One of Fos Gen's employees explained that they usually did not have data on equipment mean-failure times, so they guessed when equipment needed to be replaced. During a budget crunch, they simply stretched out their guesses. In June 2009, Fos Gen vice president Paul Fessler reported that his employees had completed 97 percent of all planned maintenance so far during periodic outages. (The target for planned maintenance was always less than 100 percent because unexpected work always arises during a periodic outage.)

Contract labor, mostly untouched during the PEP initiative, became the first area to be scrutinized by business-unit personnel. For example, the IT department's managers quickly cut 145 of its 245 contractors, reducing its contract-labor expense by $22 million annually. But their CI expert admitted that they eliminated these contractors without a plan to get the contractors' work done. The "continuous improvement" aspect of this reduction was finding ways to redistribute the work among employees and remaining contractors, or to stop it entirely. The CI expert said, "There have to be scope cuts. IT went to the business units and said, 'Here's a list of the work that we're doing. We no longer have the contractors to get all this work done. Pick the most important items on this list, and the rest will get dropped for now.'" A middle manager in Fos Gen confessed to using the same pattern: cut contractors, reassign their work to DTE Energy employees, find extra time for those employees by reducing waste elsewhere in their work processes or dropping low-priority work.

Several CI employees thought that the economic crisis came "at the perfect time" for the CI initiative because it created "a sense of urgency." They noticed that employees were willing to make changes that they would have resisted otherwise. However, they

also worried that the senior executives' haste to cut costs would have unintended consequences. A MichCon Black Belt said, "Because this [crisis] is big, we have to really clamp down. That brings you back to short-term, real fixes fast. Sometimes that is tough to manage along with a long-term, quality-oriented continuous-improvement solution. …Right now I need to show it on the balance sheet or it needs to be something in the ground out in the field. …It's definitely 'What's broken today?' We'll replace that piece with a better piece, a bigger piece, or two pieces to fix that one problem. Once that one problem's fixed, you forget about it. Then you've got four other problems that stem from it, because you didn't think about it hard enough. That's kind of how we're playing, because there's lots of training and evolution that has to happen before people see process linkages, or even have processes defined well enough." Emmett Romine, DO's former CI manager, said, "We're doing lots of cost-cutting now. We may benchmark pretty well because we had to cut so much, relative to the rest of the industry, just because Michigan is in such bad shape. …This time they went after the contractors. Will this be a sustainable benchmark? We'll get there, probably, but will it be sustainable? Did we put the processes in place? …I don't know. We'll see. Call to action is like this. Burning platforms sometimes create that kind of a momentum, so we'll see what happens."

Between February and May 2009, Schulist taught CI to CEO Tony Earley one-on-one, as he did for Anderson in late 2008. Earley completed his CI practicum at Customer Service's Southfield service center, improving how the CS representatives handle high-bill events. He presented his project at the 2nd-quarter board meeting as a way of teaching DTE Energy's board of directors about CI concepts. Schulist reported that the board members received it very well and even gave their own advice for the CI initiative. One of the board members recommended, "Don't make it a fad." Earley announced that he wanted every manager always working on a CI-related project. "That's now part of your job as management," he said. Inevitably, some managers, looking to further their careers, "repositioned themselves to look like they are part of the [CI] action," even if they did not believe in CI's value. Schulist said, "We talk about creating a safe culture. Now people feel as if it's not safe to be seen *not* being part of CI."

A former CI manager who became an operations manager suggested to Earley,

Anderson, and Meador that all managers should have specific CI goals added to their annual performance review (called EAS at DTE Energy). He believed, like many other managers I interviewed, that middle managers would not take CI seriously otherwise. A CI manager explained that managers are not penalized for ignoring the CI initiative: "Why would they bother? It's just more work for them. There's not a CI mindset. They don't care about continuously improving." One executive said, "One of our biggest challenges in the next year or two at DTE Energy is making sure that all of our supervisors and managers see value in this, and that they are measured on whether or not they are utilizing it — in terms of promotion, performance, and pay. If people really see that this isn't some intellectual exercise but it is the way we're going to run the business, I think they'll respond to that" (Wilhelm, 2009, pp. 39-40). Arguing against this suggestion, Meador said, "I don't think this organization is ready for that level of tension." But most departments were given mandates by their senior executives to hold a specific number of swarm events in 2009.

In August 2008, Schulist had failed to get Anderson and the other senior executives to define a vision for the CI initiative, called True North. (Schulist adopted this term from Toyota.) Over the next six months, therefore, Schulist defined it himself. He presented this "CI True North" to all of DTE Energy's CI personnel in March 2009 at an off-site retreat:

1. Perpetual annual improvement in safety, productivity, cost, quality, and customer service.
2. All processes are defined and mapped, and include embedded tests.
3. All employees know and exhibit CI capabilities (C1-C4).
4. Immediately responding to embedded tests and improving processes are both done at the point of activity.
5. Improvements made in one area are spread throughout the company.
6. All leaders spend equal amounts of time on (i) developing people, (ii) developing strategy, and (iii) responding to embedded tests.

OSSG co-director Bob Hemrick agreed with Schulist's stressing this True North vision statement. As a relative newcomer to the company, he praised DTE Energy for

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retaining its Operating System since 2002 but he felt the company had neither gained a deeper understanding of CI nor elaborated the Operating System to reflect such an understanding. The senior executives had become involved in the CI initiative because of the ECR plan, but Hemrick feared they would "become disenchanted and start looking for the next big thing" after the crisis subsided.

As a result of having to run a certain number of swarm events, managers increased their requests for assistance from DTE Energy's CI experts. An OSSG manager said, "As we continue down this path, we're still being seen as people who can help you train your people, improve your processes, map your processes, find mistakes, find defects.... We're still seen as helpers." One of DTE Energy's few Local 223 Black Belts said, "The biggest thing I'm starting to see is a pull for me. When the organization starts to pull you, that's good. It's good [for] CI. It's not good that I've only got so many hours in a day! ...I'm not saying it's a huge pull, but I am seeing more of that. I think these workshops are leaving people with a taste of, 'Hey, this is pretty cool. This definitely can improve things.' And it doesn't hurt to have the vice president running the workshop!"

Schulist adopted two conceptual frameworks from Steven Spear's work on executive workshops, but he wasn't able to translate them into concrete organizational practices at DTE Energy until 2009. Spear had collaborated with TSSC president Hajime Ohba to develop those executive workshops based on his TPS research and on his experiences training managers on TPS at Alcoa and at the University of Pittsburgh Medical Center (UPMC). Spear later conducted these workshops for BAMA member companies, including Hemrick's former employer Dana Corporation. The first framework was an early version of Spear's (2009) four capabilities of "operationally outstanding companies": (C1) process design, (C2) problem solving, (C3) knowledge sharing, and (C4) leaders as teachers. DTE Energy's CI personnel have stressed these four capabilities in swarm events so much that many front-line employees and middle managers use the terms "swarm" and "C1-C4" interchangeably. In March 2009, Hemrick led a committee that revised DTE Energy's Operating System diagram, the first revision since 2005, to include these four capabilities and to make it more graphical by reducing the amount of text (see Appendix C). (Surprisingly, this committee cut the previously ballyhooed 12 Operating Principles,

replacing them with DTE Energy's list of "corporate values" and four additional "guiding principles": (1) identify and eliminate waste, (2) be data driven, (3) be accountable, and (4) build collaboration.) The second framework that Schulist adopted from the TSSC workshops was a set of process-design elements based on the 'DNA rules' of the Toyota Production System (Spear & Bowen, 1999). Four elements represent the components of swimlane flowcharts: outputs, pathways, connections, and activities (OPCA). To this list, Schulist added a few other elements from TPS: prespecified work (called SWI at DTE Energy), embedded tests to signal abnormalities, and escalation procedures for addressing such abnormalities.

Schulist admitted that before he attended the TSSC workshops, he had underestimated the importance of designing processes such that front-line employees can tell easily when something goes wrong. Such process design requires SWIs (to define what is normal performance) and embedded tests (to signal abnormal conditions). Schulist said, "The [CILW] course and talking to people like [Jeffrey] Liker, [Steven] Spear, and [people at] Dana have taught me. I've changed my mental models on a lot of things. We would have put the pieces together, but it still would have been a system that wasn't making work self-diagnostic. It would have been just more Lean tools to close gaps." A CI manager emphasized the importance of embedded tests over behavioral interventions: "Sure, training is always an element of a solution, but never the solution itself, right? Training is fleeting. It is necessary to put controls in place to prevent errors from occurring. At the very least, make sure that when a defect happens, we detect it." A Black Belt said that this emphasis on embedded tests is a culture change for DTE Energy's managers: "We rely solely on behavioral change: 'You did it wrong, so you do it right next time.' And I will have that same conversation, slightly different, with the next guy who does it wrong — never figuring out how you guys were both trained in it wrong and reorganizing that, nor putting in controls to prevent it from ever happening again (unless, of course, there's a gas or electric safety thing)."

DTE Energy's senior executives gave the OSSG a few more positions in 2009. One of these positions was filled by Deborah Meyers, who joined the OSSG from the HR department's Organizational Learning group to be in charge of creating materials for

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knowledge sharing (C3) and for training executives as CI coaches (C4). (The other

positions were two additional CI managers: one for the finance organization, and one for

company-wide improvement projects like time entry and payroll, contract administration,

and the requisition-to-check process.) After Meyers joined the OSSG in January 2009, she

began creating CI materials for the senior executives. She restarted development of the CI

Champion training course that had been abandoned in 2005. She also created a

standardized template that DTE Energy's senior executives could use to diagnose and

coach the C1-C4 capabilities during departmental site visits. The OSSG personnel

originally called these site visits "executive go-and-see events" but — because they were

closer to HP's practice of MBWA — they later renamed them "CI capability assessments"

(see both *Go-and-See* and *MBWA* in the Glossary). Earley first tested this template in

February on a site visit to the IT department. An OSSG leader reported what he called the

"yellow-brick-road problem": Everyone in the IT department was calling each other

frantically, trying to figure out which areas Earley would visit (the yellow brick road) so

they could "whitewash" those areas in advance. The OSSG personnel noted that such

whitewashing — indicating fear of embarrassment, blame, and punishment — distorts the

executives' assessments. Schulist recommended that the executives make surprise visits,

although he acknowledged that only the executives' behavior over time would alleviate

the fear in the company.

According to Schulist and Hemrick, the rationale for teaching employees C1-C4 and

OPCA is to promote common terminology and shared mental models for designing

processes and solving problems. "It's not about closing gaps — it's about developing

people who close gaps," said Schulist (Wilhelm, 2009, p. 40). He also reported that the

teaching portions of CILWs and swarm events had "created an in-crowd that speaks a

special language, with [president] Steve Kurmas as its Pope." A manager in Fos Gen

perceived this growing familiarity with CI terms and concepts as the beginning of culture

change:

> We're mapping things and it's amazing. When I run into my counterparts in
> other parts of the company: "Oh, we're doing the same thing!" You get that
> we're-in-this-together kind of thing. Almost like religion, fervor, or whatever it
> is. People say it's a cult. Not quite, but there's some semblance of that. It's a

critical mass. They call it "DNA Building" in OSSG — when everybody's using the same tools together and you're pulling in the same direction. Someone says, "Yeah I did a *kaizen* on that," and you know what they're talking about. Or, "We had a swarm event," and you know. That's starts to help. It's catchy, it really is. It's almost infectious — that's the word I was looking for. It works well, it really does. People say, "He's not coming here to eliminate my job, he's coming here to help me." We're working together to make a process better or improve something.

By early 2009, DTE Energy employed a total of 120 certified Black Belts, the second CI implementation plan's target for 2006. About whether this number was adequate, one manager said, "It's not a lot, but it's plenty if they're deployed appropriately. Skilled Black Belts working successful projects that matter to their internal customers can have an impact. You could get a swell of conversion if you did it that way, but that's not how we're doing it, unfortunately." After 2006, the OSSG personnel were no longer trying to grow the Black Belt population to any particular size, but a few OSSG managers believed DTE Energy should strive to reach George Koenigsaeker's guideline of three to four percent of the total workforce (Koenigsaecker, 2009, p. 69). By the end of 2009, DTE Energy employed 139 certified Black Belts, about 1.3 percent of DTE Energy's workforce.

Managers and executives believed that the CI initiative helped the business units reach their 2009 financial targets. One middle manager said, "In the two areas I've been in lately, Fos Gen and Marketing, the people at the very top know who's working on Black Belt projects, they see the results. ...[Employees] are using the tools. They're implementing small, incremental changes, getting a lot of base hits. ...[T]he company challenged us to reduce our O&M budget by a hundred and fifty million dollars this year, because they know our revenues are going to be down. You can see it: The numbers are coming down, the savings are there. It wasn't magic. ...They used the tools to identify where things could be cut, they looked to improve things. They're measuring this stuff. It's not accidental, I tell you. ...We're doing more with less and the only way you do it is if you do it smarter."

DTE Energy met its company-wide budget in 2009, including the ECR cost-reduction targets. Certain operations and maintenance (O&M) costs — like pensions, healthcare, and environmental costs — increased from 2008 levels, but cost reductions more than

compensated for these increases. DTE Energy's net change in O&M expenses was $85 million lower. COO Anderson attributed some of this performance to the CI initiative. He said, "Our people worked hard to apply these tools to keep our company healthy in 2009. But we still have a long way to go to build excellence into every one of our processes."

4.5. The CI Initiative's Future — Beyond 2009

The OSSG's leaders were aware of some shortcomings in the CI initiative that they needed to fix going forward if they were to achieve their vision of every DTE Energy employee solving problems "at the point of activity". One shortcoming was the poor quality of CI training for front-line employees. Another shortcoming was the lack of effective channels for employees to share relevant learnings from their CI work with other employees who might benefit from that knowledge (Spear's capability C3, knowledge sharing). Finally, Schulist and Hemrick believed that swarm events were not going to be sufficient for achieving the kind of change they envisioned (for many of the reasons I enumerate in Appendix B).

The OSSG trained only about 140 OS Specialists in 2009, down from about 400 in 2008 (see Figure 4, p.91). I attribute this low number to two factors. First, swarm events supplanted the OS Specialist course as the primary means of introducing front-line employees to CI. Second, I believe that managers began to perceive that training OS Specialists was a waste of time and money. One manager said, "A lot of people have the Specialist training, but there's no requirement or even expectation to use the tools that they learned. We send people to training just to put a check in a box. ...To some people, it's just a trip downtown from the north or south area. I'm being too honest. They come and sit through the six-hour class — it was a good day, had a good lunch, and then go back." Another manager agreed: "You go in, you get out, you're a Specialist — go have fun. Last you ever hear of them. ...They're not seen any differently in the organization. You're supposed to bring all these cool ideas to your group, but in all honestly — looking at those ideas and knowing the culture — that would be difficult. ...They end up not doing it. No one ever checks on them, no one ever gives them support, so — Poof! — it's

gone." Also, a Black Belt blamed the OSSG's course for not explaining how to apply the CI tools to real-world problems: "Lot's of tools in place, but no one knows how to use the tools. They're just tools. If I give my twelve-year-old a hammer, he knows how it works. He can use the tool. [But] he might cost me thousands of dollars in damages when he's trying to drywall the bathroom."

In early 2009, Hemrick observed swarm-event teams persistently making the same errors when using the OSSG's countermeasure worksheet for problem solving (see *Countermeasure Worksheet* in the Glossary). For example, they would use a symptom as a problem statement, not link their desired outcome to their problem statement, and rush to implement countermeasures before they understood their problem's root cause(s). Consequently, one of the OSSG's managers collaborated with Raytheon consultants to design and create a training course on problem solving with the scientific method. Other evidence of poor training prompted Schulist to acknowledge that there was still "too big a gap" between the OS Specialist course and the Black Belt course. He began exploring the feasibility of creating "a rainbow of belts": turning the OS Specialist training into a White Belt, inserting a Yellow Belt and a Green Belt before the Black Belt, and creating an Executive Belt for CI "champions".

Schulist, Hemrick, and Meyers recognized the need for mechanisms to share CI knowledge across departments and business units, but they were at a loss for what these mechanisms should be. Schulist was already pestering DTE Energy's CI personnel to furnish him with A3 Reports (see Glossary) for each CILW, but he also wanted to store all Black Belt certification-project materials and swarm-event flowcharts in an OSSG database accessible from the OSSG's internal website. He had difficulty getting them to comply; Fos Gen and DO were trying to create their own flowchart repositories. Schulist had DTE Energy's Corporate Communications department begin publishing CI success stories in DTE Energy's internal newsletter, but many CI experts suspected that such broadcasting was received by employees as "noise" rather than knowledge sharing. In late 2009, Meyers conducted focus groups and interviews with CI managers and executives to solicit their suggestions for sharing CI lessons. Schulist and Hemrick discussed the need for networks of employees, or communities of practice (Lave &

Wenger, 1991), formed around solving problems of particular types. Schulist contemplated holding a quarterly CI conference, with presentations, panel discussions, and break-out sessions. At the end of 2009, the OSSG personnel had not implemented any of these ideas.

Schulist had failed to revive the learning-line approach in 2009 — renamed "beachheads" — as he had wanted to do since he became the OSSG's director in January 2007. At a CI managers' meeting, Hemrick explained that the purpose of a beachhead is for front-line employees and their supervisors to figure out how to make CI work within a particular context or business-unit location. "Like a military beach landing, the boats drop you off and withdraw, so there is no going back," he said. During the fourth quarter of 2008, Schulist and Hemrick tried monthly to convince the senior executives to adopt this approach. In the midst of DTE Energy's economic-crisis response, most of the business units' vice presidents felt they could not devote the necessary attention, resources, and effort to establish a beachhead in their areas. The one exception was Bob Richard. As we saw in section 4.2, he had already decided that Michigan Avenue Service Center would be MichCon's model location. However, a new station manager was appointed to Michigan Avenue in January 2009 and he requested a delayed start of four months while he learned his new role. By September 2009, no beachhead was underway anywhere in the company, but Hemrick was still promoting the idea and asking the OSSG veterans about the details of Coolidge's 2004 learning line. Hemrick said, "We've been only scratching the surface. We're still looking for the right recipe."

Jason Schulist, like Shawn Patterson before him, was promoted into an operational position in May 2010. He passed the leadership of the OSSG, subsequently renamed as the Continuous Improvement Strategy Group (CISG), to Bob Hemrick. Hemrick believed strongly that instilling a culture of CI at DTE Energy was going to take more than discrete projects and episodic swarm events. "Whatever it is," he said, "it needs to be systemic, not just a bunch of swarms." Arguing in favor of beachheads at a CI managers' meeting, he said, "We're not going to get there by swarms. I did swarms at Dana for twenty years and they didn't work." He also said that DTE Energy's senior executives need to understand that short-term cost cutting isn't part of the beachhead approach. TMMK

manager Jamie Bonini echoed Hemrick's opinions when he visited DTE Energy in May 2009. He told Schulist that episodic swarm events do not instill the habits of process design (C1) and problem solving (C2) "in the moment" on the front line; instilling those habits requires persistent coaching by managers.

Employees across DTE Energy's business units and at every level of the hierarchy agreed that the difference between the CI initiative in 2009 and what came before was the direct participation of the company's leaders. One of Local 223's UMP facilitators observed how DTE Energy's CI initiative was fulfilling the UMP initiative's goal from 1999: "The perfect leader is the type of leader that facilitates the success of the team, gives them the tools and materials and skills — very much what we're teaching now around leaders as teachers [C4]. If you look at our C1-C4: 'Engaging my employees and giving them the skills to be effective problem solvers.' That was the goal ten years ago with the Partnership." DO vice president Vince Dow said, "What's always enlightening is finding what the roadblock is and trying to figure out how a decision, even one I made, filters down and comes out causing a problem. You made a decision but you never even thought about all the impacts. So you find these things and get them fixed." He went on to say, "I have well over 3000 people I've got to get [CI] to, and until you actually touch it and do it, you don't get it. ...[U]ntil I get to every location with it, they won't get it. And I've got hundreds of locations. ...I think this is one of those things you either get deterred because it's so huge, or you say, 'It may just take me a little longer but I've got to keep going'" (Wilhelm, 2009, pp. 39-40).

DTE Energy has begun attracting interest from other organizations for its CI initiative. The Council for Six Sigma Executives, a group convened by The Conference Board to share CI best practices, visited DTE Energy in November 2009 to learn about its CI initiative. Then DTE Energy won the "Best Improvement Program" category of the 2010 North American Process Excellence Awards given by the International Quality and Productivity Center (IQPC) in January. The judging panel comprised Lean Six Sigma professionals from a broad cross-section of industries. In April 2010, DTE Energy hosted an event jointly organized by the Michigan Lean Consortium (MLC) and Oakland University's Pawley Lean Institute to present its CI initiative to MLC members and other

Michigan companies. Anderson and Meador spoke at length on the topic of executive leadership for CI. At the beginning of 2010, DTE Energy's CI initiative seemed to enjoy a high degree of senior executive support and involvement, and was gaining traction with the front-line employees. Anderson said, "While we made a lot of progress around continuous improvement last year, the reality is we've barely started to scratch the surface. We've got a long way to go. And that's why expanding our use of CI is one of our key priorities."

4.6. Wave Three Summary

Unstressed First Phase — 2007-2008

As the newly appointed OSSG director, Schulist's first job in 2007 was to get the CI initiative back on track, so he did not change the design of the CI initiative right away. Even though McKinsey's consultants had left, DTE Energy's business units were still required to achieve their PEP targets for 2007. However, Schulist restarted Patterson's executive development and Black Belt-led Lean projects in some of DTE Energy's service stations.

Schulist's major breakthrough was taking key executives to TSSC's week-long Lean workshops where they could learn about Lean in a hands-on manner with executives from other companies. He astutely realized the potential of running such workshops internally: They could (1) convince the executives, (2) train employees in a learn-by-doing fashion, and (3) promote a CI mindset in the company — and do all three simultaneously. For the most part, Schulist successfully achieved these three aims with CILWs in 2008 and 2009 (on the other hand, see Appendix B for an assessment of CILW problems).

In Chapter 3, I claimed that the OSSG personnel paid insufficient attention to the quality and rigor of its Black Belt training since its inception (see also Appendix B). Each Master Black Belt's overhaul of the Black Belt course and short tenure indicate inconsistency and high variability in the training content over time. The OSSG personnel did improve the Black Belt program by promulgating stricter certification criteria and

making other reforms. Mike Baum's experience as MichCon's CI manager (see section 4.2) demonstrates the tremendous difference made by the right focus: Each of MichCon's Black Belts verifiably saved more than $1 million in 2008 as compared to uncertain and doubted savings in 2007. Despite these improvements, however, the Black Belt program still had flaws in 2009 (see Appendix B).

Stressed Second Phase — 2008-2009

Swarm events were the logical extension of CILWs, aimed at training and convincing middle managers and front-line employees. Fortunately for the CI initiative, the economic crisis of October 2008 occurred when the OSSG personnel were trying to introduce swarm events. DTE Energy's senior executives, newly convinced by CILWs, vigorously promoted swarm events as a viable response to the crisis.

The senior executives' push for CI activities, therefore, propagated down the company hierarchy. I perceive that DTE Energy's executives had adequately developed their own skill with CI for supporting this push, but they did not adequately assess the skill levels of their subordinates. Whether DTE Energy's employees undertook CI activities in earnest or just "went through the motions" for the ECR plan depended on how much prior exposure and practice they had with CI techniques, as well as how much assistance they received from DTE Energy's Black Belts.

The executives' push for swarm events in 2009 was not the only pressure for CI activities. As section 4.3 shows, convinced middle managers in Fos Gen were trying to foster a CI culture, sometimes without top-down mandates for savings, projects, or workshops. These activities in DTE Energy's power plants and in other locations demonstrate how the shift in culture is a numbers game, training and convincing enough middle managers and front-line employees such that routine work behaviors change.

Chapter 5: Simulation Model

A principle aim of this simulation model was to investigate the dynamics of CI implementation arising from the interaction among levels of the company hierarchy. For this aim, I divide the company hierarchy into the following three levels: (1) the senior executive level (SE), which includes the CEO, COO, CFO, and all the presidents and vice presidents of the various business units; (2) the middle manager level (MM), which includes directors and managers; and (3) the front-line level (FL), which includes managers with no subordinates, supervisors, and front-line employees.

Most of the equations in this model are defined with the *level* subscript to represent each of these three levels:

```
level: SE,MM,FL
```

This model divides the company's workforce at each level into the following six states: *Believers* (*Bel*), *Neutrals* (*Neu*), *Skeptics* (*Ske*), *Black Belt Trainees* (*BBt*), *Black Belt Candidates* (*BBc*), and certified *Black Belts* (*BB*). Some equations are defined for a specific state; in such cases the employee state will appear in the variable name. In other equations, however, I found it more convenient to use subscripts to write these equations compactly. Each of these subscripted equations might apply to all six employee states or to a subset of them, so I have defined the following nested subscript ranges to handle all possibilities:

```
regEmployees: Bel,Neu,Ske,BBt

nonBlackBelts: regEmployees,BBc

contributor: nonBlackBelts,BB
```

5.1. Employee Belief States

This model has six employee states, each of which is represented by a stock (actually, a stock vector). Three of these stocks represent regular employees' three

possible belief states:

```
Believers[level]= INTEG(
    + BB Program Believers Dropout Rate[level]
    + BB Promotion Rate to Mgmt[level]
    + Believers Hiring Rate[level]
    + Neutrals Convincing Rate[level]
    + Skeptics Convincing Rate[level]
    - Believers BB Trainee Enrolling Rate[level]
    - Believers Attrition Rate[level]
    - Believers Disillusioning Rate[level]
    - Believers Reversion Rate[level]
    , Initial Believers[level])
Units: Person

Neutrals[level]= INTEG(
    + Believers Reversion Rate[level]
    + Neutrals Hiring Rate[level]
    + Skeptics Reversion Rate[level]
    - Neutrals BB Trainee Enrolling Rate[level]
    - Neutrals Attrition Rate[level]
    - Neutrals Convincing Rate[level]
    - Neutrals Disillusioning Rate[level]
    , Initial Neutrals[level])
Units: Person

Skeptics[level]= INTEG(
    + BB Program Skeptics Dropout Rate[level]
    + Believers Disillusioning Rate[level]
    + Neutrals Disillusioning Rate[level]
    + Skeptics Hiring Rate[level]
    - Skeptics Attrition Rate[level]
    - Skeptics Convincing Rate[level]
    - Skeptics Reversion Rate[level]
    , Initial Skeptics[level])
Units: Person
```

<Maximum Neutral BB Trainee Enrolling Rate>

<Maximum Believer BB Trainee Enrolling Rate>

<Indicated Believer BB Trainee Enrolling Rate>

<BB Program Believers Dropout Rate>

<BB Promotion Rate to Mgmt>

<Merger Believers>

<Merger Pulse>

<Indicated Neutral BB Trainee Enrolling Rate>

BB Trainee Enrolling Rate

Believers BB Trainee Enrolling Rate

Believers Avg Reversion Time

Neutrals BB Trainee Enrolling Rate

Believers Reversion Rate

Believers Hiring Rate

<BB Promotion Rate from Black Belts>

Neutrals Convincing Rate

Believers

Believers Attrition Rate

Neutrals Hiring Rate

<Neutrals Indicated Convincing Rate>

<Neutrals Maximum Convincing Rate>

<Believers Maximum Disillusioning Rate>

<Level Employees Believers Fraction>

<Skeptics Indicated Convincing Rate>

Skeptics Convincing Rate

Believers Disillusioning Rate

<Level Attrition Rate>

Neutrals

<Skeptics Maximum Convincing Rate>

<Merger Neutrals>

Neutrals Attrition Rate

<Neutrals Indicated Disillusioning Rate>

<Neutrals Maximum Disillusioning Rate>

<Level Employees Skeptics Fraction>

<Merger Pulse>

<Believers Indicated Disillusioning Rate>

Neutrals Disillusioning Rate

Skeptics Attrition Rate

<Level Attrition Rate>

<Level Employees Neutrals Fraction>

Skeptics

Skeptics Avg Reversion Time

Skeptics Reversion Rate

Skeptics Hiring Rate

<Merger Skeptics>

<BB Program Skeptics Dropout Rate>

<Merger Pulse>

Figure 6. Model Diagram of Employee Belief States

To make the formulations for *CI Work Rate* and *Cost Cutting Work Rate* (in section 5.6, p.163) more manageable, I define *Level Contributors* as a convenient matrix of all employee states (see section 5.12, p.199, for the definitions of the Black Belt states):

```
Level Contributors[level,Bel]= Believers[level]
Level Contributors[level,Neu]= Neutrals[level]
Level Contributors[level,Ske]= Skeptics[level]
Level Contributors[level,BBt]= Black Belt Trainees[level]
Level Contributors[level,BBc]= Black Belt Candidates[level]
Level Contributors[level,BB]= Black Belts[level]
Units: Person
```

I compute a vector of employees by level and a scalar employee total by summing

the elements of the *Level Contributors* matrix:

```
Total Level Employees[level]= SUM(Level
    Contributors[level,contributor!])
Units: Person

Total Employees= SUM(Level Contributors[level!,contributor!])
Units: Person

Total Regular Level Employees[level]= SUM(Level
    Contributors[level,regEmployees!])
Units: Person

Regular Level Employees Contributors Fraction[level,
    regEmployees]= ZIDZ(Level Contributors[level,regEmployees],
    Total Regular Level Employees[level])
Units: Fraction [0,1]
```

During the 12 years of history that I studied, DTE Energy's workforce shrunk because attrition exceeded hiring. Therefore, I formulate hiring rates mainly to represent increases in DTE Energy's employee stocks from Detroit Edison's merger with MichCon in 2001. I formulate this workforce increase as a discrete pulse, on the merger's closing date, using a Dirac delta function. Under conditions of no downsizing, I keep the number of employees at each level in equilibrium by replacing promoted Black Belts with hired neutrals.

```
Believers Hiring Rate[level]= Merger Believers[level]*Merger Pulse
Units: Person/Month

Neutrals Hiring Rate[level]= Merger Neutrals[level]*Merger Pulse +
    BB Promotion Rate from Black Belts[level]
Units: Person/Month

Skeptics Hiring Rate[level]= Merger Skeptics[level]*Merger Pulse
Units: Person/Month

Merger Pulse= PULSE(Merger Close Date, TIME STEP)/TIME STEP
Units: Fraction/Month
```

Under conditions of no downsizing, I keep the number of employees at each level in equilibrium by assuming that hired and promoted Black Belts replace employees who have left the company. (Note that the formulation for *Indicated Level Attrition Rate*, however, implies that hired and promoted Black Belts "push" these replaced employees

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out.) The use of *Maximum Level Attrition Rate* in the formulation for *Level Attrition Rate* ensures first-order control on employee-attrition outflows.

```
Level Attrition Rate[level]= MIN(Indicated Level Attrition
    Rate[level], Maximum Level Attrition Rate[level])
Units: Person/Month

Indicated Level Attrition Rate[level]= Level Downsizing
    Rate[level] + BB Hire Rate[level] + BB Promotion Rate to
    Mgmt[level]
Units: Person/Month

Maximum Level Attrition Rate[level]= Total Level
    Employees[level]/Minimum Attrition Time
Units: Person/Month
```

Because *Level Attrition Rate* is defined for an entire level of the company hierarchy, I allocate a fraction of this outflow to each of the employee-state stocks, proportional to each stock's size relative to the total size of the level.

```
Level Employees Believers Fraction[level]= ZIDZ(Believers[level],
    Total Level Employees[level])
Units: Fraction [0,1]

Level Employees Neutrals Fraction[level]= ZIDZ(Neutrals[level],
    Total Level Employees[level])
Units: Fraction [0,1]

Level Employees Skeptics Fraction[level]= ZIDZ(Skeptics[level],
    Total Level Employees[level])
Units: Fraction [0,1]

Believers Attrition Rate[level]= Level Attrition Rate[level]*Level
    Employees Believers Fraction[level]
Units: Person/Month

Neutrals Attrition Rate[level]= Level Attrition Rate[level]*Level
    Employees Neutrals Fraction[level]
Units: Person/Month

Skeptics Attrition Rate[level]= Level Attrition Rate[level]*Level
    Employees Skeptics Fraction[level]
Units: Person/Month
```

I assume that believers and skeptics abandon their attitudes toward CI after a long period, reverting to neutrals, if no CI activities are being conducted. For simplicity, I

represent this belief-abandonment process as first-order exponential decay and do not exclude the active CI participants from the numerators.

```
Believers Reversion Rate[level]= Believers[level]/Believers Avg
    Reversion Time
Units: Person/Month

Skeptics Reversion Rate[level]= Skeptics[level]/Skeptics Avg
    Reversion Time
Units: Person/Month
```

Employees from the stocks of *Believers* and *Neutrals* may enroll in Black Belt training as the first step toward becoming certified Black Belts. See section 5.15 (p.215) for the definitions of these enrolling rates.

Black Belts can be promoted up the company hierarchy (see also section 5.12, p.199). By definition, someone cannot be "promoted" to the front-line level. Additionally, senior-executive Black Belts cannot be promoted to a higher level, so I assume that they stay at their level.

```
BB Promotion Rate to Mgmt[SE]= BB Promotion Rate from Black
    Belts[MM] + BB Promotion Rate from Black Belts[SE]
BB Promotion Rate to Mgmt[MM]= BB Promotion Rate from Black
    Belts[FL]
BB Promotion Rate to Mgmt[FL]= 0
Units: Person/Month
```

Employees who drop out of the Black Belt program (instead of being promoted) return either to the stock of *Believers* or to the stock of *Skeptics*. See section 5.12 (p.199) for the definitions of these dropout rates.

Senior executives and middle managers who are proponents of the CI initiative generate positive word of mouth about CI (section 5.10, p.189) and want their subordinates to attend Green Belt training (section 5.19, p.228).

```
CI Proponents[level]= Believers[level] + BB Program
    Participants[level]
Units: Person

CI Proponents Fraction[level]= ZIDZ(CI Proponents[level], Total
    Level Employees[level])
Units: Fraction [0,1]
```

```
Span of Control[SE]= Total Level Employees[MM]/Total Level
    Employees[SE]
Span of Control[MM]= Total Level Employees[FL]/Total Level
    Employees[MM]
Span of Control[FL]= 0
Units: Person/Person

FL Subordinates of CI Proponents= CI Proponents[SE]*Span of
    Control[SE]*Span of Control[MM]
Units: Person
```

The total number of employees who join DTE Energy via the merger is required to compute *Baseline Routine Work Level FTEs* in section 5.4 (p.152) and *Monthly Routine Work from Merger* in section 5.5 (p.158).

```
Total Level Employees from Merger[level]= Merger Believers[level]
    + Merger Neutrals[level] + Merger Skeptics[level]
Units: Person
```

Parameters for Employee Belief States

I was able to estimate the distribution of DTE Energy's employees across the three levels of the company hierarchy after the merger. MichCon had approximately 3000 employees before the merger, so I assume that MichCon had the same distribution of employees across its levels. While not accurate, I assume for simplicity that all employees start as neutrals, except for the few senior executives at Detroit Edison who started the CI initiative.

```
Initial Believers[level]= 3,0,0
Units: Person

Initial Neutrals[level]= 27,430,7040
Units: Person

Initial Skeptics[level]= 0,0,0
Units: Person

Believers Avg Reversion Time= 60
Units: Month

Skeptics Avg Reversion Time= 60
Units: Month
```

```
Merger Believers[level]= 0,0,0
Units: Person

Merger Neutrals[level]= 10,170,2820
Units: Person

Merger Skeptics[level]= 0,0,0
Units: Person

Merger Close Date= 52
Units: Month

Minimum Attrition Time= 0.25
Units: Month
```

5.2. Employee CI Experience Co-flow

The model includes a co-flow structure, which mirrors the employee-states structure in section 5.1 (p.137), to account for the aggregate person-hours of CI experience associated with each employee stock:

```
Believers CI Experience[level]= INTEG(
    + BB Program Believers Dropout Rate CI Experience[level]
    + BB Promotion Rate to Mgmt CI Experience[level]
    + Believers CI Experience Gain Rate[level]
    + Believers Hiring Rate CI Experience[level]
    + Neutrals Convincing Rate CI Experience[level]
    + Skeptics Convincing Rate CI Experience[level]
    - Believers Attrition Rate CI Experience[level]
    - Believers BB Trainee Enrolling Rate CI Experience[level]
    - Believers CI Experience Obsolescence Rate[level]
    - Believers Disillusioning Rate CI Experience[level]
    - Believers Reversion Rate CI Experience[level]
    , 0)
Units: Person*Hours

Neutrals CI Experience[level]= INTEG(
    + Believers Reversion Rate CI Experience[level]
    + Neutrals CI Experience Gain Rate[level]
    + Neutrals Hiring Rate CI Experience[level]
    + Skeptics Reversion Rate CI Experience[level]
    - Neutrals BB Trainee Enrolling Rate CI Experience[level]
    - Neutrals Attrition Rate CI Experience[level]
    - Neutrals CI Experience Obsolescence Rate[level]
    - Neutrals Convincing Rate CI Experience[level]
    - Neutrals Disillusioning Rate CI Experience[level]
    , 0)
Units: Person*Hours
```

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```
Skeptics CI Experience[level]= INTEG(
    + BB Program Skeptics Dropout Rate CI Experience[level]
    + Believers Disillusioning Rate CI Experience[level]
    + Neutrals Disillusioning Rate CI Experience[level]
    + Skeptics CI Experience Gain Rate[level]
    + Skeptics Hiring Rate CI Experience[level]
    - Skeptics Attrition Rate CI Experience[level]
    - Skeptics CI Experience Obsolescence Rate[level]
    - Skeptics Convincing Rate CI Experience[level]
    - Skeptics Reversion Rate CI Experience[level]
    , 0)
Units: Person*Hours
```


Figure 7. Model Diagram of Employee CI Experience Co-flow

This experience co-flow structure is used to compute the average CI experience of each type of regular employee. I assume that each employee possesses the average CI experience of his or her state:

```
Believers Avg CI Experience[level]= ZIDZ(Believers CI
    Experience[level], Believers[level])
Units: Person*Hours/Person

Neutrals Avg CI Experience[level]= ZIDZ(Neutrals CI
    Experience[level], Neutrals[level])
Units: Person*Hours/Person

Skeptics Avg CI Experience[level]= ZIDZ(Skeptics CI
    Experience[level], Skeptics[level])
Units: Person*Hours/Person
```

When employees transition from one state to another, they bring their (average) CI experience with them. These transitions are the rates associated with attrition and reversion (section 5.1, p.137), convincing (section 5.10, p.189), disillusioning (section 5.11, p.195), and enrolling in Black Belt training (section 5.15, p.215).

```
Believers Attrition Rate CI Experience[level]= Believers Attrition
    Rate[level]*Believers Avg CI Experience[level]
Units: Person*Hours/Month

Neutrals Attrition Rate CI Experience[level]= Neutrals Attrition
    Rate[level]*Neutrals Avg CI Experience[level]
Units: Person*Hours/Month

Skeptics Attrition Rate CI Experience[level]= Skeptics Attrition
    Rate[level]*Skeptics Avg CI Experience[level]
Units: Person*Hours/Month

Believers Reversion Rate CI Experience[level]= Believers Reversion
    Rate[level]*Believers Avg CI Experience[level]
Units: Person*Hours/Month

Skeptics Reversion Rate CI Experience[level]= Skeptics Reversion
    Rate[level]*Skeptics Avg CI Experience[level]
Units: Person*Hours/Month

Neutrals Convincing Rate CI Experience[level]= Neutrals Convincing
    Rate[level]*Neutrals Avg CI Experience[level]
Units: Person*Hours/Month

Skeptics Convincing Rate CI Experience[level]= Skeptics Convincing
    Rate[level]*Skeptics Avg CI Experience[level]
Units: Person*Hours/Month

Believers Disillusioning Rate CI Experience[level]= Believers
    Disillusioning Rate[level]*Believers Avg CI Experience[level]
Units: Person*Hours/Month
```

```
Neutrals Disillusioning Rate CI Experience[level]= Neutrals
    Disillusioning Rate[level]*Neutrals Avg CI Experience[level]
Units: Person*Hours/Month

Believers BB Trainee Enrolling Rate CI Experience[level]=
    Believers BB Trainee Enrolling Rate[level]*Believers Avg CI
    Experience[level]
Units: Person*Hours/Month

Neutrals BB Trainee Enrolling Rate CI Experience[level]= Neutrals
    BB Trainee Enrolling Rate[level]*Neutrals Avg CI
    Experience[level]
Units: Person*Hours/Month

Similarly, hired employees join the company with their (average)
    CI experience (which might be zero).

Believers Hiring Rate CI Experience[level]= Believers Hiring
    Rate[level]*Hired Believers Avg CI Experience[level]
Units: Person*Hours/Month

Neutrals Hiring Rate CI Experience[level]= Neutrals Hiring
    Rate[level]*Hired Neutrals Avg CI Experience[level]
Units: Person*Hours/Month

Skeptics Hiring Rate CI Experience[level]= Skeptics Hiring
    Rate[level]*Hired Skeptics Avg CI Experience[level]
Units: Person*Hours/Month
```

This experience co-flow is non-conserved. Employees gain additional CI experience from participating in training and CI projects. Also, I assume that employees' CI experience becomes obsolete via first-order exponential decay. Therefore, employees must continually replenish their CI experience by participating in CI activities. I allow for the descriptively accurate possibility that CI experience gained from training is not as valuable as CI experience gained through hands-on participation in CI projects.

```
Believers CI Experience Gain Rate[level]= Believers CI Experience
    Gain from Training[level] + Believers CI Experience Gain from
    Projects[level]
Units: Person*Hours/Month

Neutrals CI Experience Gain Rate[level]= Neutrals CI Experience
    Gain from Training[level] + Neutrals CI Experience Gain from
    Projects[level]
Units: Person*Hours/Month
```

```
Skeptics CI Experience Gain Rate[level]= Skeptics CI Experience
    Gain from Training[level] + Skeptics CI Experience Gain from
    Projects[level]
Units: Person*Hours/Month

Believers CI Experience Gain from Training[level]= Believers GB
    Training Rate[level]*CI Experience Value of GB Training
Units: Person*Hours/Month

Neutrals CI Experience Gain from Training[level]= Neutrals GB
    Training Rate[level]*CI Experience Value of GB Training +
    Neutrals SE Training Rate[level]*CI Experience Value of SE
    Training
Units: Person*Hours/Month

Skeptics CI Experience Gain from Training[level]= Skeptics GB
    Training Rate[level]*CI Experience Value of GB Training +
    Skeptics SE Training Rate[level]*CI Experience Value of SE
    Training
Units: Person*Hours/Month

Believers CI Experience Gain from Projects[level]= CI Work
    Contribution Rate[level,Bel]*CI Experience Value of Projects
Units: Person*Hours/Month

Neutrals CI Experience Gain from Projects[level]= CI Work
    Contribution Rate[level,Neu]*CI Experience Value of Projects
Units: Person*Hours/Month

Skeptics CI Experience Gain from Projects[level]= CI Work
    Contribution Rate[level,Ske]*CI Experience Value of Projects
Units: Person*Hours/Month

Believers CI Experience Obsolescence Rate[level]= Believers CI
    Experience[level]/CI Experience Obsolescence Time
Units: Person*Hours/Month

Neutrals CI Experience Obsolescence Rate[level]= Neutrals CI
    Experience[level]/CI Experience Obsolescence Time
Units: Person*Hours/Month

Skeptics CI Experience Obsolescence Rate[level]= Skeptics CI
    Experience[level]/CI Experience Obsolescence Time
Units: Person*Hours/Month
```

Finally, employees who are promoted into operational roles from the Black Belt program (see sections 5.1 and 5.12) bring their (average) CI experience with them.

```
BB Promotion Rate to Mgmt CI Experience[SE]= BB Promotion Rate CI
    Experience[MM] + BB Promotion Rate CI Experience[SE]
```

```
BB Promotion Rate to Mgmt CI Experience[MM]= BB Promotion Rate CI
    Experience[FL]
BB Promotion Rate to Mgmt CI Experience[FL]= 0
Units: Person*Hours/Month
```

Parameters for Employee CI Experience Co-flow

For simplicity, I assume that hired employees have no CI experience.

```
Hired Believers Avg CI Experience[level]= 0,0,0
Units: Person*Hours/Person

Hired Neutrals Avg CI Experience[level]= 0,0,0
Units: Person*Hours/Person

Hired Skeptics Avg CI Experience[level]= 0,0,0
Units: Person*Hours/Person
```

I assume that the CI experience gained from training is less than the CI experience gained from CI projects.

```
CI Experience Value of GB Training= 0.1
Units: Fraction [0,1]

CI Experience Value of SE Training= 0.2
Units: Fraction [0,1]

CI Experience Value of Projects= 1
Units: Fraction [1,1]

CI Experience Obsolescence Time= 6
Units: Month
```

5.3. CI Skill

I use the same equation for skill with CI tools and methods for all employees. It is convenient, therefore, to represent the average CI experience associated with all employee states in matrix form:

```
Contributors Avg CI Experience[level,Bel]= Believers Avg CI
    Experience[level]
Contributors Avg CI Experience[level,Neu]= Neutrals Avg CI
    Experience[level]
Contributors Avg CI Experience[level,Ske]= Skeptics Avg CI
    Experience[level]
```

```
Contributors Avg CI Experience[level,BBt]= BB Trainee Avg CI
    Experience[level]
Contributors Avg CI Experience[level,BBc]= BB Candidate Avg CI
    Experience[level]
Contributors Avg CI Experience[level,BB]= BB Avg CI
    Experience[level]
Units: Person*Hours/Person
```

I formulate skill from CI experience using the classic learning-curve function (Teplitz, 1991; Wright, 1936; Yelle, 1979). The *Progress Ratio* defines the percentage increase in skill for every doubling of normalized CI experience (the *Learning Rate* defines the marginal percentage increase). CI experience is normalized with the *CI Experience Threshold* parameter (see below). The shape of the learning-curve function is determined by the *Experiential Learning Parameter*, based on the *Progress Ratio*. I assume that every employee has the same non-zero *Baseline Minimum Skill* — i.e., basic problem solving — and that every employee has the same *Learning Rate*.

```
Contributors Skill[level,contributor]= Baseline Minimum Skill +
    Reference Skill*(Contributors Avg CI
    Experience[level,contributor]/CI Experience
    Threshold)^Experiential Learning Parameter
Units: Fraction

Experiential Learning Parameter= LN(Progress Ratio)/LN(2)
Units: Dmnl

Progress Ratio= 1 + Learning Rate
Units: Fraction
```
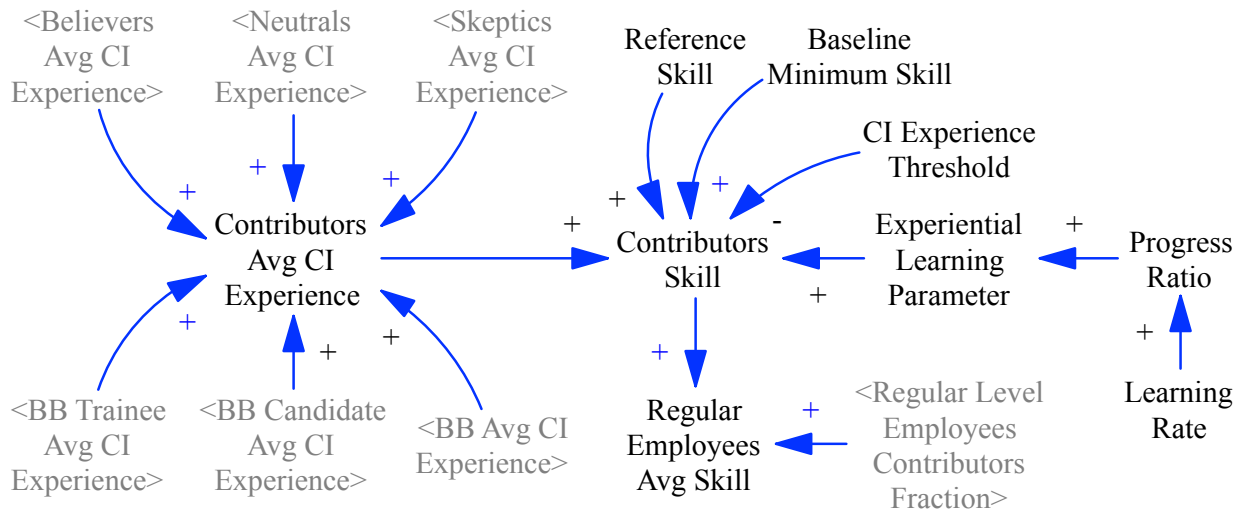
Figure 8. Model Diagram of CI Skill

The variable *FL Projects Fractional Skill Gap*, a measure of how unskilled are frontline employees compared to the Black Belts coaching them on their CI projects, is required to determine the effect of such coaching on project results in section 5.7 (p.172).

```
Avg BB Skill= SUM(Contributors Skill[level!,BB]*BB Level
    Fraction[level!])
Units: Dmnl

FL Projects Skill Gap[level,regEmployees]= MAX(Avg BB Skill -
    Contributors Skill[level,regEmployees], 0)
Units: Dmnl

FL Projects Fractional Skill Gap[level,regEmployees]= FL Projects
    Skill Gap[level,regEmployees]/Contributors
    Skill[level,regEmployees]
Units: Fraction
```

I compute the average skill level of regular employees (excluding Black Belts and Black Belt candidates) as an output measure.

```
Regular Employees Avg Skill[level]= SUM(Contributors
    Skill[level,regEmployees!]*Regular Level Employees
    Contributors Fraction[level,regEmployees!])
Units: Fraction
```

Parameters for CI Skill

I define *Reference Skill* to be the skill level of newly certified Black Belts, who are

expected to save $250 thousand with a 3-month project (480 person-hours of CI work). *CI Experience Threshold* defines the amount of CI experience, measured in person-hours, equal to *Reference Skill*. It comprises 160 person-hours of Black Belt training, discounted by *CI Experience Value of BB Training* (section 5.13, p.204), plus an assumed 1040 person-hours of CI work to complete and defend two certification projects.

```
Reference Skill= 1
Units: Dmnl

CI Experience Threshold= 1088
Units: Person*Hours/Person

Baseline Minimum Skill= 0.01
Units: Dmnl
```

The *Learning Rate* defines the marginal percentage increase in skill for every doubling of normalized CI experience.

```
Learning Rate= 0.3
Units: Fraction
```

5.4. Routine Work

I model employees' completion of routine work using the standard labor-capacitated-process structure from section 14.2 in Sterman (2000, pp. 563-569). Employees complete tasks from the stock of *Routine Work To Do* while striving to achieve the goal of *Routine Work Standard Completion Time*. This striving forms two parallel balancing-feedback loops in which employees lengthen their *Work Month* and shorten their *Time per Task* to meet their goal.

```
Routine Work To Do[level]= INTEG(
    + Routine Work Release Rate[level]
    - Routine Work Completion Rate[level]
    , Monthly Routine Work[level]*Routine Work Standard Completion
    Time)
Units: Tasks

Routine Work Release Rate[level]= Monthly Routine Work[level]
Units: Tasks/Month
```

```
Level Routine Work Desired Completion Rate[level]= Routine Work To
    Do[level]*Time per Task Standard[level]/Routine Work Standard
    Completion Time
Units: Person*Hours/Month
```
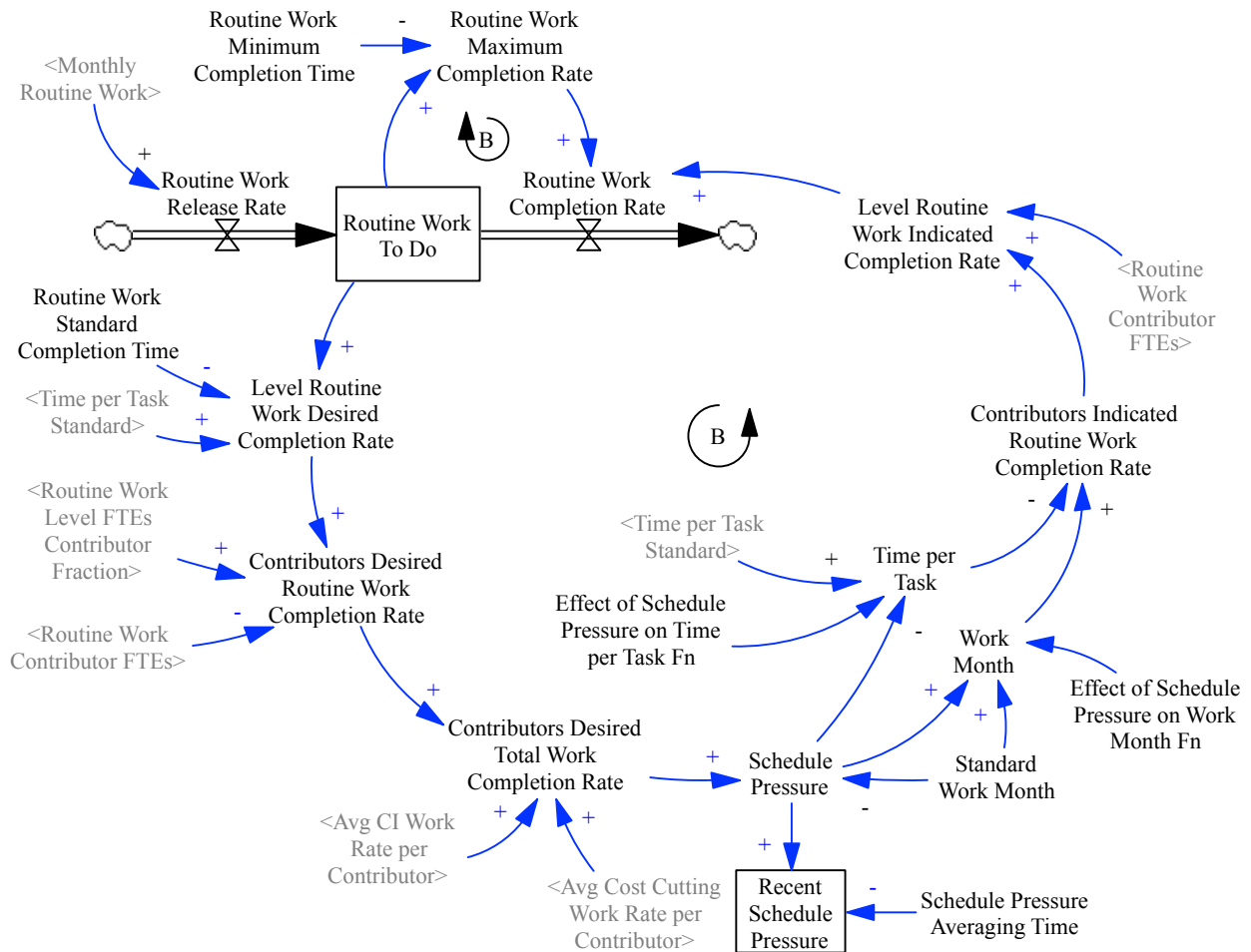

Figure 9. Model Diagram of Routine Work

For simplicity, I assume an aggregate stock of *Routine Work To Do* for each level of the company hierarchy, which must be completed by *Routine Work Contributor FTEs* at that level. Each Black Belt is less than one routine-work full-time equivalent (FTE) employee because all Black Belts are expected to complete CI projects (which I define as nonroutine work).

```
Routine Work Contributor FTEs[level,nonBlackBelts]= Level
    Contributors[level,nonBlackBelts]
Routine Work Contributor FTEs[level,BB]= Routine Work BB
    FTEs[level]
Units: Person
```

```
Routine Work BB FTEs[level]= Black Belts[level]*(1-BB Nonroutine
    Work Fraction)
Units: Person
```

Because *Level Routine Work Desired Completion Rate* is defined for an entire level, I allocate a fraction of this work rate to each of the employee-state stocks, proportional to each stock's size relative to the total.

```
Routine Work Level FTEs[level]= SUM(Routine Work Contributor
    FTEs[level,contributor!])
Units: Person

Routine Work Level FTEs Contributor Fraction[level,contributor]=
    ZIDZ(Routine Work Contributor FTEs[level,contributor], Routine
    Work Level FTEs[level])
Units: Fraction [0,1]

Contributors Desired Routine Work Completion
    Rate[level,contributor]= ZIDZ(Level Routine Work Desired
    Completion Rate[level]*Routine Work Level FTEs Contributor
    Fraction[level,contributor], Routine Work Contributor
    FTEs[level,contributor])
Units: (Person*Hours/Month)/Person
```

Employees adjust the length of their workweeks and the extent to which they cut corners (reducing both their time per task and task quality) based on the schedule pressure they feel: the ratio of how many work-hours they must do to the time in which they are expected to do them.

```
Contributors Desired Total Work Completion
    Rate[level,contributor]= Contributors Desired Routine Work
    Completion Rate[level,contributor] + Avg CI Work Rate per
    Contributor[level,contributor] + Avg Cost Cutting Work Rate
    per Contributor[level,contributor]
Units: (Person*Hours/Month)/Person

Schedule Pressure[level,contributor]= Contributors Desired Total
    Work Completion Rate[level,contributor]/Standard Work Month
Units: Dmnl

Time per Task[level,contributor]= Time per Task
    Standard[level]*Effect of Schedule Pressure on Time per Task
    Fn(Schedule Pressure[level,contributor])
Units: Person*Hours/Task
```

```
Work Month[level,contributor]= Standard Work Month*Effect of
    Schedule Pressure on Work Month Fn(Schedule
    Pressure[level,contributor])
Units: Hours/Month

Contributors Indicated Routine Work Completion
    Rate[level,contributor]= Work Month[level,contributor]/Time
    per Task[level,contributor]
Units: (Tasks/Month)/Person

Level Routine Work Indicated Completion Rate[level]=
    SUM(Contributors Indicated Routine Work Completion
    Rate[level,contributor!]*Routine Work Contributor
    FTEs[level,contributor!])
Units: Tasks/Month
```

The use of *Routine Work Maximum Completion Rate* in the formulation for *Routine Work Completion Rate* ensures first-order control on this outflow from the *Routine Work To Do* stock.

```
Routine Work Completion Rate[level]= MIN(Level Routine Work
    Indicated Completion Rate[level], Routine Work Maximum
    Completion Rate[level])
Units: Tasks/Month

Routine Work Maximum Completion Rate[level]= Routine Work To
    Do[level]/Routine Work Minimum Completion Time
Units: Tasks/Month
```

I assume that employees use their assessment of their recent schedule pressure to decide how much time they want to devote to CI work (section 5.6, p.163) and to CI training of all types (sections 5.17, p.220; 5.20, p.225; and 5.21, p.234). For simplicity, I assume that employees' assessment of their recent schedule pressure is adequately represented by first-order exponential smoothing. An average of recent schedule pressure across all employees of a given level is required to determine the *Effect of Schedule Pressure on Work Scope Increase* in section 5.6 (p.163).

```
Recent Schedule Pressure[level,contributor]= SMOOTHI(Schedule
    Pressure[level,contributor], Schedule Pressure Averaging Time,
    1)
Units: Dmnl

Recent Schedule Pressure Level Avg[level]= SUM(Recent Schedule
    Pressure[level,contributor!]*Routine Work Contributor
```

```
    FTEs[level,contributor!])/SUM(Routine Work Contributor
    FTEs[level,contributor!])
Units: Dmnl
```

The baseline number of contributor FTEs at each level, updated when the merger occurs, is required to compute *Baseline Monthly Routine Work* (section 5.5, p.158) and the improvement half-lives for productivity and operating costs (sections 5.22, p.237, and 5.23, p.241, respectively).

```
Baseline Routine Work Level FTEs[level]= STEP(Routine Work Level
    FTEs[level], INITIAL TIME) + STEP(Total Level Employees from
    Merger
[level], Merger Close Date)
Units: Person
```

Parameters for Routine Work

In this model, I assume that each work month comprises four 40-hour workweeks. Sensibly, employees should take one month to complete each month's routine work.

```
Standard Work Month= 160
Units: Hours/Month

Routine Work Standard Completion Time= 1
Units: Month
```

These lookup functions for the effects of employees' schedule pressure on their time per task and their work month were taken from Sterman (2000, pp. 571-572), based on Oliva's (1996) study of service quality at NatWest Bank.

```
Effect of Schedule Pressure on Time per Task Fn([(0,0)-
    (2,2)],(0,1.4),(0.2,1.37),(0.4,1.32),(0.6,1.24),(0.8,1.14),(1,
    1),(1.2,0.89),(1.4,0.79),(1.6,0.7),(1.8,0.65),(2,0.62),(2.2,0.
    61),(2.4,0.6),(2.6,0.6))
Units: Dmnl
```
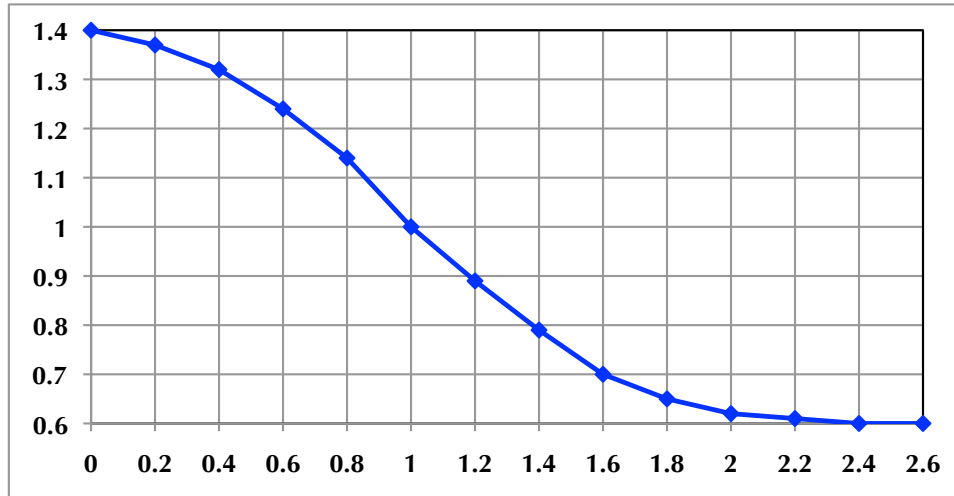
Figure 10. Lookup Function: Effect of Schedule Pressure on Time per Task Fn

```
Effect of Schedule Pressure on Work Month Fn([(0,0.5)-
    (2,1.5)],(0,0.75),(0.25,0.79),(0.5,0.84),(0.75,0.9),(1,1),(1.2
    5,1.09),(1.5,1.17),(1.75,1.23),(2,1.25))
Units: Dmnl
```
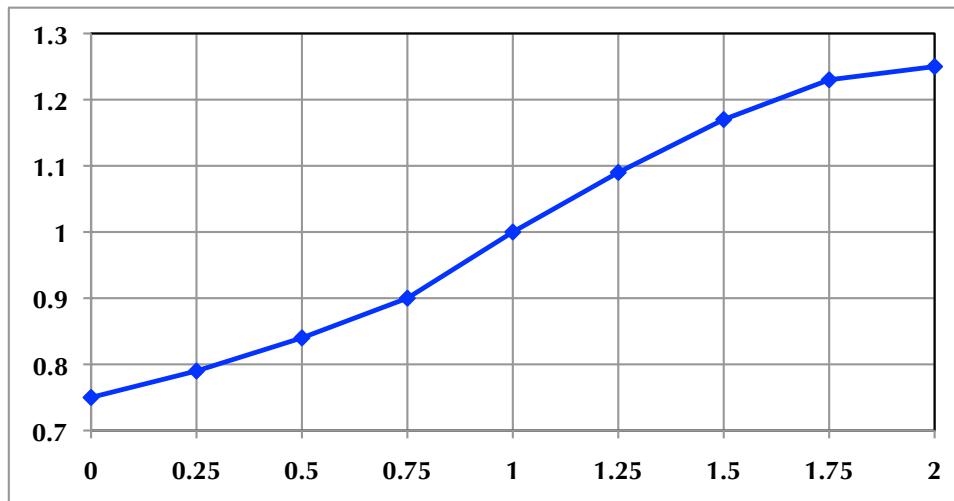

Figure 11. Lookup Function: Effect of Schedule Pressure on Work Month Fn

I assume that the shortest amount of time for an employee to complete a task is equal to the *Minimum Time per Task* divided by the *Standard Work Month*. But this duration is shorter than the simulation's *Time Step*, so I use this *Time Step* instead.

```
Routine Work Minimum Completion Time= TIME STEP
Units: Month
```

I assume employees' expectations for their schedule pressure in the near future are equal to their schedule pressures over the preceding six weeks.

```
Schedule Pressure Averaging Time= 1.5
Units: Month
```

5.5. Routine Work Allocation

For simplicity, I assume that the baseline monthly routine work at each level consists of one task per work-hour per employee at that level. In other words, each employee is expected to take one hour to complete one task per hour for all 160 work-hours per month.

```
Baseline Routine Work per FTE[level]= Standard Work Month/Baseline
    Time per Task
Units: (Tasks/Month)/Person

Baseline Monthly Routine Work[level]= Baseline Routine Work Level
    FTEs[level]*Baseline Routine Work per FTE[level]
Units: Tasks/Month
```

The *Routine Work Release Rate* in section 5.4 (p.152) is determined by the total monthly routine work allocated to all employees at each level of the company hierarchy. I model this monthly routine work as a stock, subject to work-scope increases and work-scope cuts.

```
Monthly Routine Work[level]= INTEG(
    + Work Scope Increase Rate[level]
    - Work Scope Cutting Rate[level]
    , Baseline Monthly Routine Work[level])
Units: Tasks/Month
```
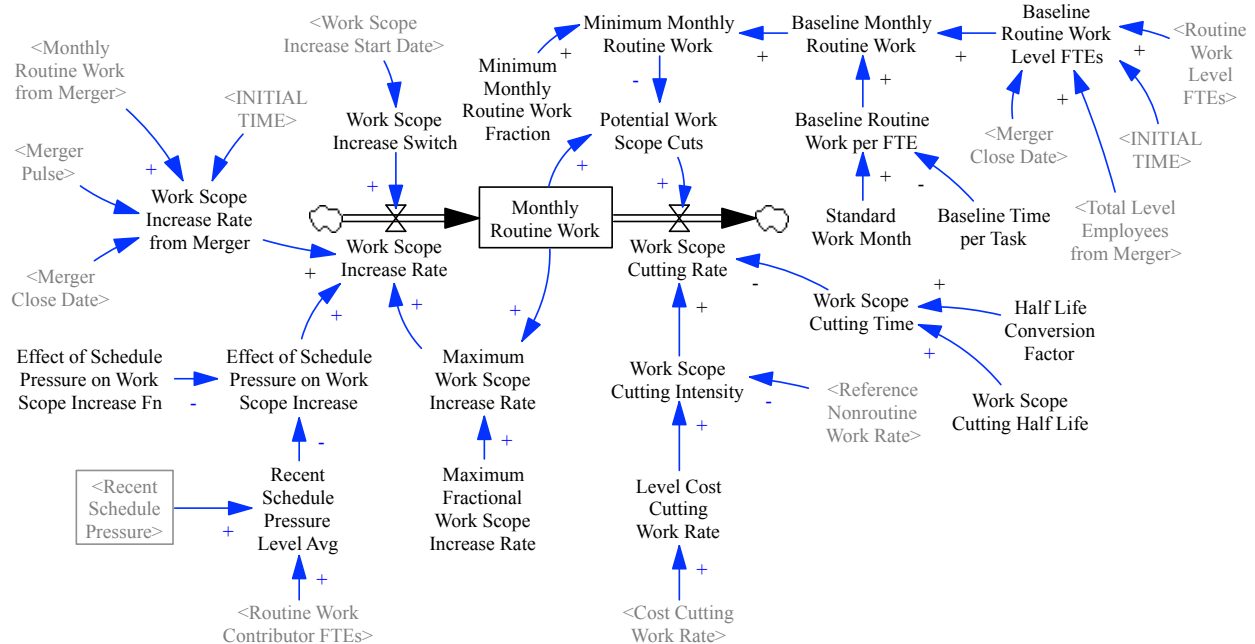
Figure 12. Model Diagram of Routine Work Allocation

I assume that a level's scope of work can be cut to save money on (variable) operating costs (see section 5.23, p.241) — such as deferring preventive maintenance on equipment or deferring clearance of overhead power lines — but only up to a minimum amount. I model the work-scope-cutting process with the same half-life formulation that I use to model improvements in productivity and operating costs in sections 5.22 (p.237) and 5.23 (p.241), respectively (see section 5.22, p.237, for explanation).

```
Work Scope Cutting Rate[level]= (Potential Work Scope
    Cuts[level]/Work Scope Cutting Time)*Work Scope Cutting
    Intensity[level]
Units: (Tasks/Month)/Month

Work Scope Cutting Time= Work Scope Cutting Half Life*Half Life
    Conversion Factor
Units: Month

Potential Work Scope Cuts[level]= MAX(Monthly Routine Work[level]
    - Minimum Monthly Routine Work[level], 0)
Units: Tasks/Month

Minimum Monthly Routine Work[level]= Baseline Monthly Routine
    Work[level]*Minimum Monthly Routine Work Fraction
Units: Tasks/Month
```

```
Work Scope Cutting Intensity[level]= ZIDZ(Level Cost Cutting Work
     Rate[level], Reference Nonroutine Work Rate[level])
Units: Fraction
```

The stock of *Monthly Routine Work* must be increased on the merger closing date to account for the routine work associated with the merged employees. The *Work Scope Increase Rate from Merger* is therefore a necessary component of the *Work Scope Increase Rate*. (Note: If the *Merger Close Date* is set equal to the simulation's *INITIAL TIME*, however, then the *Monthly Routine Work from Merger* is already included in the calculated initial value of the stock *Monthly Routine Work*.) I also include the possibility that DTE Energy's managers will increase the front line's scope of work — which DTE Energy's managers did primarily by insourcing work previously done by contractors — when productivity improvements reduce the front-line employees' schedule pressure below the normal value of 1. If the *Work Scope Increase Switch* is turned on, such insourcing forms a balancing-feedback loop in which work scope is increased until employees' schedule pressure is back to its normal value of 1.

```
Work Scope Increase Switch= STEP(1, Work Scope Increase Start
     Date)
Units: Dmnl [0,1,1]

Work Scope Increase Rate[level]= Work Scope Increase Rate from
     Merger[level] + Maximum Work Scope Increase Rate[level]*Effect
     of Schedule Pressure on Work Scope Increase[level]*Work Scope
     Increase Switch
Units: (Tasks/Month)/Month

Work Scope Increase Rate from Merger[level]= IF THEN ELSE(Merger
     Close Date > INITIAL TIME, Monthly Routine Work from
     Merger[level]*Merger Pulse, 0)
Units: (Tasks/Month)/Month

Monthly Routine Work from Merger[level]= Total Level Employees
     from Merger[level]*Baseline Routine Work per FTE[level]
Units: Tasks/Month

Maximum Work Scope Increase Rate[level]= Monthly Routine
     Work[level]*Maximum Fractional Work Scope Increase Rate
Units: (Tasks/Month)/Month
```

```
Effect of Schedule Pressure on Work Scope Increase[level]= Effect
    of Schedule Pressure on Work Scope Increase Fn(Recent Schedule
    Pressure Level Avg[level])
Units: Fraction [0,1]
```

I assume that the company's managers do not consider the contract labor associated with insourced work as avoided labor costs forever. Instead, they gradually revise their expectations for how much routine work each employee should do every month. For simplicity, I model this expectation-revision process using first-order exponential smoothing. However, I assume that DTE Energy managers' expectation revisions exhibit a ratchet effect: they are quick to revise workload standards upward, but very slow to revise them downward.

```
Routine Work per FTE[level]= Monthly Routine Work[level]/Total
    Level Employees[level]
Units: (Tasks/Month)/Person

Routine Work per FTE Standard[level]= INTEG(
    + Routine Work per FTE Standard Increase Rate[level]
    - Routine Work per FTE Standard Decrease Rate[level]
    , Baseline Routine Work per FTE[level])
Units: (Tasks/Month)/Person

Routine Work per FTE Standard Increase Rate[level]= Work Standard
    Additions[level]/Work Standard Increase Time
Units: (Tasks/Month)/Person/Month

Work Standard Additions[level]= MAX(Routine Work per FTE[level] -
    Routine Work per FTE Standard[level], 0)
Units: (Tasks/Month)/Person

Routine Work per FTE Standard Decrease Rate[level]= Work Standard
    Reductions[level]/Work Standard Decrease Time
Units: (Tasks/Month)/Person/Month

Work Standard Reductions[level]= MAX(Routine Work per FTE
    Standard[level] - Routine Work per FTE[level], 0)
Units: (Tasks/Month)/Person

Extra Routine Work[level]= Extra Routine Work per FTE[level]*Total
    Level Employees[level]
Units: Tasks/Month
```

I initially formulated *Extra Routine Work per FTE* as follows:

```
Extra Routine Work per FTE[level]= MAX(Routine Work per FTE[level]
    - Routine Work per FTE Standard[level], 0)
Units: (Tasks/Month)/Person
```

However, I was compelled to replace it with the formulation below because the division in *Routine Work per FTE* was creating tiny nonnegative artifacts in this subtraction.

```
Extra Routine Work per FTE[level]= IF THEN ELSE(Routine Work per
    FTE[level] - Routine Work per FTE Standard[level] > 0.002 ,
    Routine Work per FTE[level] - Routine Work per FTE
    Standard[level], 0)
Units: (Tasks/Month)/Person
```

Parameters for Routine Work Allocation

I express the minimum amount to which *Monthly Routine Work* can be cut as a fraction of *Baseline Monthly Routine Work*.

```
Minimum Monthly Routine Work Fraction= 0.7
Units: Fraction [0,1]

Work Scope Cutting Half Life= 1
Units: Month
```

DTE Energy did not start insourcing until the ECR plan began in October 2008. I assume that DTE Energy's employees got to keep their productivity gains until then. For simplicity, I assume that managers reduce their rate of insourcing linearly from *Maximum Fractional Work Scope Increase Rate* to zero as employees' schedule pressure increases from 0 to 1.

```
Work Scope Increase Start Date= 141
Units: Month

Maximum Fractional Work Scope Increase Rate= 0.1
Units: Fraction/Month

Effect of Schedule Pressure on Work Scope Increase Fn([(0,0)-
    (1.5,1)],(0,1),(1,0),(1.5,0))
Units: Fraction [0,1]
```
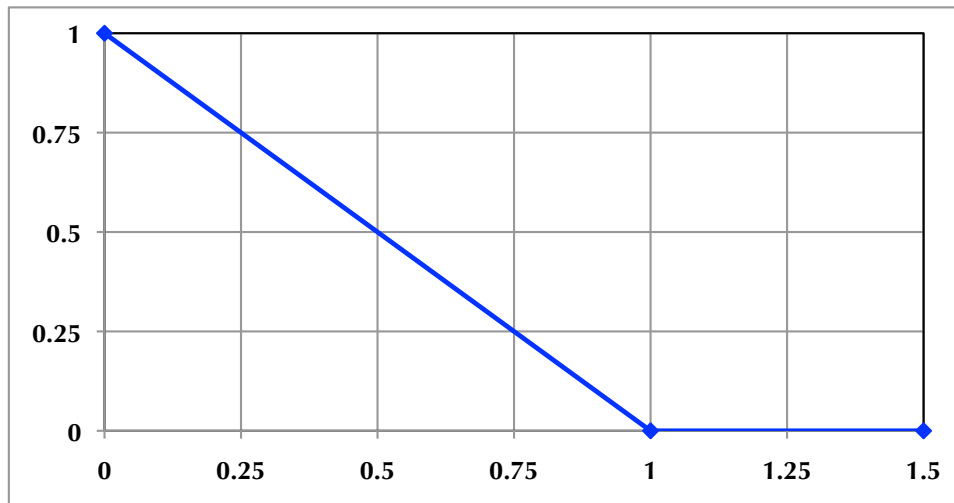
Figure 13. Lookup Function: Effect of Schedule Pressure on Work Scope Increase Fn

DTE Energy's managers will increase employees' workload standard more readily than they will decrease it.

```
Work Standard Increase Time= 2
Units: Month

Work Standard Decrease Time= 12
Units: Month
```

5.6. Nonroutine Work

I assume that all employees have a maximum fraction of their work month that they can feasibly devote to nonroutine work; their routine work of running the company must take priority, after all.

```
Maximum Nonroutine Work[level,nonBlackBelts]= Standard Work
    Month*Regular Employee Maximum Nonroutine Work Fraction[level]
Maximum Nonroutine Work[level,BB]= Standard Work Month*BB
    Nonroutine Work Fraction
Units: Hours/Month
```
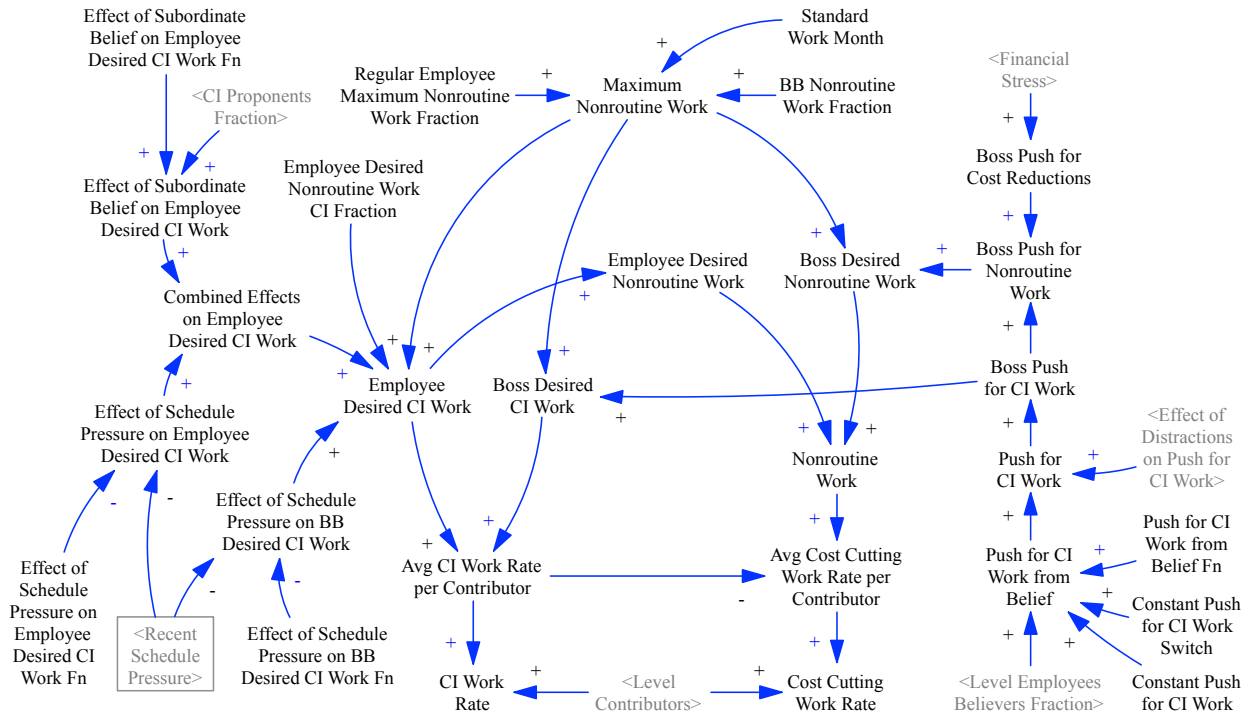
Figure 14. Model Diagram of Nonroutine Work

Employee Pull for Nonroutine Work

I assume that employee pull for nonroutine work consists only of desired CI work by employees who believe in CI (that is, by believers and Black Belt program participants). These believing employees, however, reduce their desired CI work as their schedule pressure increases because their routine work takes priority over nonroutine work. I also assume that senior executives and middle managers curtail their desired CI work in direct proportion to the fraction of their subordinates who are not CI proponents.

```
Employee Desired Nonroutine Work[level,contributor]= Employee
    Desired CI Work[level,contributor]
Units: Hours/Month

Employee Desired CI Work[level,nonBlackBelts]= Maximum Nonroutine
    Work[level,nonBlackBelts]*Employee Desired Nonroutine Work CI
    Fraction[level,nonBlackBelts]*Combined Effects on Employee
    Desired CI Work[level,nonBlackBelts]
Employee Desired CI Work[level,BB]= Maximum Nonroutine
    Work[level,BB]*Employee Desired Nonroutine Work CI
    Fraction[level,BB]*Effect of Schedule Pressure on BB Desired
    CI Work[level]
```

```
Units: Hours/Month

Combined Effects on Employee Desired CI Work[level,contributor]=
     MIN(Effect of Schedule Pressure on Employee Desired CI
     Work[level,contributor], Effect of Subordinate Belief on
     Employee Desired CI Work[level])
Units: Fraction [0,1]

Effect of Schedule Pressure on Employee Desired CI
     Work[level,contributor]= Effect of Schedule Pressure on
     Employee Desired CI Work Fn(Recent Schedule
     Pressure[level,contributor])
Units: Fraction [0,1]

Effect of Schedule Pressure on BB Desired CI Work[level]= Effect
     of Schedule Pressure on BB Desired CI Work Fn(Recent Schedule
     Pressure[level,BB])
Units: Fraction [0,1]

Effect of Subordinate Belief on Employee Desired CI Work[SE]=
     Effect of Subordinate Belief on Employee Desired CI Work Fn(CI
     Proponents Fraction[MM])
Effect of Subordinate Belief on Employee Desired CI Work[MM]=
     Effect of Subordinate Belief on Employee Desired CI Work Fn(CI
     Proponents Fraction[FL])
Effect of Subordinate Belief on Employee Desired CI Work[FL]= 1
Units: Fraction [0,1]
```

Boss Push for Nonroutine Work

I define two types of "boss pushes" in this model: (1) a push for CI work specifically, and (2) a push for cost reductions with nonroutine work, which may be satisfied with CI work or with cost-cutting work. If managers' push for CI work is less than their push for cost reductions, then they implicitly expect the difference to be addressed with cost-cutting work. Obviously, these boss pushes felt by employees at a given level of the company hierarchy are determined by their bosses one level above them.

I assume that the financial stress faced by the company (which, in this model, is exogenous) constitutes the "boss push" for cost reductions felt by the senior executives. I further assume that the push for cost reductions arising from this financial stress is transferred unaltered down the company hierarchy.

```
Financial Stress= Exogenous Financial Stress
Units: Dmnl [0,1]
```

```
Boss Push for Cost Reductions[SE]= Financial Stress
Boss Push for Cost Reductions[MM]= Boss Push for Cost
    Reductions[SE]
Boss Push for Cost Reductions[FL]= Boss Push for Cost
    Reductions[MM]
Units: Dmnl [0,1]
```

The push for CI work that managers exert on their subordinates arises from their belief in CI. The overall push for CI work that all managers at a given level exert on their subordinates increases as more managers at that level become believers. For simplicity, I assume that senior executives are not pushed for CI work by anyone, and that middle managers exert the larger of their push or their bosses' push for CI on their front-line subordinates. I also assume that DTE Energy's managers reduce their push for CI work when distracted by, for example, the MichCon merger. For testing purposes, I allow for the push for CI work to be set at a constant value, instead of being determined endogenously from managers' belief states.

```
Push for CI Work from Belief[level]= Push for CI Work from Belief
    Fn(Level Employees Believers Fraction[level])*(1-Constant Push
    for CI Work Switch) + Constant Push for CI Work*Constant Push
    for CI Work Switch
Units: Dmnl [0,1]

Push for CI Work[SE]= Push for CI Work from Belief[SE]*Effect of
    Distractions on Push for CI Work[SE]
Push for CI Work[MM]= MAX(Push for CI Work from Belief[MM], Push
    for CI Work[SE])*Effect of Distractions on Push for CI
    Work[MM]
Push for CI Work[FL]= 0
Units: Dmnl [0,1]

Effect of Distractions on Push for CI Work[level]= 1-Exogenous
    Distractions Index[level]
Units: Dmnl [0,1]

Boss Push for CI Work[SE]= 0
Boss Push for CI Work[MM]= Push for CI Work[SE]
Boss Push for CI Work[FL]= Push for CI Work[MM]
Units: Dmnl [0,1]
```

Employees might experience both a push for reducing costs *and* a push for CI work from their bosses simultaneously. They must reconcile these two pushes when

determining how much nonroutine work to do. Because employees can meet their bosses' demand for cost reductions with CI work, I assume that they consider the larger of these two pushes as their bosses' push for nonroutine work.

```
Boss Push for Nonroutine Work[level]= MAX(Boss Push for Cost
     Reductions[level], Boss Push for CI Work[level])
Units: Dmnl [0,1]
```

I assume that as *Boss Push for Nonroutine Work* increases from 0 to 1, the average amount of nonroutine work that managers expect from each of their subordinates increases from zero to *Maximum Nonroutine Work*. Black Belts, however, are an exception. Because Black Belts are specially trained CI experts, I assume that managers always want them to be contributing the most nonroutine work possible.

```
Boss Desired Nonroutine Work[level,nonBlackBelts]= Maximum
     Nonroutine Work[level,nonBlackBelts]*Boss Push for Nonroutine
     Work[level]
Boss Desired Nonroutine Work[level,BB]= Maximum Nonroutine
     Work[level,BB]
Units: Hours/Month
```

Employees must also reconcile their bosses' push for nonroutine work and their own pull for nonroutine work (which is always pull for CI work). Because employees reduce their desired nonroutine work in the face of high schedule pressure, I assume that managers allow their subordinates to do their desired nonroutine work if it is larger than the managers' demanded nonroutine work, because employees' desired nonroutine work indicates a certain amount of slack. Otherwise, employees are compelled to do their managers' demanded nonroutine work, regardless of their schedule pressure.

```
Nonroutine Work[level,contributor]= MAX(Boss Desired Nonroutine
     Work[level,contributor], Employee Desired Nonroutine
     Work[level,contributor])
Units: Hours/Month
```

After employees determine how much nonroutine work they will do, they must determine how much of that nonroutine work is CI work and how much of it is cost-cutting work. To do so, they must reconcile their bosses' desired CI work with their own desired CI work. Because they must do this nonroutine work regardless of their prevailing

schedule pressure, I assume that they choose the larger of these desired amounts of CI work. The fraction of employees' nonroutine work that remains is their cost-cutting work. Again, Black Belts are an exception: I assume that their bosses always want them to be using their CI expertise doing CI work.

```
Boss Desired CI Work[level,nonBlackBelts]= Maximum Nonroutine
    Work[level,nonBlackBelts]*Boss Push for CI Work[level]
Boss Desired CI Work[level,BB]= Maximum Nonroutine Work[level,BB]
Units: Hours/Month

Avg CI Work Rate per Contributor[level,contributor]= MAX(Boss
    Desired CI Work[level,contributor], Employee Desired CI
    Work[level,contributor])
Units: Hours/Month

CI Work Rate[level,contributor]= Level
    Contributors[level,contributor]*Avg CI Work Rate per
    Contributor[level,contributor]
Units: Person*Hours/Month

Avg Cost Cutting Work Rate per Contributor[level,contributor]=
    MAX(Nonroutine Work[level,contributor] - Avg CI Work Rate per
    Contributor[level,contributor], 0)
Units: Hours/Month

Cost Cutting Work Rate[level,contributor]= Level
    Contributors[level,contributor]*Avg Cost Cutting Work Rate per
    Contributor[level,contributor]
Units: Person*Hours/Month
```

I assume that all cost-cutting work consists of cutting work scope (see the equation for *Work Scope Cutting Intensity* in section 5.5, p.158), which reduces the company's variable operating costs.

```
Level Cost Cutting Work Rate[level]= SUM(Cost Cutting Work
    Rate[level,contributor!])
Units: Person*Hours/Month
```

The following sums of CI work by regular employees, by Black Belt candidates, and by certified Black Belts are needed to compute required management support in section 5.8 (p.179).

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```
FL Projects Work Rate[level]= SUM(CI Work
    Rate[level,regEmployees!])
Units: Person*Hours/Month

BB Candidate Projects Work Rate[level]= CI Work Rate[level,BBc]
Units: Person*Hours/Month

BB Projects Work Rate[level]= CI Work Rate[level,BB]*(1-BB
    Coaching Fraction)
Units: Person*Hours/Month
```

The total amount of CI-project work being done by front-line employees, and associated support work by their managers, is needed to compute required Black Belt coaching in section 5.14 (p.209). This coaching work by Black Belts is a fraction of their total CI work.

```
FL Projects Total Work Rate= SUM(CI Work
    Rate[level!,regEmployees!])
Units: Person*Hours/Month

BB Total CI Work Rate= SUM(CI Work Rate[level!,BB])
Units: Person*Hours/Month
```

Parameters for Nonroutine Work

I assume that employees and managers agree on the maximum fraction of their workweeks that could possibly be devoted to nonroutine work.

```
Regular Employee Maximum Nonroutine Work Fraction[level]=
    0.2,0.2,0.2
Units: Fraction [0,1]

BB Nonroutine Work Fraction= 1
Units: Fraction [0,1]
```

Parameters for Employee Pull for Nonroutine Work

In the absence of schedule-pressure effects, I assume that employees who believe in CI — believers and Black Belt program participants — want to devote the maximum nonroutine-work fraction of their workweeks to CI work. I assume that neutrals and skeptics do not want to do any CI work. As schedule pressure increases, however, all types of employees reduce their desired CI work, giving priority to their routine work.

```
Employee Desired Nonroutine Work CI Fraction[level,Bel]= 1,1,1
Employee Desired Nonroutine Work CI Fraction[level,Neu]= 0,0,0
Employee Desired Nonroutine Work CI Fraction[level,Ske]= 0,0,0
Employee Desired Nonroutine Work CI Fraction[level,BBt]= 1,1,1
Employee Desired Nonroutine Work CI Fraction[level,BBc]= 1,1,1
Employee Desired Nonroutine Work CI Fraction[level,BB]= 1,1,1
Units: Fraction [0,1]

Effect of Schedule Pressure on Employee Desired CI Work Fn([(0,0)-
    (1.25,1)],(0,1),(1,0.63),(1.05,0.55),(1.2,0.02),(1.25,0))
Units: Fraction [0,1]
```
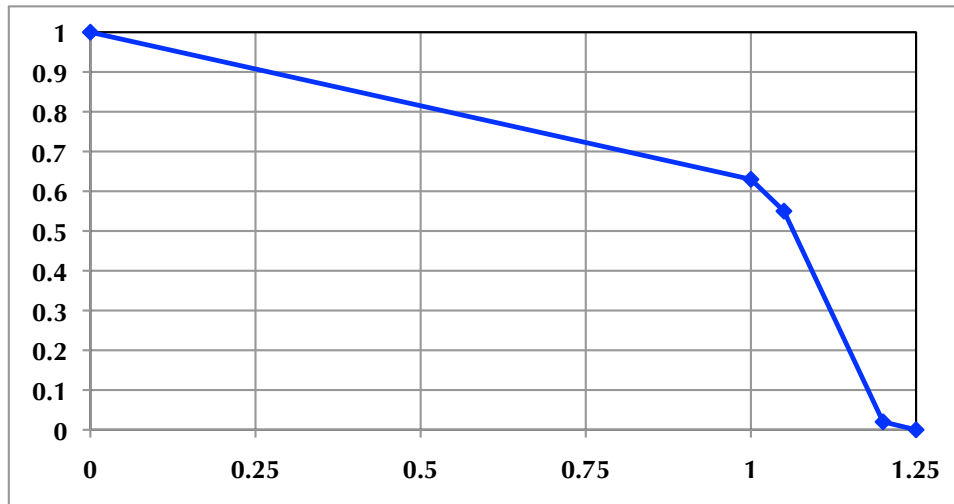

Figure 15. Lookup Function: Effect of Schedule Pressure on Employee Desired CI Work Fn

```
Effect of Schedule Pressure on BB Desired CI Work Fn([(0,0)-
    (2,1.5)],(0,1),(1,1),(1.25,0.5),(1.5,0),(2,0))
Units: Fraction [0,1]
```

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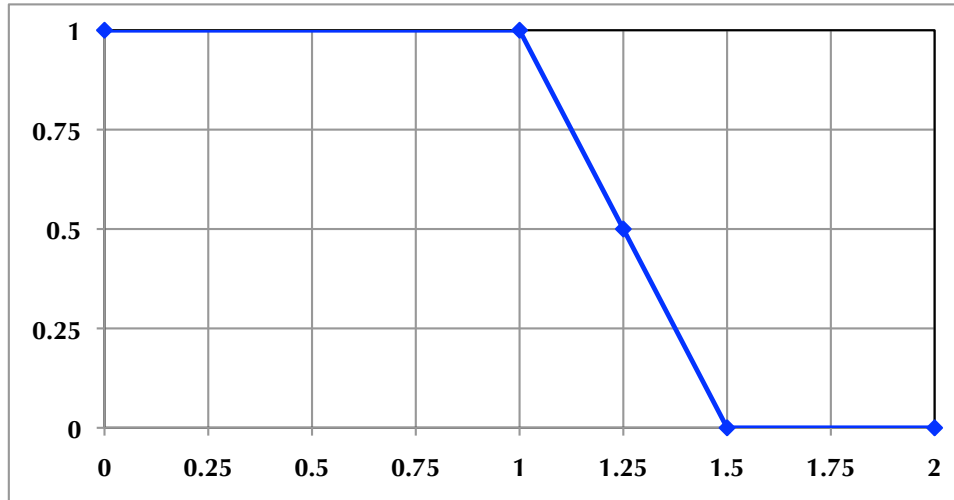
Figure 16. Lookup Function: Effect of Schedule Pressure on BB Desired CI Work Fn

DTE Energy's managers reduce their desired CI work in direct proportion to the fraction of their subordinates who are not CI proponents. In other words, they will only provide the management support demanded by their CI-proponent subordinates.

```
Effect of Subordinate Belief on Employee Desired CI Work
    Fn([(0,0)-(1,1)],(0,0),(1,1))
Units: Fraction [0,1]
```
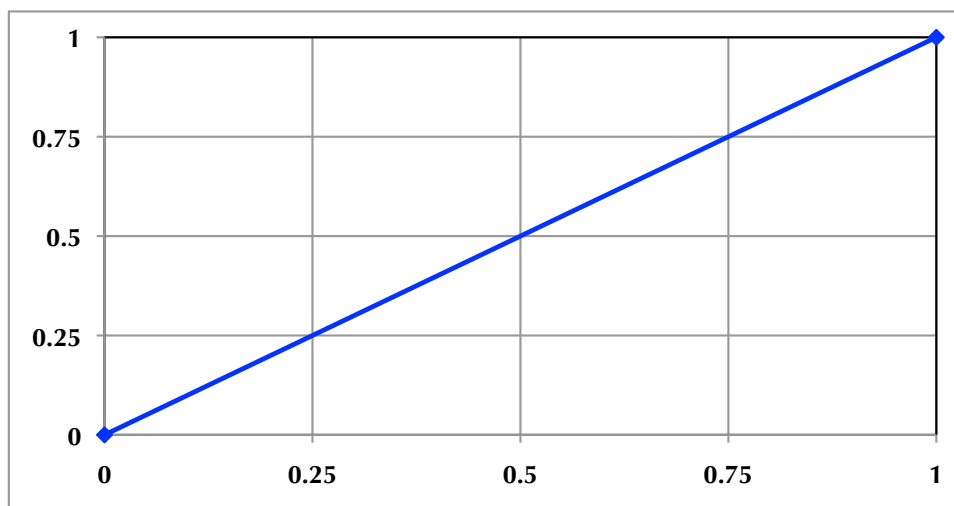

Figure 17. Lookup Function: Effect of Subordinate Belief on Employee Desired CI Work Fn

Parameters for Boss Push for Nonroutine Work

As more managers at a given level believe in CI, their aggregate push for CI work increases from 0 to 1.

```
Push for CI Work from Belief Fn([(0,0)-(1,1),(0,0),(1,1)],
     (0,0),(0.25,0.025),(0.5,0.1),(0.75,0.25),(0.9,0.5),(1,1))
Units: Dmnl [0,1]
```
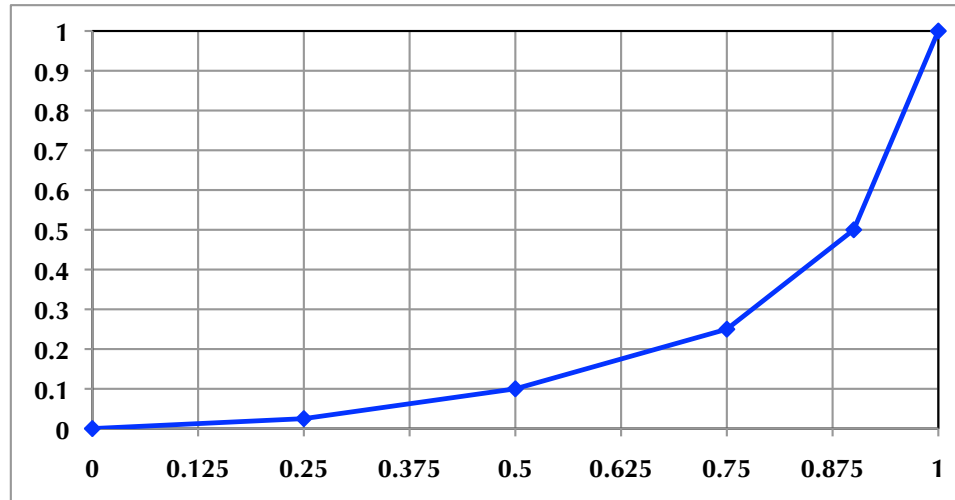

Figure 18. Lookup Function: Push for CI Work from Belief Fn

```
Exogenous Financial Stress :HOLD BACKWARD::= GET XLS DATA(Excel
     File Name, Excel File Scenario Name, Excel File Time Row,
     'C18')
Units: Dmnl [0,1]

Exogenous Distractions Index[level] :HOLD BACKWARD::= GET XLS
     DATA(Excel File Name, Excel File Scenario Name, Excel File
     Time Row, 'C21')
Units: Dmnl [0,1]

Constant Push for CI Work Switch= 0
Units: Dmnl [0,1,1]

Constant Push for CI Work= 0.05
Units: Dmnl [0,1]
```

5.7. Improvement Work Effectiveness

My theory of CI work holds that CI activities do not yield gains proportional to the time that employees spend on them. Why would this be the case? First, managers might

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coerce their subordinate employees to do CI work. In such a scenario, employees would put in the necessary CI work hours, but they would not make an earnest effort. They would conform only ceremonially with their bosses' directive[6]. Employees' effort earnestness, therefore, depends on their belief in CI. Second, employees reduce their effort earnestness when they feel they do not have adequate job security, management support, and coaching from CI experts. For simplicity, I assume that employees determine their effort earnestness from whichever of these three possible demotivating factors has the largest prevailing effect. Finally, the gains that employees achieve depend on their skill with CI tools and methods. Coaching by CI experts, if provided adequately, can ameliorate any shortfall in employees' CI skill.

```
CI Work Contribution Rate[level,nonBlackBelts]= CI Work
    Rate[level,nonBlackBelts]*CI Effort
    Earnestness[level,nonBlackBelts]
CI Work Contribution Rate[level,BB]= BB Projects Work
    Rate[level]*CI Effort Earnestness[level,BB]
Units: Person*Hours/Month

CI Effort Earnestness[level,contributor]= Baseline Effort
    Earnestness from Belief[level,contributor]*Combined
    Demotivator Effects on Effort[level,contributor]
Units: Dmnl [0,1]

Combined Demotivator Effects on Effort[level,contributor]=
    MIN(MIN(Effect of Job Security on Effort[level,contributor],
    Effect of Mgmt Support on Effort[level,contributor]), Effect
    of BB Coaching on Effort[level,contributor])
Units: Dmnl [0,1]
```

---

[6] Williamson (1975, 1985) calls such behavior "perfunctory cooperation".
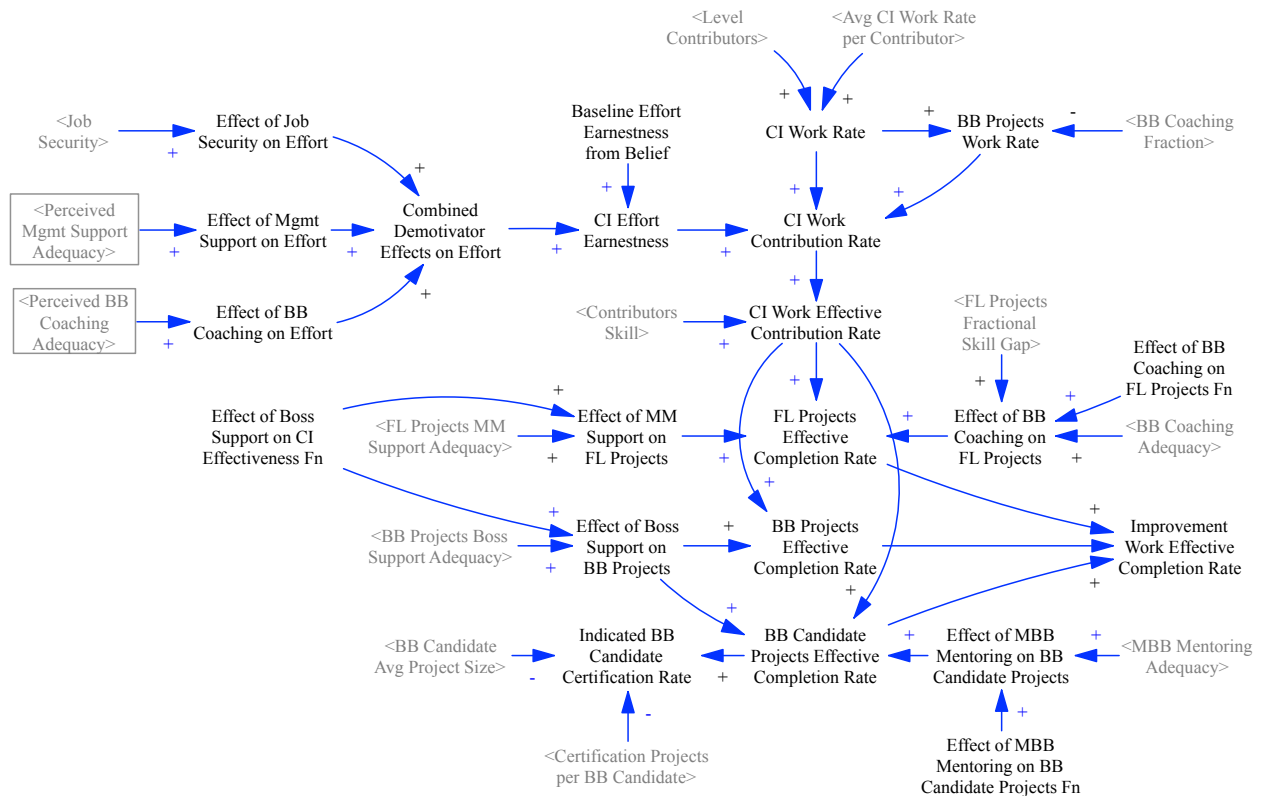
Figure 19. Model Diagram of Improvement Work Effectiveness

I assume that the effect of low job security on effort applies to regular front-line employees only. (I assume that Black Belts and Black Belt candidates believe they are indispensable employees because of their CI expertise.)

```
Effect of Job Security on Effort[level,contributor] :EXCEPT:
    [FL,regEmployees]= 1
Effect of Job Security on Effort[FL,regEmployees]= Job
    Security[FL]
Units: Dmnl [0,1]
```

Employees are extremely sensitive to their bosses not "walking the talk". I assume, therefore, that they will reduce their effort in direct proportion to any perceived inadequacy in management support. I assume that Black Belts and Black Belt candidates, confident in their own CI expertise, have no such effect on their effort. (A lack of management support will, however, affect the results they can achieve.)

```
Effect of Mgmt Support on Effort[level,regEmployees]=
    MIN(Perceived Mgmt Support Adequacy[level], 1)
Effect of Mgmt Support on Effort[level,BBc]= 1
```

```
Effect of Mgmt Support on Effort[level,BB]= 1
Units: Dmnl [0,1]
```

I assume that regular employees and Black Belt trainees reduce their effort in direct proportion to any perceived inadequacy of coaching by Black Belts. This effect does not apply to Black Belt candidates, who are coached by the Master Black Belts, or to certified Black Belts, who are able to do CI work independently.

```
Effect of BB Coaching on Effort[level,regEmployees]= MIN(Perceived
    BB Coaching Adequacy[level,regEmployees], 1)
Effect of BB Coaching on Effort[level,BBc]= 1
Effect of BB Coaching on Effort[level,BB]= 1
Units: Dmnl [0,1]
```

Employees' effective CI work contribution overall reflects their level of skill with CI tools and methods. Their effective CI work on front-line projects, specifically, also reflects their bosses' amount of management support and the amount of coaching they receive from Black Belts.

```
CI Work Effective Contribution Rate[level,contributor]= CI Work
    Contribution Rate[level,contributor]*Contributors
    Skill[level,contributor]
Units: Person*Hours/Month

FL Projects Effective Completion Rate= SUM(CI Work Effective
    Contribution Rate[FL,regEmployees!]*Effect of BB Coaching on
    FL Projects[FL,regEmployees!]*Effect of MM Support on FL
    Projects)
Units: Person*Hours/Month

Effect of MM Support on FL Projects= Effect of Boss Support on CI
    Effectiveness Fn(FL Projects MM Support Adequacy)
Units: Fraction
```

Black Belt coaching (section 5.14, p.209) closes the skill gap, if any, between the assisting Black Belts and the regular employees working on front-line CI projects.

```
Effect of BB Coaching on FL Projects[level,regEmployees]= 1 + FL
    Projects Fractional Skill Gap[level,regEmployees]*Effect of BB
    Coaching on FL Projects Fn(BB Coaching
    Adequacy[level,regEmployees])
Units: Fraction
```

The effectiveness of Black Belts' CI project work is reduced if management support is

inadequate.

```
BB Projects Effective Completion Rate[level]= CI Work Effective
    Contribution Rate[level,BB]*Effect of Boss Support on BB
    Projects[level]
Units: Person*Hours/Month

Effect of Boss Support on BB Projects[level]= Effect of Boss
    Support on CI Effectiveness Fn(BB Projects Boss Support
    Adequacy[level])
Units: Fraction
```

The effectiveness of Black Belt candidates' CI project work is reduced if either management support (section 5.8, p.179) or Master Black Belts' mentoring (section 5.18, p.225) is inadequate. The rate at which Black Belt candidates complete their CI projects determines how fast they earn their Black Belt certifications (see section 5.12, p.199).

```
BB Candidate Projects Effective Completion Rate[level]= CI Work
    Effective Contribution Rate[level,BBc]*Effect of MBB Mentoring
    on BB Candidate Projects*Effect of Boss Support on BB
    Projects[level]
Units: Person*Hours/Month

Effect of MBB Mentoring on BB Candidate Projects= Effect of MBB
    Mentoring on BB Candidate Projects Fn(MBB Mentoring Adequacy)
Units: Fraction
```

The total amount of improvement work being done comprises front-line CI projects, Black Belt projects, and Black Belt candidates' certification projects.

```
Improvement Work Effective Completion Rate= FL Projects Effective
    Completion Rate + SUM(BB Projects Effective Completion
    Rate[level!]) + SUM(BB Candidate Projects Effective Completion
    Rate[level!])
Units: Person*Hours/Month
```

Regular employees' average CI effort earnestness influences how much time Black Belts want to devote to coaching (see section 5.14, p.209). This average is computed by weighting contributors' *CI Effort Earnestness* by their respective *CI Work Rate*.

```
Contributors Avg CI Effort Earnestness= ZIDZ(SUM(CI Work
    Rate[level!,regEmployees!]*CI Effort
    Earnestness[level!,regEmployees!]), FL Projects Total Work
    Rate)
```

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```
Units: Dmnl [0,1]
```

As a performance measure for the CI initiative as a whole, I compute the ratio of employees' actual CI contributions in person-hours (before adjusting for their skill) to their maximum possible CI contributions.

```
Level CI Work Contribution Rate[level]= SUM(CI Work Contribution
     Rate[level,contributor!])
Units: Person*Hours/Month

Level Maximum CI Work Contribution Rate[level]= SUM(Level
     Contributors[level,contributor!]*Maximum Nonroutine
     Work[level,contributor!])
Units: Person*Hours/Month

CI Contribution Percentage[level]= ZIDZ(Level CI Work Contribution
     Rate[level], Level Maximum CI Work Contribution Rate[level])
Units: Fraction [0,1]
```

Parameters for Improvement Work Effectiveness

In the absence of any demotivating factors, I assume that believers and Black Belt program participants put forth their full effort toward CI work. I assume that neutrals put forth 50-percent effort and skeptics put forth 10-percent effort.

```
Baseline Effort Earnestness from Belief[level,Bel]= 1
Baseline Effort Earnestness from Belief[level,Neu]= 0.5
Baseline Effort Earnestness from Belief[level,Ske]= 0.1
Baseline Effort Earnestness from Belief[level,BBt]= 1
Baseline Effort Earnestness from Belief[level,BBc]= 1
Baseline Effort Earnestness from Belief[level,BB]= 1
Units: Dmnl [0,1]
```

I assume that the effect of boss-support adequacy is the same for all three types of CI projects: front-line projects, Black Belt projects, and Black Belt candidate projects. I assume the effect is asymmetric, as follows. When boss support is inadequate, employees' effectiveness is gradually reduced to 60 percent. When boss support is more than adequate, their effectiveness is increased, but only up to a maximum of 5 percent above the exactly adequate level.

```
Effect of Boss Support on CI Effectiveness Fn([(0,0)-
    (2.5,2)],(0,0.6),(0.25,0.63),(0.5,0.7),(0.75,0.8),(1,1),(1.25,
    1.03),(1.5,1.045),(2,1.05))
Units: Fraction
```
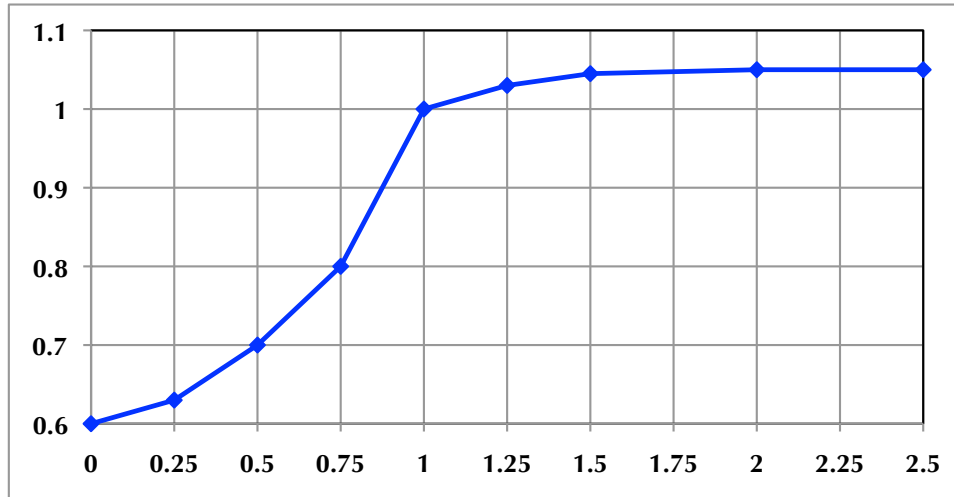

Figure 20. Lookup Function: Effect of Boss Support on CI Effectiveness Fn

The relative amount of coaching provided by Black Belts to regular employees closes a fraction of the skill gap, if any, between those Black Belts and regular employees.

```
Effect of BB Coaching on FL Projects Fn([(0,0)-
    (4,1)],(0,0),(1,0.75),(2,0.9),(3,0.95),(4,1))
Units: Fraction [0,1]
```
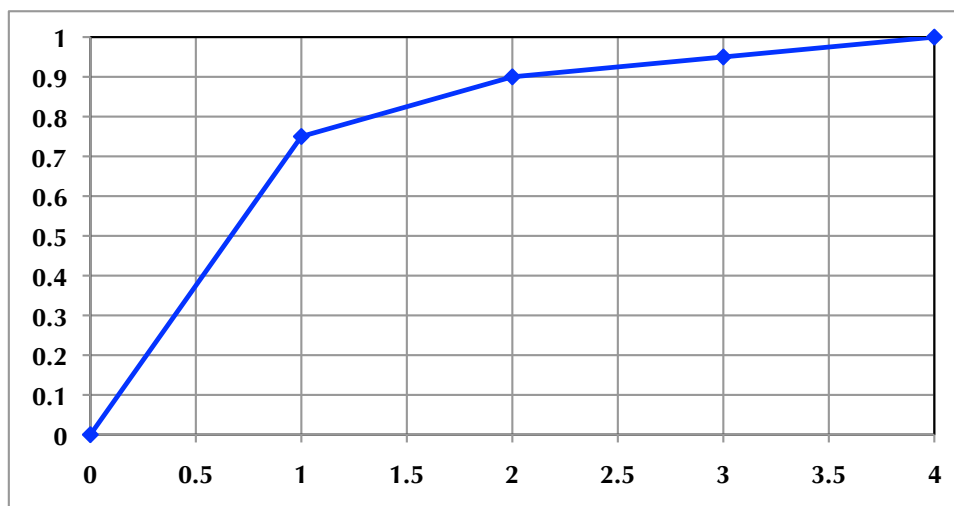

Figure 21. Lookup Function: Effect of BB Coaching on FL Projects Fn

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I assume that Master Black Belt mentoring helps Black Belt candidates complete their certification projects faster than they would without mentoring. When mentoring is zero, Black Belt candidates take four times as long to complete a project. I assume that Black Belt candidates take the minimum amount of time per project — two months — when their mentoring is 300 percent of the exactly adequate level.

```
Effect of MBB Mentoring on BB Candidate Projects Fn([(0,0)-
    (3,2)],(0,0.25),(1,1),(2,1.35),(3,1.5))
Units: Dmnl
```
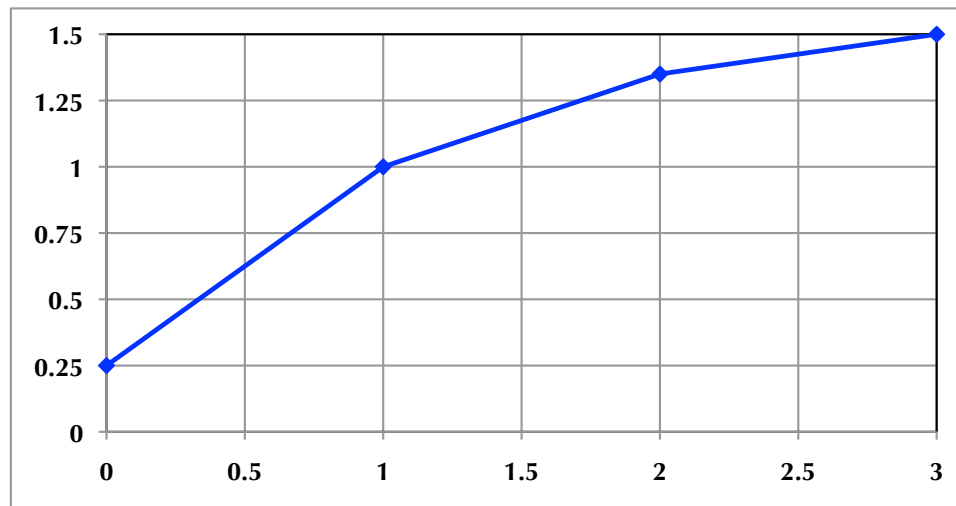

Figure 22. Lookup Function: Effect of MBB Mentoring on BB Candidate Projects Fn

5.8. Management Support

I assume that all employees require a certain amount of management support, measured in person-hours of attention, from their bosses for every hour that they spend working on their respective types of CI projects (front-line projects, Black Belt candidate projects, and Black Belt projects).

```
FL Projects Required MM Support= FL Projects Work Rate[FL]*FL
    Projects Required Fractional MM Support
Units: Person*Hours/Month

BB Projects Required MM Support= (BB Candidate Projects Work
    Rate[FL] + BB Projects Work Rate[FL])*BB Projects Required
    Fractional MM Support
Units: Person*Hours/Month
```

```
Required MM Support Total= FL Projects Required MM Support + BB
     Projects Required MM Support
Units: Person*Hours/Month
```
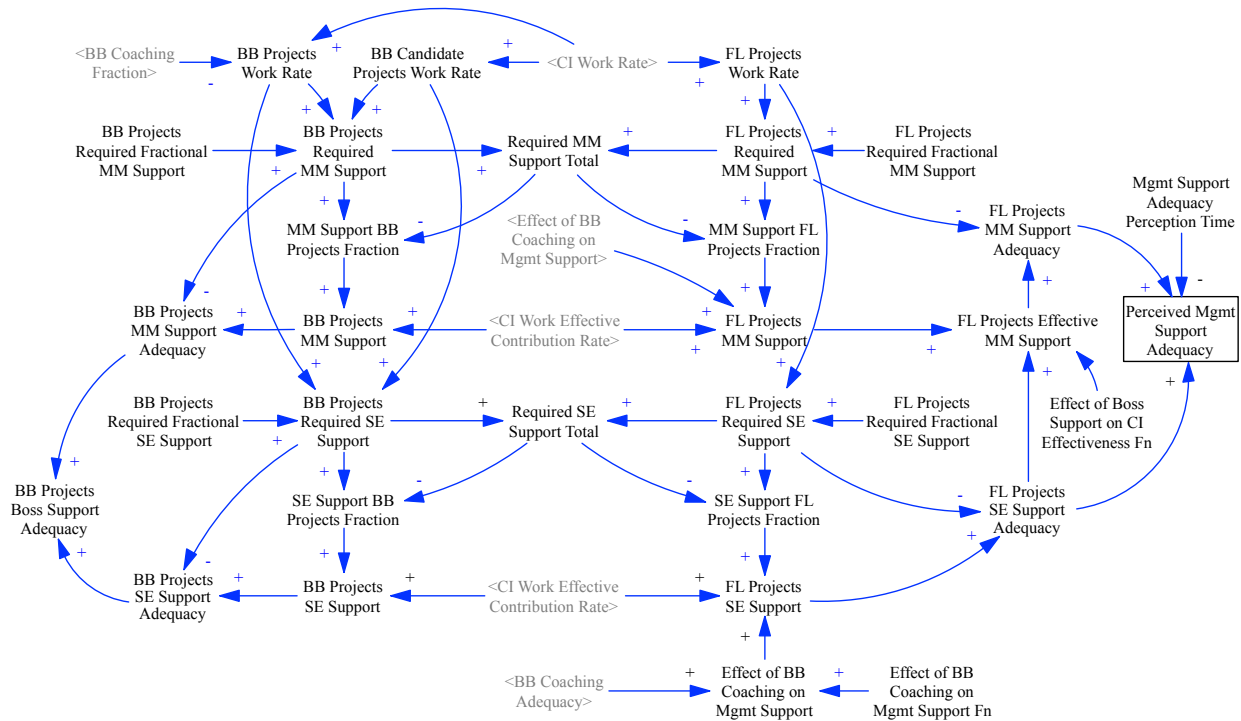

Figure 23. Model Diagram of Management Support

Middle managers may not be willing to provide all of the management support demanded by their subordinates for Black Belt and front-line CI projects. Whatever support they do provide, I assume that they allocate it proportionally according to each project type's fraction of the total support demanded. I also assume that middle managers, if their skill is low, require a minimal amount of Black Belt coaching to make their support of front-line CI projects fully effective.

```
MM Support FL Projects Fraction= ZIDZ(FL Projects Required MM
     Support, Required MM Support Total)
Units: Fraction [0,1]

MM Support BB Projects Fraction= ZIDZ(BB Projects Required MM
     Support, Required MM Support Total)
Units: Fraction [0,1]
```

```
FL Projects MM Support= SUM(CI Work Effective Contribution
    Rate[MM,regEmployees!]*MM Support FL Projects Fraction*Effect
    of BB Coaching on Mgmt Support[MM,regEmployees!])
Units: Person*Hours/Month

Effect of BB Coaching on Mgmt Support[level,regEmployees]= Effect
    of BB Coaching on Mgmt Support Fn(BB Coaching
    Adequacy[level,regEmployees])
Units: Fraction [0,1]

BB Projects MM Support= SUM(CI Work Effective Contribution
    Rate[MM,regEmployees!]*MM Support BB Projects Fraction)
Units: Person*Hours/Month
```

I assume that middle managers supporting front-line CI projects in turn require support from their senior-executive bosses. Similarly, middle-manager Black Belts require support from their senior-executive bosses just like front-line Black Belts require support from their middle-manager bosses. These equations for senior executive support, therefore, parallel the equations for middle manager support.

```
FL Projects Required SE Support= FL Projects Work Rate[MM]*FL
    Projects Required Fractional SE Support
Units: Person*Hours/Month

BB Projects Required SE Support= (BB Candidate Projects Work
    Rate[MM] + BB Projects Work Rate[MM])*BB Projects Required
    Fractional SE Support
Units: Person*Hours/Month

Required SE Support Total= FL Projects Required SE Support + BB
    Projects Required SE Support
Units: Person*Hours/Month

SE Support FL Projects Fraction= ZIDZ(FL Projects Required SE
    Support, Required SE Support Total)
Units: Fraction [0,1]

SE Support BB Projects Fraction= ZIDZ(BB Projects Required SE
    Support, Required SE Support Total)
Units: Fraction [0,1]

FL Projects SE Support= SUM(CI Work Effective Contribution
    Rate[SE,regEmployees!]*SE Support FL Projects Fraction*Effect
    of BB Coaching on Mgmt Support[SE,regEmployees!])
Units: Person*Hours/Month

BB Projects SE Support= SUM(CI Work Effective Contribution
    Rate[SE,regEmployees!]*SE Support BB Projects Fraction)
```

```
Units: Person*Hours/Month
```

The adequacy of management support is simply the ratio of the support provided by one's boss to the support demanded by oneself. However, there are a few subtleties. I assume that the effectiveness of middle managers' support of front-line CI projects depends on the adequacy of the support that *they* receive, in turn, from their senior-executive bosses. For simplicity, I assume that this effect is the same as the effect of middle managers' support adequacy on the effectiveness of front-line employees' CI work (see section 5.7, p.172). Finally, I assume that senior-executive Black Belts do not require any management support.

```
FL Projects SE Support Adequacy= XIDZ(FL Projects SE Support, FL
    Projects Required SE Support, 1)
Units: Dmnl

BB Projects SE Support Adequacy= XIDZ(BB Projects SE Support, BB
    Projects Required SE Support, 1)
Units: Dmnl

FL Projects Effective MM Support= FL Projects MM Support*Effect of
    Boss Support on CI Effectiveness Fn(FL Projects SE Support
    Adequacy)
Units: Person*Hours/Month

FL Projects MM Support Adequacy= XIDZ(FL Projects Effective MM
    Support, FL Projects Required MM Support, 1)
Units: Dmnl

BB Projects MM Support Adequacy= XIDZ(BB Projects MM Support, BB
    Projects Required MM Support, 1)
Units: Dmnl

BB Projects Boss Support Adequacy[SE]= 1
BB Projects Boss Support Adequacy[MM]= BB Projects SE Support
    Adequacy
BB Projects Boss Support Adequacy[FL]= BB Projects MM Support
    Adequacy
Units: Dmnl
```

For simplicity, I assume that employees at each level perceive the overall adequacy of management support at their level. I use first-order exponential smoothing to represent the process of employees' perceiving and updating their assessments of management-support adequacy.

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```
Perceived Mgmt Support Adequacy[SE]= 1
Perceived Mgmt Support Adequacy[MM]= SMOOTHI(FL Projects SE
     Support Adequacy, Mgmt Support Adequacy Perception Time, 1)
Perceived Mgmt Support Adequacy[FL]= SMOOTHI(FL Projects MM
     Support Adequacy, Mgmt Support Adequacy Perception Time, 1)
Units: Dmnl
```

Parameters for Management Support

The number of hours that front-line employees require from their middle-manager bosses for every hour they spend on FL projects:

```
FL Projects Required Fractional MM Support= 0.1
Units: (Person*Hour)/(Person*Hour)
```

The number of hours that middle managers require from their senior-executive bosses for every hour they spend supporting FL projects:

```
FL Projects Required Fractional SE Support= 0.125
Units: (Person*Hours)/(Person*Hour)
```

The number of hours that front-line Black Belts require from their middle-manager bosses for every hour they spend on BB projects:

```
BB Projects Required Fractional MM Support= 0.075
Units: (Person*Hours)/(Person*Hour)
```

The number of hours that middle-manager Black Belts require from their senior-executive bosses for every hour they spend on BB projects:

```
BB Projects Required Fractional SE Support= 0.075
Units: (Person*Hours)/(Person*Hour)
```

As the adequacy of Black Belt coaching of middle managers and senior executives approaches zero, their support effectiveness is reduced from 100 percent to 25 percent.

```
Effect of BB Coaching on Mgmt Support Fn([(0,0)-
     (2,1)],(0,0.25),(1,1),(2,1))
Units: Dmnl [0,1]
```
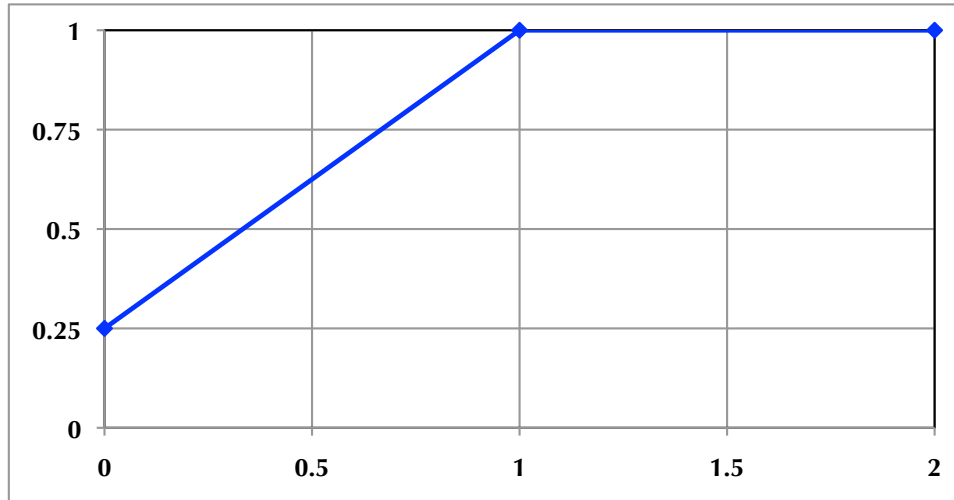
Figure 24. Lookup Function: Effect of BB Coaching on Mgmt Support Fn

```
Mgmt Support Adequacy Perception Time= 1
Units: Month
```

5.9. Job Security

This formulation of the entire *Job Security* structure, as described in this section, is an adaptation of the *Job Security* formulation in the Analog Devices model (Repenning & Sterman, 1994b, pp. 92-94; Sterman, Repenning, et al., 1997c, p. 509). While this construct should be properly called "employment security" in the case of DTE Energy, I keep the Analog Devices' name "job security" for continuity and because it is less cumbersome. *Job Security* is defined as an index variable, ranging from zero to one, indicating the degree to which front-line employees feel they are safe from the possibility of being laid off or being pressured to take a voluntary buy-out. Employees derive this feeling of (in)security from their perception of the prevailing rate of downsizing throughout the company. In this model, I assume that middle managers and senior executives never feel job insecurity.

```
Job Security[FL]= Job Security from Downsizing Fn(Memory of
     Downsizing[FL]/Reference Fractional Downsizing Rate)
Job Security[MM]= 1
Job Security[SE]= 1
Units: Dmnl [0,1]
```

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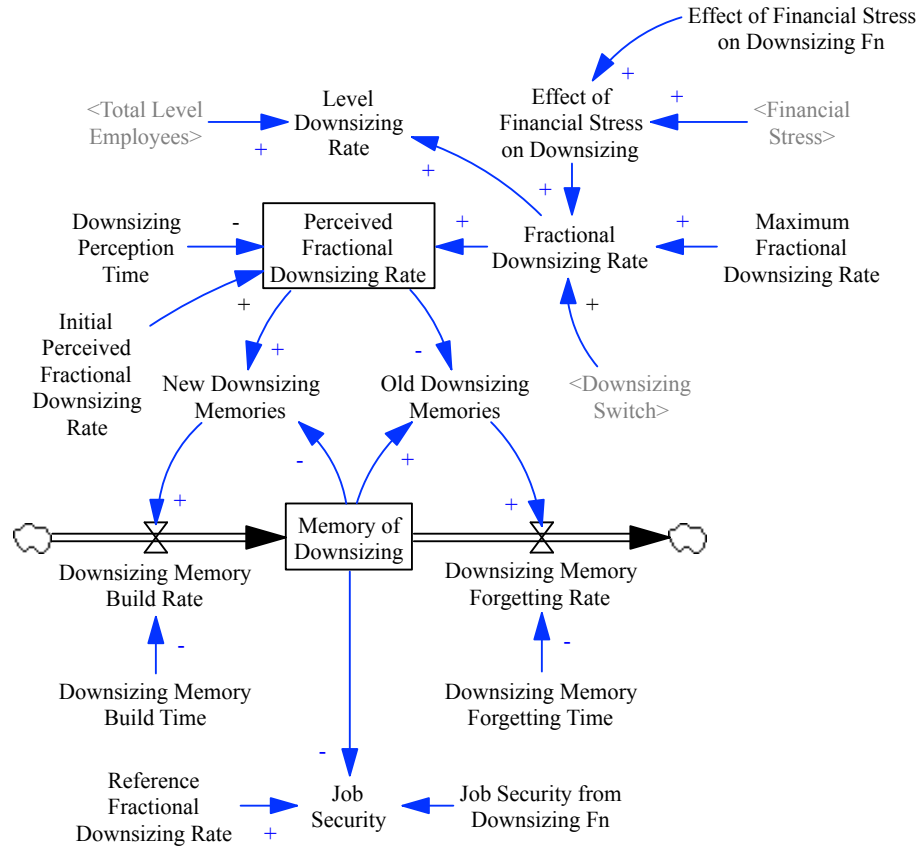
Figure 25. Model Diagram of Job Security

Changes to employees' aggregate *Memory of Downsizing* stock reflect a ratchet effect. Employees' memory of downsizing, like distrust, fades only when there is no downsizing for a long period of time. I define employees' *Old Downsizing Memories* as the amount, if any, by which their *Memory of Downsizing* exceeds their perception of the company's current (fractional) downsizing rate. I model employees' forgetting these old memories with first-order exponential decay.

```
Memory of Downsizing[level]= INTEG(
     + Downsizing Memory Build Rate[level]
     - Downsizing Memory Forgetting Rate[level]
     , Initial Perceived Fractional Downsizing Rate[level])
Units: Fraction/Month

Downsizing Memory Forgetting Rate[level]= Old Downsizing
     Memories[level]/Downsizing Memory Forgetting Time
Units: (Fraction/Month)/Month

Old Downsizing Memories[level]= MAX(Memory of Downsizing[level] -
     Perceived Fractional Downsizing Rate[level], 0)
```

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```
Units: Fraction/Month
```

By contrast, employees are extremely quick to increase their *Memory of Downsizing* to their perception of the company's current (fractional) downsizing rate if the current rate is higher. I define employees' *New Downsizing Memories* as the amount, if any, by which their perception of the current (fractional) downsizing rate exceeds their *Memory of Downsizing*. I model employees' building these new memories with first-order exponential smoothing.

```
Downsizing Memory Build Rate[level]= New Downsizing
    Memories[level]/Downsizing Memory Build Time
Units: (Fraction/Month)/Month

New Downsizing Memories[level]= MAX(Perceived Fractional
    Downsizing Rate[level] - Memory of Downsizing[level], 0)
Units: Fraction/Month
```

I assume that senior executives decide to use downsizing to cut costs as a response to the financial stress on the company. DTE Energy's senior executives made such a decision only once in the 12-year span that I studied, and it lasted for only a short duration. For simplicity, I assume that employees, somewhat unrealistically, perceive the company-wide downsizing rate rather than the downsizing rate local to their respective power plants, service stations, or other business locations. I model this perception process with first-order exponential smoothing.

```
Downsizing Switch= PULSE(Downsizing Start Date, Downsizing
    Duration)
Units: Dmnl [0,1,1]

Effect of Financial Stress on Downsizing= Effect of Financial
    Stress on Downsizing Fn(Financial Stress)
Units: Dmnl [0,1]

Fractional Downsizing Rate[level]= Maximum Fractional Downsizing
    Rate[level]*Effect of Financial Stress on
    Downsizing*Downsizing Switch
Units: Fraction/Month

Perceived Fractional Downsizing Rate[level]= SMOOTHI(Fractional
    Downsizing Rate[level], Downsizing Perception Time, Initial
    Perceived Fractional Downsizing Rate[level])
Units: Fraction/Month
```

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The downsizing rate is one component of the employee attrition rate defined in section 5.1 (p.137).

```
Level Downsizing Rate[level]= Total Level
     Employees[level]*Fractional Downsizing Rate[level]
Units: Person/Month
```

Parameters for Job Security

This lookup function for employees' job security, arising from their (normalized) memory of downsizing, was taken from Repenning and Sterman (1994b, p. 93). (Repenning and Sterman called it "Company Commitment to Job Security".)

```
Job Security from Downsizing Fn([(0,0)-
     (10,1)],(0,1),(1,0.38),(2,0.18),(3,0.085),(4,0.045),(5,0.025),
     (6,0.01),(7,0.005),(8,0),(9,0),(10,0))
Units: Dmnl [0,1]
```
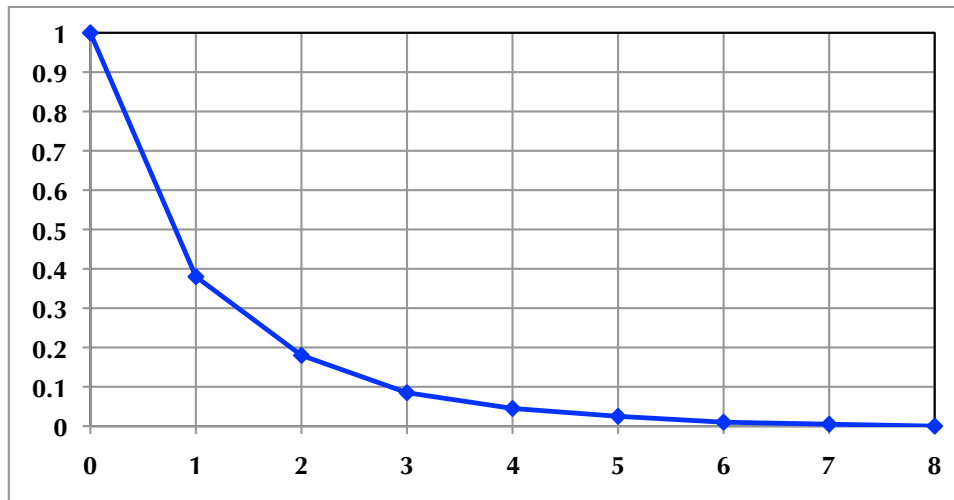

Figure 26. Lookup Function: Job Security from Downsizing Fn

```
Reference Fractional Downsizing Rate= 0.001
Units: Fraction/Month
```

These time constants for the building and forgetting of downsizing memory were also taken from Repenning and Sterman (1994b, p. 94).

```
Downsizing Memory Forgetting Time= 90
Units: Month
```

```
Downsizing Memory Build Time= 1
Units: Month

Downsizing Perception Time= 3
Units: Month

Downsizing Start Date= 108
Units: Month

Downsizing Duration= 12
Units: Month

Initial Perceived Fractional Downsizing Rate[level]= 0,0,0
Units: Fraction/Month
```

I assume that as the financial stress faced by the company increases from 0 to 1, the senior executives are willing to increase the fractional downsizing rate from zero to the *Maximum Fractional Downsizing Rate*.

```
Effect of Financial Stress on Downsizing Fn([(0,0)-
    (1,1)],(0,0),(0.5,0.03),(0.75,0.14),(0.9,0.4),(1,1))
Units: Dmnl [0,1]
```
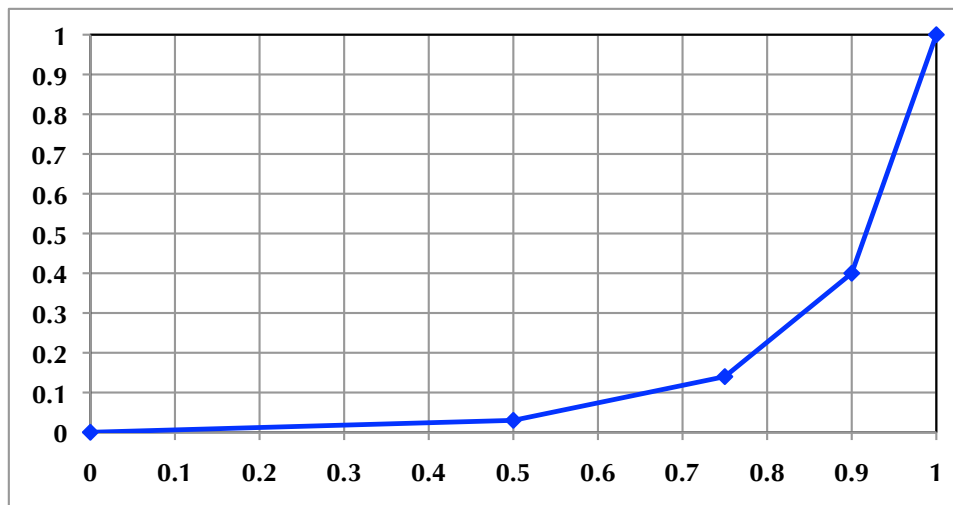

Figure 27. Lookup Function: Effect of Financial Stress on Downsizing Fn

```
Maximum Fractional Downsizing Rate[level]= 0,0.004,0.004
Units: Fraction/Month
```

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5.10. Convincing Rates

At its core, this model is a diffusion model. Its main dynamics arise from neutral and skeptical employees having experiences that convince them to become believers (described in this section), and believers and neutrals having experiences that disillusion them to become skeptics (described in section 5.11, p.195).

In this model, I include three different mechanisms whereby neutral and skeptical employees are convinced to become believers. Two of these mechanisms, positive word of mouth (PWOM) and training, are analogous to the two mechanisms[7] that constitute the classic Bass diffusion model (Bass, 1969). I add a third mechanism: Employees forming an opinion about CI for the first time after participating in their first CI activity. I call their rate of forming these first impressions their "CI trials" rate. (Because of a small non-zero rate of believers and skeptics reverting to neutrals (see section 5.1, p.137), these employees can have another "first" experience with CI. In other words, the CI proponents do have another chance to make a "first" impression.)

---

[7] Bass (1969, p. 217) calls these two mechanisms "imitation" and "innovation", respectively.
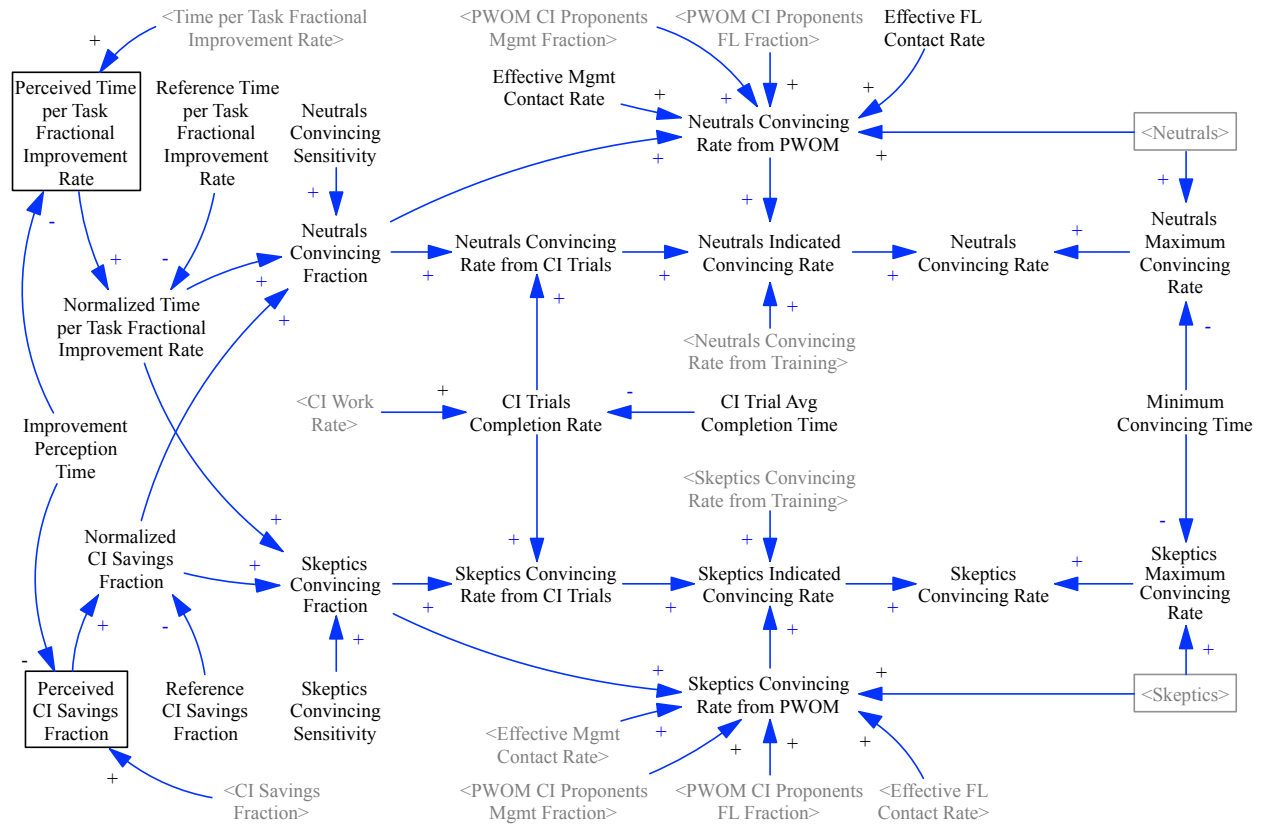
Figure 28. Model Diagram of Convincing Rates

The use of maximum convincing rates in the formulations for *Neutrals Convincing Rate* and *Skeptics Convincing Rate* ensures first-order control on the convinced-employee outflows from the stocks of *Neutrals* and *Skeptics*, respectively.

```
Neutrals Indicated Convincing Rate[level]= Neutrals Convincing
    Rate from CI Trials[level] + Neutrals Convincing Rate from
    PWOM[level] + Neutrals Convincing Rate from Training[level]
Units: Person/Month

Skeptics Indicated Convincing Rate[level]= Skeptics Convincing
    Rate from CI Trials[level] + Skeptics Convincing Rate from
    PWOM[level] + Skeptics Convincing Rate from Training[level]
Units: Person/Month

Neutrals Convincing Rate[level]= MIN(Neutrals Indicated Convincing
    Rate[level], Neutrals Maximum Convincing Rate[level])
Units: Person/Month

Skeptics Convincing Rate[level]= MIN(Skeptics Indicated Convincing
    Rate[level], Skeptics Maximum Convincing Rate[level])
Units: Person/Month
```

```
Neutrals Maximum Convincing Rate[level]= Neutrals[level]/Minimum
    Convincing Time
Units: Person/Month

Skeptics Maximum Convincing Rate[level]= Skeptics[level]/Minimum
    Convincing Time
Units: Person/Month
```

I assume that all regular employees form their own initial opinions about CI after participating in CI activities themselves for a certain duration. For simplicity, I assume that this duration is the same for every employee, no matter their belief state or level.

```
CI Trials Completion Rate[level,contributor]= CI Work
    Rate[level,contributor]/CI Trial Avg Completion Time
Units: Person/Month

Neutrals Convincing Rate from CI Trials[level]= CI Trials
    Completion Rate[level,Neu]*Neutrals Convincing Fraction[level]
Units: Person/Month

Skeptics Convincing Rate from CI Trials[level]= CI Trials
    Completion Rate[level,Ske]*Skeptics Convincing Fraction[level]
Units: Person/Month
```

I assume that the convincing function is the same for all employees and takes the form $Y = 1 - e^{\wedge}(-s*X)$, where Y is the probability of an employee being convinced, X is employees' (normalized) perception of their CI work improvement results, and s is how sensitive they are to the magnitude of their improvement results. Skeptics are less sensitive to a given level of improvement results than neutrals are, which means that they are harder to convince. I assume that front-line employees and managers care about different types of improvement results. Front-line employees care about only the rate at which their jobs get easier through improvements in process efficiency. Senior executives and middle managers care about only the CI savings (as a fraction of total costs) that hit the company's bottom line. I model employees' perceptions of these (average) improvement results using first-order exponential smoothing.

```
Neutrals Convincing Fraction[SE]= MAX(1-EXP(-Neutrals Convincing
    Sensitivity*Normalized CI Savings Fraction), 0)
Neutrals Convincing Fraction[MM]= MAX(1-EXP(-Neutrals Convincing
    Sensitivity*Normalized CI Savings Fraction), 0)
```

```
Neutrals Convincing Fraction[FL]= MAX(1-EXP(-Neutrals Convincing
    Sensitivity*Normalized Time per Task Fractional Improvement
    Rate[FL]), 0)
Units: Fraction [0,1]

Skeptics Convincing Fraction[SE]= MAX(1-EXP(-Skeptics Convincing
    Sensitivity*Normalized CI Savings Fraction), 0)
Skeptics Convincing Fraction[MM]= MAX(1-EXP(-Skeptics Convincing
    Sensitivity*Normalized CI Savings Fraction), 0)
Skeptics Convincing Fraction[FL]= MAX(1-EXP(-Skeptics Convincing
    Sensitivity*Normalized Time per Task Fractional Improvement
    Rate[FL]), 0)
Units: Fraction [0,1]

Normalized CI Savings Fraction= Perceived CI Savings
    Fraction/Reference CI Savings Fraction
Units: Dmnl

Perceived CI Savings Fraction= SMOOTH(CI Savings Fraction,
    Improvement Perception Time)
Units: Fraction

Normalized Time per Task Fractional Improvement Rate[level]=
    Perceived Time per Task Fractional Improvement
    Rate[level]/Reference Time per Task Fractional Improvement
    Rate
Units: Dmnl

Perceived Time per Task Fractional Improvement Rate[level]=
    SMOOTH(Time per Task Fractional Improvement Rate[level],
    Improvement Perception Time)
Units: Fraction/Month
```

My formulation for the convincing rates from positive word of mouth (PWOM) mirrors the classic infection-rate formulation typically used in models of disease epidemiology (see Sterman, 2000, p. 302). For example, neutral employees (the susceptible population) come into contact with other employees at a certain rate (the contact rate). A fraction of those contacts will be with employees who are CI proponents (the infectious population). The probability that a CI proponent convinces (infects) a neutral employee is the convincing fraction (infectivity). Note that this formulation implies perfect mixing of employees: each employee has an equal probability of coming into contact with any other employee. I adopt this perfect-mixing assumption for convenience, despite its descriptive inaccuracy. For simplicity, I use the same convincing fractions from the CI trial convincing rates above. My usage of these same convincing

fractions, however, implies specific definitions of the contact rates: they are interactions among employees where their communication is effective enough to be equivalent to a CI trial.

```
Neutrals Convincing Rate from PWOM[SE]= Neutrals[SE]*Effective
    Mgmt Contact Rate*CI Proponents Mgmt Fraction*Neutrals
    Convincing Fraction[SE]
Neutrals Convincing Rate from PWOM[MM]= Neutrals[MM]*Effective
    Mgmt Contact Rate*CI Proponents Mgmt Fraction*Neutrals
    Convincing Fraction[MM]
Neutrals Convincing Rate from PWOM[FL]= Neutrals[FL]*Effective FL
    Contact Rate*CI Proponents FL Fraction*Neutrals Convincing
    Fraction[FL]
Units: Person/Month

Skeptics Convincing Rate from PWOM[SE]= Skeptics[SE]*Effective
    Mgmt Contact Rate*CI Proponents Mgmt Fraction*Skeptics
    Convincing Fraction[SE]
Skeptics Convincing Rate from PWOM[MM]= Skeptics[MM]*Effective
    Mgmt Contact Rate*CI Proponents Mgmt Fraction*Skeptics
    Convincing Fraction[MM]
Skeptics Convincing Rate from PWOM[FL]= Skeptics[FL]*Effective FL
    Contact Rate*CI Proponents FL Fraction*Skeptics Convincing
    Fraction[FL]
Units: Person/Month
```

Based on my case study of DTE Energy, I model the possible PWOM CI proponents for the front-line employees differently from the possible PWOM CI proponents for the middle managers and senior executives. Managers can be convinced by CI proponents — believers and Black Belt program participants (see section 5.1, p.137) — from both of their two levels of the company hierarchy. Front-line employees, on the other hand, are convinced only by their believer colleagues. They disregard any positive word of mouth from management or from Black Belt program participants.

```
PWOM CI Proponents Mgmt Fraction= ZIDZ(CI Proponents[SE] + CI
    Proponents[MM], Total Level Employees[SE] + Total Level
    Employees[MM])
Units: Fraction [0,1]

PWOM CI Proponents FL Fraction= ZIDZ(CI Proponents[FL] - BB
    Program Participants[FL], Total Level Employees[FL])
Units: Fraction [0,1]
```

The rate at which employees are convinced by training is analogous to their

convincing rate from CI trials. The fraction of trainees convinced by training is equal to the ratio of the training hours required to convince one employee to the number of hours of a typical training course. Note that the senior executive training rates are, by definition, zero for the other levels of the company hierarchy (see section 5.21, p.234).

```
Neutrals Convincing Rate from Training[level]= Neutrals GB
    Training Rate[level]/GB Training to Convince Neutrals +
    Neutrals SE Training Rate[level]/SE Training to Convince
    Neutrals
Units: Person/Month

Skeptics Convincing Rate from Training[level]= Skeptics GB
    Training Rate[level]/GB Training to Convince Skeptics +
    Skeptics SE Training Rate[level]/SE Training to Convince
    Skeptics
Units: Person/Month
```

Parameters for Convincing Rates

```
Minimum Convincing Time= 0.25
Units: Month
```

This parameter defines how many hours of CI work, on average, an employee must complete before he or she develops an opinion about CI, either favorable or unfavorable.

```
CI Trial Avg Completion Time= 96
Units: Person*Hours/Person
```

I assume that skeptics are twice as hard to convince as neutrals. Equivalently, skeptics require improvement results that are twice as good to be convinced at the same rate as neutrals.

```
Neutrals Convincing Sensitivity= 1
Units: Dmnl

Skeptics Convincing Sensitivity= 0.5
Units: Dmnl

Reference CI Savings Fraction= 0.002
Units: Fraction

Reference Time per Task Fractional Improvement Rate= -0.0005
Units: Fraction/Month
```

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```
Improvement Perception Time= 1
Units: Month
```

These contact-rate parameters represent employee interactions that are equivalent to a CI trial, rather than raw contact rates.

```
Effective Mgmt Contact Rate= 0.1
Units: (Person/Person)/Month

Effective FL Contact Rate= 0
Units: (Person/Person)/Month
```

I assume that the number of training hours required to convince an employee of a certain belief state is the same across all three levels of the company hierarchy. (Note, however, that only senior executives can receive SE training.)

```
GB Training to Convince Neutrals= 3200
Units: Person*Hours/Person

GB Training to Convince Skeptics= 1e+06
Units: Person*Hours/Person

SE Training to Convince Neutrals= 100
Units: Person*Hours/Person

SE Training to Convince Skeptics= 200
Units: Person*Hours/Person
```

5.11. Disillusioning Rates

The formulations for believers' and neutrals' disillusioning rates mirror those for the convincing rates in section 5.10 (p.189), but with a few minor differences. I assume that training can never disillusion employees. Only negative first experiences with CI — i.e., disappointing CI trials — and negative word of mouth (NWOM) from skeptics can disillusion employees.

```
Believers Indicated Disillusioning Rate[level]= Believers
    Disillusioning Rate from CI Trials[level] + Believers
    Disillusioning Rate from NWOM[level]
Units: Person/Month
```

```
Neutrals Indicated Disillusioning Rate[level]= Neutrals
     Disillusioning Rate from CI Trials[level] + Neutrals
     Disillusioning Rate from NWOM[level]
Units: Person/Month
```
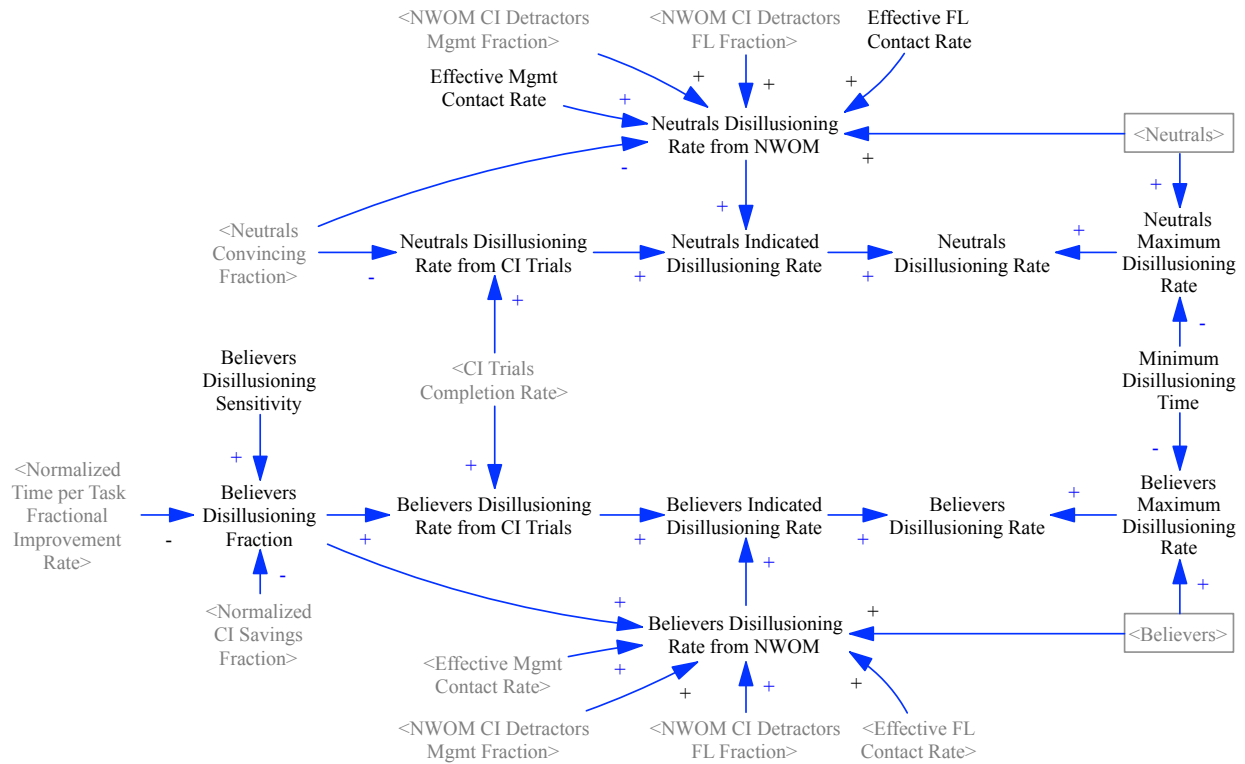

Figure 29. Model Diagram of Disillusioning Rates

The use of maximum convincing rates in the formulations for *Believers Disillusioning Rate* and *Neutrals Disillusioning Rate* ensures first-order control on the disillusioned-employee outflows from the stocks of *Believers* and *Neutrals*, respectively.

```
Believers Disillusioning Rate[level]= MIN(Believers Indicated
     Disillusioning Rate[level], Believers Maximum Disillusioning
     Rate[level])
Units: Person/Month

Neutrals Disillusioning Rate[level]= MIN(Neutrals Indicated
     Disillusioning Rate[level], Neutrals Maximum Disillusioning
     Rate[level])
Units: Person/Month

Believers Maximum Disillusioning Rate[level]=
     Believers[level]/Minimum Disillusioning Time
Units: Person/Month
```

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```
Neutrals Maximum Disillusioning Rate[level]=
    Neutrals[level]/Minimum Disillusioning Time
Units: Person/Month
```

I assume that all the neutrals who were not convinced by their CI trials are disillusioned. In other words, employees form a definite opinion about CI after their CI trial activity, becoming either a believer or a skeptic; they do not remain neutral. I define employees' disillusioning fraction as the fractional complement of their convincing fraction.

```
Believers Disillusioning Rate from CI Trials[level]= CI Trials
    Completion Rate[level,Bel]*Believers Disillusioning
    Fraction[level]
Units: Person/Month

Neutrals Disillusioning Rate from CI Trials[level]= CI Trials
    Completion Rate[level,Neu]*(1-Neutrals Convincing
    Fraction[level])
Units: Person/Month
```

I define the believers' disillusioning fraction to be the fractional complement of the convincing fraction in section 5.10 (p.189): $Y = e^{\wedge}(-s*X)$, where Y is the probability of an employee being disillusioned, X is employees' (normalized) perception of their CI work improvement results, and s is how sensitive they are to the magnitude of their improvement results. I assume that it is equally as hard for CI detractors to disillusion believers as it is for CI proponents to convince skeptics.

```
Believers Disillusioning Fraction[SE]= MIN(EXP(-Believers
    Disillusioning Sensitivity*Normalized CI Savings Fraction), 1)
Believers Disillusioning Fraction[MM]= MIN(EXP(-Believers
    Disillusioning Sensitivity*Normalized CI Savings Fraction), 1)
Believers Disillusioning Fraction[FL]= MIN(EXP(-Believers
    Disillusioning Sensitivity*Normalized Time per Task Fractional
    Improvement Rate[FL]), 1)
Units: Fraction [0,1]
```

I formulate negative word of mouth (NWOM) the same way as I formulated positive word of mouth in section 5.10 (p.189). The difference, of course, is employees coming into contact with CI detractors — all of whom are skeptics — who induce them to become skeptics themselves.

```
Believers Disillusioning Rate from NWOM[SE]=
    Believers[SE]*Effective Mgmt Contact Rate*CI Detractors Mgmt
    Fraction*Believers Disillusioning Fraction[SE]
Believers Disillusioning Rate from NWOM[MM]=
    Believers[MM]*Effective Mgmt Contact Rate*CI Detractors Mgmt
    Fraction*Believers Disillusioning Fraction[MM]
Believers Disillusioning Rate from NWOM[FL]=
    Believers[FL]*Effective FL Contact Rate*CI Detractors FL
    Fraction*Believers Disillusioning Fraction[FL]
Units: Person/Month

Neutrals Disillusioning Rate from NWOM[SE]= Neutrals[SE]*Effective
    Mgmt Contact Rate*CI Detractors Mgmt Fraction*(1-Neutrals
    Convincing Fraction[SE])
Neutrals Disillusioning Rate from NWOM[MM]= Neutrals[MM]*Effective
    Mgmt Contact Rate*CI Detractors Mgmt Fraction*(1-Neutrals
    Convincing Fraction[MM])
Neutrals Disillusioning Rate from NWOM[FL]= Neutrals[FL]*Effective
    FL Contact Rate*CI Detractors FL Fraction*(1-Neutrals
    Convincing Fraction[FL])
Units: Person/Month
```

Just as with positive word of mouth (section 5.10, p.189), I assume that senior executives and middle managers are influenced by each other but not by front-line employees. Front-line employees, for their part, are influenced only by their front-line colleagues, not their bosses.

```
NWOM CI Detractors Mgmt Fraction= ZIDZ(Skeptics[SE] +
    Skeptics[MM], Total Level Employees[SE] + Total Level
    Employees[MM])
Units: Fraction [0,1]

NWOM CI Detractors FL Fraction= ZIDZ(Skeptics[FL], Total Level
    Employees[FL])
Units: Fraction [0,1]
```

Parameters for Disillusioning Rates

```
Minimum Disillusioning Time= 0.25
Units: Month
```

I assume that it is equally as hard for CI detractors to disillusion believers as it is for CI proponents to convince skeptics.

```
Believers Disillusioning Sensitivity= 2
Units: Dmnl
```

5.12. Black Belt States

The definitions for three of the six employee stocks were given in section 5.1 (p.137).

The remaining three stocks pertain to the Black Belt program:

```
Black Belt Trainees[level]= INTEG(
    + BB Trainee Enrolling Rate[level]
    - BB Trainee Attrition Rate[level]
    - BB Trainee Dropout Rate[level]
    - BB Training Completion Rate[level]
    , 0)
Units: Person

Black Belt Candidates[level]= INTEG(
    + BB Training Completion Rate[level]
    - BB Candidate Attrition Rate[level]
    - BB Candidate Dropout Rate[level]
    - BB Certification Rate[level]
    , 0)
Units: Person

Black Belts[level]= INTEG(
    + BB Certification Rate[level]
    + BB Hire Rate[level]
    - BB Attrition Rate[level]
    - BB Dropout Rate[level]
    - BB Promotion Rate from Black Belts[level]
    , Initial Black Belts[level])
Units: Person
```
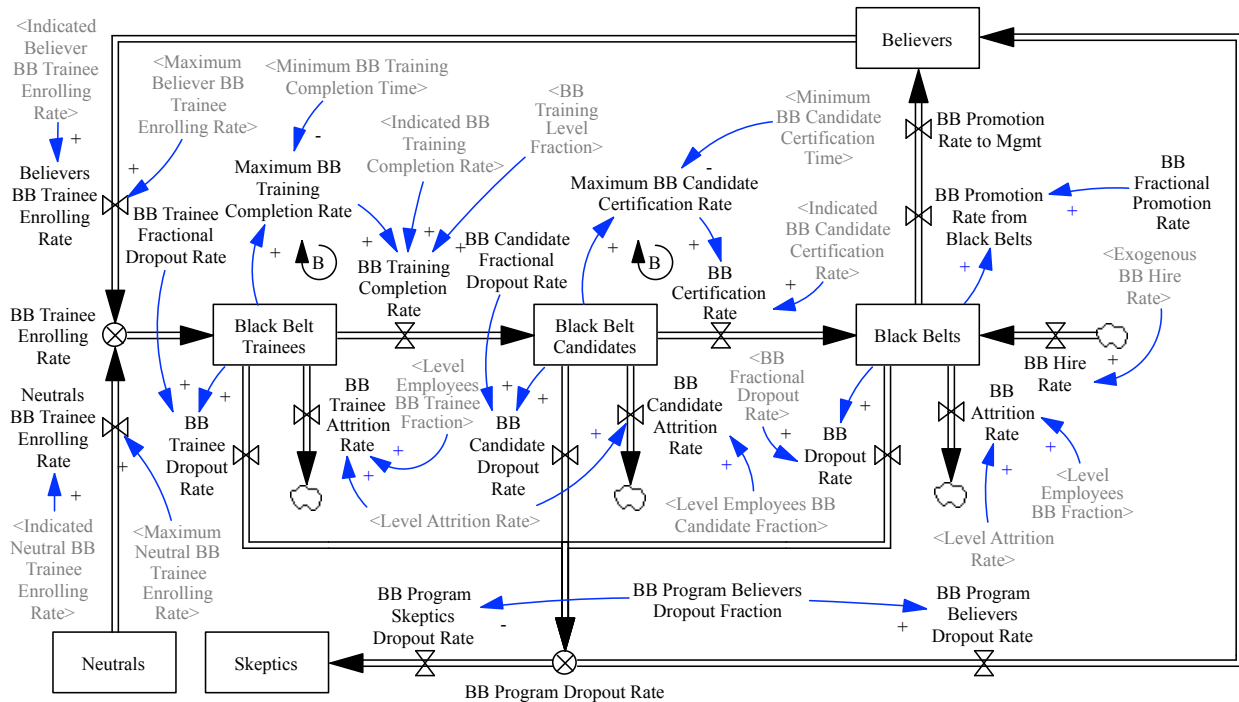
Figure 30. Model Diagram of Black Belt States

Because *Level Attrition Rate* is defined for an entire level of the company hierarchy, I allocate a fraction of this outflow to each of the employee-state stocks, proportional to each stock's size relative to the total.

```
Level Employees BB Trainee Fraction[level]= ZIDZ(Black Belt
    Trainees[level], Total Level Employees[level])
Units: Fraction [0,1]

Level Employees BB Candidate Fraction[level]= ZIDZ(Black Belt
    Candidates[level], Total Level Employees[level])
Units: Fraction [0,1]

Level Employees BB Fraction[level]= ZIDZ(Black Belts[level], Total
    Level Employees[level])
Units: Fraction [0,1]

BB Trainee Attrition Rate[level]= Level Attrition
    Rate[level]*Level Employees BB Trainee Fraction[level]
Units: Person/Month

BB Candidate Attrition Rate[level]= Level Attrition
    Rate[level]*Level Employees BB Candidate Fraction[level]
Units: Person/Month
```

```
BB Attrition Rate[level]= Level Attrition Rate[level]*Level
     Employees BB Fraction[level]
Units: Person/Month
```

Employees may drop out of the Black Belt program at any of its three stages.

```
BB Fractional Dropout Rate= Exogenous BB Fractional Dropout
     Rate*(1-Constant BB Fractional Dropout Switch) + Constant BB
     Fractional Dropout Rate*Constant BB Fractional Dropout Switch
Units: Fraction/Month

BB Trainee Dropout Rate[level]= Black Belt Trainees[level]*BB
     Trainee Fractional Dropout Rate
Units: Person/Month

BB Candidate Dropout Rate[level]= Black Belt Candidates[level]*BB
     Candidate Fractional Dropout Rate
Units: Person/Month

BB Dropout Rate[level]= Black Belts[level]*BB Fractional Dropout
     Rate
Units: Person/Month

BB Program Dropout Rate[level]= BB Trainee Dropout Rate[level] +
     BB Candidate Dropout Rate[level] + BB Dropout Rate[level]
Units: Person/Month
```

I assume that employees who drop out of the Black Belt program have definite attitudes toward CI; that is, they do not become neutrals. I also assume that the fraction of believer dropouts is the same across all three types of Black Belt program participants (trainees, candidates, and certified Black Belts).

```
BB Program Believers Dropout Rate[level]= BB Program Dropout
     Rate[level]*BB Program Believers Dropout Fraction
Units: Person/Month

BB Program Skeptics Dropout Rate[level]= BB Program Dropout
     Rate[level]*(1-BB Program Believers Dropout Fraction)
Units: Person/Month
```

Employees from the stocks of believers and neutrals may enroll in Black Belt training as the first step toward becoming certified Black Belts. See section 5.15 (p.215) for the definitions of these enrolling rates.

```
BB Trainee Enrolling Rate[level]= Believers BB Trainee Enrolling
    Rate[level] + Neutrals BB Trainee Enrolling Rate[level]
Units: Person/Month
```

The rate at which Black Belt candidates become Black Belts depends on the rate at which they complete their certification projects (see the equations for *Indicated BB Candidate Certification Rate* and *Minimum BB Candidate Certification Time* in section 5.18, p.225). The use of *Maximum BB Candidate Certification Rate* in the formulation for *BB Candidate Certification Rate* ensures first-order control on this outflow from the *Black Belt Candidates* stock.

```
BB Certification Rate[level]= MIN(Indicated BB Candidate
    Certification Rate[level], Maximum BB Candidate Certification
    Rate[level])
Units: Person/Month

Maximum BB Candidate Certification Rate[level]= Black Belt
    Candidates[level]/Minimum BB Candidate Certification Time
Units: Person/Month
```

When Black Belts are promoted up the company hierarchy, they leave the stock of Black Belts at their former level (as specified by the equation below) and join the stock of believers at one level higher (see the equation for *BB Promotion Rate to Mgmt* in section 5.1, p.137).

```
BB Promotion Rate from Black Belts[level]= Black Belts[level]*BB
    Fractional Promotion Rate[level]
Units: Person/Month
```

Certified Black Belts are hired from other companies after the start of the Black Belt program.

```
BB Hire Rate[level]= Exogenous BB Hire Rate[level]*(1-Constant BB
    Hire Switch) + Constant BB Hire Rate[level]*Constant BB Hire
    Switch
Units: Person/Month

Constant BB Hire Switch= 0
Units: Dmnl [0,1,1]

Constant BB Hire Rate[level]= 0,0,0.54
Units: Person/Month
```

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The average time that Black Belt trainees take to complete their training course is required to determine the rate at which they accumulate CI experience from it (see section 5.13, p.204). I compute this average completion time using Little's Law (Little, 1961), which I acknowledge is strictly true only in equilibrium.

```
BB Trainee Avg Completion Time[level]= ZIDZ(Black Belt
    Trainees[level], BB Training Completion Rate[level])
Units: Month
```

The following variables are various counts of Black Belt program participants used elsewhere in the model or for output.

```
BB Program Participants[level]= Black Belts[level] + Black Belt
    Candidates[level] + Black Belt Trainees[level]
Units: Person

Total BB Program Participants= SUM(BB Program
    Participants[level!])
Units: Person

Total Black Belt Trainees= SUM(Black Belt Trainees[level!])
Units: Person

Total Black Belt Candidates= SUM(Black Belt Candidates[level!])
Units: Person

Total Black Belts= SUM(Black Belts[level!])
Units: Person

BB Level Fraction[level]= ZIDZ(Black Belts[level], Total Black
    Belts)
Units: Fraction [0,1]
```

Parameters for Black Belt States

```
Initial Black Belts[level]= 0,0,0
Units: Person

BB Trainee Fractional Dropout Rate= 0.01
Units: Fraction/Month

BB Candidate Fractional Dropout Rate= 0.1
Units: Fraction/Month
```

```
Exogenous BB Fractional Dropout Rate :HOLD BACKWARD::= GET XLS
    DATA(Excel File Name, Excel File Scenario Name, Excel File
    Time Row, 'C12')
Units: Fraction/Month

Constant BB Fractional Dropout Switch= 0
Units: Dmnl [0,1,1]

Constant BB Fractional Dropout Rate= 0
Units: Fraction/Month
```

I assume that the fraction of believer dropouts is the same across all three types of Black Belt program participants (trainees, candidates, and certified Black Belts). By definition, dropouts who are not believers are skeptics; I assume that dropouts are not neutral on CI.

```
BB Program Believers Dropout Fraction= 0.5
Units: Fraction [0,1]
```

I assume Black Belts are only promoted into middle management. Senior executive and middle manager Black Belts return to operational roles at their respective levels by dropping out of the Black Belt program.

```
BB Fractional Promotion Rate[level]= 0,0,0.0046
Units: Fraction/Month
```

Certified Black Belts are hired from other companies after the start of the Black Belt program.

```
Exogenous BB Hire Rate[level] :HOLD BACKWARD::= GET XLS DATA(Excel
    File Name, Excel File Scenario Name, Excel File Time Row,
    'C5')
Units: Person/Month
```

5.13. Black Belt CI Experience Co-flow

This model includes a co-flow structure, which mirrors the Black Belt program participants structure in section 5.12 (p.199), to track the aggregate person-hours of CI experience associated with each employee stock:

```
Black Belt Trainees CI Experience[level]= INTEG(
```

```
        + BB Trainee CI Experience Gain Rate[level]
        + BB Trainee Enrolling Rate CI Experience[level]
        - BB Trainee Attrition Rate CI Experience[level]
        - BB Trainee CI Experience Obsolescence Rate[level]
        - BB Trainee Dropout Rate CI Experience[level]
        - BB Training Completion Rate CI Experience[level]
        , 0)
Units: Person*Hours

Black Belt Candidates CI Experience[level]= INTEG(
        + BB Candidate CI Experience Gain Rate[level]
        + BB Training Completion Rate CI Experience[level]
        - BB Candidate Attrition Rate CI Experience[level]
        - BB Candidate CI Experience Obsolescence Rate[level]
        - BB Candidate Dropout Rate CI Experience[level]
        - BB Certification Rate CI Experience[level]
        , 0)
Units: Person*Hours

Black Belts CI Experience[level]= INTEG(
        + BB Certification Rate CI Experience[level]
        + BB CI Experience Gain Rate[level]
        + BB Hire Rate CI Experience[level]
        - BB CI Experience Obsolescence Rate[level]
        - BB Attrition Rate CI Experience[level]
        - BB Dropout Rate CI Experience[level]
        - BB Promotion Rate CI Experience[level]
        , Initial Black Belts CI Experience[level])
Units: Person*Hours

Initial Black Belts CI Experience[level]= Initial Black
        Belts[level]*Initial BB Average CI Experience
Units: Person*Hours
```
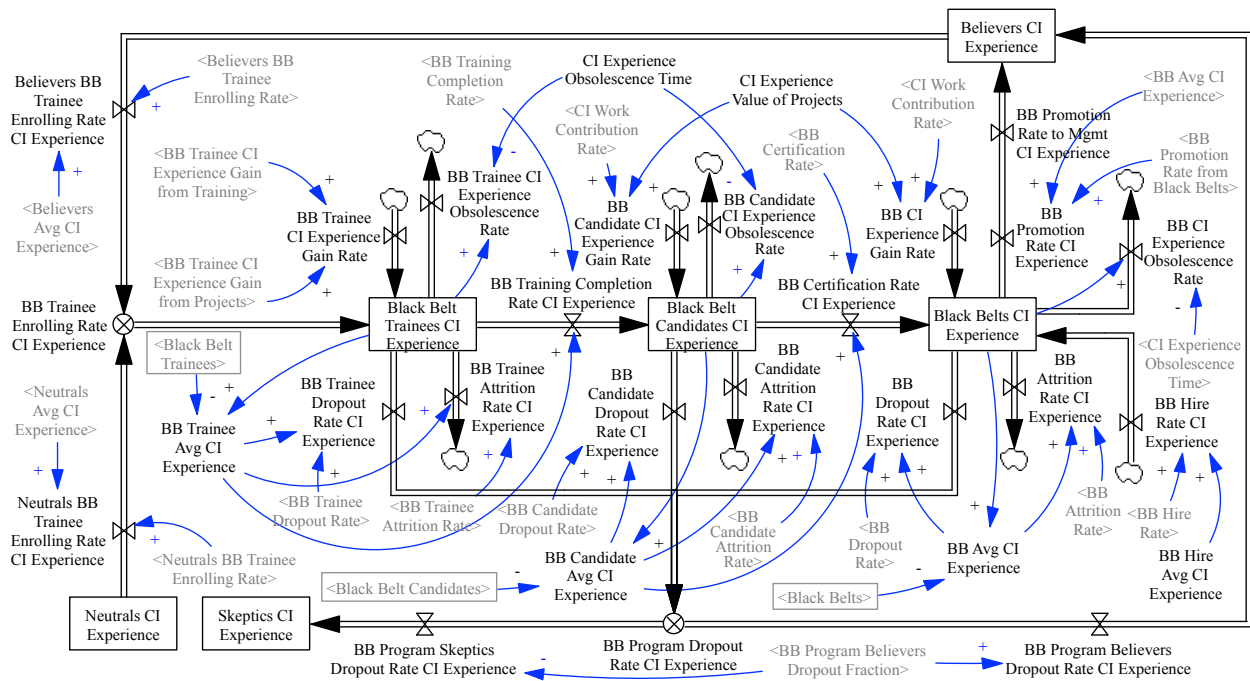
Figure 31. Model Diagram of Black Belt CI Experience Co-flow

This experience co-flow structure is used to compute the average CI experience of each type of Black Belt program participant. I assume that each participant possesses the average CI experience of all participants at the same stage of the Black Belt program:

```
BB Trainee Avg CI Experience[level]= ZIDZ(Black Belt Trainees CI
    Experience[level], Black Belt Trainees[level])
Units: Person*Hours/Person

BB Candidate Avg CI Experience[level]= ZIDZ(Black Belt Candidates
    CI Experience[level], Black Belt Candidates[level])
Units: Person*Hours/Person

BB Avg CI Experience[level]= ZIDZ(Black Belts CI
    Experience[level], Black Belts[level])
Units: Person*Hours/Person
```

When Black Belt program participants transition from one stage to the next, or back to the regular employee states of section 5.1 (p.137), they bring their (average) CI experience with them.

```
BB Trainee Attrition Rate CI Experience[level]= BB Trainee
    Attrition Rate[level]*BB Trainee Avg CI Experience[level]
Units: Person*Hours/Month
```

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```
BB Candidate Attrition Rate CI Experience[level]= BB Candidate
    Attrition Rate[level]*BB Candidate Avg CI Experience[level]
Units: Person*Hours/Month

BB Attrition Rate CI Experience[level]= BB Attrition
    Rate[level]*BB Avg CI Experience[level]
Units: Person*Hours/Month

BB Trainee Dropout Rate CI Experience[level]= BB Trainee Dropout
    Rate[level]*BB Trainee Avg CI Experience[level]
Units: Person*Hours/Month

BB Candidate Dropout Rate CI Experience[level]= BB Candidate
    Dropout Rate[level]*BB Candidate Avg CI Experience[level]
Units: Person*Hours/Month

BB Dropout Rate CI Experience[level]= BB Dropout Rate[level]*BB
    Avg CI Experience[level]
Units: Person*Hours/Month

BB Program Dropout Rate CI Experience[level]= BB Trainee Dropout
    Rate CI Experience[level] + BB Candidate Dropout Rate CI
    Experience[level] + BB Dropout Rate CI Experience[level]
Units: Person*Hours/Month

BB Program Believers Dropout Rate CI Experience[level]= BB Program
    Dropout Rate CI Experience[level]*BB Program Believers Dropout
    Fraction
Units: Person*Hours/Month

BB Program Skeptics Dropout Rate CI Experience[level]= BB Program
    Dropout Rate CI Experience[level]*(1-BB Program Believers
    Dropout Fraction)
Units: Person*Hours/Month

BB Training Completion Rate CI Experience[level]= BB Training
    Completion Rate[level]*BB Trainee Avg CI Experience[level]
Units: Person*Hours/Month

BB Certification Rate CI Experience[level]= BB Certification
    Rate[level]*BB Candidate Avg CI Experience[level]
Units: Person*Hours/Month

BB Promotion Rate CI Experience[level]= BB Promotion Rate from
    Black Belts[level]*BB Avg CI Experience[level]
Units: Person*Hours/Month
```

Similarly, hired Black Belts join the company with their (average) CI experience.

```
BB Hire Rate CI Experience[level]= BB Hire Rate[level]*BB Hire Avg
    CI Experience
```

```
Units: Person*Hours/Month

BB Hire Avg CI Experience= Exogenous BB Hire Avg CI Experience*(1-
    Constant BB Hire Avg CI Experience Switch) + Constant BB Hire
    Avg CI Experience*Constant BB Hire Avg CI Experience Switch
Units: Person*Hours/Person
```

Both believers and neutrals can enroll in Black Belt training (section 5.15, p.215), so both types of employees bring their prior CI experience (see section 5.2, p.144) with them to the Black Belt program.

```
BB Trainee Enrolling Rate CI Experience[level]= Believers BB
    Trainee Enrolling Rate CI Experience[level] + Neutrals BB
    Trainee Enrolling Rate CI Experience[level]
Units: Person*Hours/Month
```

This experience co-flow is non-conserved. Black Belt program participants gain additional CI experience from attending training and by doing CI projects. Also, I assume that employees' CI experience becomes obsolete via first-order exponential decay. Therefore, employees must continually replenish their CI experience by participating in CI activities. I allow for the descriptively accurate possibility that CI experience gained from training is not as valuable as CI experience gained through hands-on participation in CI projects.

```
BB Trainee CI Experience Gain Rate[level]= BB Trainee CI
    Experience Gain from Training[level] + BB Trainee CI
    Experience Gain from Projects[level]
Units: Person*Hours/Month

BB Trainee CI Experience Gain from Training[level]= ZIDZ(Black
    Belt Trainees[level]*BB Training Classroom Hours*CI Experience
    Value of BB Training, BB Trainee Avg Completion Time[level])
Units: Person*Hours/Month

BB Trainee CI Experience Gain from Projects[level]= CI Work
    Contribution Rate[level,BBt]*CI Experience Value of Projects
Units: Person*Hours/Month

BB Candidate CI Experience Gain Rate[level]= CI Work Contribution
    Rate[level,BBc]*CI Experience Value of Projects
Units: Person*Hours/Month
```

```
BB CI Experience Gain Rate[level]= CI Work Contribution
     Rate[level,BB]*CI Experience Value of Projects
Units: Person*Hours/Month

BB Trainee CI Experience Obsolescence Rate[level]= Black Belt
     Trainees CI Experience[level]/CI Experience Obsolescence Time
Units: Person*Hours/Month

BB Candidate CI Experience Obsolescence Rate[level]= Black Belt
     Candidates CI Experience[level]/CI Experience Obsolescence
     Time
Units: Person*Hours/Month

BB CI Experience Obsolescence Rate[level]= Black Belts CI
     Experience[level]/CI Experience Obsolescence Time
Units: Person*Hours/Month
```

Parameters for Black Belt Experience Co-flow

```
Initial BB Average CI Experience= 1056
Units: Person*Hours/Person

Exogenous BB Hire Avg CI Experience :HOLD BACKWARD::= GET XLS
     DATA(Excel File Name, Excel File Scenario Name, Excel File
     Time Row, 'C9')
Units: Person*Hours/Person

Constant BB Hire Avg CI Experience Switch= 0
Units: Dmnl [0,1,1]

Constant BB Hire Avg CI Experience= 4160
Units: Person*Hours/Person
```

I assume that the CI experience gained from training is less than the CI experience gained from CI projects.

```
CI Experience Value of BB Training= 0.3
Units: Fraction [0,1]
```

5.14. Coaching by Black Belts

To be as effective as high-skill employees, low-skill employees require a certain amount of coaching by Black Belts to compensate for their low CI skill. For simplicity, I define this required coaching as a certain number of (fractional) work-hours of Black Belt coaching for every employee hour of CI project work. As their skill increases, employees

need fewer work-hours of coaching for each of their CI project work-hours.

```
FL Projects Required BB Coaching[level,regEmployees]= CI Work
    Rate[level,regEmployees]*FL Projects Baseline Fractional
    Required BB Coaching[regEmployees]*Effect of Contributors
    Skill on Required Coaching[level,regEmployees]
Units: Person*Hours/Month

Effect of Contributors Skill on Required
    Coaching[level,contributor]= Effect of Contributors Skill on
    Required Coaching Fn(Contributors
    Skill[level,contributor]/Reference Skill)
Units: Fraction [0,1]

Total Required BB Coaching= SUM(FL Projects Required BB
    Coaching[level!,regEmployees!])
Units: Person*Hours/Month
```
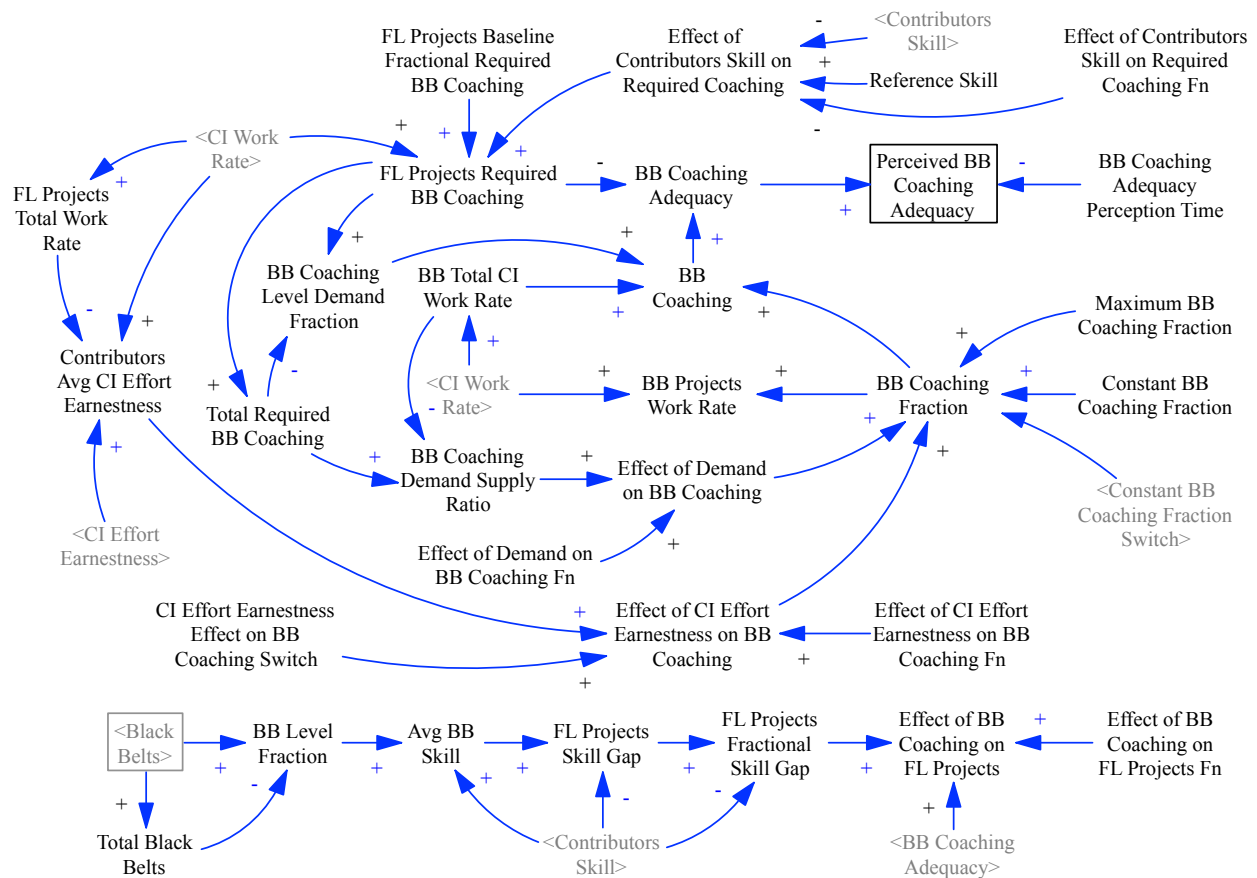

Figure 32. Model Diagram of Coaching by Black Belts

Black Belts must decide what fraction of their CI work they will allocate to coaching employees; they spend the rest of their CI work time on their own Black Belt projects. I

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assume that Black Belts make this allocation decision based on two factors: (1) employees' demand for their coaching time relative to their total time available for CI work, and (2) their assessment of employees' average CI effort earnestness. Blacks Belts, as specially trained CI experts, typically command a salary premium and, in return, are expected to "pay for themselves" with CI project improvement gains. This incentive means that Black Belts have a bias against coaching. Furthermore, they definitely do not want to coach employees who are simply "going through the motions" of CI work with low CI effort earnestness. *BB Total CI Work Rate* is computed in section 5.6 (p.163) and *Contributors Avg CI Effort Earnestness* is computed in section 5.7 (p.172). The *kaizen* facilitators, by contrast, dedicated 100 percent of their time to coaching front-line *kaizen* event teams until they were replaced by OS Experts about July 2002.

```
BB Coaching Demand Supply Ratio= XIDZ(Total Required BB Coaching,
     BB Total CI Work Rate, 1e+06)
Units: Dmnl

Effect of Demand on BB Coaching= Effect of Demand on BB Coaching
     Fn(BB Coaching Demand Supply Ratio)
Units: Fraction [0,1]

Effect of CI Effort Earnestness on BB Coaching= Effect of CI
     Effort Earnestness on BB Coaching Fn(Contributors Avg CI
     Effort Earnestness)*CI Effort Earnestness Effect on BB
     Coaching Switch + (1-CI Effort Earnestness Effect on BB
     Coaching Switch)
Units: Fraction [0,1]

BB Coaching Fraction= Maximum BB Coaching Fraction*Effect of
     Demand on BB Coaching*Effect of CI Effort Earnestness on BB
     Coaching*(1-Constant BB Coaching Fraction Switch) + Constant
     BB Coaching Fraction*Constant BB Coaching Fraction Switch
Units: Fraction [0,1]

Constant BB Coaching Fraction Switch= PULSE(Constant BB Coaching
     Start Date, Constant BB Coaching Duration)
Units: Dmnl [0,1,1]
```

I assume that senior executives and middle managers who are supporting CI work on the front lines require coaching time from the Black Belts in the same way that the front-line employees do. For simplicity, I assume that Black Belts allocate their coaching time

to each employee group according to each group's coaching demand relative to the total coaching demand.

```
BB Coaching Level Demand Fraction[level,regEmployees]= ZIDZ(FL
    Projects Required BB Coaching[level,regEmployees], Total
    Required BB Coaching)
Units: Fraction [0,1]

BB Coaching[level,regEmployees]= BB Total CI Work Rate*BB Coaching
    Fraction*BB Coaching Level Demand Fraction[level,regEmployees]
Units: Person*Hours/Month
```

Black Belt coaching compensates for employees' low CI skill at all three levels of the company hierarchy. I assume, however, that inadequate Black Belt coaching is a demotivating factor (see section 5.7, p.172) only for front-line employees. For simplicity, I model employees' perception of the adequacy of the Black Belt coaching they receive with first-order exponential smoothing.

```
BB Coaching Adequacy[level,regEmployees]= XIDZ(BB
    Coaching[level,regEmployees], FL Projects Required BB
    Coaching[level,regEmployees], 1)
Units: Fraction

Perceived BB Coaching Adequacy[FL,regEmployees]= SMOOTHI(BB
    Coaching Adequacy[FL,regEmployees], BB Coaching Adequacy
    Perception Time, 1)
Perceived BB Coaching Adequacy[MM,regEmployees]= 1
Perceived BB Coaching Adequacy[SE,regEmployees]= 1
Units: Fraction
```

Parameters for Coaching by Black Belts

The number of coaching hours that employees with zero CI skill, at any level, require from Black Belts for every hour they spend supporting or working on CI projects. As employees' CI skill increases from zero to *Reference Skill*, their required Black Belt coaching decreases to zero.

```
FL Projects Baseline Fractional Required BB
    Coaching[regEmployees]= 0.125
Units: (Person*Hours)/(Person*Hour)
```

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```
Effect of Contributors Skill on Required Coaching Fn([(0,0)-
    (1.5,1)],(0,1),(1,0),(1.5,0))
Units: Fraction [0,1]
```
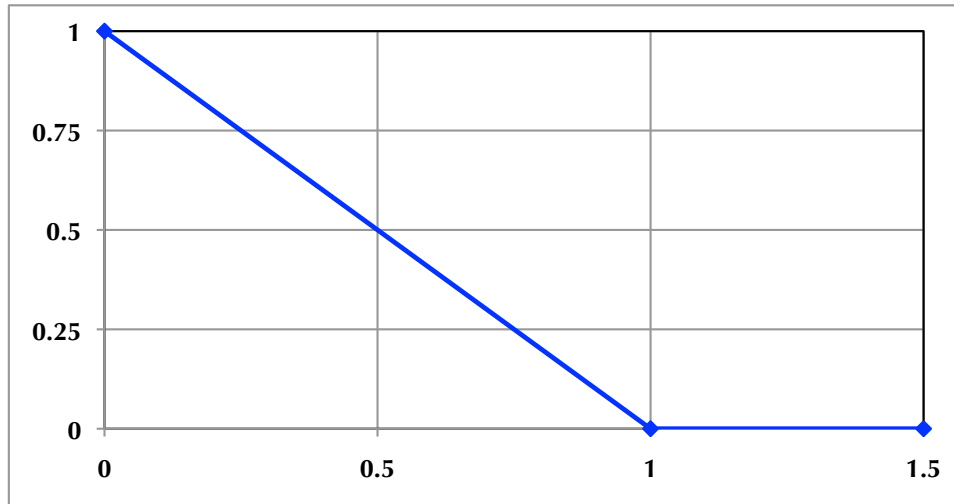

Figure 33. Lookup Function: Effect of Contributors Skill on Required Coaching Fn

As demand for coaching increases from 0 to 100 percent of Black Belts' total CI work time, the fraction that they allocate to coaching increases from 10 percent to their *Maximum BB Coaching Fraction* (assuming no effect from CI effort earnestness).

```
Effect of Demand on BB Coaching Fn([(0,0)-
    (2,1)],(0,0.1),(1,1),(2,1))
Units: Fraction [0,1]
```
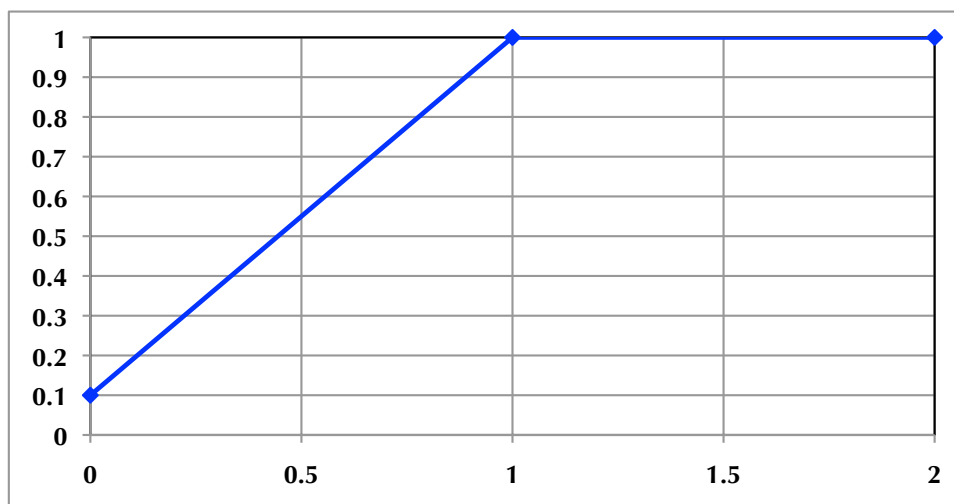

Figure 34. Lookup Function: Effect of Demand on BB Coaching Fn

```
Maximum BB Coaching Fraction= 0.5
Units: Fraction [0,1]
```

As employees' average CI effort earnestness decreases from 100 to 0 percent, the fraction of their total CI work time that Black Belts want to allocate to coaching decreases from *Maximum BB Coaching Fraction* to 50 percent (assuming no effect from coaching demand).

```
Effect of CI Effort Earnestness on BB Coaching Fn([(0,0)-
    (1,1)],(0,0.5),(1,1))
Units: Fraction [0,1]
```
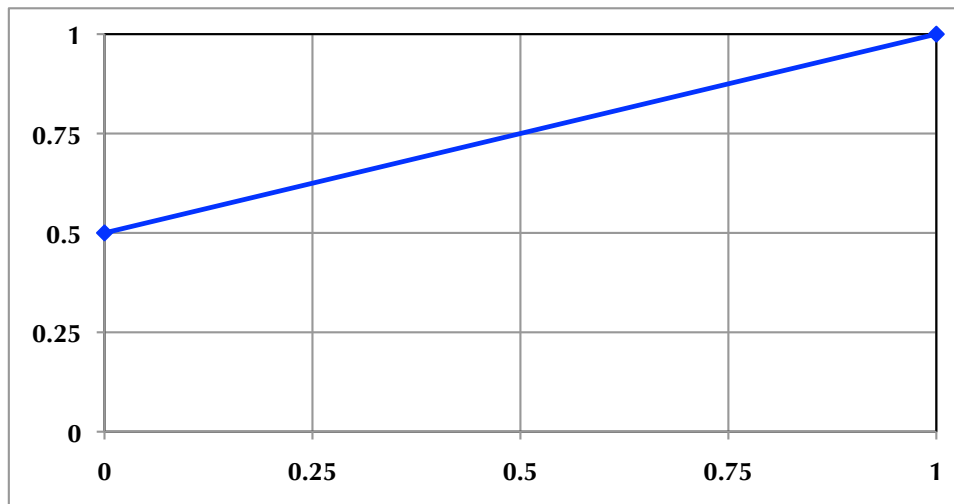

Figure 35. Lookup Function: Effect of CI Effort Earnestness on BB Coaching Fn

Kaizen facilitators dedicated 100 percent of their time to coaching front-line *kaizen* event teams until July 2002.

```
Constant BB Coaching Fraction= 1
Units: Fraction [0,1]

Constant BB Coaching Start Date= 27
Units: Month

Constant BB Coaching Duration= 39
Units: Month
```

For testing purposes, I allow for the possibility that Black Belts ignore employees' CI

effort earnestness when deciding how much coaching to provide.

```
CI Effort Earnestness Effect on BB Coaching Switch= 1
Units: Dmnl [0,1,1]

BB Coaching Adequacy Perception Time= 0.25
Units: Month
```

5.15. Black Belt Program Enrolling

DTE Energy's managers set a target for Black Belts expressed as a fraction of the company's total workforce. They planned to reach this target after two years of training. Note that this definition for *Desired BB Trainee Enrolling Rate* implies that DTE Energy's managers are always able to recruit their desired number of employees to Black Belt training. In DTE Energy's case, this is a reasonable assumption because enough employees considered Black Belt certification as valuable professional development. Consequently, DTE Energy's Master Black Belts never had difficulty filling their Black Belt training courses. For the equations below, *Total Employees* is computed in section 5.1 (p.137), *Total BB Program Participants* is computed in section 5.12 (p.199), and *BB Training Maximum Capacity* is computed in section 5.17 (p.220).

```
BB Target= Total Employees*Target BB to Workforce Ratio
Units: Person

Target BB to Workforce Ratio= Exogenous Target BB to Workforce
    Ratio*(1-Constant Target BB to Workforce Ratio Switch) + BB
    Target Switch*Constant Target BB to Workforce Ratio*Constant
    Target BB to Workforce Ratio Switch
Units: Person/Person

BB Target Switch= STEP(1, BB Target Start Date)
Units: Dmnl [0,1,1]

BB Shortfall= MAX(BB Target - Total BB Program Participants, 0)
Units: Person

Desired BB Trainee Enrolling Rate= BB Shortfall/BB Shortfall
    Correction Time
Units: Person/Month

Feasible BB Trainee Enrolling Rate= MIN(Desired BB Trainee
    Enrolling Rate, BB Training Maximum Capacity)
Units: Person/Month
```
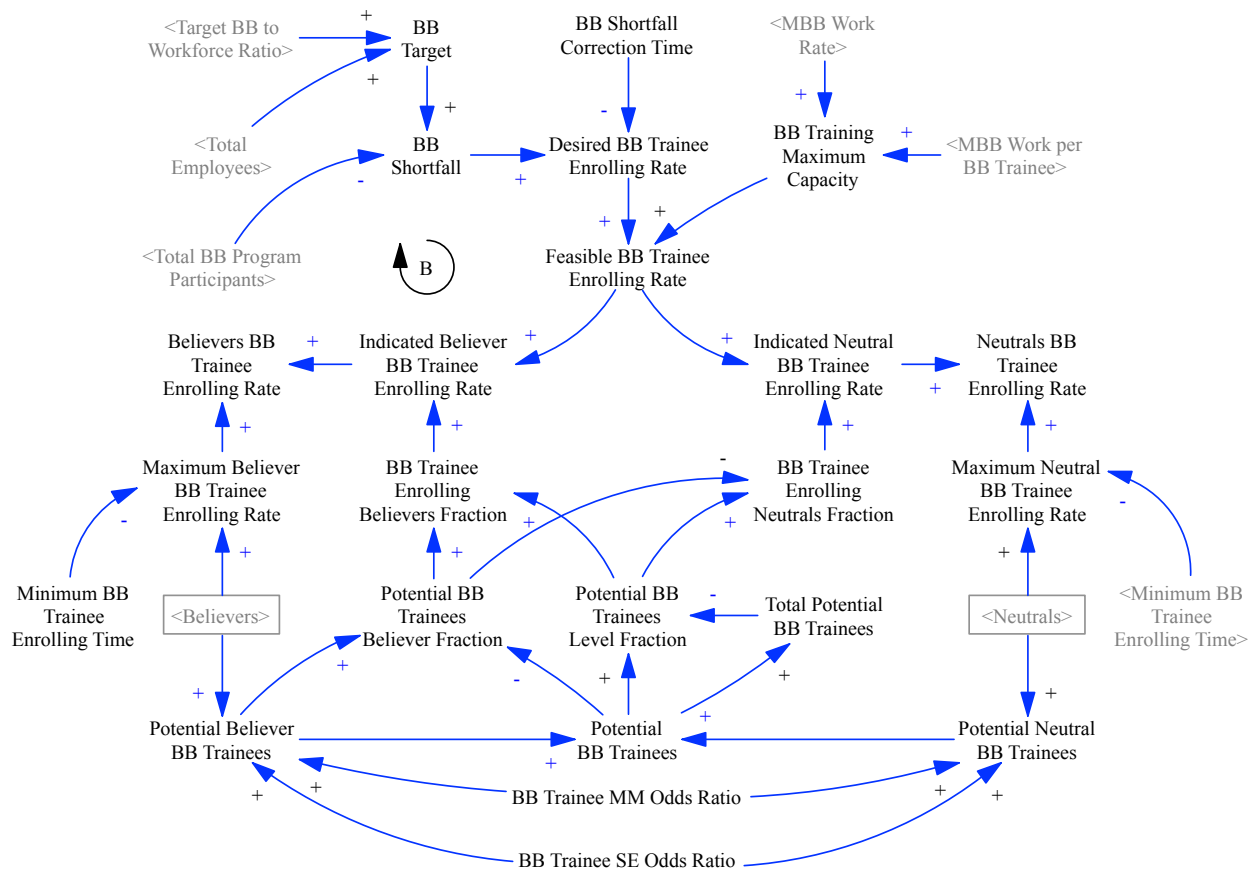
Figure 36. Model Diagram of Black Belt Program Enrolling

An employee from any level of the company hierarchy may enroll in Black Belt training. Almost all Black Belt trainees, however, enroll from the front-line level. I define the rates of middle managers and senior executives enrolling in Black Belt training relative to the enrolling rate of these front-line employees using odds ratios. I assume that skeptics never enroll in Black Belt training.

```
Potential Believer BB Trainees[SE]= Believers[SE]*BB Trainee SE
     Odds Ratio
Potential Believer BB Trainees[MM]= Believers[MM]*BB Trainee MM
     Odds Ratio
Potential Believer BB Trainees[FL]= Believers[FL]
Units: Person

Potential Neutral BB Trainees[SE]= Neutrals[SE]*BB Trainee SE Odds
     Ratio
Potential Neutral BB Trainees[MM]= Neutrals[MM]*BB Trainee MM Odds
     Ratio
Potential Neutral BB Trainees[FL]= Neutrals[FL]
```

```
Units: Person

Potential BB Trainees[level]= Potential Believer BB
    Trainees[level] + Potential Neutral BB Trainees[level]
Units: Person

Total Potential BB Trainees= SUM(Potential BB Trainees[level!])
Units: Person
```

It is possible that demand for Black Belt training might exceed the company's training capacity. The actual enrolling rate, therefore, must be the lesser of the desired rate and the feasible rate determined from the company's training capacity. I allocate the actual enrolling rate among the believers and neutrals at all three levels proportionally according to each group's demand relative to the total demand. This allocation requires two marginal distributions — across levels, and across believers/neutrals — which I multiply together to compute the joint distribution.

```
Potential BB Trainees Level Fraction[level]= ZIDZ(Potential BB
    Trainees[level], Total Potential BB Trainees)
Units: Fraction [0,1]

Potential BB Trainees Believer Fraction[level]= ZIDZ(Potential
    Believer BB Trainees[level], Potential BB Trainees[level])
Units: Fraction [0,1]

BB Trainee Enrolling Believers Fraction[level]= Potential BB
    Trainees Level Fraction[level]*Potential BB Trainees Believer
    Fraction[level]
Units: Fraction [0,1]

BB Trainee Enrolling Neutrals Fraction[level]= Potential BB
    Trainees Level Fraction[level]*(1-Potential BB Trainees
    Believer Fraction[level])
Units: Fraction [0,1]

Indicated Believer BB Trainee Enrolling Rate[level]= Feasible BB
    Trainee Enrolling Rate*BB Trainee Enrolling Believers
    Fraction[level]
Units: Person/Month

Indicated Neutral BB Trainee Enrolling Rate[level]= Feasible BB
    Trainee Enrolling Rate*BB Trainee Enrolling Neutrals
    Fraction[level]
Units: Person/Month
```

The use of maximum enrolling rates in the formulation for *Believers BB Trainee*

Enrolling Rate and *Neutrals BB Trainee Enrolling Rate* ensures first-order control on these outflows from the stocks of *Believers* and *Neutrals*, respectively.

```
Believers BB Trainee Enrolling Rate[level]= MIN(Indicated Believer
     BB Trainee Enrolling Rate[level], Maximum Believer BB Trainee
     Enrolling Rate[level])
Units: Person/Month

Neutrals BB Trainee Enrolling Rate[level]= MIN(Indicated Neutral
     BB Trainee Enrolling Rate[level], Maximum Neutral BB Trainee
     Enrolling Rate[level])
Units: Person/Month

Maximum Believer BB Trainee Enrolling Rate[level]=
     Believers[level]/Minimum BB Trainee Enrolling Time
Units: Person/Month

Maximum Neutral BB Trainee Enrolling Rate[level]=
     Neutrals[level]/Minimum BB Trainee Enrolling Time
Units: Person/Month
```

Parameters for Black Belt Program Enrolling

I assume that DTE Energy's managers always expected that it would take two years to reach "full implementation" of the CI initiative.

```
Exogenous Target BB to Workforce Ratio :HOLD BACKWARD::= GET XLS
     DATA(Excel File Name, Excel File Scenario Name, Excel File
     Time Row, 'C15')
Units: Person/Person

Constant Target BB to Workforce Ratio Switch= 0
Units: Dmnl [0,1,1]

Constant Target BB to Workforce Ratio= 0.02
Units: Person/Person

BB Target Start Date= 12
Units: Month

BB Shortfall Correction Time= 24
Units: Month
```

These odds ratios specify the probability of a senior executive or middle manager becoming a Black Belt relative to a front-line employee.

```
BB Trainee MM Odds Ratio= 0.125
Units: Fraction

BB Trainee SE Odds Ratio= 0
Units: Fraction

Minimum BB Trainee Enrolling Time= 1
Units: Month
```

5.16. Master Black Belts

I model the stock of Master Black Belts separately from the other employee stocks for three reasons: (1) it is much simpler; (2) DTE Energy's CI department, with one short-lived exception, hired its Master Black Belts from outside the company; and (3) DTE Energy never employed more than about 1.5 Master Black Belt full-time equivalent (FTE) employees at any time during its 12-year history with its CI initiative.

```
Master Black Belts= INTEG(
    + MBB Hire Rate
    - MBB Attrition Rate
    , Initial Master Black Belts)
Units: Person
```
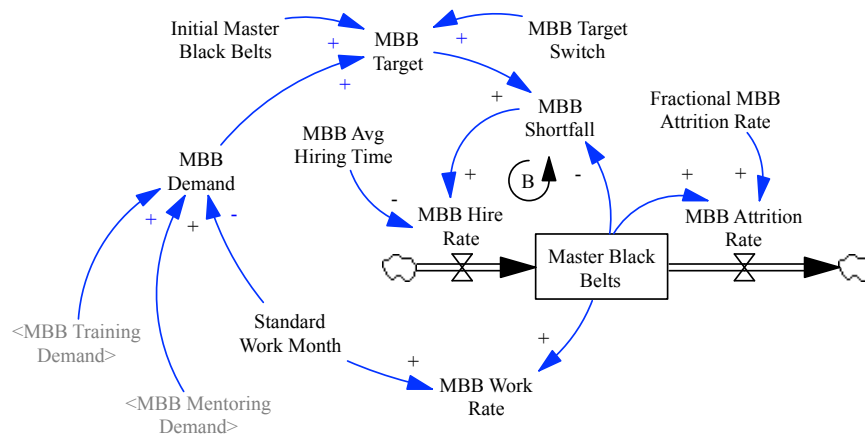

Figure 37. Model Diagram of Master Black Belts

By default, I assume a constant number of Master Black Belts. However, I allow for the possibility of adjusting the number of Master Black Belts upward endogenously to meet the demand for their training and mentoring.

```
MBB Demand= (MBB Training Demand + MBB Mentoring Demand)/Standard
    Work Month
```

```
Units: Person

MBB Target= MBB Demand*MBB Target Switch + Initial Master Black
     Belts*(1-MBB Target Switch)
Units: Person

MBB Shortfall= MAX(MBB Target - Master Black Belts, 0)
Units: Person

MBB Hire Rate= MBB Shortfall/MBB Avg Hiring Time
Units: Person/Month
```

For simplicity, I assume no Master Black Belt attrition or effects of schedule pressure.

```
MBB Attrition Rate= Master Black Belts*Fractional MBB Attrition
     Rate
Units: Person/Month

MBB Work Rate= Master Black Belts*Standard Work Month
Units: Person*Hours/Month
```

Parameters for Master Black Belts

```
Initial Master Black Belts= 1
Units: Person

MBB Target Switch= 0
Units: Dmnl [0,1,1]

MBB Avg Hiring Time= 2
Units: Month

Fractional MBB Attrition Rate= 0
Units: Fraction/Month
```

5.17. Black Belt Training

Just as Black Belts must divide their time between coaching and working on their own CI projects (section 5.14, p.209), Master Black Belts must divide their time between training Black Belt trainees and mentoring Black Belt candidates who are working on their certification projects. In general, I assume that Master Black Belts allocate their time according to the relative demand for each type of work, with a possible bias for training.
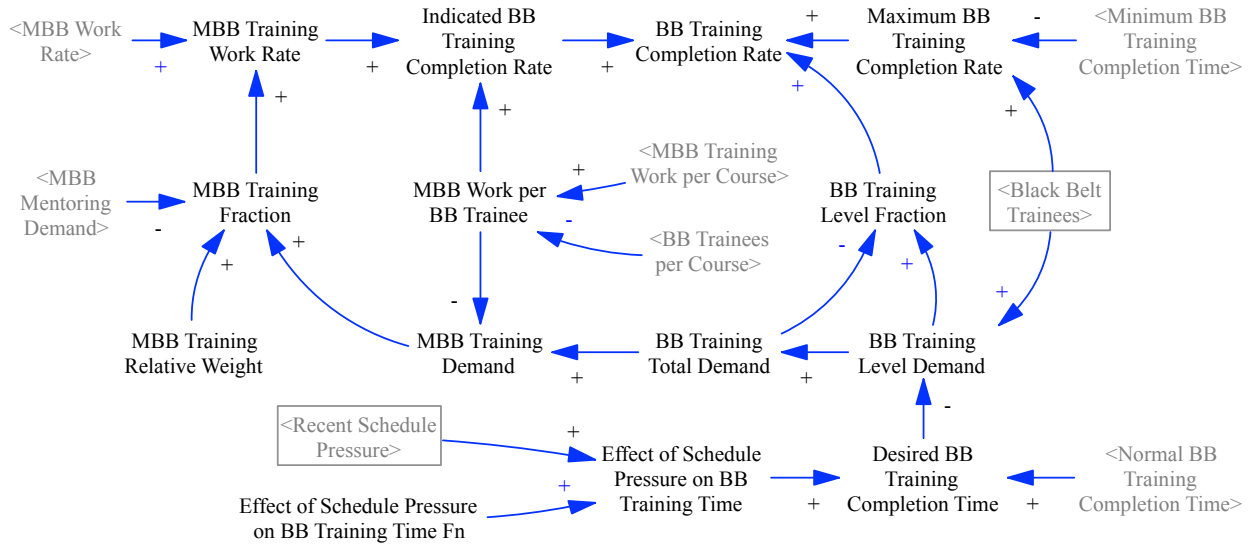
Figure 38. Model Diagram of Black Belt Training

  I assume that Black Belt trainees want to complete the Black Belt course at the normal rate, but they will delay attending classes if their schedule pressure becomes too high.

```
BB Training Level Demand[level]= Black Belt
    Trainees[level]/Desired BB Training Completion Time[level]
Units: Person/Month

Desired BB Training Completion Time[level]= Normal BB Training
    Completion Time*Effect of Schedule Pressure on BB Training
    Time[level]
Units: Month

Effect of Schedule Pressure on BB Training Time[level]= Effect of
    Schedule Pressure on BB Training Time Fn(Recent Schedule
    Pressure[level,BBt])
Units: Dmnl
```

  The demand on Master Black Belts for training depends on how many trainees attend each course and how much work each course entails. The model formulation allows for one change to the training program, which I use to model the OSSG's switch from training *kaizen* facilitators to training OS Experts.

```
BB Training Total Demand= SUM(BB Training Level Demand[level!])
Units: Person/Month
```

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```
MBB Training Demand= BB Training Total Demand*MBB Work per BB
     Trainee
Units: Person*Hours/Month

MBB Work per BB Trainee= ZIDZ(MBB Training Work per Course, BB
     Trainees per Course)
Units: (Person*Hours)/Person

MBB Training Work per Course= First MBB Training Work per
     Course*(1-BB Training Change Switch) + Second MBB Training
     Work per Course*BB Training Change Switch
Units: Person*Hours/Course

BB Trainees per Course= First BB Trainees per Course*(1-BB
     Training Change Switch) + Second BB Trainees per Course*BB
     Training Change Switch
Units: Person/Course

BB Training Change Switch= STEP(1, BB Training Change Date)
Units: Dmnl [0,1,1]

Normal BB Training Completion Time= First Normal BB Training
     Completion Time*(1-BB Training Change Switch) + Second Normal
     BB Training Completion Time*BB Training Change Switch
Units: Month
```

I assume that Master Black Belts allocate their time based on the relative demand for training and for mentoring, but with a possible bias for training.

```
MBB Training Fraction= XIDZ(MBB Training Demand*MBB Training
     Relative Weight, MBB Training Demand*MBB Training Relative
     Weight + MBB Mentoring Demand, 0.5)
Units: Fraction [0,1]

MBB Training Work Rate= MBB Work Rate*MBB Training Fraction
Units: Person*Hours/Month
```

The rate at which Black Belt trainees complete their training depends primarily on the rate at which Master Black Belts teach their courses. I assume that Black Belt trainees from the three levels of the company hierarchy all attend their courses at the same rate. The use of *Maximum BB Training Completion Rate* in the formulation for *BB Training Completion Rate* ensures first-order control on the outflow from the *Black Belt Trainees* stock.

```
Indicated BB Training Completion Rate= ZIDZ(MBB Training Work
    Rate, MBB Work per BB Trainee)
Units: Person/Month

BB Training Level Fraction[level]= ZIDZ(BB Training Level
    Demand[level], BB Training Total Demand)
Units: Fraction [0,1]

BB Training Completion Rate[level]= MIN(Indicated BB Training
    Completion Rate*BB Training Level Fraction[level], Maximum BB
    Training Completion Rate[level])
Units: Person/Month

Maximum BB Training Completion Rate[level]= Black Belt
    Trainees[level]/Minimum BB Training Completion Time
Units: Person/Month

Minimum BB Training Completion Time= First Minimum BB Training
    Completion Time*(1-BB Training Change Switch) + Second Minimum
    BB Training Completion Time*BB Training Change Switch
Units: Month
```

Master Black Belts' maximum capacity for Black Belt training is used in section 5.15 (p.215) to limit the enrolling rate of Black Belt trainees.

```
BB Training Maximum Capacity= ZIDZ(MBB Work Rate, MBB Work per BB
    Trainee)
Units: Person/Month
```

The Black Belt course's number of classroom hours is used in section 5.13 (p.204) to compute *BB Trainee CI Experience Gain from Training*.

```
BB Training Classroom Hours= First BB Training Classroom Hours*(1-
    BB Training Change Switch) + Second BB Training Classroom
    Hours*BB Training Change Switch
Units: Person*Hours/Person
```

Parameters for Black Belt Training

I assume that the *kaizen* facilitators received two weeks of training spread over one month. DTE Energy's Black Belt course, by contrast, was designed to be four weeks of training spread over four months. The OSSG personnel made this switch about July 2002.

```
BB Training Change Date= 66
Units: Month
```

```
First BB Training Classroom Hours= 80
Units: Person*Hours/Person

Second BB Training Classroom Hours= 160
Units: Person*Hours/Person

First Normal BB Training Completion Time= 1
Units: Month

Second Normal BB Training Completion Time= 4
Units: Month
```

I assume that Black Belt trainees will take the normal amount of time to complete their training when their schedule pressure is between 0 and 1. As their schedule pressure increases to 200 percent of normal, they extend their Black Belt training completion time to 300 percent of normal.

```
Effect of Schedule Pressure on BB Training Time Fn([(0,0)-
    (2,6)],(0,1),(1,1),(1.25,2),(1.5,3),(2,3))
Units: Dmnl
```
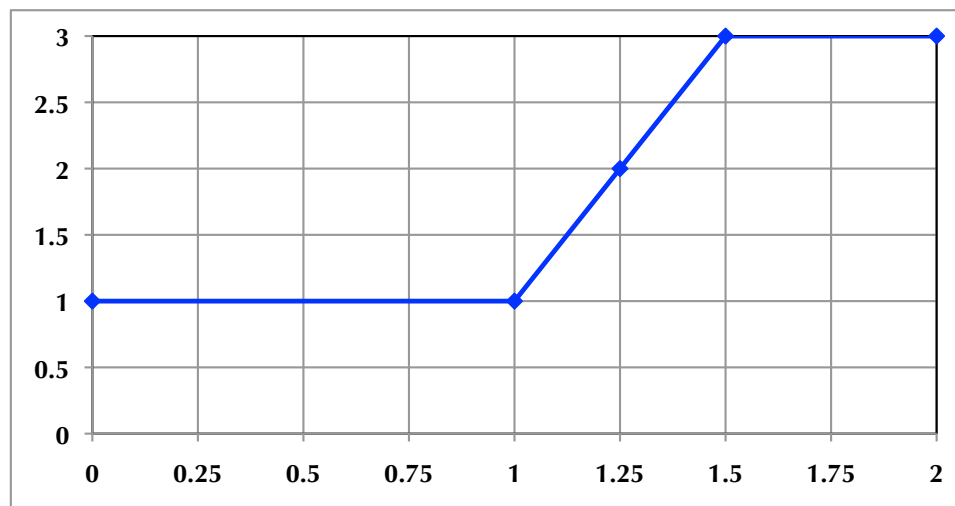

Figure 39. Lookup Function: Effect of Schedule Pressure on BB Training Time Fn

```
First MBB Training Work per Course= 160
Units: Person*Hours/Course

Second MBB Training Work per Course= 320
Units: Person*Hours/Course

First BB Trainees per Course= 4.15
Units: Person/Course
```

224

```
Second BB Trainees per Course= 25
Units: Person/Course
```

The following parameter defines the degree to which Master Black Belts weigh demand for training over demand for mentoring. A weight of 1 means that they weigh these two demands equally.

```
MBB Training Relative Weight= 1.1
Units: Dmnl
```

Because the Black Belt course was four weeks of training, the minimum feasible completion time is two months. I assume that the minimum feasible completion time for *kaizen* facilitators was two weeks.

```
First Minimum BB Training Completion Time= 0.5
Units: Month

Second Minimum BB Training Completion Time= 1
Units: Month
```

5.18. Mentoring by Master Black Belts

Black Belt candidates require mentoring by Master Black Belts for their certification projects in the same way that regular employees require coaching by Black Belts. For simplicity, I define this required mentoring as a certain number of (fractional) work-hours of Master Black Belt mentoring for every hour that Black Belt candidates spend on project work. Black Belt candidates need fewer work-hours of mentoring for each of their project work-hours as their CI skill increases. I assume that this skill-related reduction in mentoring demand follows the same function as employees' skill-related reduction in Black Belt coaching demand (see section 5.14, p.209).

```
MBB Mentoring Demand= SUM(Perceived BB Candidate Projects
    Completion Rate[level!]*BB Candidate Projects Baseline
    Required Fractional MBB Mentoring*Effect of Contributors Skill
    on Required Coaching[level!,BBc])
Units: Person*Hours/Month
```

Reference Skill   <Contributors Skill>   MBB Training Relative Weight

<Effect of Contributors Skill on Required Coaching Fn>

Effect of Contributors Skill on Required Coaching

MBB Training Fraction   <MBB Training Demand>

BB Candidate Projects Baseline Required Fractional MBB Mentoring

MBB Mentoring Demand

MBB Mentoring Rate   <MBB Work Rate>

<BB Candidate Projects Effective Completion Rate>

Perceived BB Candidate Projects Completion Rate

MBB Mentoring Adequacy

BB Candidate Projects Completion Rate Perception Time
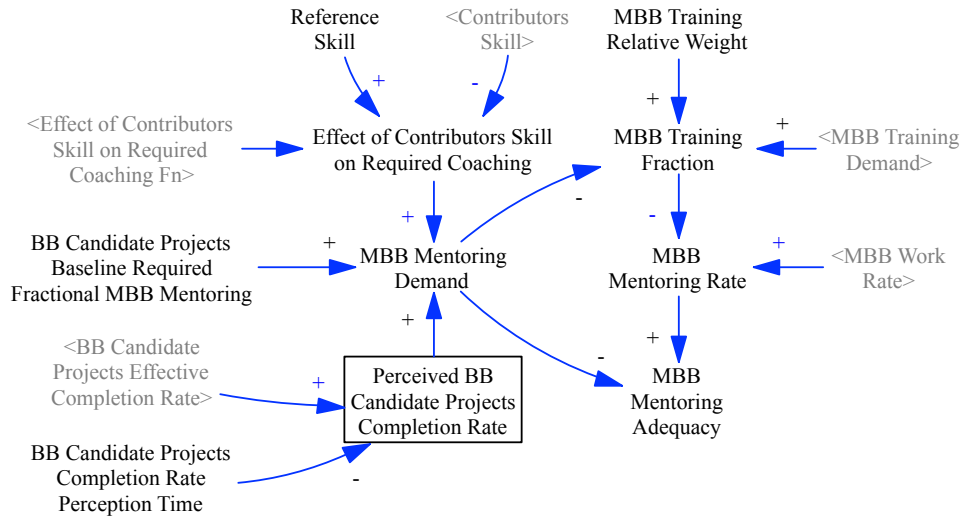
Figure 40. Model Diagram of Mentoring by Master Black Belts

To assess Black Belt candidates' demand for mentoring, Master Black Belts must perceive the rate at which those Black Belt candidates are completing their projects. I use first-order exponential smoothing to represent the process of Master Black Belts assessing the Black Belt candidates' project completion rate. (The stock included in the model for *Perceived BB Candidate Projects Completion Rate* is also necessary to resolve simultaneous equations: the amount of Master Black Belt coaching and the rate of Black Belt candidate project completions are mutually determined.)

```
Perceived BB Candidate Projects Completion Rate[level]= SMOOTHI(BB
     Candidate Projects Effective Completion Rate[level], BB
     Candidate Projects Completion Rate Perception Time, 0)
Units: Person*Hours/Month

MBB Mentoring Rate= MBB Work Rate*(1-MBB Training Fraction)
Units: Person*Hours/Month

MBB Mentoring Adequacy= ZIDZ(MBB Mentoring Rate, MBB Mentoring
     Demand)
Units: Dmnl
```

The model allows for one change to both *Certification Projects per BB Candidate* and *BB Candidate Avg Project Size* on the *BB Certification Start Date*. I use this single change to model DTE Energy's switch from OS Experts, who were not required to complete certification projects, to Black Belts.

```
BB Certification Switch= STEP(1, BB Certification Start Date)
Units: Dmnl [0,1,1]

Certification Projects per BB Candidate= First Certification
    Projects per BB Candidate*(1-BB Certification Switch) + Second
    Certification Projects per BB Candidate*BB Certification
    Switch
Units: Project/Person

BB Candidate Avg Project Size= First BB Candidate Avg Project
    Size*(1-BB Certification Switch) + Second BB Candidate Avg
    Project Size*BB Certification Switch
Units: Person*Hours/Project

Indicated BB Candidate Certification Rate[level]= BB Candidate
    Projects Effective Completion Rate[level]/(Certification
    Projects per BB Candidate*BB Candidate Avg Project Size)
Units: Person/Month

Minimum BB Candidate Certification Time= First Minimum BB
    Candidate Certification Time*(1-BB Certification Switch) +
    Second Minimum BB Candidate Certification Time*BB
    Certification Switch
Units: Month
```

Parameters for Mentoring by Master Black Belts

The number of mentoring hours that Black Belt candidates with zero CI skill, at any level, require from Master Black Belts for every hour they spend on their Black Belt certification projects.

```
BB Candidate Projects Baseline Required Fractional MBB Mentoring=
    0.05
Units: (Person*Hours)/(Person*Hour)

BB Candidate Projects Completion Rate Perception Time= 1
Units: Month
```

The following parameters partially determine how fast Black Belt candidates earn their Black Belt certifications. Prior to the start of the Black Belt program, there was no candidate stage, so I define an arbitrary, small project size to move the CI expert trainees to the CI expert stock quickly.

```
BB Certification Start Date= 90
Units: Month
```

227

```
First Certification Projects per BB Candidate= 1
Units: Project/Person

Second Certification Projects per BB Candidate= 2
Units: Project/Person

First BB Candidate Avg Project Size= 1
Units: Person*Hours/Project

Second BB Candidate Avg Project Size= 480
Units: Person*Hours/Project

First Minimum BB Candidate Certification Time= TIME STEP
Units: Month

Second Minimum BB Candidate Certification Time= 4
Units: Month
```

5.19. Green Belt Training Target

I assume that believer senior executives want all of their front-line subordinates to attend Green Belt training. Of course, Black Belt program participants are excluded from this target population.

```
GB Training Unadjusted FL Target= MAX(FL Subordinates of CI
     Proponents - BB Program Participants[FL], 0)
Units: Person
```
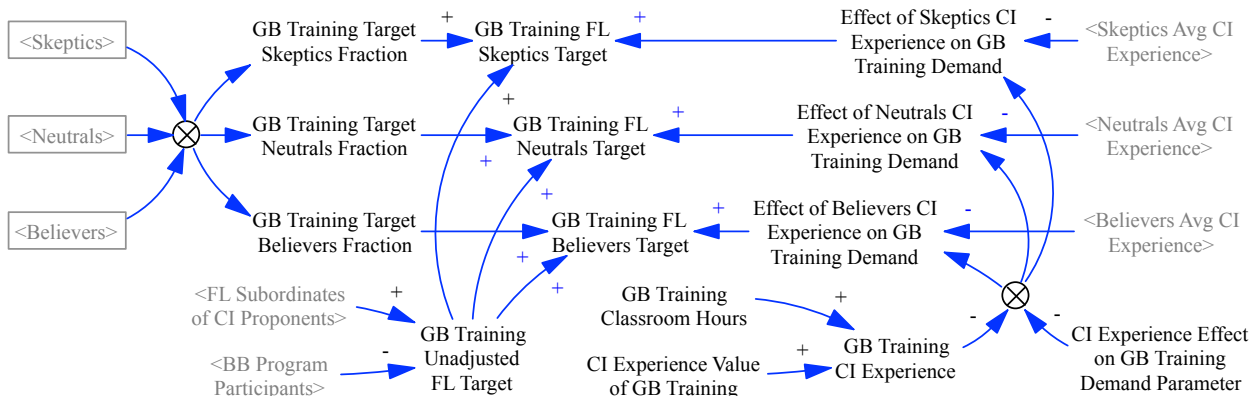

Figure 41. Model Diagram of Green Belt Training Target

I divide the Green Belt training target across the regular-employee stocks according to each stock's size relative to the total.

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```
GB Training Target Believers Fraction[level]=
    ZIDZ(Believers[level],
    Believers[level]+Neutrals[level]+Skeptics[level])
Units: Fraction [0,1]

GB Training Target Neutrals Fraction[level]= ZIDZ(Neutrals[level],
    Believers[level]+Neutrals[level]+Skeptics[level])
Units: Fraction [0,1]

GB Training Target Skeptics Fraction[level]= ZIDZ(Skeptics[level],
    Believers[level]+Neutrals[level]+Skeptics[level])
Units: Fraction [0,1]

GB Training FL Believers Target= GB Training Unadjusted FL
    Target*GB Training Target Believers Fraction[FL]*Effect of
    Believers CI Experience on GB Training Demand[FL]
Units: Person

GB Training FL Neutrals Target= GB Training Unadjusted FL
    Target*GB Training Target Neutrals Fraction[FL]*Effect of
    Neutrals CI Experience on GB Training Demand[FL]
Units: Person

GB Training FL Skeptics Target= GB Training Unadjusted FL
    Target*GB Training Target Skeptics Fraction[FL]*Effect of
    Skeptics CI Experience on GB Training Demand[FL]
Units: Person
```

For simplicity, I avoided building another co-flow structure to track the fraction of employees in each stock who are alumni of the Green Belt training course. Instead, I assume that demand for Green Belt training decreases as employees' (average) CI skill increases. For this skill-dependent reduction in Green Belt training demand, I use the power-law function $Y = b^{\wedge}(-X)$, where Y is the fraction of full demand; X is employees' average CI experience, normalized with the CI experience that they would gain from Green Belt training; and b is a parameter that determines the steepness of their demand curve. For simplicity, I assume that all employees have the same demand curve.

```
Effect of Believers CI Experience on GB Training Demand[level]= CI
    Experience Effect on GB Training Demand Parameter^(-Believers
    Avg CI Experience[level]/GB Training CI Experience)
Units: Fraction [0,1]

Effect of Neutrals CI Experience on GB Training Demand[level]= CI
    Experience Effect on GB Training Demand Parameter^(-Neutrals
    Avg CI Experience[level]/GB Training CI Experience)
```

```
Units: Fraction [0,1]

Effect of Skeptics CI Experience on GB Training Demand[level]= CI
     Experience Effect on GB Training Demand Parameter^(-Skeptics
     Avg CI Experience[level]/GB Training CI Experience)
Units: Fraction [0,1]
```

Parameters for Green Belt Training Target

```
CI Experience Effect on GB Training Demand Parameter= 1.1
Units: Dmnl
```

5.20. Green Belt Training

Demand for Green Belt training arises from two sources: (1) believer senior executives want their front-line subordinates to attend the training (see section 5.19, p.228), and (2) believers at all levels of the company hierarchy want to attend Green Belt training if their CI skill is low. I assume that believers want to complete Green Belt training faster than the senior executives want their subordinates to do so.

```
FL Believers Target GB Training Rate= GB Training FL Believers
     Target/GB Training SE Target Completion Time
Units: Person/Month

Believers Own GB Training Demand[level]= Believers[level]*Effect
     of Believers CI Experience on GB Training
     Demand[level]/Believers Desired GB Training Completion Time
Units: Person/Month
```
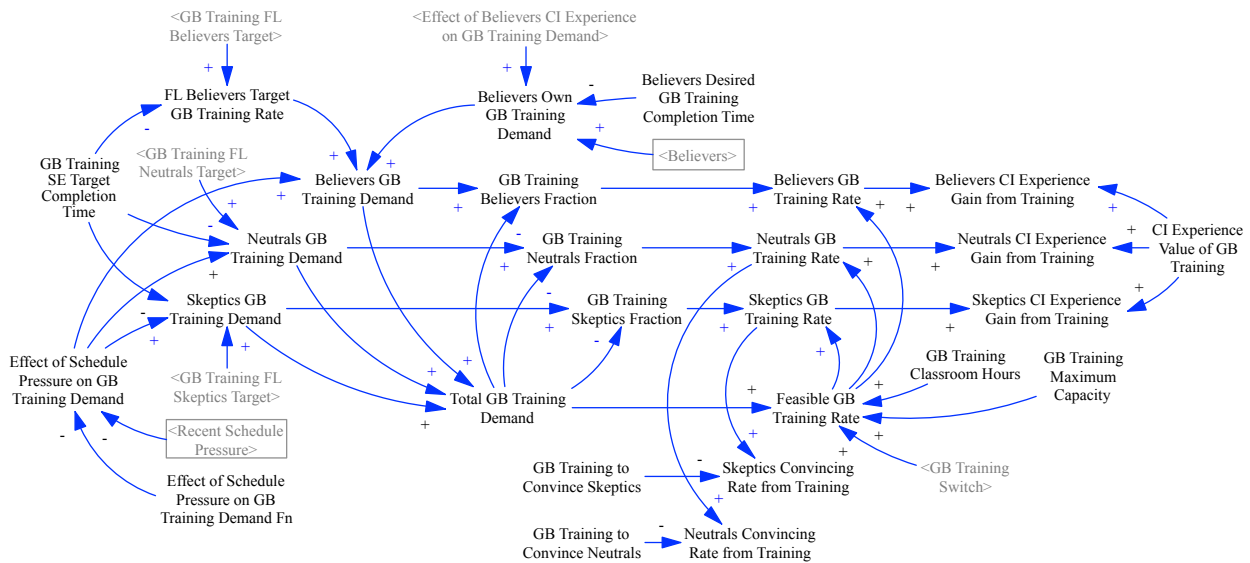
Figure 42. Model Diagram of Green Belt Training

I assume that all potential Green Belt trainees, just like Black Belt trainees (section 5.17, p.220), will delay attending classes if their schedule pressure becomes too high.

```
Believers GB Training Demand[SE]= Believers Own GB Training
     Demand[SE]*Effect of Schedule Pressure on GB Training
     Demand[SE,Bel]
Believers GB Training Demand[MM]= Believers Own GB Training
     Demand[MM]*Effect of Schedule Pressure on GB Training
     Demand[MM,Bel]
Believers GB Training Demand[FL]= MAX(FL Believers Target GB
     Training Rate, Believers Own GB Training Demand[FL])*Effect of
     Schedule Pressure on GB Training Demand[FL,Bel]
Units: Person/Month

Neutrals GB Training Demand[SE]= 0
Neutrals GB Training Demand[MM]= 0
Neutrals GB Training Demand[FL]= GB Training FL Neutrals
     Target*Effect of Schedule Pressure on GB Training
     Demand[FL,Neu]/GB Training SE Target Completion Time
Units: Person/Month

Skeptics GB Training Demand[SE]= 0
Skeptics GB Training Demand[MM]= 0
Skeptics GB Training Demand[FL]= GB Training FL Skeptics
     Target*Effect of Schedule Pressure on GB Training
     Demand[FL,Ske]/GB Training SE Target Completion Time
Units: Person/Month

Effect of Schedule Pressure on GB Training
     Demand[level,contributor]= Effect of Schedule Pressure on GB
```

```
        Training Demand Fn(Recent Schedule
        Pressure[level,contributor])
Units: Fraction [0,1]

Total GB Training Demand= SUM(Believers GB Training Demand[level!]
        + Neutrals GB Training Demand[level!] + Skeptics GB Training
        Demand[level!])
Units: Person/Month
```

It is possible that demand for Green Belt training might exceed the company's
training capacity. The actual Green Belt training rate, therefore, must be the lesser of the
demanded rate and the feasible rate. I allocate the actual Green Belt training rate among
the employee groups at all three levels proportionally according to each group's demand
relative to the total demand.

```
GB Training Switch= STEP(1, GB Training Start Date)
Units: Dmnl [0,1,1]

Feasible GB Training Rate= MIN(Total GB Training Demand, GB
        Training Maximum Capacity)*GB Training Classroom Hours*GB
        Training Switch
Units: Person*Hours/Month

GB Training Believers Fraction[level]= ZIDZ(Believers GB Training
        Demand[level], Total GB Training Demand)
Units: Fraction [0,1]

GB Training Neutrals Fraction[level]= ZIDZ(Neutrals GB Training
        Demand[level], Total GB Training Demand)
Units: Fraction [0,1]

GB Training Skeptics Fraction[level]= ZIDZ(Skeptics GB Training
        Demand[level], Total GB Training Demand)
Units: Fraction [0,1]

Believers GB Training Rate[level]= Feasible GB Training Rate*GB
        Training Believers Fraction[level]
Units: Person*Hours/Month

Neutrals GB Training Rate[level]= Feasible GB Training Rate*GB
        Training Neutrals Fraction[level]
Units: Person*Hours/Month

Skeptics GB Training Rate[level]= Feasible GB Training Rate*GB
        Training Skeptics Fraction[level]
Units: Person*Hours/Month
```

To determine the effect of employees' CI experience on their demand for Green Belt

training in section 5.19 (p.228), the amount of CI experience gained from Green Belt training is used to normalize employees' average CI experience.

```
GB Training CI Experience= GB Training Classroom Hours*CI
    Experience Value of GB Training
Units: Person*Hours/Person
```

Parameters for Green Belt Training

Believers want to complete Green Belt training faster than the senior executives want their subordinates to do so.

```
GB Training SE Target Completion Time= 24
Units: Month

Believers Desired GB Training Completion Time= 12
Units: Month
```

I assume that employees will attend Green Belt training as long as their schedule pressure is between 0 and 0.95. As their schedule pressure increases to 125 percent of normal, the fraction of employees who will attend Green Belt training classes drops to zero.

```
Effect of Schedule Pressure on GB Training Demand Fn([(0,0)-
    (1.5,1)],(0,1),(0.95,1),(1.25,0),(1.5,0))
Units: Fraction [0,1]
```
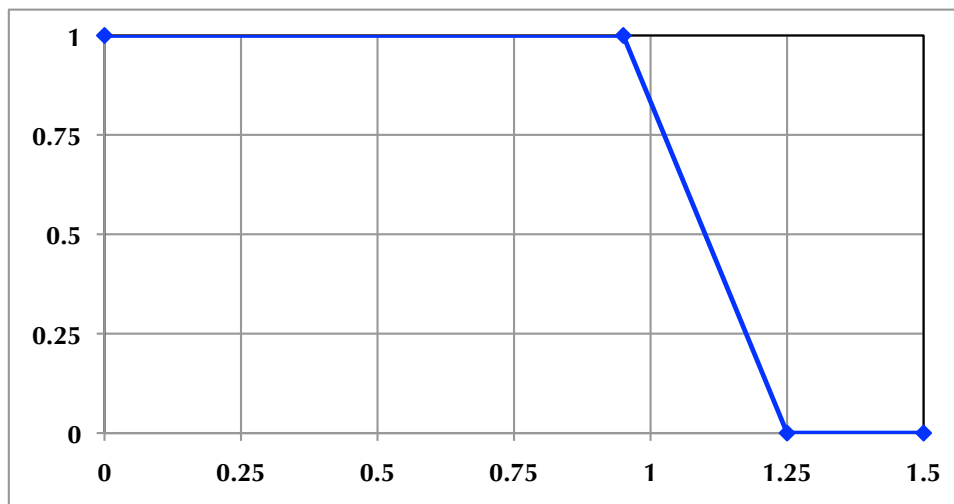

Figure 43. Lookup Function: Effect of Schedule Pressure on GB Training Demand Fn

```
GB Training Start Date= 76
Units: Month

GB Training Maximum Capacity= 100
Units: Person/Month
```

DTE Energy's Green Belt training course was designed to be four days of classes taken over a period of three weeks.

```
GB Training Classroom Hours= 32
Units: Person*Hours/Person
```

5.21. Senior Executive Training

The leaders of the CI initiative sought to train DTE Energy's senior executives via networking and discussions with pro-CI executives from other companies and with leading CI researchers from academia.

```
SE Training Rate[SE]= Total Level Employees[SE]*SE Training Rate
     per Person*SE Training Switch
SE Training Rate[MM]= 0
SE Training Rate[FL]= 0
Units: Person*Hours/Month

SE Training Switch= STEP(1, SE Training Start Date)
Units: Dmnl [0,1,1]
```
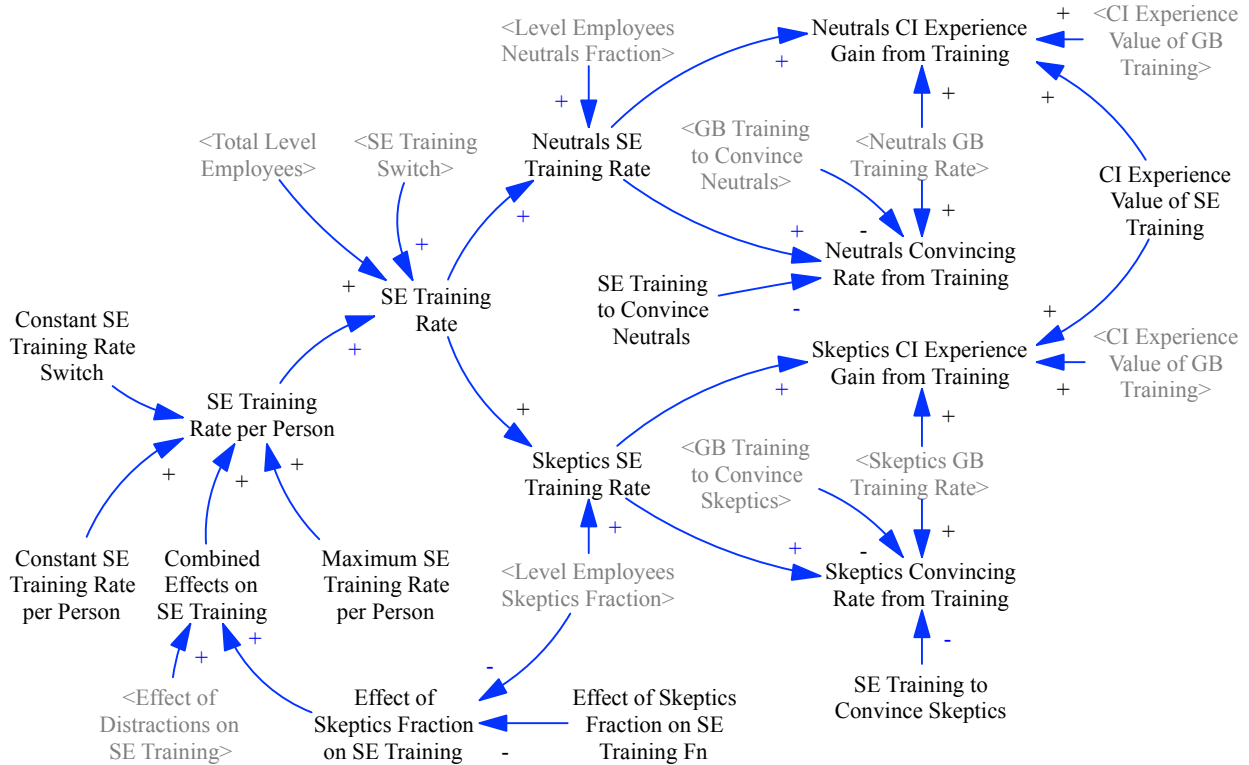
Figure 44. Model Diagram of Senior Executive Training

The CI initiative's leaders could only commandeer a certain (average) amount of each senior executive's time for such CI training. I assume that as the number of skeptical senior executives increases, the harder it becomes for the CI leaders to train everyone because most of this training was done in the context of senior executive meetings. Additionally, I assume that the senior executives will not make time for CI training if they are distracted by, for example, the MichCon merger (see Parameters for Boss Push for Nonroutine Work, p.172). For testing purposes, I allow for the possibility of a constant amount of senior executive training.

```
SE Training Rate per Person= Maximum SE Training Rate per
    Person*Combined Effects on SE Training*(1-Constant SE Training
    Rate Switch) + Constant SE Training Rate per Person*Constant
    SE Training Rate Switch
Units: Hours/Month

Combined Effects on SE Training= MIN(Effect of Skeptics Fraction
    on SE Training, Effect of Distractions on SE Training)
Units: Fraction [0,1]
```

```
Effect of Skeptics Fraction on SE Training= Effect of Skeptics
     Fraction on SE Training Fn(Level Employees Skeptics
     Fraction[SE])
Units: Fraction [0,1]

Effect of Distractions on SE Training= 1-Exogenous Distractions
     Index[SE]
Units: Dmnl [0,1]
```

Even though most senior executives at DTE Energy received CI training in the context of meetings, I assume that only the neutral and skeptical executives gain CI experience and are potentially convinced from it (because the believer senior executives do not need convincing).

```
Neutrals SE Training Rate[level]= SE Training Rate[level]*Level
     Employees Neutrals Fraction[level]
Units: Person*Hours/Month

Skeptics SE Training Rate[level]= SE Training Rate[level]*Level
     Employees Skeptics Fraction[level]
Units: Person*Hours/Month
```

Parameters for Senior Executive Training

```
SE Training Start Date= 12
Units: Month

Maximum SE Training Rate per Person= 4
Units: Hours/Month

Constant SE Training Rate Switch= 0
Units: Dmnl [0,1,1]

Constant SE Training Rate per Person= 4
Units: Hours/Month
```

As the fraction of senior executive skeptics increases from 0 to 100 percent, the amount of senior executive training that the CI leaders can deliver decreases from the *Maximum SE Training Rate per Person* to zero.

```
Effect of Skeptics Fraction on SE Training Fn([(0,0)-
     (1,1)],(0,1),(0.25,0.5),(0.5,0.25),(0.75,0.1),(1,0))
Units: Fraction [0,1]
```
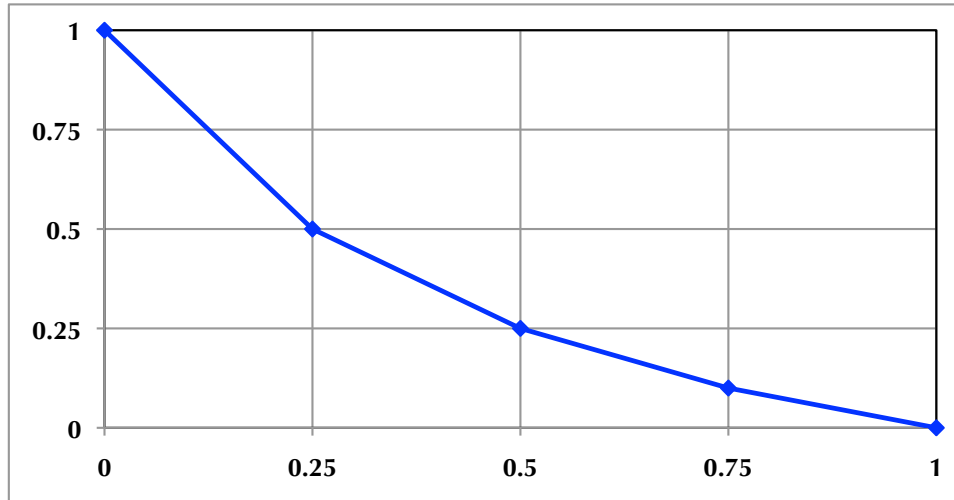
Figure 45. Lookup Function: Effect of Skeptics Fraction on SE Training Fn

5.22. Improvements in Productivity

The number of hours that employees need to complete their monthly routine work reflects the efficiency of their work procedures and process design. The following structure for *Required Work Hours*, therefore, is a co-flow of the *Monthly Routine Work* structure in section 5.5 (p.158). This co-flow is necessary to compute employees' prevailing standard time per task.

```
Required Work Hours[level]= INTEG(
    + Required Work Hours Erosion Rate[level]
    + Required Work Hours Increase Rate[level]
    - Required Work Hours Improvement Rate[level]
    - Required Work Hours Reduction Rate[level]
    , Baseline Routine Work Rate[level])
Units: Person*Hours/Month

Baseline Routine Work Rate[level]= Baseline Routine Work Level
    FTEs[level]*Standard Work Month
Units: Person*Hours/Month

Time per Task Standard[level]= Required Work Hours[level]/Monthly
    Routine Work[level]
Units: Person*Hours/Task
```

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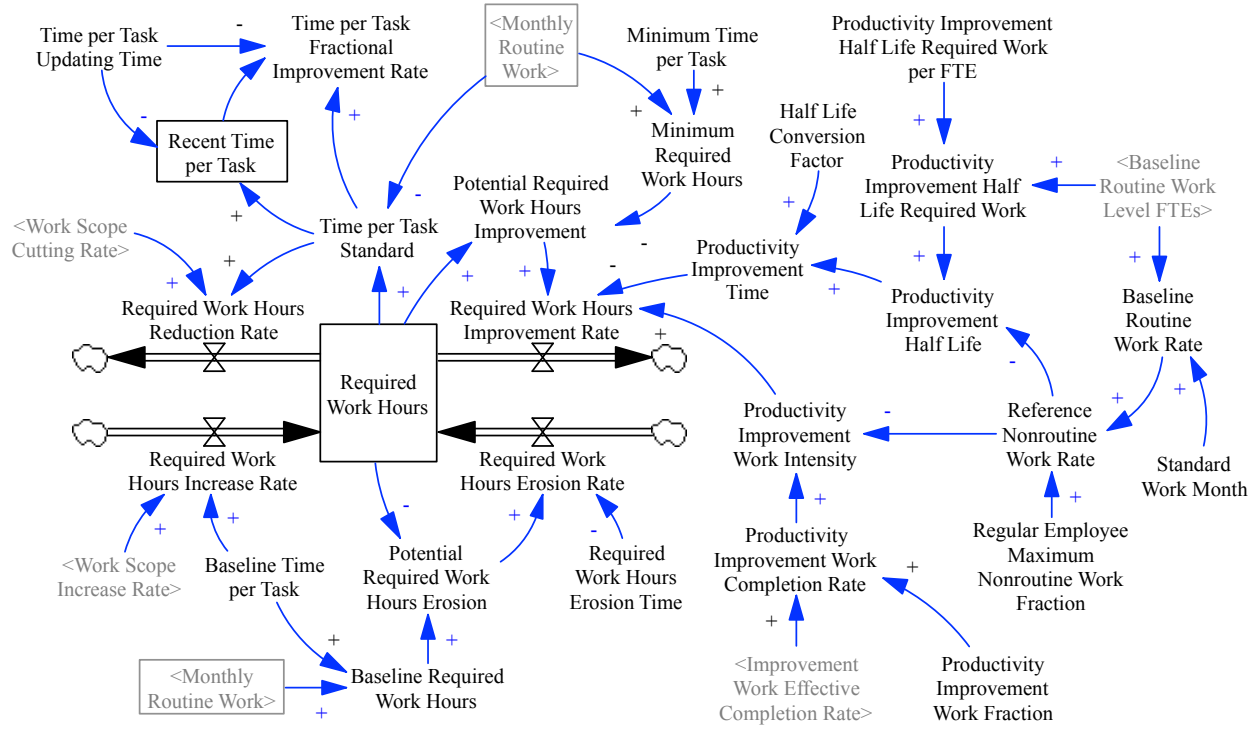
Figure 46. Model Diagram of Improvements in Productivity

When the scope of employees' monthly routine work is cut, then the currently required work hours associated with those cuts — given by *Time per Task Standard* — must be removed from the stock of *Required Work Hours*.

```
Required Work Hours Reduction Rate[level]= Work Scope Cutting
    Rate[level]*Time per Task Standard[level]
Units: (Person*Hours/Month)/Month
```

By contrast, when the scope of employees' monthly routine work is increased, I assume that employees' efficiency doing that new work starts at the unimproved, baseline level.

```
Required Work Hours Increase Rate[level]= Work Scope Increase
    Rate[level]*Baseline Time per Task
Units: (Person*Hours/Month)/Month
```

Engaging in CI work, employees may boost their productivity by improving the efficiency of their work procedures or the design of their work processes. I assume that these improvements will gradually erode over a long period of time if they are not sustained. For simplicity, I model this improvement erosion with first-order exponential

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decay.

```
Baseline Required Work Hours[level]= Monthly Routine
    Work[level]*Baseline Time per Task
Units: Person*Hours/Month

Potential Required Work Hours Erosion[level]= MAX(Baseline
    Required Work Hours[level] - Required Work Hours[level], 0)
Units: Person*Hours/Month

Required Work Hours Erosion Rate[level]= Potential Required Work
    Hours Erosion[level]/Required Work Hours Erosion Time
Units: (Person*Hours/Month)/Month
```

In a few cases, some CI work at DTE Energy improved the work processes of middle managers and senior executives. However, the majority of CI projects improved the company's front-line work. For simplicity, I assume that all productivity improvements are made on the front lines.

I use Schneiderman's (1988) exponential formulation for improvement in which, for any target process characteristic, 50 percent of the potential improvement gap remaining is closed when a "legitimate QIP [quality improvement process]" is applied for a duration equal to the process' improvement half-life. Schneiderman defines "legitimate QIP" as "a process that achieves a benchmark rate of continuous improvement" (Schneiderman, 1988, p. 53). Schneiderman estimates improvement half-lives for a broad range of process types and target characteristics, but unfortunately he leaves this "benchmark rate" of CI work unspecified. Obviously, Schneiderman's half-life estimates are not commensurable unless the same benchmark CI work rate was used for each process; a lower CI work rate would yield a longer improvement half-life. I adapt Repenning and Sterman's (1994b) extension to Schneiderman's model to accommodate a possibly varying CI work rate by defining a CI work intensity based on a reference work rate.

```
Required Work Hours Improvement Rate[SE]= 0
Required Work Hours Improvement Rate[MM]= 0
Required Work Hours Improvement Rate[FL]= (Potential Required Work
    Hours Improvement[FL]/Productivity Improvement
    Time)*Productivity Improvement Work Intensity
Units: (Person*Hours/Month)/Month
```

```
Potential Required Work Hours Improvement[level]= MAX(Required
    Work Hours[level] - Minimum Required Work Hours[level], 0)
Units: Person*Hours/Month

Minimum Required Work Hours[level]= Monthly Routine
    Work[level]*Minimum Time per Task
Units: Person*Hours/Month

Productivity Improvement Work Intensity= ZIDZ(Productivity
    Improvement Work Completion Rate, Reference Nonroutine Work
    Rate[FL])
Units: Dmnl

Reference Nonroutine Work Rate[level]= Baseline Routine Work
    Rate[level]*Regular Employee Maximum Nonroutine Work
    Fraction[level]
Units: Person*Hours/Month
```

I assume that all employees' CI work improves either productivity or variable operating costs (see section 5.23, p.241). I define the fraction allocated to each type of improvement exogenously.

```
Productivity Improvement Work Completion Rate= Improvement Work
    Effective Completion Rate*Productivity Improvement Work
    Fraction
Units: Person*Hours/Month
```

I determine the productivity improvement half-life from the amount of improvement work required of every employee to cut everyone's time per task in half. Then I compute the productivity improvement time constant from this half-life.

```
Productivity Improvement Half Life Required Work= Productivity
    Improvement Half Life Required Work per FTE*Baseline Routine
    Work Level FTEs[FL]
Units: Person*Hours

Productivity Improvement Half Life= XIDZ(Productivity Improvement
    Half Life Required Work, Reference Nonroutine Work Rate[FL],
    1e+06)
Units: Month

Productivity Improvement Time= Productivity Improvement Half
    Life*Half Life Conversion Factor
Units: Month
```

Front-line employees must perceive improvement results to become convinced (or

disillusioned) of CI's benefits (sections 5.10, p.189, and 5.11, p.195). I adapt Repenning and Sterman's (1994b) formulation for employees' perception of results, which assumes that employees assess and are influenced by the fractional rate of improvement relative to a standard. However, employees also update their assessment of the standard, which I represent, for simplicity, with first-order exponential smoothing.

```
Recent Time per Task[level]= SMOOTHI(Time per Task
    Standard[level], Time per Task Updating Time, Baseline Time
    per Task)
Units: Person*Hours/Task

Time per Task Fractional Improvement Rate[level]= (Time per Task
    Standard[level] - Recent Time per Task[level])/(Recent Time
    per Task[level]*Time per Task Updating Time)
Units: Fraction/Month
```

Parameters for Improvements in Productivity

```
Baseline Time per Task= 1
Units: Person*Hours/Task

Required Work Hours Erosion Time= 120
Units: Month

Minimum Time per Task= 0.5
Units: Person*Hours/Task

Productivity Improvement Work Fraction= 0.5
Units: Fraction [0,1]

Productivity Improvement Half Life Required Work per FTE= 100
Units: Person*Hours/Person

Time per Task Updating Time= 3
Units: Month
```

5.23. Improvements in Operating Costs

For simplicity, I include only variable operating costs in this model because I assume that the company's fixed operating costs cannot be improved. Like the structure for *Required Work Hours* in section 5.22 (p.237), this structure for *Operating Costs* is a co-flow of the *Monthly Routine Work* structure in section 5.5 (p.158). Consequently, this

structure mirrors the *Required Work Hours* structure in every other respect.

```
Operating Costs= INTEG(
     + Operating Costs Erosion Rate
     + Operating Costs Increase Rate
     - Operating Costs Improvement Rate
     - Operating Costs Reduction Rate
     , Baseline Operating Costs)
Units: Dollars/Month

Baseline Operating Costs= Monthly Routine Work[FL]*Baseline
     Operating Costs per Task
Units: Dollars/Month

Operating Costs per Task= Operating Costs/Monthly Routine Work[FL]
Units: Dollars/Task
```
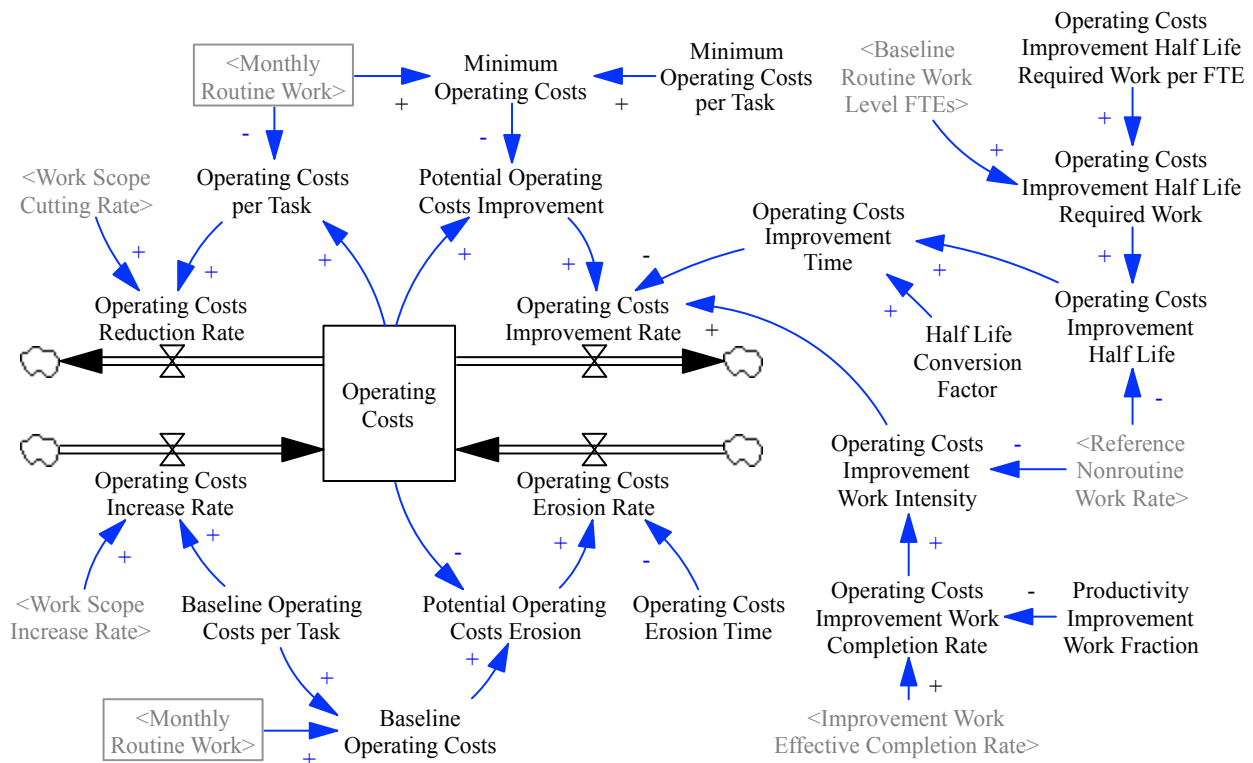

Figure 47. Model Diagram of Improvements in Operating Costs

When the scope of employees' monthly routine work is cut, the company then saves the current variable operating costs associated with that eliminated work.

```
Operating Costs Reduction Rate= Work Scope Cutting
     Rate[FL]*Operating Costs per Task
Units: (Dollars/Month)/Month
```

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When the scope of employees' monthly routine work is increased, I assume that the variable operating costs associated with that new work start at the unimproved, baseline level.

```
Operating Costs Increase Rate= Work Scope Increase
     Rate[FL]*Baseline Operating Costs per Task
Units: (Dollars/Month)/Month
```

Employees can reduce the variable operating costs of their routine work by engaging in CI work. Like productivity improvements (section 5.22, p.237), I assume that such improvements in variable operating costs will gradually erode over a long period of time if they are not sustained. For simplicity, I model this improvement erosion with first-order exponential decay.

```
Potential Operating Costs Erosion= MAX(Baseline Operating Costs -
     Operating Costs, 0)
Units: Dollars/Month

Operating Costs Erosion Rate= Potential Operating Costs
     Erosion/Operating Costs Erosion Time
Units: (Dollars/Month)/Month
```

I formulate the rate of improvement in variable operating costs by adapting Repenning and Sterman's (1994b) extension of Schneiderman's (1988) improvement half-life model. (See section 5.22, p.237, for an explanation of this formulation.)

```
Operating Costs Improvement Rate= (Potential Operating Costs
     Improvement/Operating Costs Improvement Time)*Operating Costs
     Improvement Work Intensity
Units: (Dollars/Month)/Month

Potential Operating Costs Improvement= MAX(Operating Costs -
     Minimum Operating Costs, 0)
Units: Dollars/Month

Minimum Operating Costs= Monthly Routine Work[FL]*Minimum
     Operating Costs per Task
Units: Dollars/Month

Operating Costs Improvement Work Intensity= ZIDZ(Operating Costs
     Improvement Work Completion Rate, Reference Nonroutine Work
     Rate[FL])
Units: Dmnl
```

I assume that employees' CI work time not spent improving productivity (section 5.22, p.237) is spent improving variable operating costs.

```
Operating Costs Improvement Work Completion Rate= Improvement Work
    Effective Completion Rate*(1-Productivity Improvement Work
    Fraction)
Units: Person*Hours/Month
```

I determine the improvement half-life for operating costs from the amount of improvement work required of every employee to cut the variable operating costs of everyone's monthly routine work in half. Then I compute the operating-costs improvement time constant from this half-life.

```
Operating Costs Improvement Half Life Required Work= Operating
    Costs Improvement Half Life Required Work per FTE*Baseline
    Routine Work Level FTEs[FL]
Units: Person*Hours

Operating Costs Improvement Half Life= XIDZ(Operating Costs
    Improvement Half Life Required Work, Reference Nonroutine Work
    Rate[FL], 1e+06)
Units: Month

Operating Costs Improvement Time= Operating Costs Improvement Half
    Life*Half Life Conversion Factor
Units: Month
```

I assume that DTE Energy's managers do not consider operating-cost reductions as savings forever, but rather revise their expectations for variable operating costs. I model this expectation-revision process using first-order exponential smoothing.

```
Operating Costs per Task Standard= SMOOTHI(Operating Costs per
    Task, Operating Cost Standard Adjustment Time, Baseline
    Operating Costs per Task)
Units: Dollars/Task
```

Parameters for Improvements in Operating Costs

```
Baseline Operating Costs per Task= 28
Units: Dollars/Task
```

```
Operating Costs Erosion Time= 120
Units: Month

Minimum Operating Costs per Task= 14
Units: Dollars/Task

Operating Costs Improvement Half Life Required Work per FTE= 100
Units: Person*Hours/Person

Operating Cost Standard Adjustment Time= 3
Units: Month
```

5.24. CI Savings Rate

The financial gains from CI work are two-fold. First, if employees improve their productivity, they are able to take on more work without increasing the company's labor costs. In many companies, such expansion would require an increase in sales or diversification. DTE Energy employed a large number of contractors, so DTE Energy's managers could enact work-scope increases for regular employees (see section 5.5, p.158) by cutting contractors and insourcing those contractors' work. For simplicity, I assume that DTE Energy's amount of outsourced work is larger than any amount that could be potentially insourced, and that DTE Energy's employees have the ability to perform any insourced work. I also assume that DTE Energy's contractors are paid the same hourly wages as DTE Energy's regular employees.
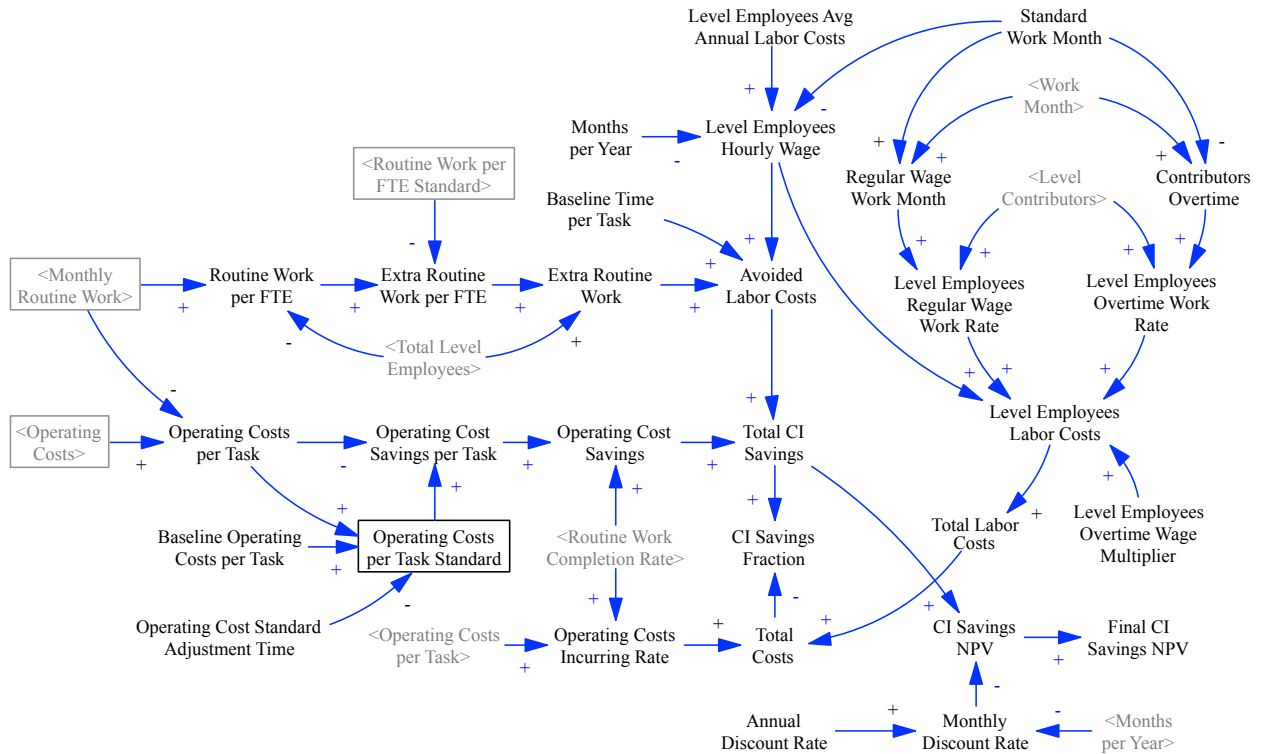
Figure 48. Model Diagram of CI Savings Rate

```
Avoided Labor Costs= SUM(Extra Routine Work[level!]*Baseline Time
    per Task*Level Employees Hourly Wage[level!])
Units: Dollars/Month

Level Employees Hourly Wage[level]= Level Employees Annual Labor
    Costs[level]/(Standard Work Month*Months per Year)
Units: Dollars/(Person*Hour)
```

The second source of financial gains from CI work is the direct reduction in variable operating costs.

```
Operating Cost Savings per Task= MAX(Operating Costs per Task
    Standard - Operating Costs per Task, 0)
Units: Dollars/Task

Operating Cost Savings= Routine Work Completion Rate[FL]*Operating
    Cost Savings per Task
Units: Dollars/Month
```

I assume that the company's senior executives and middle managers are convinced (or disillusioned) of CI's benefits by comparing these financial savings from CI work to the company's total costs (which, in this model, comprise only labor and variable operating

costs).

```
Total CI Savings= Avoided Labor Costs + Operating Cost Savings
Units: Dollars/Month

CI Savings Fraction= ZIDZ(Total CI Savings, Total Costs)
Units: Fraction

Total Costs= Total Labor Costs + Operating Costs Incurring Rate
Units: Dollars/Month

Operating Costs Incurring Rate= Routine Work Completion
    Rate[FL]*Operating Costs per Task
Units: Dollars/Month

Total Labor Costs= SUM(Level Employees Labor Costs[level!])
Units: Dollars/Month
```

I account for the extra pay earned by front-line employees for any overtime that they work, which increases labor costs.

```
Level Employees Labor Costs[level]= (Level Employees Regular Wage
    Work Rate[level] + Level Employees Overtime Work
    Rate[level]*Level Employees Overtime Wage
    Multiplier[level])*Level Employees Hourly Wage[level]
Units: Dollars/Month

Level Employees Regular Wage Work Rate[level]= SUM(Level
    Contributors[level,contributor!]*Regular Wage Work
    Month[level,contributor!])
Units: Person*Hours/Month

Regular Wage Work Month[SE,contributor]= Standard Work Month
Regular Wage Work Month[MM,contributor]= Standard Work Month
Regular Wage Work Month[FL,contributor]= MIN(Work
    Month[FL,contributor], Standard Work Month)
Units: Hours/Month

Level Employees Overtime Work Rate[level]=SUM(Level
    Contributors[level,contributor!]*Contributors
    Overtime[level,contributor!])
Units: Person*Hours/Month

Contributors Overtime[level,contributor]= MAX(Work
    Month[level,contributor] - Standard Work Month, 0)
Units: Hours/Month
```

In Chapter 7 I search for the optimal values of policy parameters. I use the net-

present value of each simulation's entire stream of CI savings as the payoff function for these optimization routines.

```
CI Savings NPV= NPV(Total CI Savings, Monthly Discount Rate, 0, 1)
Units: Dollars

Monthly Discount Rate= Annual Discount Rate/Months per Year
Units: Fraction/Month

Final CI Savings NPV= IF THEN ELSE(Time > (FINAL TIME - TIME
    STEP/2), CI Savings NPV, 0)
Units: Dollars
```

Parameters for CI Savings Rate

```
Level Employees Avg Annual Labor Costs[level]= 250000,90000,45000
Units: Dollars/Person/Year

Level Employees Overtime Wage Multiplier[level]= 1,1,1.5
Units: Dmnl

Annual Discount Rate= 0.11
Units: Fraction/Year
```

5.25. Service Quality

The quality of service being provided is made up of two components, task quality and work quantity. Service quality decreases (increases) when employees complete less (more) work — such as preventive equipment maintenance and clearance of overhead power lines — than their baseline work. Service quality also decreases (increases) when employees spend less (more) time per task as a result of schedule pressure.

```
Service Quality Index[level]= Monthly Routine Work
    Ratio[level]*Level Time per Task Ratio[level]
Units: Dmnl

Monthly Routine Work Ratio[level]= Routine Work Completion
    Rate[level]/Baseline Monthly Routine Work[level]
Units: Fraction
```

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```
Level Time per Task Ratio[level]= SUM(Contributors Time per Task
    Ratio[level,contributor!]*Routine Work Level FTEs Contributor
    Fraction[level,contributor!])
Units: Fraction

Contributors Time per Task Ratio[level,contributor]= Time per
    Task[level,contributor]/Baseline Time per Task
Units: Fraction
```

5.26. Other Parameters

The *Half Life Conversion Factor* converts an improvement half-life duration into a first-order exponential-decay time constant (which is also called the "mean lifetime").

```
Half Life Conversion Factor= 1/LN(2)
Units: Dmnl

Months per Year= 12
Units: Month/Year
```

The following Excel spreadsheet contains the model's exogenous time series data. A separate worksheet holds the data for each simulation scenario.

```
Excel File Name :IS: 'DTEdata2.xls'

Excel File Scenario Name :IS: 'scenario6'

Excel File Time Row :IS: '2'
```

The simulation model is set up to run from January 1997 (Month 0) to January 2012 (Month 180).

```
INITIAL TIME= 0
Units: Month

FINAL TIME= 180
Units: Month

TIME STEP= 0.0078125
Units: Month [0,?]

SAVEPER= 0.1
Units: Month [0,?]
```

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Chapter 6: Simulation Analysis

My approach to analyzing DTE Energy's experience with its CI initiative over the 12-year period 1997-2009 consisted of simulating six scenarios. Each scenario divides this 12-year period into two portions. The first portion of each scenario represents DTE Energy's actual experience until a certain cut-off date. The end of each of the six phases that I describe in Chapters 2-4 is the cut-off date for each of the six scenarios, respectively. The second portion of each scenario is a counterfactual history during which I allow the simulation of each scenario to proceed until January 2012 with all model parameters unchanged from the cut-off date. In this way, each successive scenario adds one more phase to the portion representing DTE Energy's actual experience. The counterfactual portions enable me to assess how the CI initiative would have unfolded with no changes in policy or circumstances beyond each scenario's cut-off date.

The six simulation scenarios are defined according to the timing of significant changes either in the design of the CI initiative, enacted by DTE Energy's OSSG personnel, or in the directives given by DTE Energy's senior executives in response to the exigencies faced by the company. Because my formal model represents the structures of DTE Energy in such a stylized fashion, these changes in CI initiative design and in executive directives are formulated as exogenous parameter changes or exogenous time series. The parameters for each of the six scenarios are given in Table 4 (p.253), and the exogenous time series are given in Table 5 (p.255).

The cut-off dates for each of the six scenarios are defined as follows. Scenario 1 represents DTE Energy's actual history from January 1997 (the start of the simulation), through the April 1999 start of the CI initiative in earnest, until April 2000 when the distractions of the MichCon merger would have diverted upper management's attention away from CI. Instead, no merger occurs and the strategy of conducting (only) *kaizen* events continues.

Scenario 2 adds the actual 13 months of merger trouble and the merger's close in May 2001. In Scenario 2's counterfactual portion beyond May 2001, I assume that the

kaizen facilitator training resumes and facilitators stop dropping out of the CI initiative.

Scenario 3 adds the many significant changes to the CI initiative enacted by the OSSG personnel until the start of the PEP initiative in August 2005. These changes included replacing the *kaizen* facilitators with OS Experts in July 2002, the inception of Green Belt training in May 2003, and replacing OS Experts with Black Belts in July 2004. The counterfactual portion of Scenario 3 is important because it shows the outcome of what would later be the enduring core features of the CI initiative but in the absence of any financial stress.

Scenario 4 adds the financial stress and associated cost cutting and downsizing of the PEP initiative from August 2005 onward. Scenario 4's counterfactual portion is less instructive because it reflects how DTE Energy's history would have unfolded if the company's financial stress and the PEP initiative had continued indefinitely.

Scenario 5 adds the abatement of the company's financial stress and concomitant return to the CI initiative's Lean Six Sigma strategy in January 2007. Scenario 5's counterfactual portion begins in October 2008 when the economic crisis would have happened but does not in this scenario.

Scenario 6 adds the financial stress of this economic crisis and DTE Energy's ECR plan, which lasted through the end of 2009. The one significant change in the actual portion of Scenario 6 was the tactic of eliminating contractors, instead of downsizing the employee workforce, and insourcing those contractors' work. My case study ends in January 2010 with the passing of the economic crisis, but I continue to simulate the effects of DTE Energy's managers continuing to insource contract labor through the end of 2011.

Parameter Variable	Units	1. Kaizens		2. Merger		3. Six Sigma		4. PEP		5. Lean Six Sigma		6. ECR	
		Value	Date	Value	Date	Value	Date	Value	Date	Value	Date	Value	Date
SE Training Start Date	Month	12	Jan 1998	12	Jan 1998	12	Jan 1998	12	Jan 1998	12	Jan 1998	12	Jan 1998
Constant BB Coaching Start Date	Month	27	Apr 1999	27	Apr 1999	27	Apr 1999	27	Apr 1999	27	Apr 1999	27	Apr 1999
Merger Close Date	Month	180	Never	52	May 2001	52	May 2001	52	May 2001	52	May 2001	52	May 2001
Constant BB Coaching Duration	Months	180	Always	180	Always	39	until Jul 2002	39	until Jul 2002	39	until Jul 2002	39	until Jul 2002
BB Training Change Date	Month	180	Never	180	Never	66	Jul 2002	66	Jul 2002	66	Jul 2002	66	Jul 2002
GB Training Start Date	Month	180	Never	180	Never	76	May 2003	76	May 2003	76	May 2003	76	May 2003
BB Certification Start Date	Month	180	Never	180	Never	90	Jul 2004	90	Jul 2004	90	Jul 2004	90	Jul 2004
Downsizing Start Date	Month	180	Never	180	Never	180	Never	108	Jan 2006	108	Jan 2006	108	Jan 2006
Downsizing Duration	Months	0	None	0	None	0	None	72	until Jan 2012	12	until Jan 2007	12	until Jan 2007
Work Scope Increase Start Date	Month	180	Never	180	Never	180	Never	180	Never	180	Never	141	Oct 2008

Table 4. Parameter Values for Simulation Scenarios

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Exogenous Time Series	Units	Change Date	Month	1. Kaizens Value	2. Merger Value	3. Six Sigma Value	4. PEP Value	5. Lean Six Sigma Value	6. ECR Value
Target BB to Workforce Ratio	Person/Person	Jan 1997	0	0	0	0	0	0	0
		Apr 1999	27	0.02	0.02	0.02	0.02	0.02	0.02
		Apr 2000	39		0	0	0	0	0
		May 2001	52		0.02	0	0	0	0
		Jul 2002	66			0.02	0.02	0.02	0.02
BB Fractional Dropout Rate	Fraction/Month	Jan 1997	0	0	0	0	0	0	0
		Apr 2000	39		0.2	0.2	0.2	0.2	0.2
		May 2001	52		0	0.2	0.2	0.2	0.2
		Jul 2002	66			0	0	0	0
Distractions Index[SE]	Dmnl	Jan 1997	0	0	0	0	0	0	0
		Apr 2000	39		1	1	1	1	1
		May 2001	52		0	0	0	0	0
Distractions Index[MM]	Dmnl	Jan 1997	0	0	0	0	0	0	0
		Apr 2000	39		0.5	0.5	0.5	0.5	0.5
		May 2001	52		0	0	0	0	0
Distractions Index[FL]	Dmnl	Jan 1997	0	0	0	0	0	0	0
BB Hire Rate[SE]	Person/Month	Jan 1997	0	0	0	0	0	0	0
BB Hire Rate[MM]	Person/Month	Jan 1997	0	0	0	0	0	0	0
BB Hire Rate[FL]	Person/Month	Jan 1997	0	0	0	0	0	0	0
		Jan 2004	84			0.9	0.9	0.9	0.9
		Jan 2005	96			0.54	0.54	0.54	0.54
BB Hire Avg CI Experience	Person*Hours / Person	Jan 1997	0	0	0	0	0	0	0
		Jan 2004	84			4160	4160	4160	4160
Financial Stress	Dmnl	Jan 1997	0	0	0	0	0	0	0
		Aug 2005	103				1	1	1
		Jan 2007	120					0.3	0.3
		Jan 2008	132					0	0
		Oct 2008	141						1
		Jan 2010	156						0

Table 5. Exogenous Time Series for Simulation Scenarios

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6.1. Scenario 1: *Kaizen* Events

A few senior executives were CI believers at the start of the simulation in January 1997. Without any CI activities during 1997 to produce results, aggregate senior executive belief eroded slowly (Figure 51) until the CCI personnel began training DTE Energy's executives in January 1998 (Figure 49). This senior executive training was necessary to keep executive belief from eroding to zero.
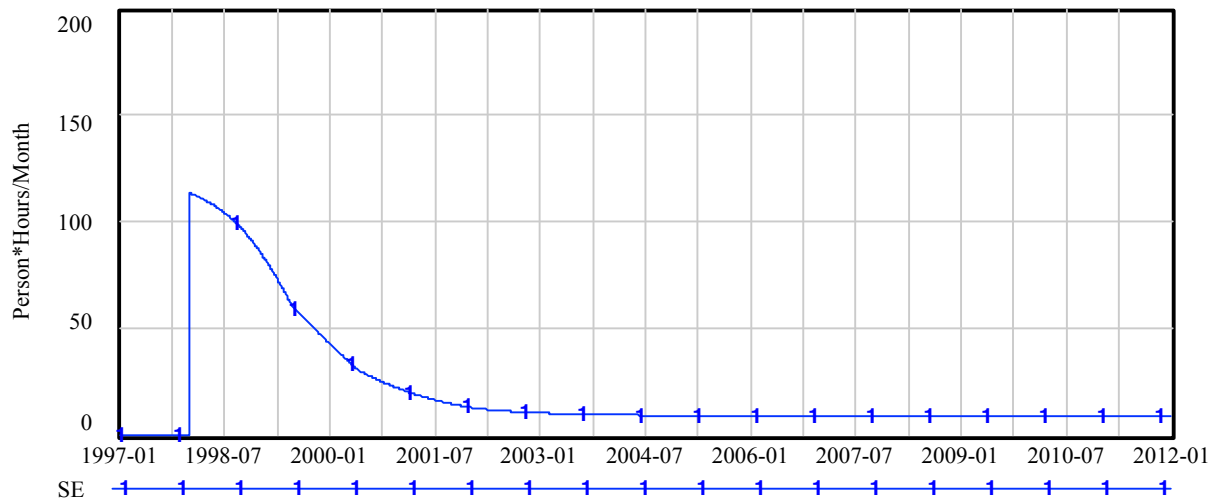
Figure 49. Scenario 1: Senior Executive Training Rate

The model structure reflects the assumption that senior executive believers always push their subordinates for CI work. This assumption implies a small push for CI work in 1997 even though DTE Energy had no CI initiative yet. This push created a "disillusioning machine". Employees attempted a small number of CI activities but with no training from the CI personnel or support from managers or CI experts, all of these CI activities failed, producing only skeptical middle managers and front-line employees.

The CCI personnel began training *kaizen* facilitators in April 1999. These *kaizen* facilitators' CI skill was low because their training was short and they were not required to complete their own CI projects before coaching others (see Figure 50 below). Front-line employees' effort earnestness was boosted by the coaching provided by these *kaizen* facilitators after April 1999, but not by enough for them to achieve convincing results. Put simply, everyone in the company lacked sufficient CI skill to trigger a reinforcing feedback process of good results convincing employees to participate enough to build their CI skill.

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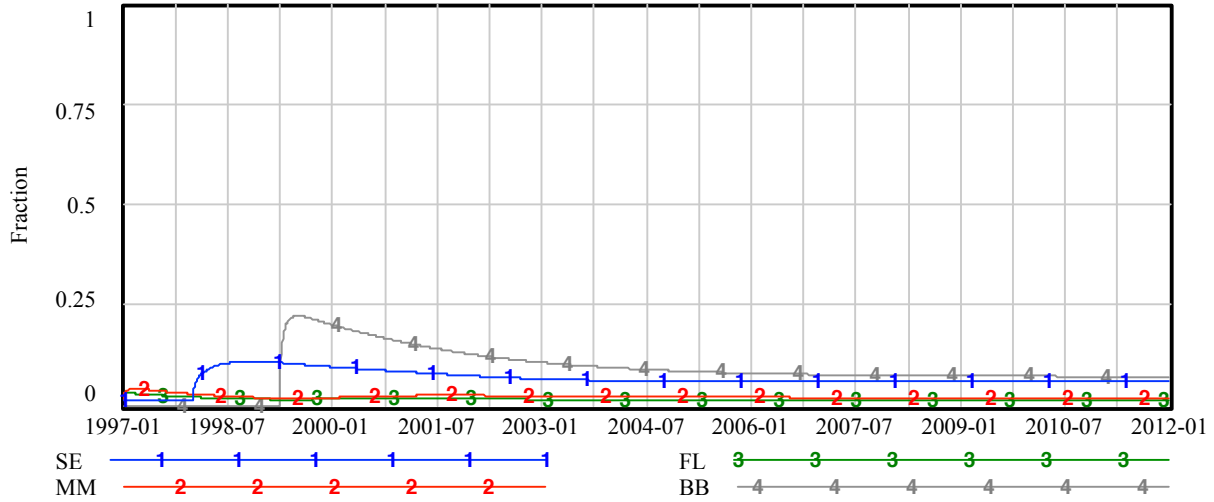
Figure 50. Scenario 1: Average CI Skill

The number of senior executive believers peaked in March 1999 (Figure 52), right before the start of *kaizen* facilitator training in April. At this point, the senior executives' disillusioning rates from poor CI results began to outpace their convincing rates from their training (Figure 52). The growing number of senior executive and middle manager skeptics gave rise to two forces that accelerated the disillusioning of upper management: a reduction in senior executive training (Figure 49) and an increase in negative word of mouth.
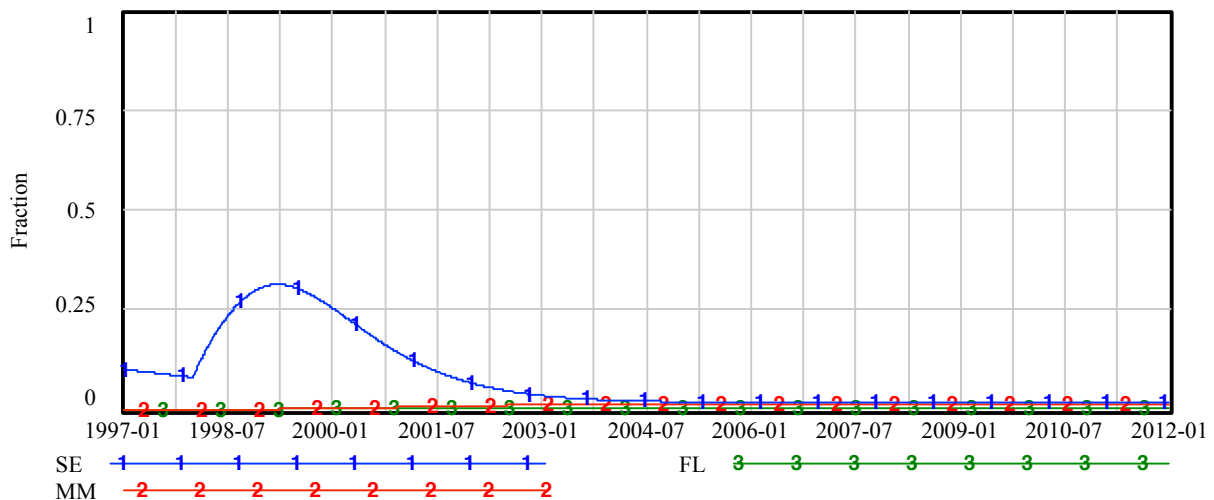
Figure 51. Scenario 1: Believers Fraction

This scenario excludes actual events from April 2000 onward, when the MichCon merger would have distracted DTE Energy's senior executives from the CI initiative and

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halted *kaizen* facilitator training. Instead, a counterfactual history unfolds in which senior executives and middle managers became largely anti-CI from negative word of mouth (Figure 52). Front-line employees, less susceptible to the effects of negative word of mouth, mostly revert to being neutral.
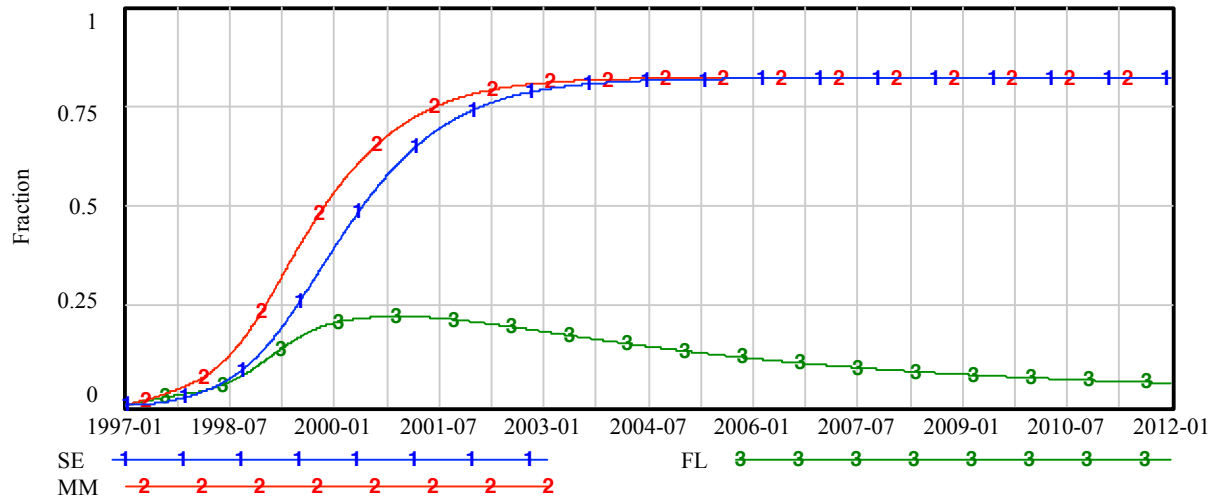
Figure 52. Scenario 1: Skeptics Fraction

6.2. Scenario 2: MichCon Merger

The merger negotiations between Detroit Edison and MichCon became contentious and difficult from April 2000 until the merger's eventual close in May 2001 (Table 5, p.255). I model four effects of the merger trouble during this 12-month period: (1) it distracted senior executives from their CI training (Figure 53), (2) it distracted both senior executives and middle managers from pushing for CI work, (3) it caused the CCI personnel to suspend their goal for training a certain number of *kaizen* facilitators and, consequently, (4) the existing *kaizen* facilitators began dropping out of the CI initiative because they believed it would not last (Figure 54).
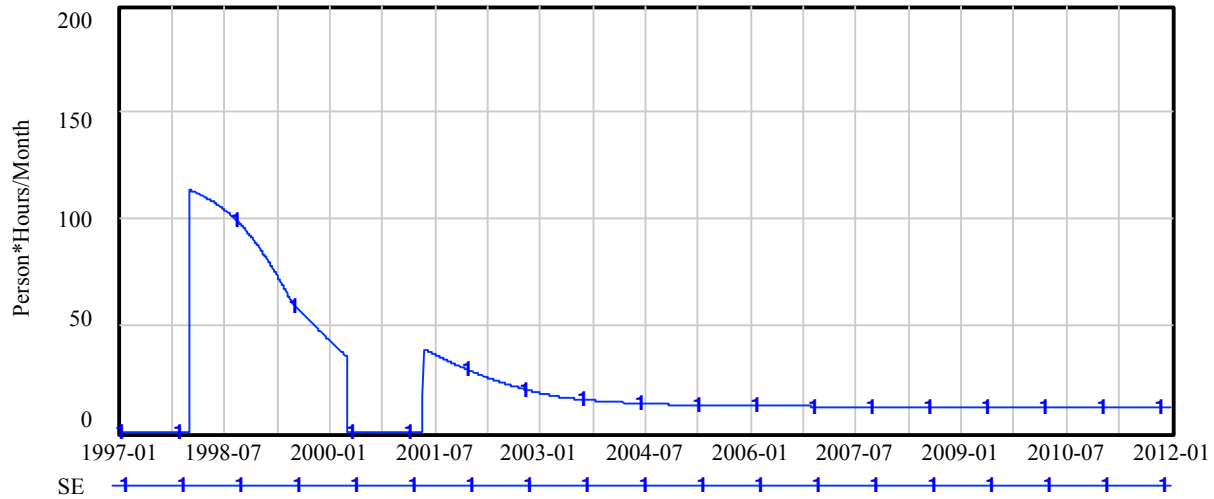
Figure 53. Scenario 2: Senior Executive Training Rate
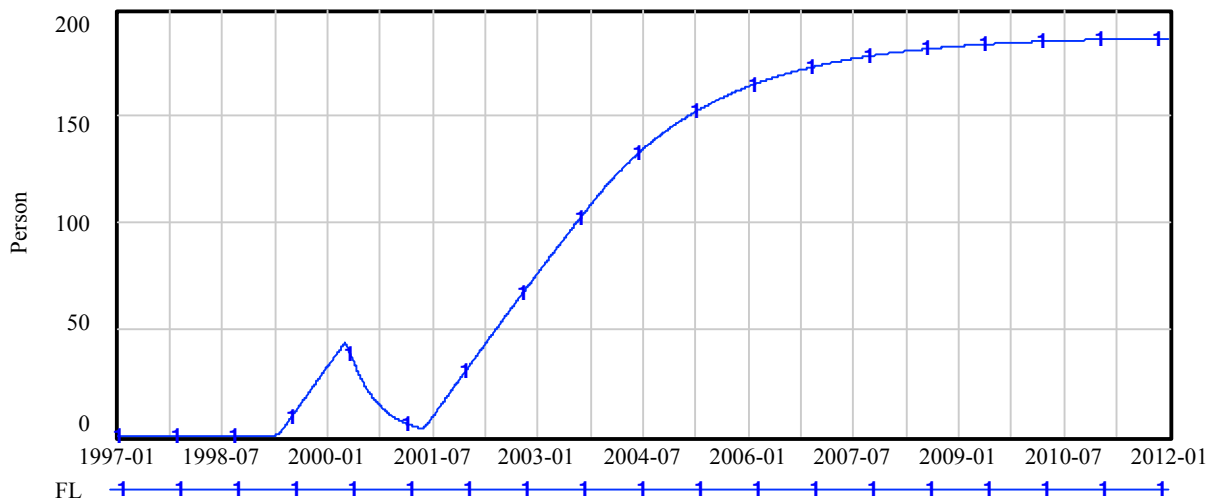
Figure 54. Scenario 2: Front-Line Black Belts

The overall trajectory of this scenario is similar to Scenario 1's trajectory. Several senior executives, convinced of CI's benefit by the CCI group's training, unwittingly created a disillusioning machine by pushing for CI work without ensuring that front-line employees were receiving the skilled coaching that they needed from the *kaizen* facilitators. Skepticism of CI mounted as before (Figure 56). During the 12 months of merger trouble, however, senior executive believers became disillusioned at a faster rate because senior executive training was cut back (Figure 53), but negative word of mouth from skeptics remained unchanged. On the other hand, the distraction of upper

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management helped reduce the number of skeptical front-line employees. How?
Distracted managers did not push for as much CI work, resulting in fewer front-line
employees being pushed through the disillusioning machine.
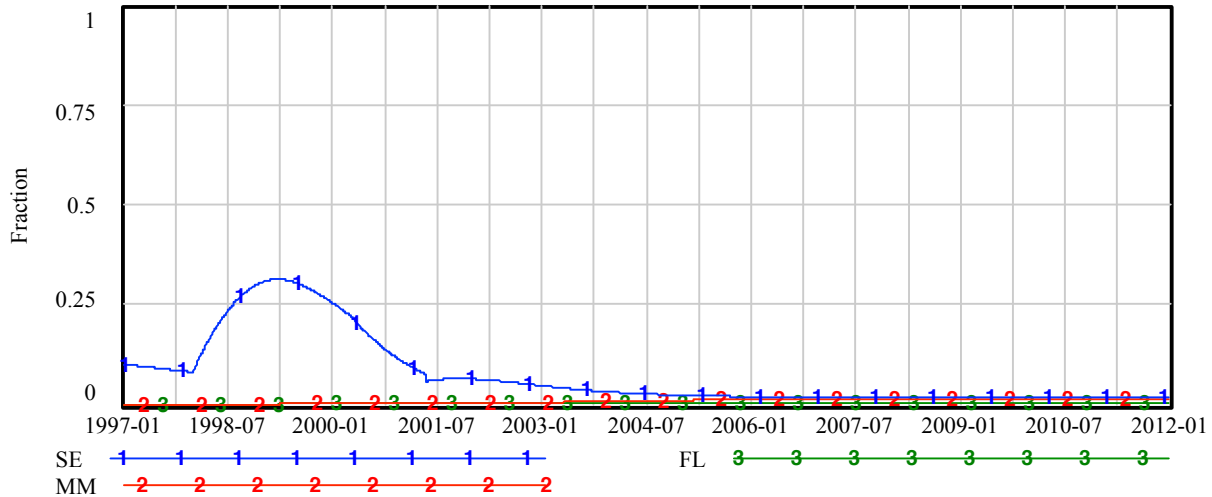
Figure 55. Scenario 2: Believers Fraction

When the merger closed in May 2001 (Table 4, p.253), DTE Energy experienced a
sudden step-wise increase in neutral employees as all of MichCon's employees joined the
company (Figure 56). But the same end-state equilibrium was reached: about 82 percent
of upper management and about 5 percent of front-line employees became skeptical
through negative word of mouth. In this scenario, the CI initiative fails because
employees never accumulate enough skill to produce convincing CI results.
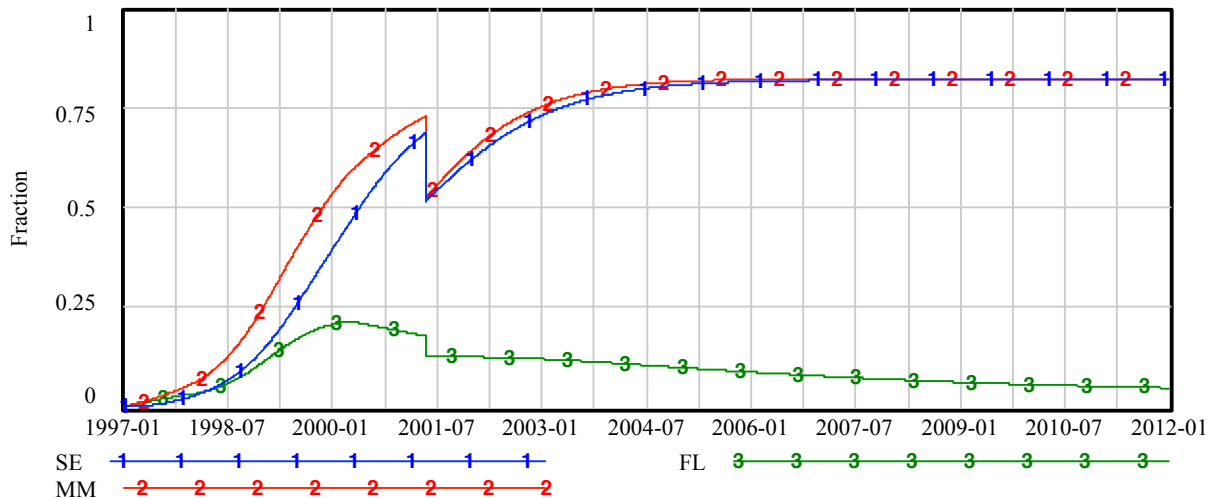
Figure 56. Scenario 2: Skeptics Fraction

6.3. Scenario 3: Six Sigma

The primary flaw in the CI initiative's design through 2001 was the *kaizen* facilitators' relatively low skill (Figure 50). Furthermore, the *kaizen* facilitators were dedicated completely to coaching (Figure 57); they were not responsible for achieving CI results that would have slowed the rate of senior executive and middle manager disillusioning.
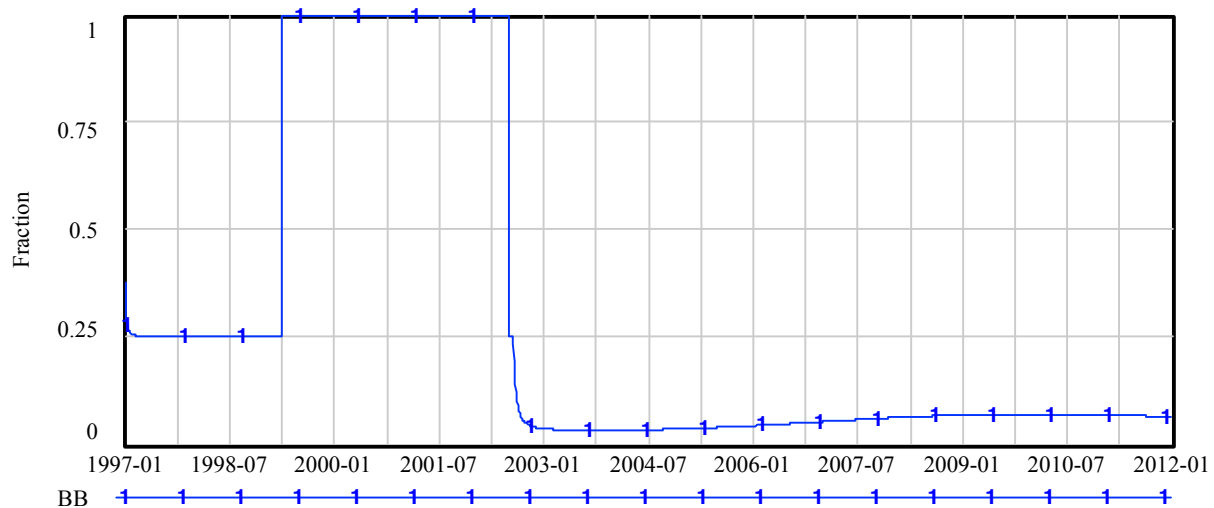
Figure 57. Scenario 3: Black Belt Coaching Fraction

The OSSG's first and second CI implementation plans corrected this primary flaw. The first plan called for training OS Experts who would focus on completing their own CI projects concurrently with coaching employees. The OSSG personnel began training OS Experts in July 2002 (Table 4, p.253). Between the first and second plans, DTE Energy formally added Six Sigma elements to its CI initiative. In the second plan, therefore, OS Experts were renamed Black Belts and their training was strengthened in July 2004 to require two certification projects (Table 4, p.253; Figure 59). When it became clear that DTE Energy was going to adopt Six Sigma practices, managers began hiring certified Six Sigma Black Belts from outside the company. Such hiring began aggressively between January and December 2004 before settling to a stable rate (Table 5, p.255). These experienced Black Belts further boosted the average skill of DTE Energy's coaching experts (Figure 58).

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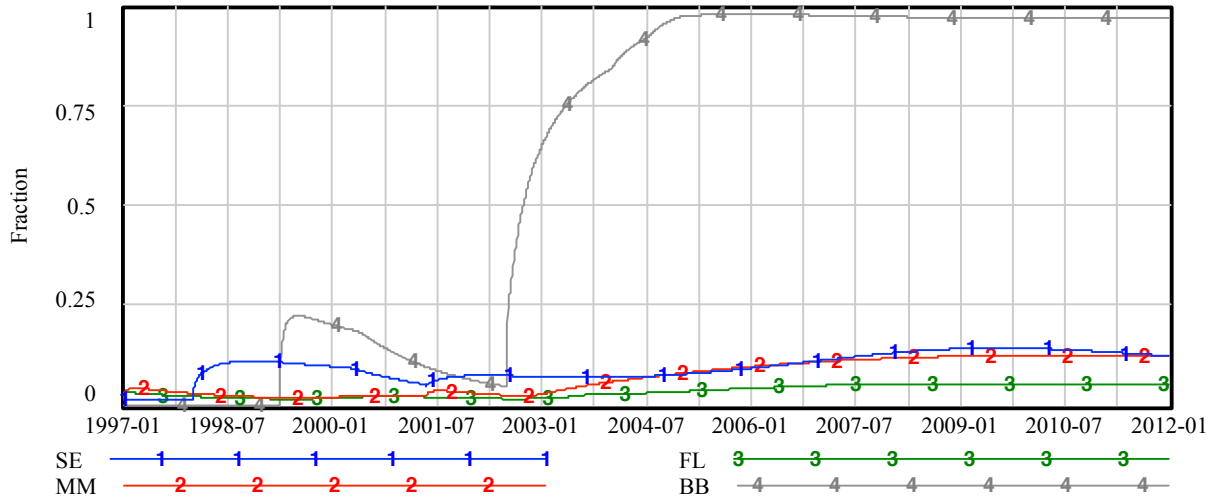
Figure 58. Scenario 3: Average Skill

With a growing cadre of Black Belts in the company, the OSSG leaders replaced *kaizen* events with Black Belt-led CI projects as DTE Energy's principle way of enacting CI. When the MichCon merger extinguished managers' willingness to hold *kaizen* events, DTE Energy's *kaizen* facilitators simply stopped their CI activities. They were never recalled to CI duty after the merger, so this scenario reflects a high *kaizen* facilitator dropout rate between April 2000 and May 2001 (Table 5, p.255; Figure 59).
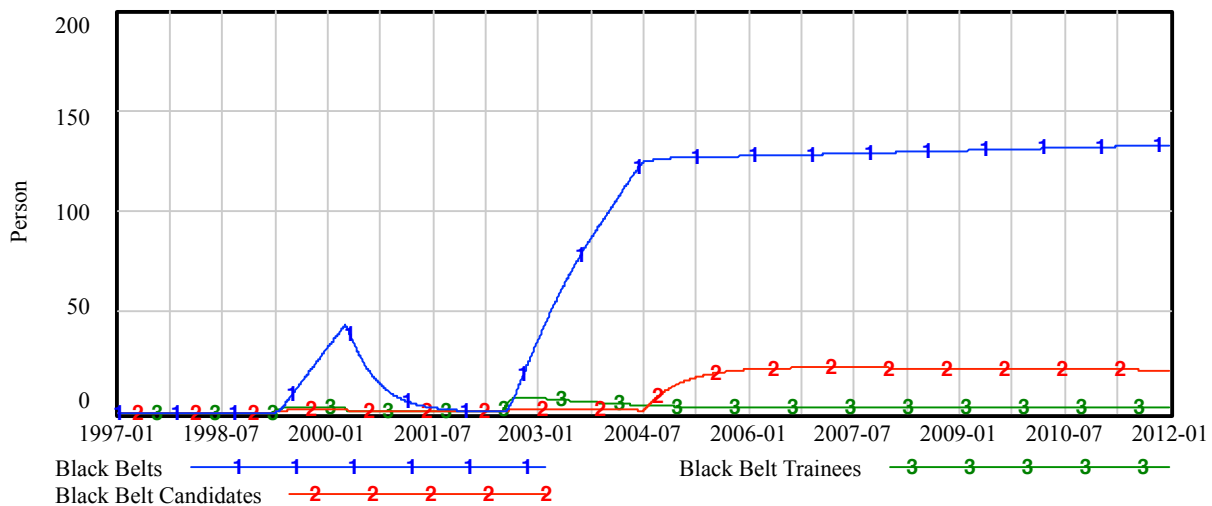
Figure 59. Scenario 3: Front-Line Black Belt Program Participants

In addition to improving the OS Expert and Black Belt training, the OSSG personnel also began training front-line employees as OS Specialists (ostensibly equivalent to Six Sigma Green Belt training; see Figure 60). The OSSG personnel sporadically set loose

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goals for training Green Belts but, realistically, employees would enroll in Green Belt training only if (1) their senior executive was a believer and pushed for it, or (2) they became convinced through their participation in a CI project and wanted to learn more about CI tools and methods. Green Belt training helped promote awareness of DTE Energy's CI initiative among the front-line employees but its payoff in higher employee skill was minimal (Figure 58). Employees acquired much more applicable CI experience working on CI projects with Black Belts. Consequently, Green Belt training did not affect the CI initiative's adoption (and abandonment) dynamics substantially.
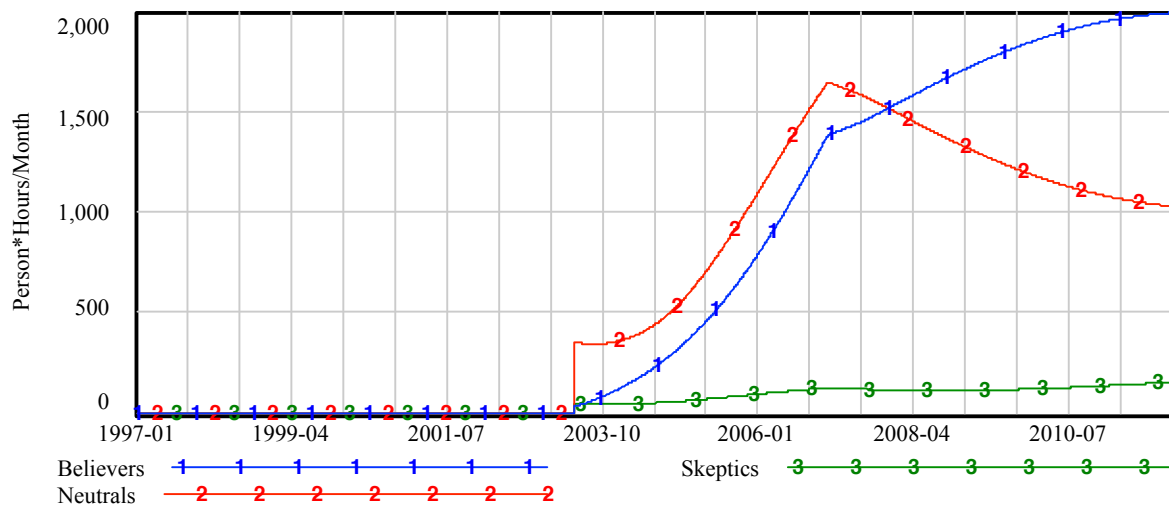
Figure 60. Scenario 3: Front-Line Green Belt Training Rates

This simulation scenario reproduces DTE Energy's actual history until August 2005, beyond which the simulation is counterfactual. In many respects, this counterfactual future is desirable: Black Belt and Green Belt training was underway, Black Belts were achieving notable results with CI projects, and DTE Energy's aggregate workforce CI skill and belief were both increasing. So what went wrong? As we shall see in the next section, DTE Energy experienced mounting financial stress in 2005, which raised the senior executives' expectations for the CI initiative to a level its participants could not meet.
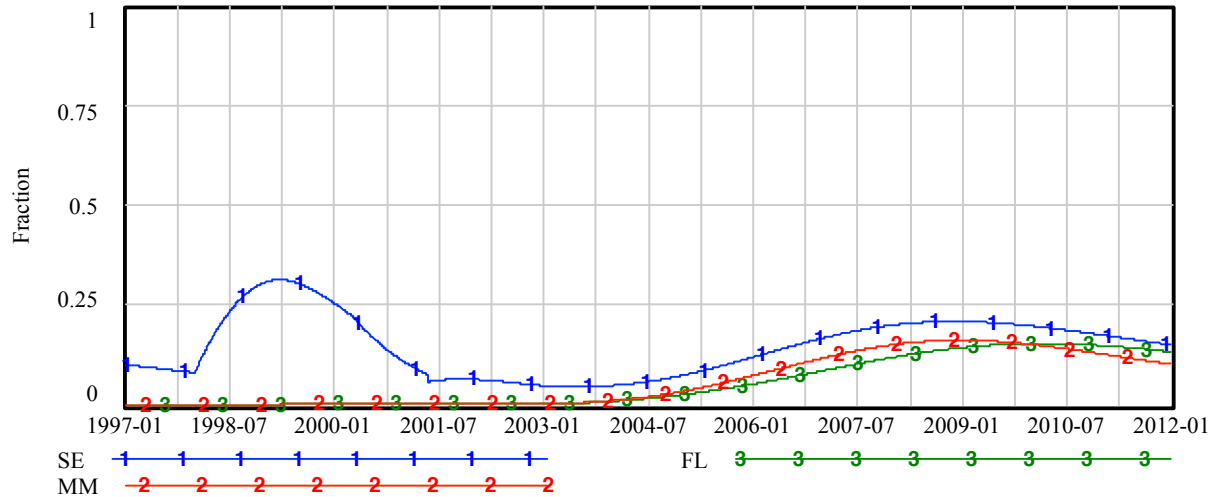
Figure 61. Scenario 3: Believers Fraction

As Figure 58 and Figure 61 indicate, it took a long time for DTE Energy's employees to build their belief and skill. This process was inhibited by downward pressures from several reinforcing feedback loops. All employees require good results to become convinced; unconvinced employees conform only ceremonially to their bosses' push for CI work, thereby reducing their chances of success and trapping themselves in a skeptical state. Unconvinced managers do not allocate enough time to supporting their subordinates' CI efforts, thereby also reducing their subordinates' effort earnestness (Figure 62). Black Belts, under pressure to justify their salaries, have a bias toward completing their own CI projects rather than coaching front-line employees (Figure 57), a bias which is exacerbated by low effort earnestness by front-line employees.
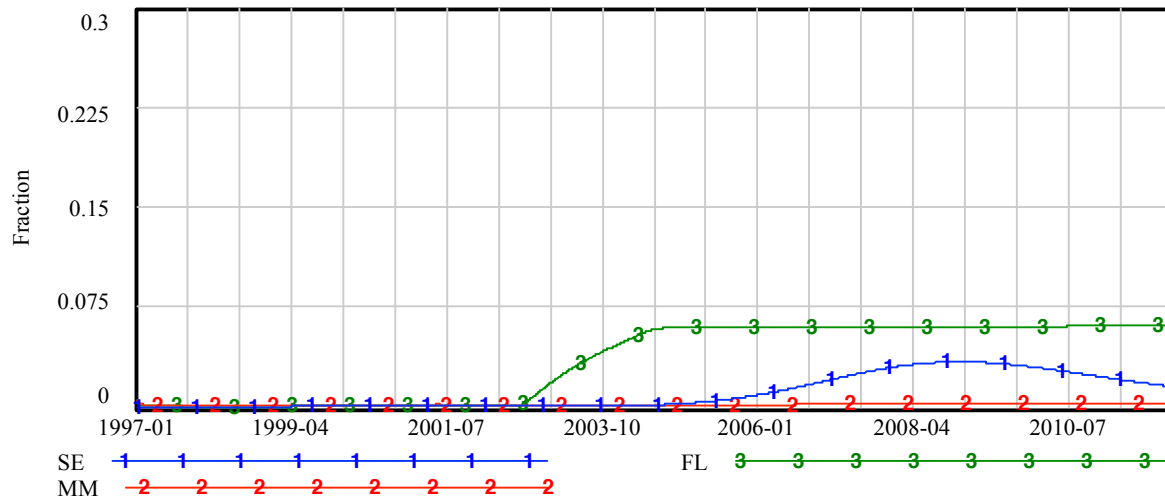
Figure 62. Scenario 3: CI Contribution Percentage

In this scenario, Black Belts must carry the CI torch long enough for the employees' collective accumulations of belief, participation, effort earnestness, and CI skill to overcome these downward pressures. This model suggests that the Black Belts need to carry the CI torch for 4-5 years before regular employees gain traction with their CI work. DTE Energy's senior executives couldn't wait that long.

6.4. Scenario 4: Performance Excellence Process (PEP)

When DTE Energy's financial stress mounted in August 2005 (Table 5, p.255), the senior executives demanded an all-hands-on-deck approach in which every employee was expected to perform the maximum 32 hours per month of nonroutine work to reducing costs. I assume that employees who were CI believers or those pushed by their bosses to do so would attempt to reduce costs with CI work. Any difference between upper management's total push for cost reductions and employees' aggregate desired CI work is, by definition, cost-cutting work (Figure 63). The model reflects the assumption that costs are cut through two mechanisms, both of which reduce variable operating costs: layoffs and reductions in the scope of work performed.

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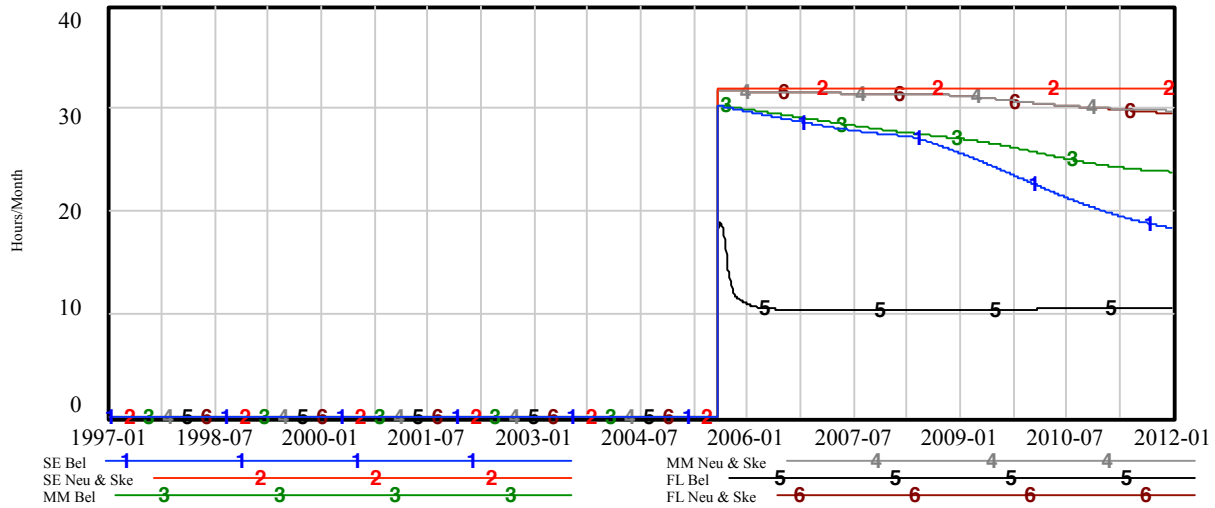
Figure 63. Scenario 4: Cost Cutting Work Rate per Employee

Employees began cutting the scope — and thereby the quality — of their work in August 2005. One immediate consequence of this work-scope cutting was a drop in each employee's monthly routine work (Figure 64).
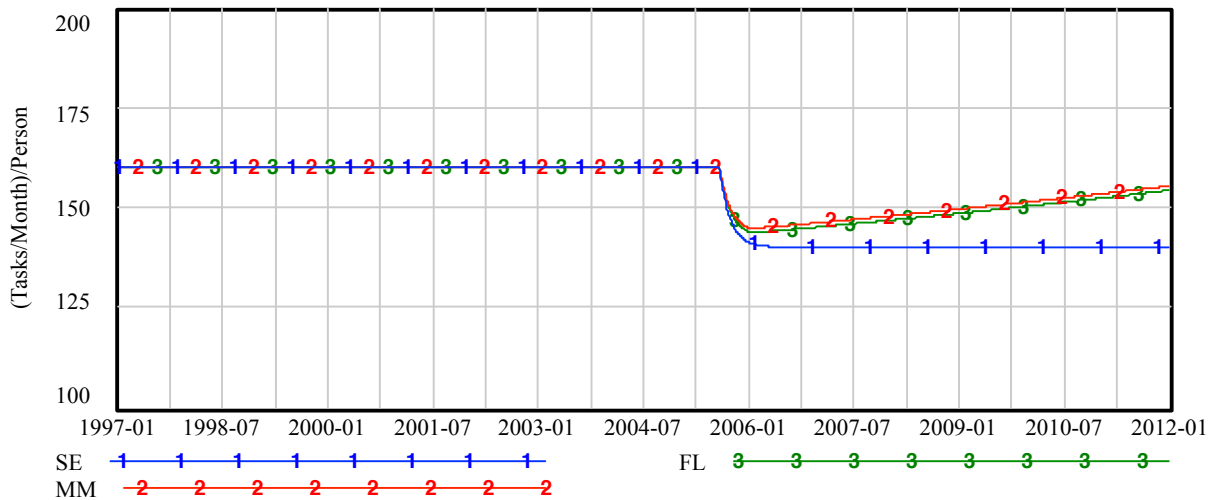
Figure 64. Scenario 4: Monthly Routine Work per FTE

Variable operating costs were reduced but labor costs remained high (Figure 65). Because the model includes no downsizing at the senior-executive level, DTE Energy's senior executives enjoyed a smaller workload after the scope of the company's operations were cut. Employees lower in the company hierarchy also enjoyed a smaller workload but only until downsizing began. After layoffs started in January 2006 (Table 4, p.253), the monthly routine work per employee began to climb back up. But it had not reached

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its pre-August 2005 level by the end of this simulation because DTE Energy employees' labor unions constrained how aggressively DTE Energy's senior executives could downsize the workforce.
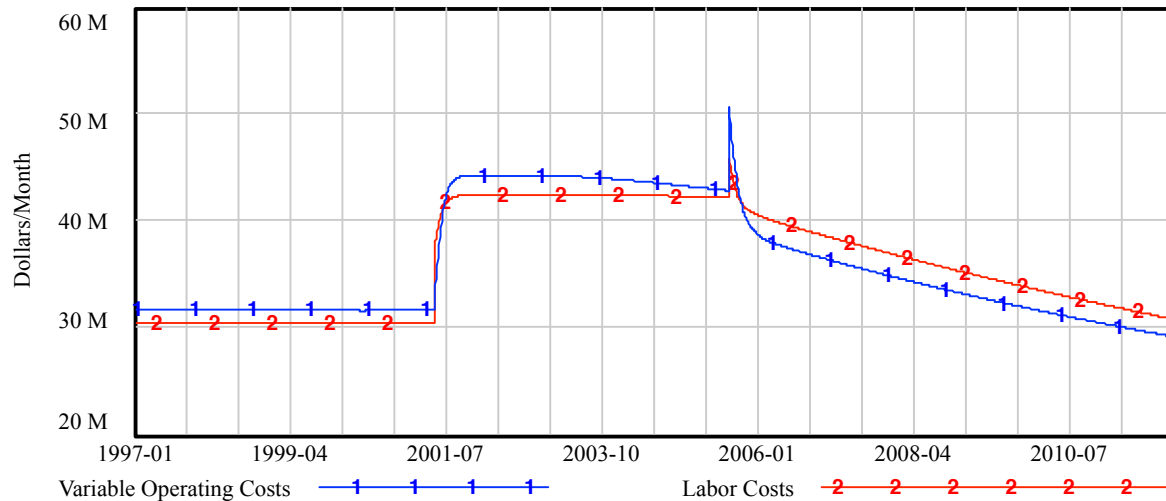
Figure 65. Scenario 4: Monthly Operating Costs

The model reflects the assumption that upper management's expectations for the appropriate amount of monthly routine work per employee were adaptive (although I do formulate these adaptive expectations with a ratchet effect: managers increase workload standards more readily than they reduce them). Although monthly routine work per employee did not reach its pre-August 2005 level by January 2012 (Figure 64), it did breach upper management's changing workload standard in February 2008 (14 months after the beginning of this simulation scenario's counterfactual portion in January 2007). From February 2008 onward, layoffs increased the monthly routine work per employee faster than work-scope cutting decreased it. This net increase in monthly routine work per employee created apparent avoided labor costs as employees' workload increased above upper management's standard (Figure 66).
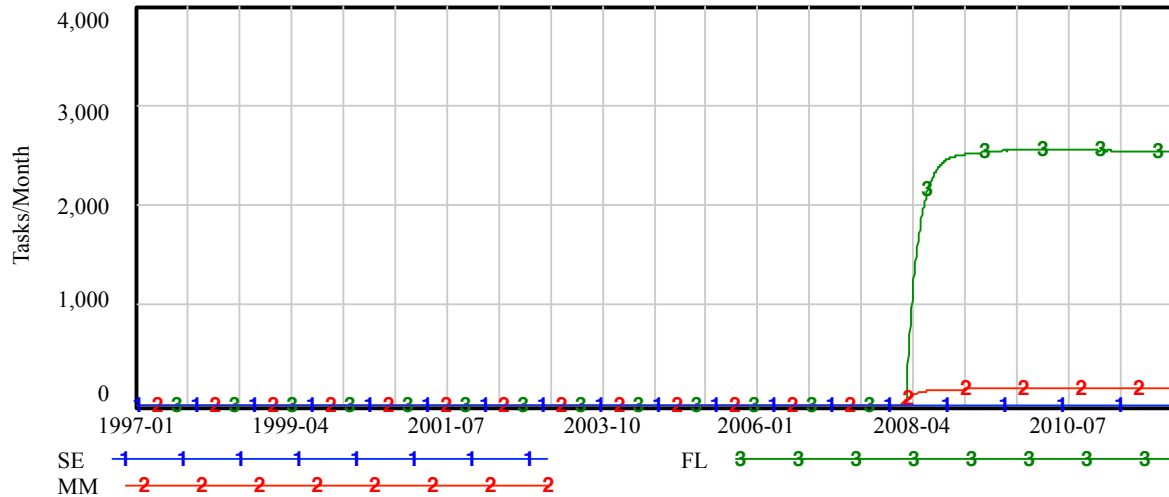
Figure 66. Scenario 4: Extra Monthly Routine Work

These labor "savings" were commingled with the results from employees' CI work, which increased the convincing rate of the senior executives and middle managers, but not the front-line employees (Figure 67).
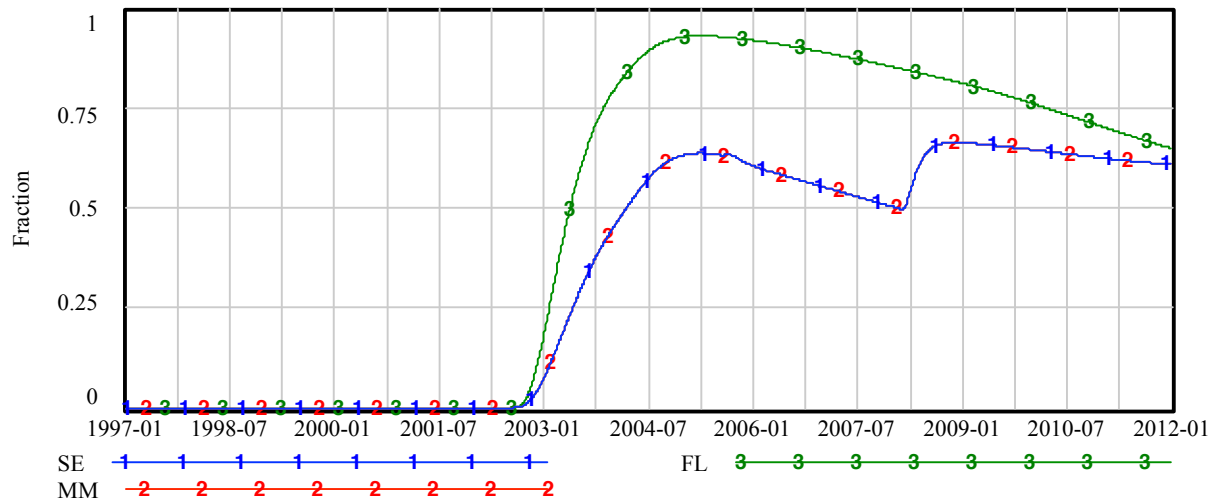
Figure 67. Scenario 4: Neutrals Convincing Fraction

In this simulation scenario, the fractional rate at which senior executives and middle managers were convinced exceeded that of the front-line employees (Figure 68). CI savings and the addition of apparent avoided labor costs from February 2008 onward kept increasing the numbers of upper management believers. In the counterfactual portion of this scenario, the fraction of believer middle managers exceeded that of senior executives in January 2011 because of Black Belts promoted into middle management. The

fractional improvement rate of their productivity perceived by front-line employees peaked in April 2005 after dramatic increases in the 33 months since July 2002. As this improvement rate decreased, so did the rates at which front-line employees became convinced.
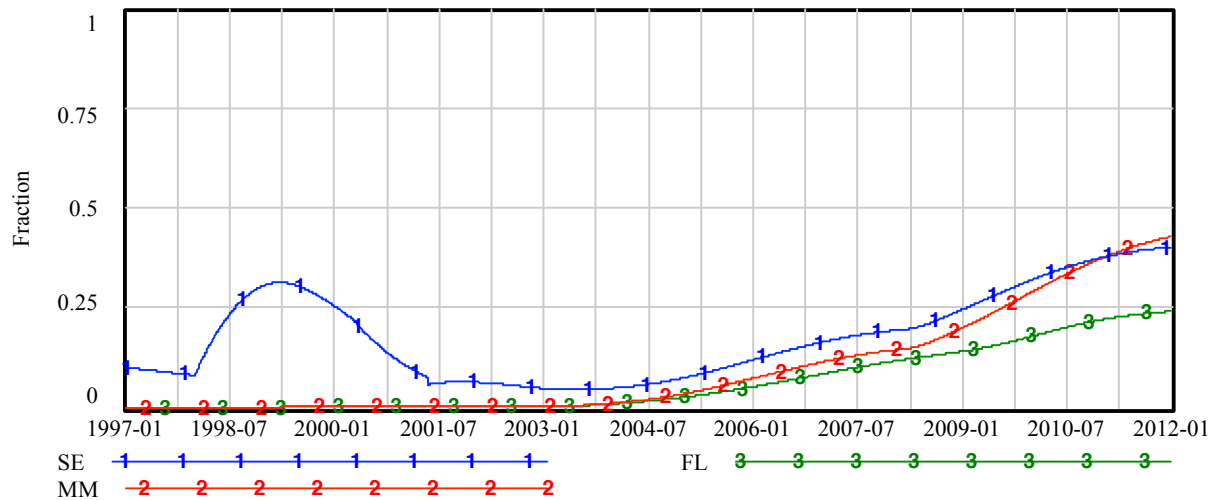
Figure 68. Scenario 4: Believers Fraction

Front-line employees' job security was drastically reduced when layoffs started in January 2006 (Table 4, p.253), which implied a large reduction in their effort earnestness. In these scenarios, however, the inadequacy of management support for CI work was always the primary demotivator (Figure 69).
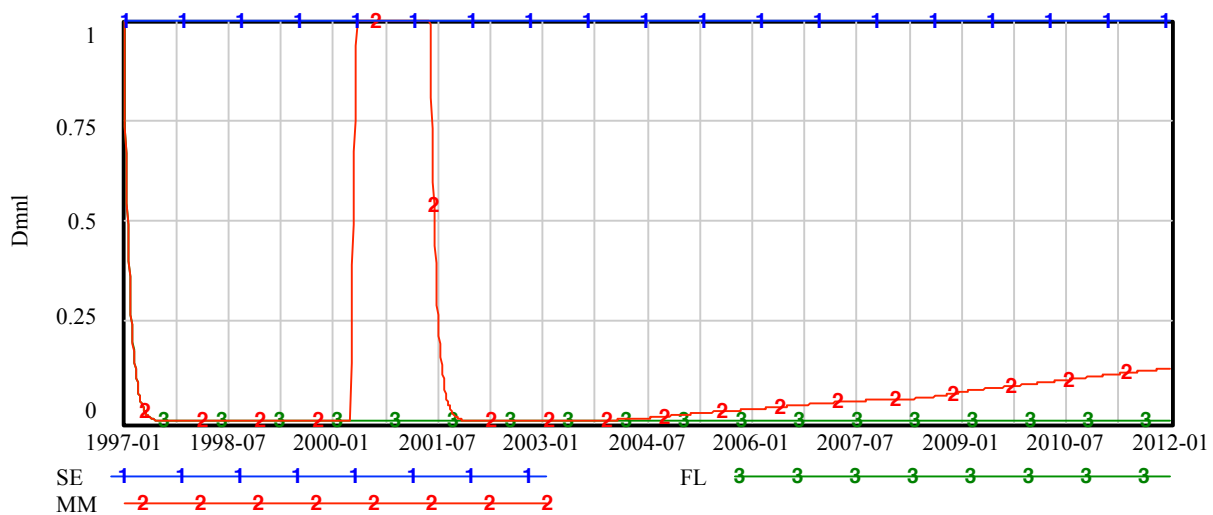
Figure 69. Scenario 4: Effect of Management Support on Effort Earnestness

The chronic inadequacy of management support derives from the imbalance in

support required by employees, measured in person-hours of manager attention, compared to the maximum amount of time managers are willing to spend on CI work. For every hour they spent on CI work, front-line employees require 0.1 hours from their managers, and middle managers require 0.125 hours from their executives (see Parameters for Management Support, p.183). An employee believer can spend, at most, 32 hours per month on CI work, which implies 3.2 hours per month of support required by front-line employees and 4 hours per month of support required by middle managers. Following the MichCon merger, DTE Energy's average spans of control were 16.43 front-line subordinates per middle manager and 15 middle managers per senior executive. Each believer middle manager can spend a maximum of 32 hours per month on CI work, which is only about 61 percent of the 52.6 hours per month demanded by 16.43 believer subordinates. Similarly, each believer senior executive's maximum of 32 hours per month devoted to CI work is only 53 percent of the 60 hours per month demanded by 15 believer subordinates.

6.5. Scenario 5: Lean Six Sigma

The counterfactual portion of scenario 4 — from January 2007 onward — was unrealistic because the company's financial stress did not stay high in actuality; employees' cost-reduction work alleviated it. In this scenario, by contrast, DTE Energy's financial stress was high only from late 2005 through 2006, while the McKinsey consultants were actively engaged at DTE Energy. It dropped to a lower level in 2007 after the consultants had left and only a few of DTE Energy's business units still had cost-reduction targets to meet (Figure 70). The PEP initiative was over by the end of 2007 (Table 5, p.255).
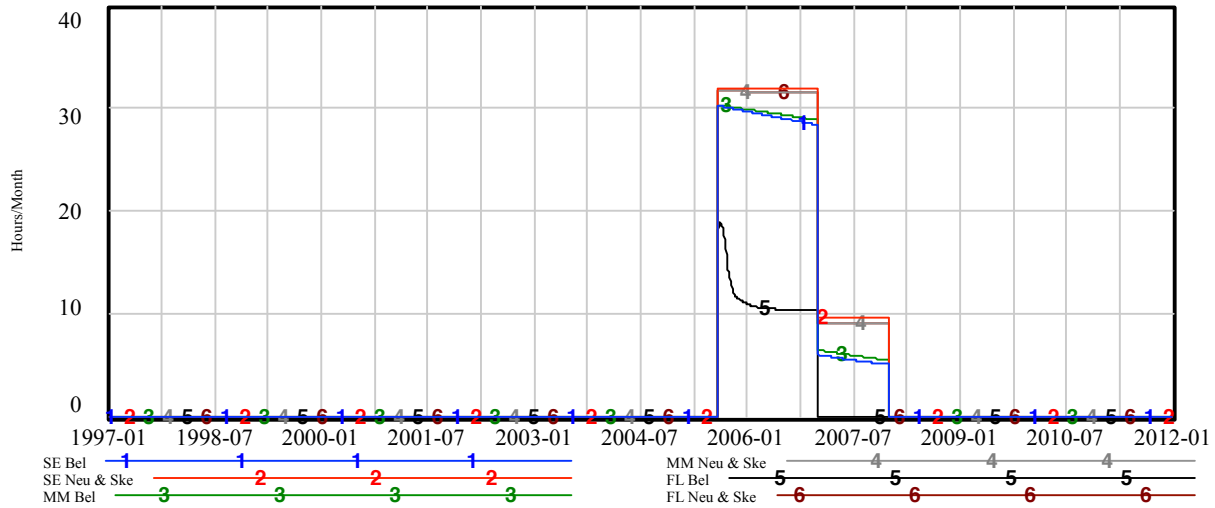
Figure 70. Scenario 5: Cost Cutting Work Rate per Employee

This simulation scenario's trajectories of believers and skeptics are essentially the same as those of scenario 4 prior to February 2008 because there were no effects that would have caused different CI results during that period. This simulation scenario represents DTE Energy's actual history until October 2008. During this history, downsizing was in effect only during 2006 (Table 4, p.253), which was not long enough for changes in employee-workload standards to create the apparent avoided-labor "savings" seen in the counterfactual portion of scenario 4. Instead, employees' monthly routine work settled to a new, lower level following the cuts to their scope of work (Figure 71).
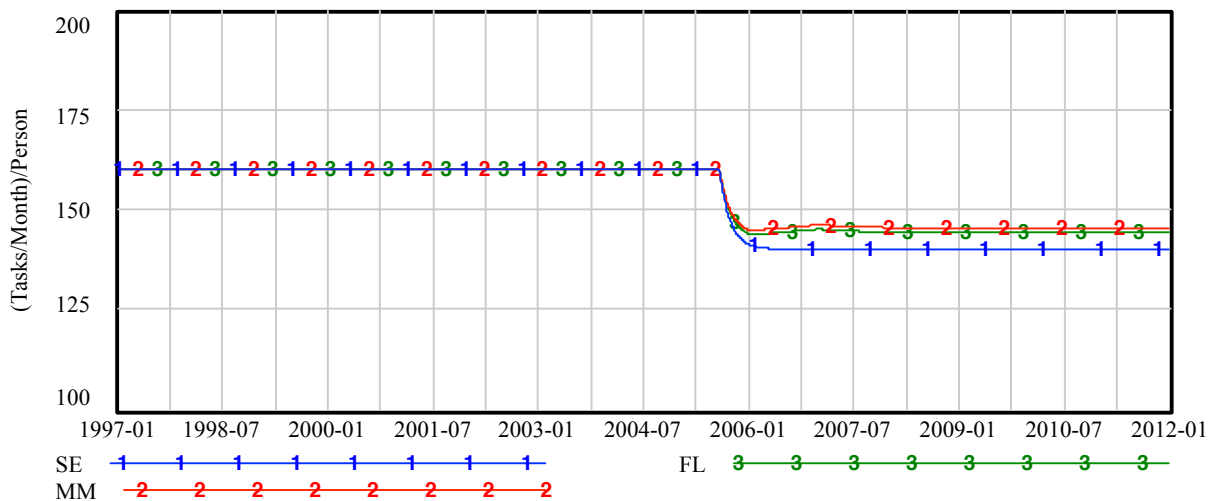
Figure 71. Scenario 5: Monthly Routine Work per FTE

Without these avoided-labor "savings", the convincing rates for senior executives and middle managers were not boosted after February 2008. With a shorter duration of downsizing, the convincing rates for front-line employees were higher than in scenario 4, although they were still declining after April 2005 as before.
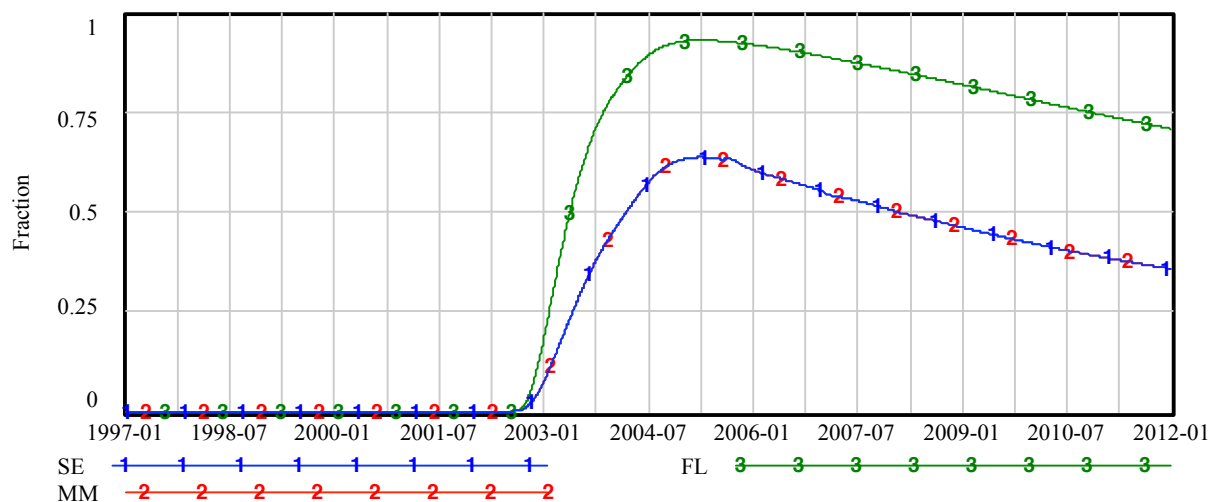
Figure 72. Scenario 5: Neutrals Convincing Fraction

The demotivating effect of inadequate management support superseded any effect of inadequate Black Belt coaching on employees' effort earnestness, but Black Belt coaching still influenced the CI results achieved by employees (Figure 73). The model's parameters reflect the assumption that all unskilled employees, regardless of their level in the company hierarchy, require 0.125 hours of Black Belt coaching for every hour they spend doing CI work (see Parameters for Coaching by Black Belts, p.212). Each unskilled employee devoting the maximum 32 hours per month to CI work would require 4 hours per month of Black Belt coaching. Of course, the model also reflects the assumption that employees require progressively less coaching as they acquire more skill. From July 2004 onward, DTE Energy's number of Black Belts stabilized at between 124 and 127. These Black Belts were performing roughly 20 thousand hours of CI work per month. If 126 Black Belts spent 50 percent of their time coaching, which I assume to be their maximum coaching fraction, then they can adequately support 2,500 unskilled employees. In other words, these Black Belts could adequately support only 24 percent of DTE Energy's workforce, at best.
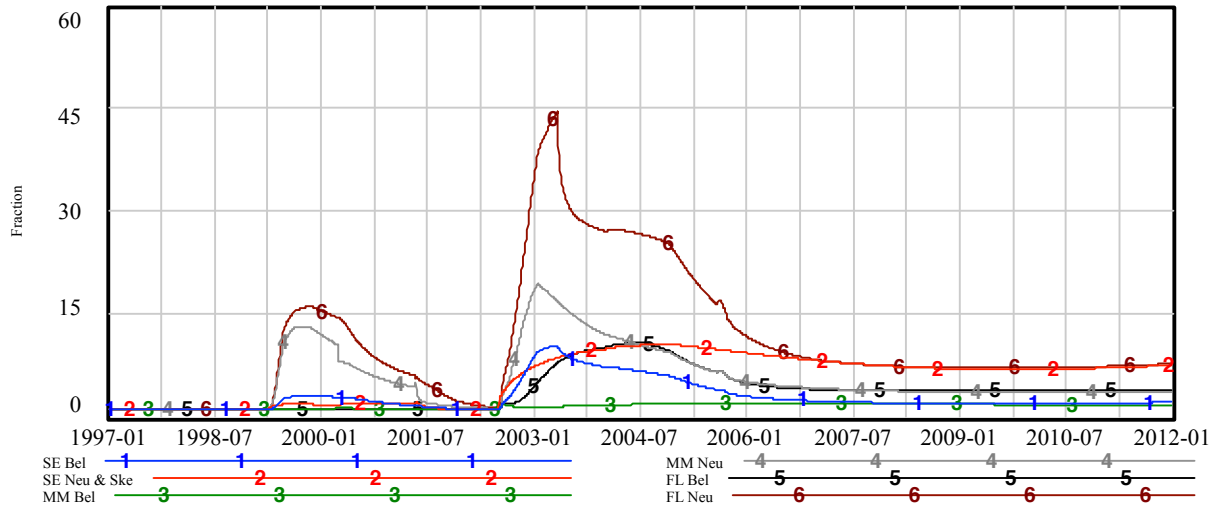
Figure 73. Scenario 5: Effect of Black Belt Coaching on CI Project Results

If DTE Energy achieved its goal of training two percent of its (post-merger) 10,500 employees as Black Belts, then 50 percent of those Black Belts' monthly work represents 16,800 hours per month of coaching. If the remaining 10,290 employees were all unskilled believers, they would require 41,160 hours per month of coaching from the Black Belts. Like management support, Black Belt coaching was chronically inadequate. The detrimental effects of this coaching inadequacy would be reduced with three possible situations. The total amount of coaching that employees require from the Black Belts would be lower if employees acquired skill quicker or if they became convinced slower. Thirdly, Black Belts could potentially devote a greater fraction of their work time to coaching, but then they would be at risk of not producing enough CI savings to meet the company's targets and to justify their salaries.

6.6. Scenario 6: Economic Crisis Response (ECR)

The economic crisis began (for DTE Energy) in October 2008. The company experienced another period of high financial stress, which I assume lasted only through the end of 2009 (Table 5, p.255). As they did during the PEP initiative, DTE Energy's senior executives once again pushed aggressively for cost reductions. The main difference between the push for cost reductions in this scenario and the push for cost reductions in

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scenario 4 was insourcing. Having seen the damage to employee morale caused by the PEP initiative's downsizing, DTE Energy's senior executives sought to reduce labor costs by eliminating contractors, who could not expect job security. Upper management also pushed for cost reductions via CI work and cost-cutting work, as before (Figure 74). This combination of CI work, cost-cutting work, and insourcing produced dynamics that were much more complicated during DTE Energy's ECR plan than during the PEP initiative.
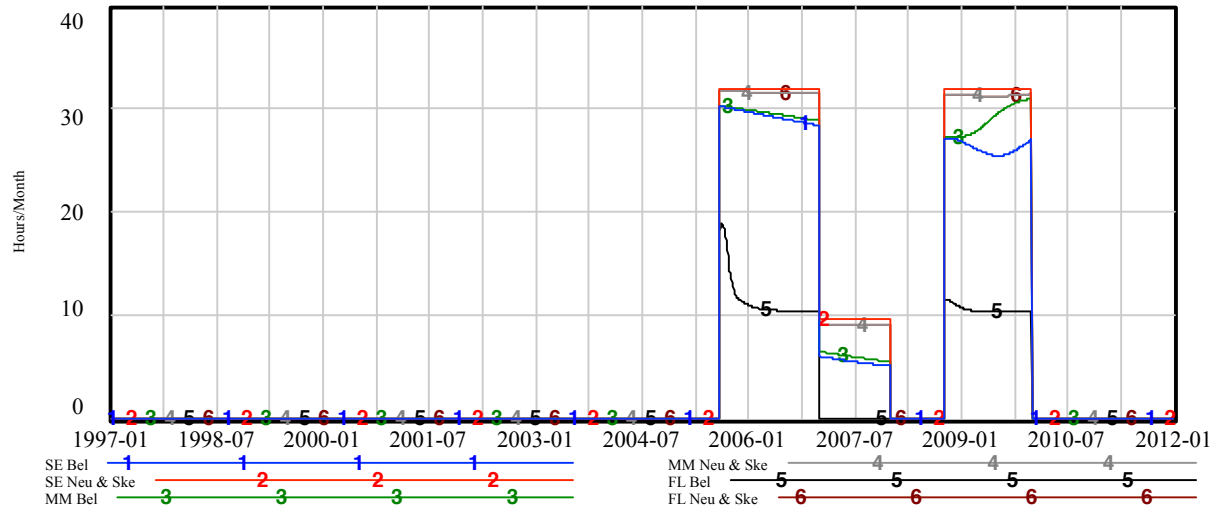
Figure 74. Scenario 6: Cost Cutting Work Rate per Employee

From the start of DTE Energy's ECR plan in October 2008, employees' monthly routine work was simultaneously increasing from insourcing and decreasing from work-scope cutting, both of which were intended to reduce costs (Figure 75). Employees stopped cutting their scope of work when the ECR plan came to a close at the end of the 2009 fiscal year, but I assume that they continued to eliminate contractors and insource those contractors' work where possible (Table 4, p.253).

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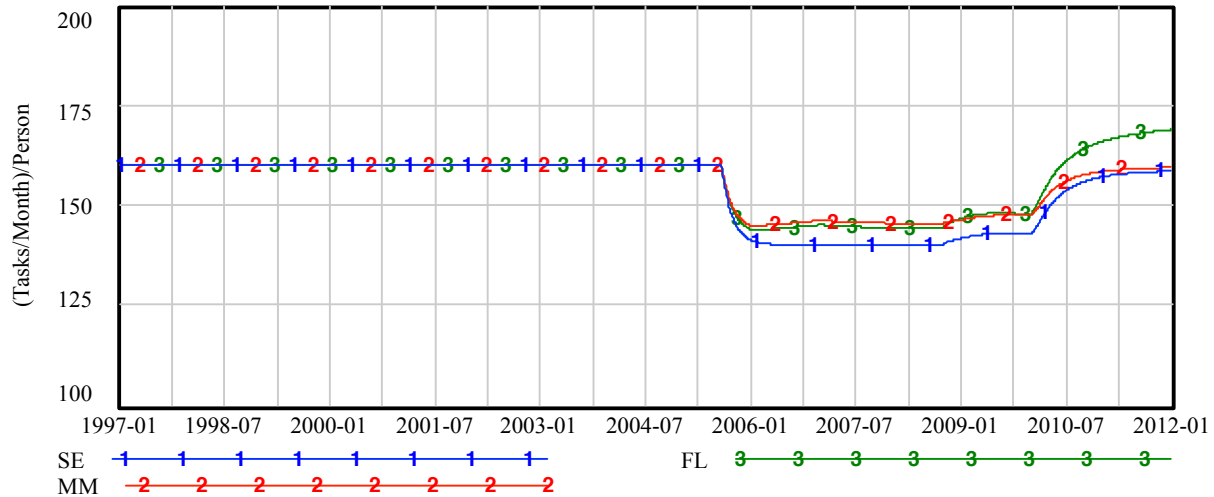
Figure 75. Scenario 6: Monthly Routine Work per FTE

DTE Energy employees' schedule pressure was high while the senior executives were pushing them to reduce costs because they were each compelled to perform the maximum amount of nonroutine work per month. With a heavier workload than normal, they were unable to take on as much insourced contractor work as they would have taken on otherwise. Employees' cost cutting work produced economic gains that boosted the convincing rates of middle managers and senior executives, but only temporarily. These executives and managers soon perceived diminishing returns to these efforts. When DTE Energy's economic crisis plan ended, employees were no longer compelled to devote so much time to nonroutine work, so they absorbed more work from eliminated contractors. The economic gains from this insourcing were much larger than the gains from work-scope cutting, so the convincing rates for middle managers and senior executives rebounded quickly to a high level (Figure 76).

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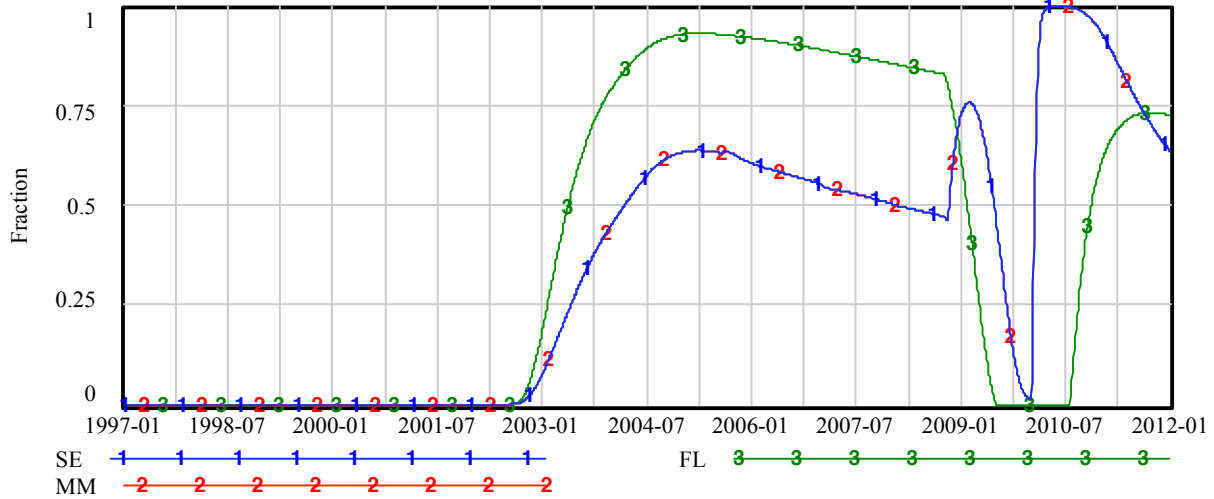
Figure 76. Scenario 6: Neutrals Convincing Fraction

The model formulation reflects the assumption that front-line employees are convinced when they perceive their own productivity improving rather than by CI savings. During the 15 months of DTE Energy's ECR plan, front-line employees became disillusioned because they were unable to complete enough CI work to sustain their previous rate of productivity increases. Their amount of CI work was insufficient for two reasons: (1) their bosses' high pressure for cost-cutting work crowded out their CI work, and (2) the work they acquired from eliminated contractors diluted their productivity gains for their monthly routine work. These two effects caused front-line employees' productivity to worsen from May 2009 onward (Figure 77).
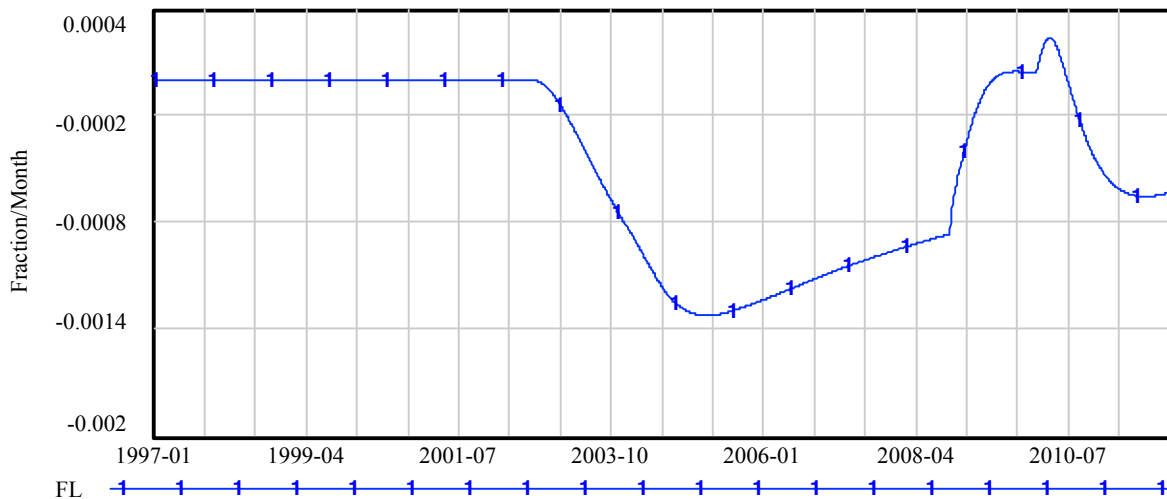
Figure 77. Scenario 6: Front-Line Time per Task Fractional Improvement Rate

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When upper management stopped their push for cost reductions at the end of 2009, the front-line employees were no longer compelled to perform such a large amount of nonroutine cost-cutting work. This drop in workload created capacity for the front line to absorb even more contractor work. Because this contractor work was never subjected to CI, I assume that employees' acquired this work at the baseline time per task. Their productivity worsened at a faster rate until their CI work halted the accelerating decline in productivity in March 2010 and began producing productivity gains again in June 2010. Ironically, this period of front-line productivity deterioration was beneficial for the CI initiative. Because front-line employees notice percentage increases in their productivity, a period of productivity decline restores their ability to achieve high improvement rates (which, of course, cannot last forever).

The final three years of this simulation scenario illustrate how the information signals received by upper management and by the front line regarding the success of the CI initiative can be contradictory (Figure 76). Cost cutting disillusioned the front line while it convinced upper management. The senior executives and middle managers were enthusiastic about the immediate gains from insourcing, but front-line employees were disillusioned until they began to make inroads improving the efficiency of their newly acquired work (Figure 78).
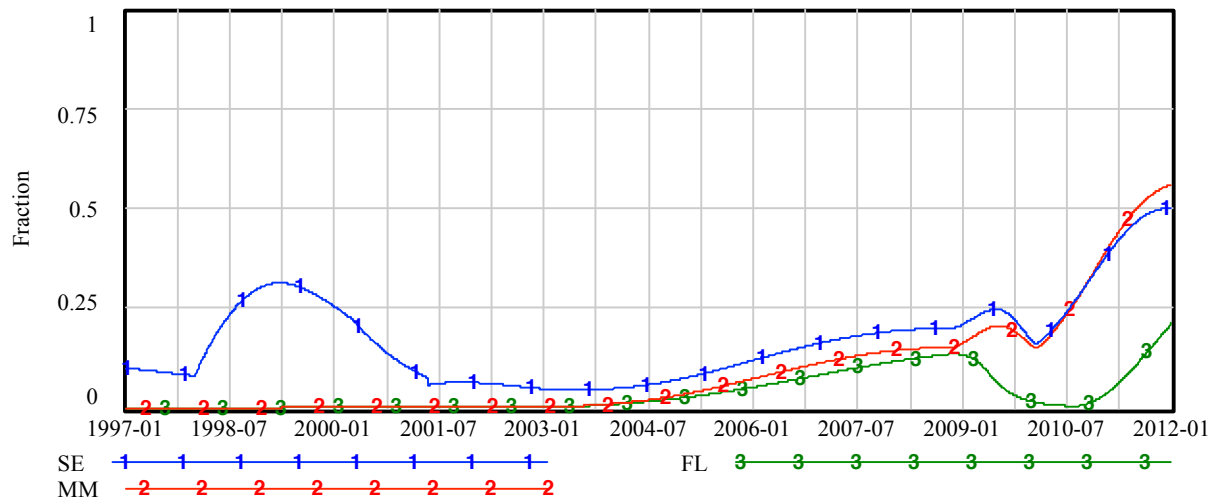
Figure 78. Scenario 6: Believers Fraction

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Chapter 7: Policy Analysis

I took a three-step approach in searching for those policies that would maximize my payoff function, which I defined to be DTE Energy's net present value (NPV) of all CI savings over a 15-year period (see section 5.24, p.245). In all three steps, I used the optimization routine, based on Powell's method (Powell, 1964; Press, Teukolsky, Vetterling, & Flannery, 1992), that is included in the Vensim simulation software (in the Pro and DSS versions only). I performed a sensitivity analysis following each optimization in which I assessed the change in my payoff function for a 10-precent increase and a 10-percent decrease in each optimized parameter. (If a parameter has an optimal value of zero, Vensim tests an increase and decrease of 0.1 instead of +/- 10 percent.) My Vensim files for these optimization scenarios are provided in Appendix G.

In each of the three steps, which I describe in the sections that follow, I search for the best parameter values under two different conditions: with and without DTE Energy's three organizational crises. These crises are (1) the MichCon merger's trouble in 2000, (2) the financial stress that precipitated the PEP cost-cutting initiative in 2005 and 2006, and (3) the financial stress that precipitated DTE Energy's economic-crisis response initiative in 2008.

My first step was to cast a wide net by searching over every model parameter that could potentially be a candidate for a managerial policy intervention. I defined each parameter's allowable range as broadly as seemed possible, if not plausible, in the real world. After running the optimizer, I investigated the reasons for each parameter's optimal value by examining my model equations and by using additional simulations and causal tracing. I present the results of this first step in section 7.1.

I discovered that the response surface formed by my payoff function over all possible values of my policy parameters, within their allowable ranges, was not "well-behaved" in all regions. (Powell's optimization method requires a continuously smooth response surface.) Vensim's optimizer yielded some anomalous parameter values in my first step. Consequently, I defined a new optimization scenario in which I re-optimized over these

problematic parameters, setting all other parameters to their optimal values. Additionally, I tightened the plausible range of a few parameters. I report the results of this second step in section 7.2.

Finally, I repeated my re-optimization over the smaller set of parameters with anomalous values from step two. This third step, which I describe in section 7.3, resolved the outstanding anomalies in both policy-optimization conditions.

7.1. Wide Policy Optimizations

The results of the first step of my policy analysis are presented in Table 6 (p.281). The policy optimization without the three organizational crises is labeled A1 and the policy optimization with the three crises is labeled A2.

The CI personnel urged DTE Energy's senior executives to provide an employment guarantee to the front-line employees because they were aware of the chilling effect that downsizing would have on the CI initiative. The senior executives offered such a guarantee explicitly or implicitly throughout the CI initiative's history except for a 1-year period during the PEP cost-cutting initiative. Vensim's optimizer finds that, with downsizing, DTE Energy forgoes more economic gains from CI work than it saves in lower labor costs.

As expected, more Black Belts working to complete CI projects is always better because my model does not include any balancing feedback loops that would endogenously limit the number of Black Belts based on their labor expense. Consequently, it is optimal to train and hire Black Belts as early and as quickly as possible (*BB Training Change Date* as early as possible; *BB Shortfall Correction Time* as short as possible; and the largest possible values for *Constant Target BB to Workforce Ratio* and *Constant BB Hire Rate[FL]*).

Parameter	Lower Bound	"Best" without Org Crises (A1)	"Best" with Org Crises (A2)	Upper Bound	Payoff Changes without Org Crises (A1)		Payoff Changes with Org Crises (A2)	
					"Best" - 10% (or 0.1)	"Best" + 10% (or 0.1)	"Best" - 10% (or 0.1)	"Best" + 10% (or 0.1)
BB Certification Start Date	12	180	68.6246	180	0	0	-21681.6	-1.30E+33
BB Fractional Promotion Rate[FL]	0	0	0.0046	0.01	-1.30E+33	-3.32E+06	-1.30E+33	-2340.75
BB Fractional Promotion Rate[MM]	0	0	0	0.01	0	0	-1.30E+33	-87.4062
BB Nonroutine Work Fraction	0	1	1	1	-1.63E+06	657026	-18713.5	-1.30E+33
BB Shortfall Correction Time	0.5	0.5	32.4178	180	756	-907	0	-54.5469
BB Trainee MM Odds Ratio	0	0	0.0155142	2	-1.30E+33	-509606	1.625	-1.09375
BB Trainee SE Odds Ratio	0	0.0302744	0	2	-257	-194	-1.30E+33	-1.30E+33
BB Training Change Date	12	12	12	180	0	-911220	0	-2732.88
Constant BB Coaching Duration	0	2.80806	0	180	-688325	-17607	0.59375	-8.96875
Constant BB Coaching Fraction	0	0.783187	0.9874	1	-683603	-18005	-0.40625	-0.59375
Constant BB Coaching Start Date	12	68.7621	12	180	-746188	-596945	0.140625	-1.1875
Constant BB Hire Rate[FL]	0	1	0.592566	1	-33067	29925	-1806.09	-1.30E+33
Constant Target BB to Workforce Ratio	0	0.1	0.1	0.1	-1.27E+06	351514	-265.797	0
Downsizing Duration	0	11.8754	0	180	0	0	0	0
Downsizing Start Date	0	180	180	180	0	0	0	0
GB Training Maximum Capacity	0	54.8759	100	400	-49	-14	-0.296875	-0.046875
GB Training SE Target Completion Time	0.5	76.333	24	180	-26	-46	-0.046875	-0.09375
GB Training Start Date	12	28.6518	13.988	180	0	0	0.078125	-0.234375
Improvement Perception Time	0.5	0.5	1	3	6678	-10921	-1.30E+33	-2.42188
Initial Master Black Belts	0	5	1	5	-116851	82791	-12578.6	-1.30E+33
Maximum BB Coaching Fraction	0	0	0	1	-1.30E+33	-85180	-1.30E+33	-5054
Maximum Fractional Work Scope Increase Rate	0	1	1	1	-67818	62524	-4052.33	-1.30E+33
Maximum SE Training Rate per Person	0	12	4	12	-494	434	-0.140625	-0.4375
MBB Training Relative Weight	0.1	1.65037	1.1	10	-189	-15	-1.30E+33	-105.25
Operating Cost Standard Adjustment Time	1	1000	3	1000	-41298	34268	-1.30E+33	9626.3
Productivity Improvement Work Fraction	0	0.616167	0.5	1	-915697	-86181	2463.23	-1.30E+33
Regular Employee Maximum Nonroutine Work Fraction[FL]	0	0.5	0.5	0.5	-235509	77751	-7508.84	-1.30E+33
Regular Employee Maximum Nonroutine Work Fraction[MM]	0	0	0.5	0.5	-1.30E+33	-539384	-1.30E+33	788.625
Regular Employee Maximum Nonroutine Work Fraction[SE]	0	0.486447	0.5	0.5	-143	-20	-191.875	-1.30E+33
SE Training Start Date	12	101.026	154.022	180	-451666	-247	-258.969	-1.30E+33
Work Scope Increase Start Date	12	12	153.995	180	-37	-4288	19601.6	-1.30E+33
Work Standard Decrease Time	1	12	12	1000	0	0	148.766	-173.828
Work Standard Increase Time	1	1000	2	1000	-29862	24987	-12730.8	12682.7

Table 6. Policy Optimizations A1 and A2

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Black Belts working on CI projects yield larger economic returns than any other activity. Consequently, Black Belts should be dedicated to CI full-time (*BB Nonroutine Work Fraction* = 1). But two surprising and controversial findings follow from this result. First, Vensim's optimizer finds that Black Belts should not bother coaching front-line employees on their CI projects (*Maximum BB Coaching Fraction* = 0 and, therefore, there is no need for any period of constant Black Belt coaching). One reason for this finding, however, is that inadequate management support is the primary determinant of front-line employees' low effort earnestness in all simulation scenarios I ran (including those in Chapter 6). In other words, any potential benefit that Black Belt coaching could make on front-line employees' effective contributions to CI work is overwhelmed by the dampening effect of inadequate management support.

Second, Black Belts should not be promoted (*BB Fractional Promotion Rate[MM]* and *BB Fractional Promotion Rate[FL]* should both be zero, although I confirmed that the latter in step two). The reasoning is the same as for why they should not coach front-line employees: Black Belts deliver greater economic benefits completing CI projects than they do as believer middle managers (or believer senior executives) because Black Belts, unlike managers, are dedicated to CI work full-time. As long as they are working on CI projects, it does not matter from which level of the company hierarchy an employee enrolled in the Black Belt training, so I set *BB Trainee MM Odds Ratio* and *BB Trainee SE Odds Ratio* to zero in the later simulations.

Another surprising and controversial result from this optimization is the policy of not requiring certification projects of Black Belt candidates (*BB Certification Start Date* equal to the simulation's final time; i.e., never). This result is opposite of DTE Energy's experience: the CI personnel introduced a certification-project requirement in 2004 to ensure that their Black Belt graduates were well trained. But most of DTE Energy's Black Belts were not working on CI projects full-time. It is possible that there is some threshold allocation of time to CI work below which Black Belt candidates, completing certification projects with Master Black Belts' mentoring, yield greater economic gains than un-mentored Black Belts would yield immediately after completing their training. (With no

indicated mentoring, the parameter *MBB Training Relative Weight* does not matter.)

The timing and pace of Green Belt training does not matter. Vensim's optimizer found values for *GB Training Start Date* and *GB Training SE Target Completion Time*, but the sensitivity analysis for both optimizations A1 and A2 revealed a "flat" payoff function response surface around these values. This result is unsurprising because the CI experience gained from Green Belt training is minimal (*CI Experience Value of GB Training* = 0.1). For simplicity in later simulations, I set the start of Green Belt training to coincide with the start of Black Belt training (in month 12) and ensured in each case that the default value for *GB Training Maximum Capacity* did not constrain the Green Belt training rate.

The optimizer's results for the remaining parameters were equivocal so I included them all in the policy re-optimizations presented in section 7.2, but their step one values did hint at what some of the best values would be. It seemed better for *Improvement Perception Time* to be short, the *Work Scope Increase Start Date* to be early, the upward adjustment of management standards for routine work (*Work Standard Increase Time*) and operating costs (*Operating Cost Standard Adjustment Time*) to be long, and the downward adjustment of management standards for routine work (*Work Standard Decrease Time*) to be short. Of particular interest was the optimal allocation of CI work to improving productivity versus improving operating costs (*Productivity Improvement Work Fraction*) because, according to my model's assumptions, the former convinces front-line employees but the latter does not.

As expected, the maximum fraction of their work month that senior executives and front-line employees can devote to CI work should be as high as possible (at least up to my upper bound of 50 percent). This result was true also for middle managers in optimization A2, but not A1. The only balancing feedback that limits this allocation of time to CI work is an effect of schedule pressure. My model omits other possible balancing feedback effects from service quality and relative marginal financial returns from routine work. I investigated the puzzling value for middle managers' maximum CI work allocation in the next steps.

I was surprised that the optimizer's indicated start date for senior executive training

was very late: month 101 in optimization A1 and month 154 in optimization A2. In both cases, this training served to boost senior executives' belief in CI when front-line employees most needed a renewed push for CI work from their bosses. In DTE Energy's actual experience, however, the CI personnel trained senior executives for another reason: as a way to lobby for resources for the CI initiative, especially during its early days. I did not include this link from senior executive belief to CI initiative resources in my model. The payoff function, however, is not sensitive to the start of senior executive training. In fact, the best start date found by Vensim's optimizer in step three was month 6, close to DTE Energy's actual start date.

7.2. Narrow Policy Optimizations

The results of the second step of my policy analysis are presented in Table 7 (p.287). The policy optimization without the three organizational crises is labeled B1 and the policy optimization with the three crises is labeled B2.

The parameters for optimization B2 were slightly different from those for optimization B1, but only to verify a few results from the policy optimizations in section 7.1. Specifically, I confirmed that there should be no Black Belt promotions (*BB Fractional Promotion Rate[FL]* = 0) or Black Belt certification projects (*BB Certification Start Date* equal to the simulation's final time — that is, never — which renders the value of *MBB Training Relative Weight* irrelevant). I also confirmed that the Black Belt hiring rate and the maximum nonroutine work fractions for senior executives and front-line employees should all be as high as realistically possible (*Constant BB Hire Rate[FL]* = 0.54 and *Regular Employee Maximum Nonroutine Work Fraction* = 0.2 for SE and FL).

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Parameter	Lower Bound	"Best" without Org Crises (B1)	"Best" with Org Crises (B2)	Upper Bound	Payoff Changes without Org Crises (B1)		Payoff Changes with Org Crises (B2)	
					"Best" - 10% (or 0.1)	"Best" + 10% (or 0.1)	"Best" - 10% (or 0.1)	"Best" + 10% (or 0.1)
BB Certification Start Date	12		180	180			0	0
BB Fractional Promotion Rate[FL]	0	0	0	0.01	-1.30E+33	-67865.7	-1.30E+33	-1.22E+06
BB Shortfall Correction Time	6	6	6	180	997.609	-981.109	37485.8	-36811
Constant BB Hire Rate[FL]	0		0.54	0.54			-22190.2	21971.2
Improvement Perception Time	0.5	1.50129	2.99243	3	-5.17188	-8.57812	-163.75	126
Initial Master Black Belts	1	2.25351	2.25351	20	0	0	0	0
Maximum BB Coaching Fraction	0	0	0	1	-1.30E+33	-2485.34	-1.30E+33	-33517
Maximum Fractional Work Scope Increase Rate	0	0.1	0.1	0.1	-537.266	429.078	-22058.5	22272
Maximum SE Training Rate per Person	0	5.65359	8	8	-0.015625	-0.015625	-2787.25	2657.25
MBB Training Relative Weight	0		0.729999	100			0	0
Operating Cost Standard Adjustment Time	1		1000	1000			-18885.8	15339.5
Productivity Improvement Work Fraction	0	0.357926	0	1	-97.7031	-198.188	89986.5	-137156
Regular Employee Maximum Nonroutine Work Fraction[FL]	0	0.2	0.2	0.2	-20.5781	-5.76562	-4080	3700
Regular Employee Maximum Nonroutine Work Fraction[MM]	0	0.0620878	0.000121301	0.2			-7.75	-11.5
Regular Employee Maximum Nonroutine Work Fraction[SE]	0	0.2	0.2	0.2	1.45312	-0.125	-52.25	39.5
SE Training Start Date	0	175.977	110.184	180	-0.28125	-7.26562	-15677.2	-6109.5
Work Scope Increase Start Date	12	12.0688	12	180			0	0
Work Standard Decrease Time	1		1	1000			901.75	-986.25
Work Standard Increase Time	1	1000	1000	1000			-645.25	2425

Table 7. Policy Optimizations B1 and B2

Parameter	Lower Bound	"Best" without Org Crises (C1)	"Best" with Org Crises (C2)	Upper Bound	Payoff Changes without Org Crises (C1)		Payoff Changes with Org Crises (C2)	
					"Best" - 10% (or 0.1)	"Best" + 10% (or 0.1)	"Best" - 10% (or 0.1)	"Best" + 10% (or 0.1)
Improvement Perception Time	0.5	0.5	0.5	3	-5.14062	-4.75	3.73438	-6.65625
Maximum SE Training Rate per Person	0	8	7.9688	8	-56.0156	31	-11.1875	2.875
Productivity Improvement Work Fraction	0	0.341551	0	1	-99.7344	-127.344	1816.14	-2194.5
Regular Employee Maximum Nonroutine Work Fraction[MM]	0	0.0926604	0.2	0.2	-9.75	-8.67188	-33.8594	23.6875
SE Training Start Date	0	5.9514	5.8477	180	-5.67188	-6.25	-1.5	-0.75

Table 8. Policy Optimizations C1 and C2

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I confirmed that the best time constants for adjusting management standards for routine work and operating costs in optimization B2 match the values found in optimization A1. Specifically, the values for *Work Standard Increase Time* and *Operating Cost Standard Adjustment Time* should be as large as possible and the value for *Work Standard Decrease Time* should be as small as possible. These results were expected but unrealistic because they imply that DTE Energy's executives should continue to carry forward annual CI savings from improvements in productivity and in operating costs by not adjusting their baseline expectations for what they consider normal performance. Such baselines, however, become obsolete as they get older. Wall Street analysts typically compare DTE Energy's financial performance only to the previous fiscal year's performance. It is reasonable to assume, therefore, that DTE Energy's executives are compelled to adjust these standards quickly in response to such external pressures. In the optimization scenarios that follow, I remove these adjustment times as policy levers, setting them back to their default values.

I confirmed some expected results that are consistent across both optimizations B1 and B2. Employees work scope should be increased as soon and as quickly as possible (*Work Scope Increase Start Date* = 12 and *Maximum Fractional Work Scope Increase Rate* at its upper bound). Improvements in productivity do not translate into "hard" savings unless and until employees fill their increased slack time with more work, such as by insourcing contractor work, or the number of employees is reduced via downsizing or gradual attrition.

Similar to the number of Black Belts, the model contains no financial penalty for larger numbers of Master Black Belts. It is sufficient, therefore, to ensure that the number of Master Black Belts never constrains the Black Belt training rate. I verified that this condition was met after setting the lower bound on the *BB Shortfall Correction Time* to a more realistic six months. With no Black Belt candidates, there is no demand for mentoring and, therefore, having only one Master Black Belt is sufficient. (In both optimizations B1 and B2, Vensim's optimizer yields *Initial Master Black Belts* = 2.25, but sensitivity analysis shows the payoff function's response surface is "flat" at this point.)

Policy optimizations B1 and B2 yielded ambiguous results for five parameters, so I

conducted another iteration of my policy optimization analysis. These parameters included the *SE Training Start Date*, the *Maximum SE Training Rate per Person*, the *Improvement Perception Time*, and the *Productivity Improvement Work Fraction*. The maximum fraction of middle managers' nonroutine work was also uncertain.

7.3. Specific Policy Optimizations

The results of the third step of my policy analysis are presented in Table 8 (p.287). The policy optimization without the three organizational crises is labeled C1 and the policy optimization with the three crises is labeled C2.

In my model, there are no negative ramifications of senior executive training. Consequently, Vensim's optimizer finds that senior executive training should be as extensive as possible and begin as soon as possible, as expected (*SE Training Start Date* = 6 and *Maximum SE Training Rate per Person* at its upper bound).

I did not expect the results I obtained for the final three optimization parameters. These optimizations suggest that *Improvement Perception Time*, how quickly employees' perceive the results of their CI work, should be as short as possible. But the sensitivity analysis and optimization results for B1 and B2 suggest that the payoff function is insensitive to the value of this parameter across its range of plausible values (from 0.5 to 3 months).

I expected the result that middle managers should devote as much of their work months to nonroutine work as possible, which was what Vensim's optimizer yielded for the senior executives and front-line employees (that is, *Regular Employee Maximum Nonroutine Work Fraction* = 0.2). This expectation was correct for optimization C2, but not for C1. The effect of middle managers' contribution to CI work in my model, however, is small for two main reasons. First, my model equations reflect the assumption that middle managers will push their front-line subordinates for CI work at least as strongly as they are being pushed for CI work by their senior executive bosses (see the equation for *Push for CI Work* in section 5.6, p.165). If this assumption is descriptively accurate, it diminishes the importance of middle managers' belief in CI. Second, as I explained in

section 6.4 (p.266), middle managers' support of the front-line employees' CI work was chronically inadequate because of middle managers' (average) span of control at DTE Energy and the amount of managerial support required for each person-hour of front-line CI work. If middle managers' support is already inadequate, reducing their maximum participation in CI work does not harm front-line results much further. (The sensitivity analysis shows the payoff function's response surface to be relatively "flat" along the vector defined by the parameter *Regular Employee Maximum Nonroutine Work Fraction[MM]*.)

Finally, the allocation of 34 percent of all CI work to improving productivity, with the remaining 66 percent allocated to improving operating costs, turns out to be best in optimization C1. The result for optimization C2, however, was surprising: CI work should be directed entirely to improving operating costs, with no fraction allocated to improving productivity. With the optimal policy of relying on Black Belts to achieve the lion's share of CI savings, this result is understandable. I assume Black Belts remain believers unless they drop out of the Black Belt program. Front-line employees, for their part, are sensitive to changes in their productivity improvement rate. Cost cutting diverts focus away from previous productivity-improvement work, creating disillusionment among front-line employees. It is therefore better to avoid the larger numbers of skeptical employees created by cost cutting by disabling that feedback loop entirely. The difference to the payoff function, however, is not large so I simulate different values for the *Productivity Improvement Work Fraction* with the three organizational crises in the next section.

7.4. Optimal Policy Scenarios

In this section, I simulate the best values for policy parameters found via the preceding optimization simulations. These "optimal" policy scenarios can be compared to the simulation scenarios of DTE Energy's actual experiences in Chapter 6. I simulate scenario D1 without the three organizational crises and scenario D2 with the three crises. I also simulate a third scenario that includes the three crises and a nonzero *Productivity Improvement Work Fraction*, labeled as D3.

All three of these simulation scenarios have the following policies in common (see

Appendix G for the specific parameter values):

- Begin the Black Belt program in month 12.
- Employ one Master Black Belt to train 2 percent of DTE Energy's entire workforce as Black Belts within 6 months from the start of the Black Belt program.
- Recruit Black Belt trainees from the front line only.
- Do not require certification projects (i.e., no Black Belt candidate step).
- Hire experienced Black Belts as quickly as possible from the start of the Black Belt program.
- Black Belts work on CI projects full-time; they do not devote any time to coaching front-line employees.
- No Black Belt promotions into upper management.
- Begin Green Belt training with the start of the Black Belt program.
- Train senior executives as much as possible beginning at six months prior to the start of the Black Belt program.
- No downsizing.
- Limit all employees' CI work time to at most 20 percent of their work months.
- From the start of the Black Belt program, increase work scope as quickly as possible when indicated.
- Shorten all employees' time to perceive improvement results to 2 weeks.

Except for the three organizational crises, the difference among the three scenarios D1, D2, and D3 is the value of the parameter *Productivity Improvement Work Fraction*. Scenarios D1 and D3 test the value of 34 percent from optimization C1 and scenario D2 tests the value of zero from optimization C2 (see Appendix G).

The financial parameters in my model were not calibrated to match DTE Energy's actual financial data, so only the relative magnitudes of the CI savings NPVs from each simulation scenario are important. These CI savings NPVs are listed in Table 9 below.

Scenario	Org Crises Included	Productivity Improvement Work Fraction	CI Savings NPV
6	Yes	0.50	$ 6.04 million
D1	No	0.34	$18.67 million
D2	Yes	0.00	$19.77 million
D3	Yes	0.34	$18.25 million

Table 9. Comparison of Policy Scenarios

Scenario D1 is not directly comparable to the other scenarios because it alone excludes DTE Energy's three organizational crises. But it serves as a useful baseline for assessing the results of scenarios D2 and D3. Scenario D2 shows that the set of "optimal" policies yields an NPV of CI savings that is 227 percent higher than scenario 6's reproduction of DTE Energy's actual experiences (see section 6.6, p.274). Scenario D3's CI savings NPV was almost 6 percent higher than scenario D1's CI savings NPV because DTE Energy's financial stress created a stronger imperative for nonroutine work — including CI work — during certain periods. Scenario D3 includes the same Productivity Improvement Work Fraction of 34 percent as scenario D1. It exhibits an approximate 7.7 percent drop in CI savings NPV from scenario D2. Scenario D3's performance is only a 2.25 percent decrease in CI savings NPV as a result of DTE Energy's three organizational crises.

Optimal Policy Scenario D1

Figure 79 shows that the "optimal" set of policies described above is effective because it leads to the highest convincing rates. In scenario D1, DTE Energy builds its cadre of Black Belts quickly. These Black Belts get to work immediately producing convincing results. Their high rate of achieving CI savings cannot last forever: the diminishing returns to their constant CI work rate are clearly illustrated in Figure 79.
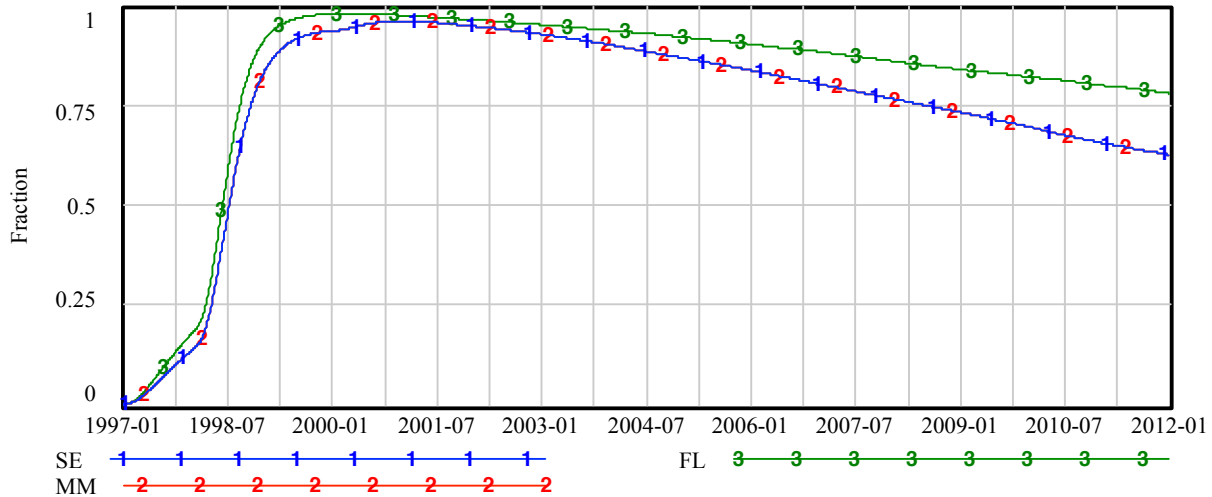
Figure 79. Scenario D1: Neutrals Convincing Fraction

With high convincing rates, the fraction of believer employees at all levels of the company hierarchy climbs rapidly and only begins to fall gradually when later CI projects are not as successful as the earlier ones. Because the CI personnel began training the senior executives six months prior to the start of the Black Belt program, Figure 80 shows the earlier growth in senior executive Believers.
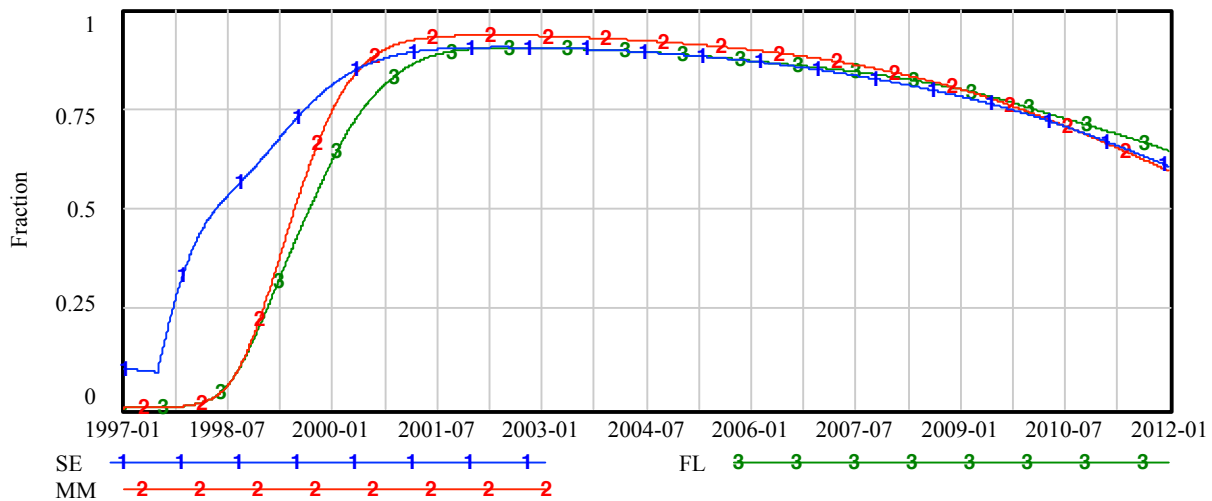
Figure 80. Scenario D1: Believers Fraction

Figure 81 shows the steady increase in the front-line employees' scope of work as a result of productivity improvments and subsequent insourcing of contractor work. Note, however, that such insourcing did not start until January 2000. It took two years of persistent improvement work before front-line productivity increases overcame the

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additional burden that CI work placed on front-line employees.
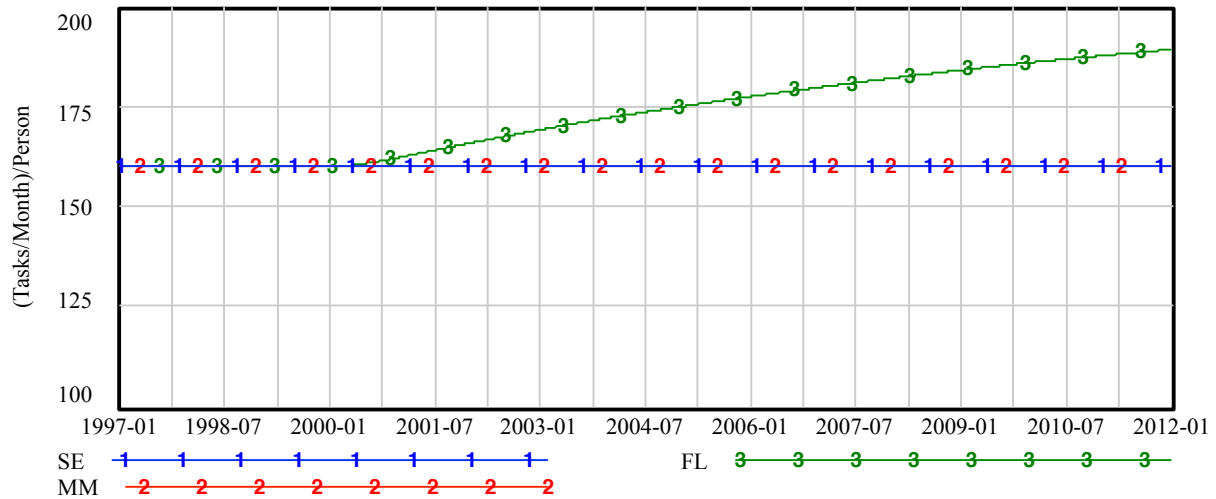
Figure 81. Scenario D1: Monthly Routine Work per FTE

Monthly variable operating costs, on the other hand, began to fall as soon as the front-line employees started their operating costs improvement work. This rate of improvement accelerated when the number of Black Belts grew dramatically after January 1998, and decelerated as their improvements exhibited diminishing returns.
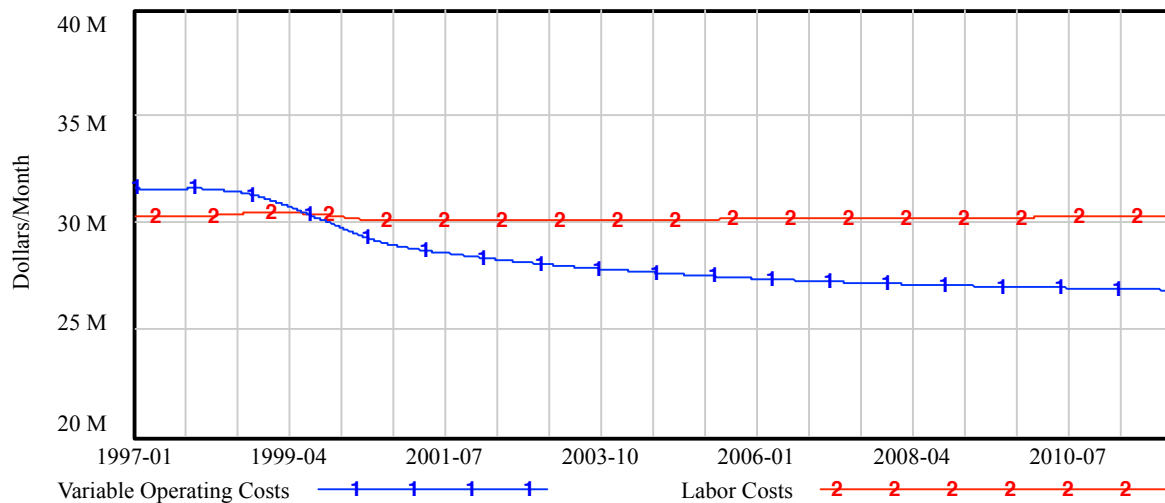
Figure 82. Scenario D1: Monthly Operating Costs

Optimal Policy Scenario D2

The effect of the three organizational crises – the MichCon merger's trouble between April 2000 and May 2001, the PEP cost-cutting initiative between August 2005 and January 2007 (with lingering effects through January 2008), and the economic crisis between October 2008 and January 2010 – are clearly seen in Figure 83 and in Figure 84. Each of these crises distracted employees' attention away from achieving CI results, either because upper management lessened their push for CI work or their push for nonroutine work crowding out CI work.
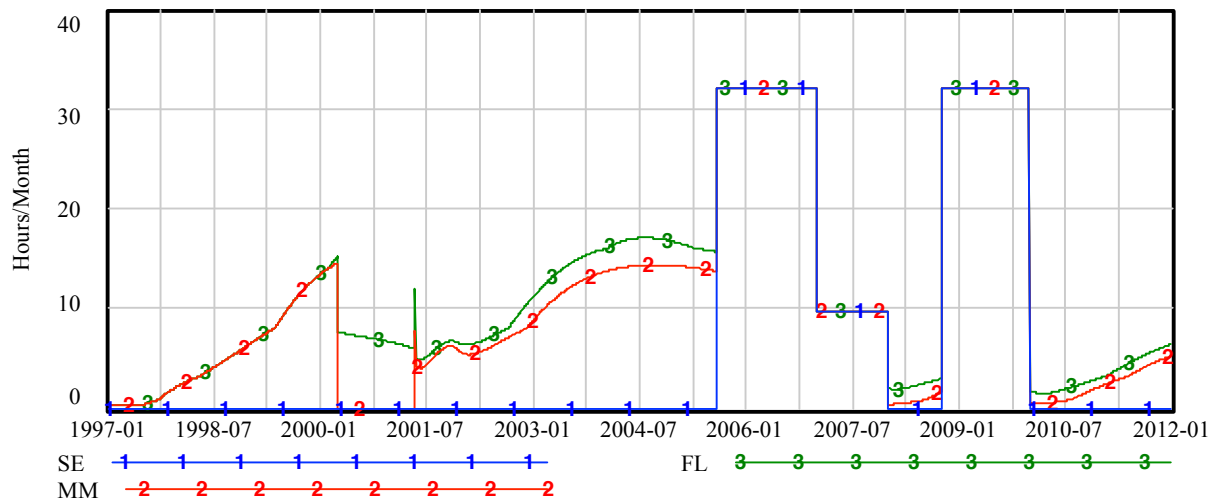
Figure 83. Scenario D2: Boss Desired Nonroutine Work
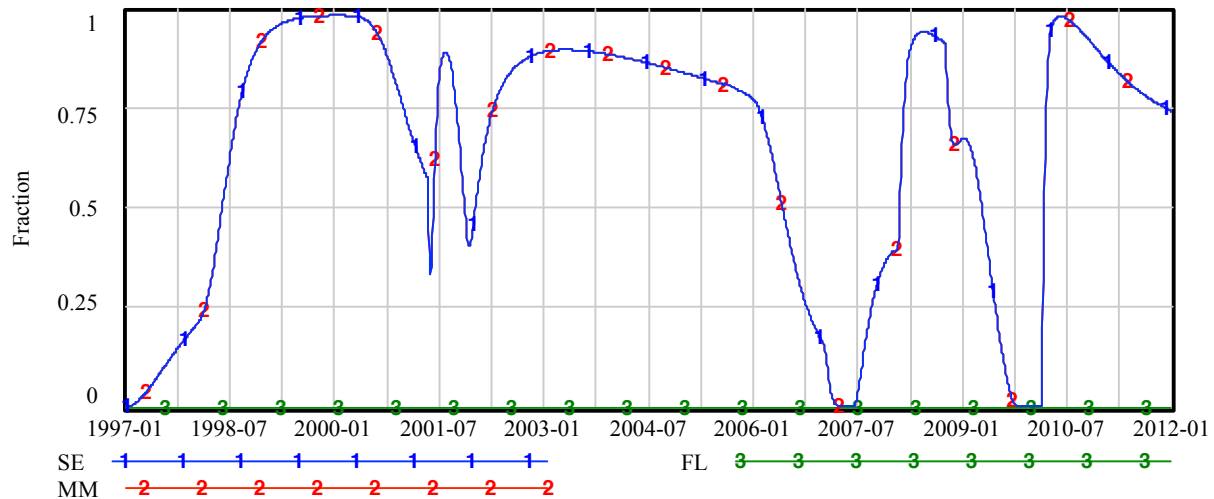
Figure 84. Scenario D2: Neutrals Convincing Fraction

Because this scenario D2 includes no improvement work for front-line productivity, front-line employees are never convinced of CI's benefits (Figure 84 and Figure 85). To the extent that their bosses push them to engage in CI work (Figure 83), however, they are disillusioned and become skeptics (Figure 86).
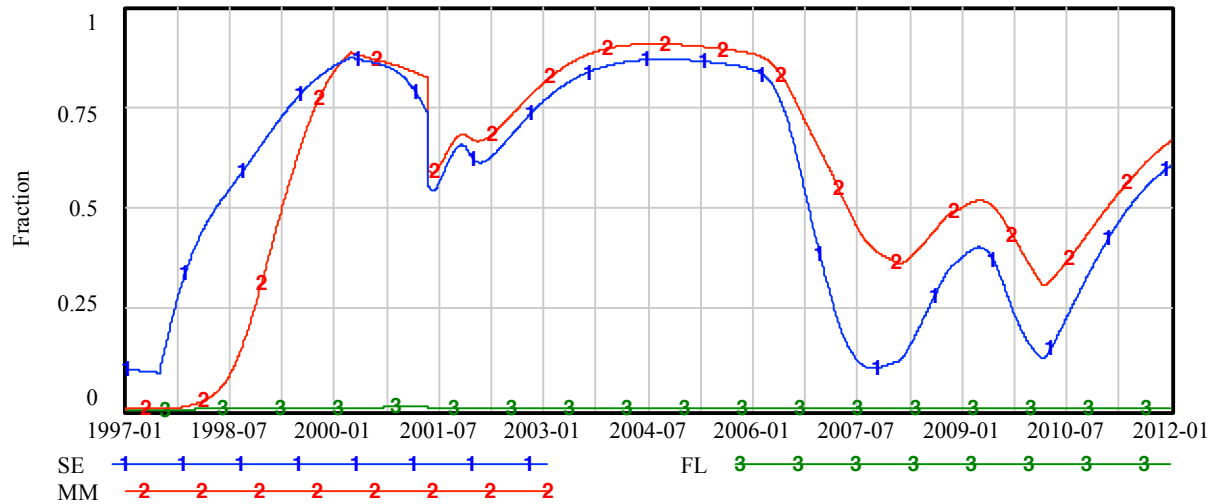
Figure 85. Scenario D2: Believers Fraction
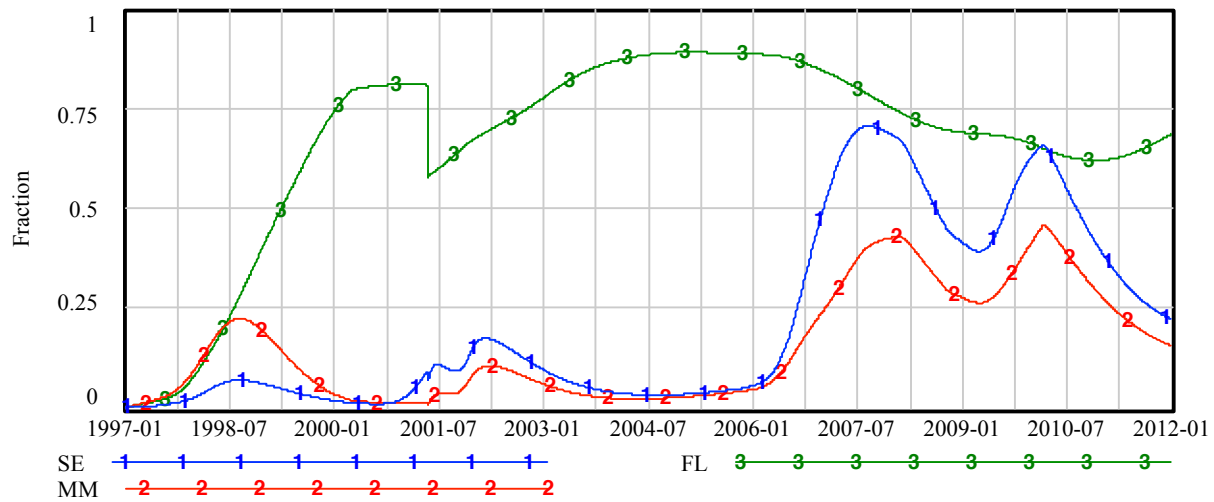
Figure 86. Scenario D2: Skeptics Fraction

Figure 87 shows the increase in operating costs for DTE Energy as a whole following the close of its merger with MichCon in May 2001 and the decrease in operating costs from CI work, primarily before August 2005, and from work cost cutting and scope cutting after August 2005.
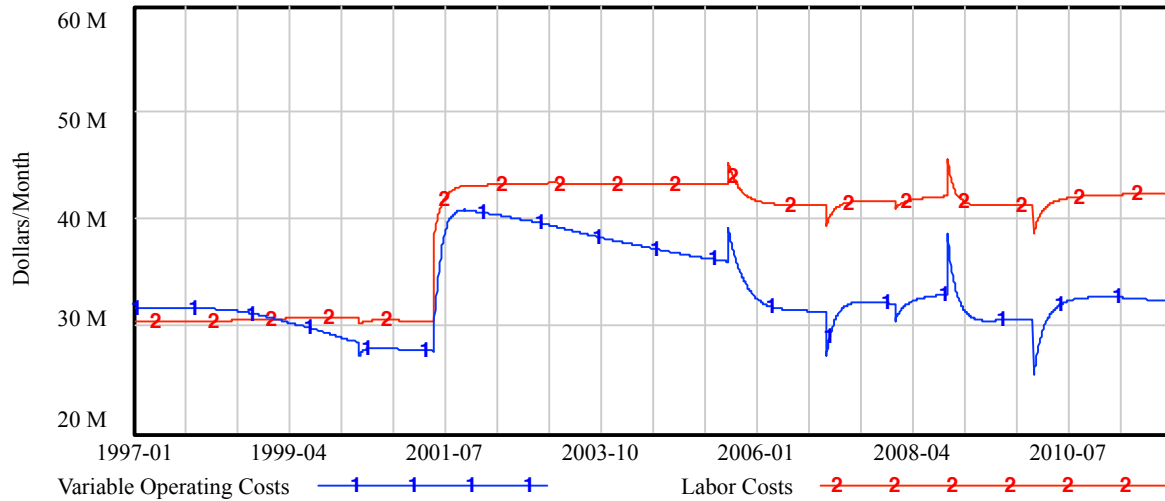
Figure 87. Scenario D2: Monthly Operating Costs

Optimal Policy Scenario D3

Scenario D3 is exactly the same as scenario D2 except that the Productivity Improvement Work Fraction was set at 34 percent instead of at zero percent. This policy change exchanges a slightly lower convincing rate for senior executives and middle managers for a nonzero convincing rate for front-line employees.
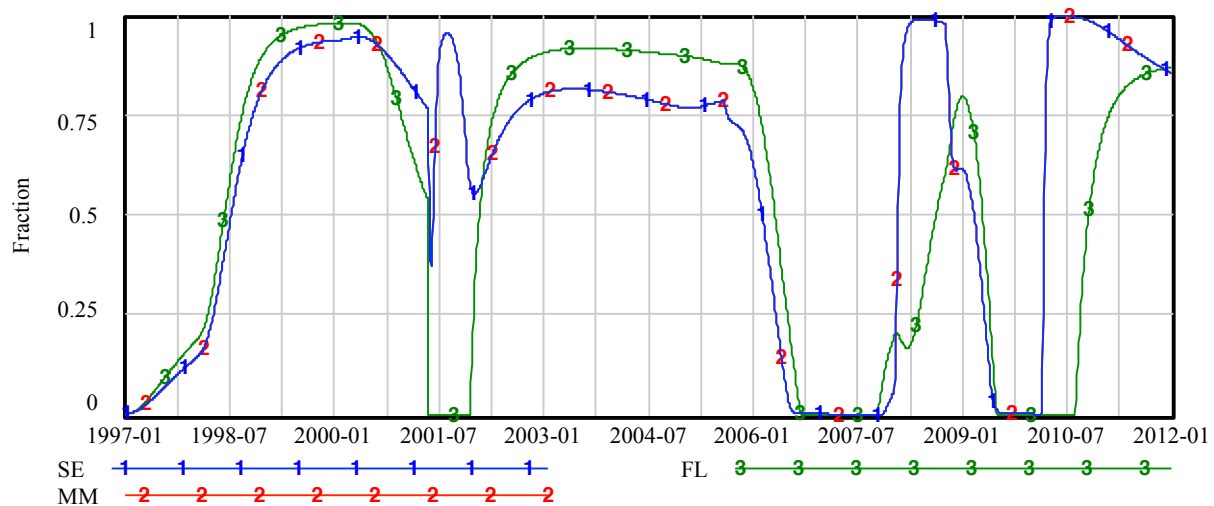
Figure 88. Scenario D3: Neutrals Convincing Fraction

The dynamics of this scenario are similar to scenario D2. Each organizational crisis disrupts the CI work being done by employees at all levels. Because my model assumes

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that all employees are convinced by the rate at which improvements are being made, these disruptions cause quick erosion of convincing rates. Recovering from these disruptions take time, particularly for front-line employes.
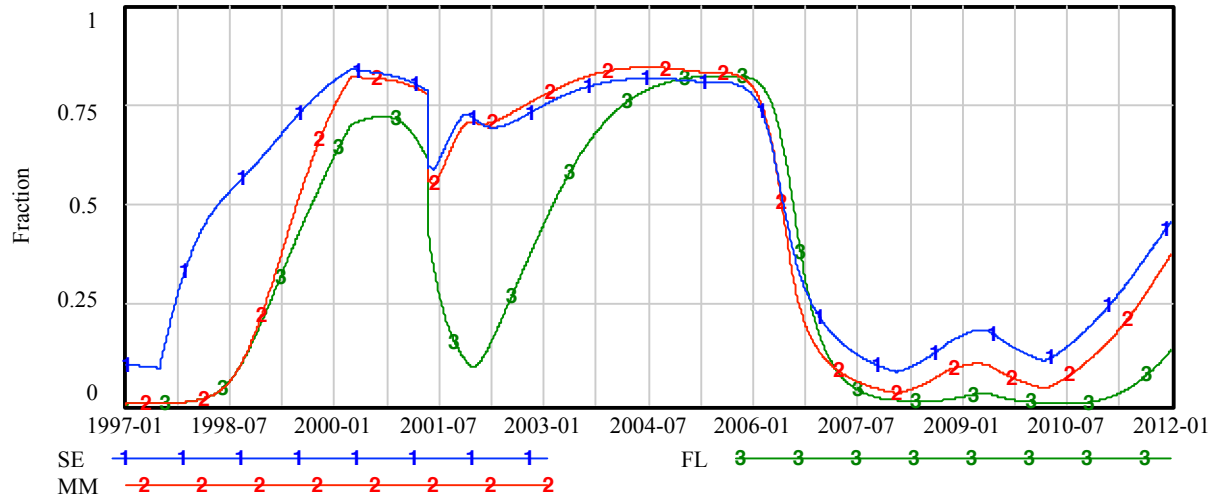
Figure 89. Scenario D3: Believers Fraction

Figure 90 shows why scenario D2 has a better payoff than scenario D3. The marginal return to CI work that reduces variable operating costs is higher than the marginal return to CI work that enables insourcing. Allocating front-line employees' CI work to improving their productivity reduces the improvements made to operating costs.
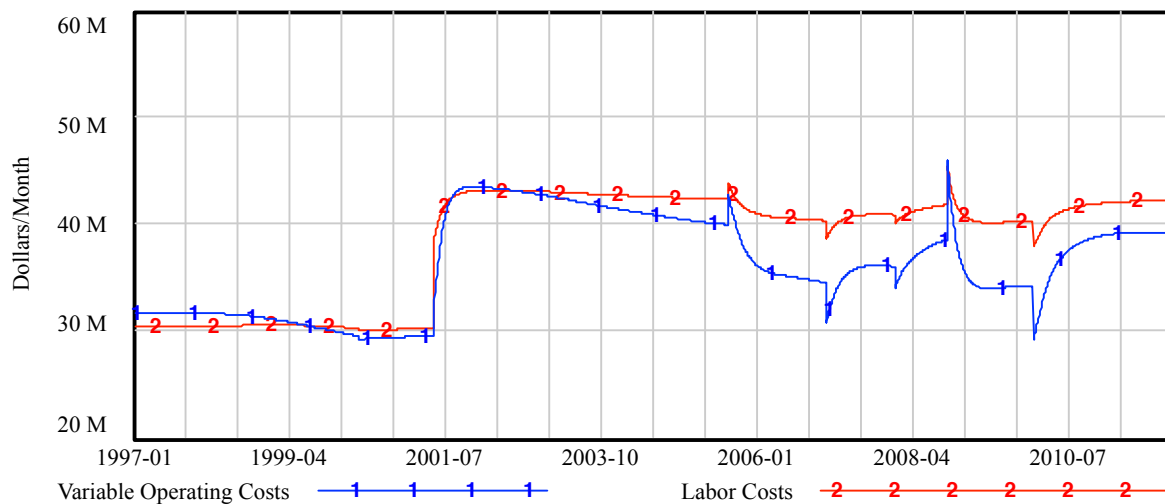
Figure 90. Scenario D3: Monthly Operating Costs

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Chapter 8: Discussion & Conclusions

8.1. Discussion

In its early days, if not later, DTE Energy's CI initiative appeared to be a paragon. Several of DTE Energy's influential senior executives were pro-CI. CEO Tony Earley learned about CI from his executive peers at the automotive companies in southeast Michigan, who included Rick Wagoner at GM and Dennis Pawley at Chrysler. A few of these executives later joined DTE Energy, including 14-year Chrysler veteran Dave Meador. Senior vice president Bob Richard joined DTE Energy after 13 years at GE where he became a certified Black Belt. Bob Buckler, president of Detroit Edison until December 2008, was a member of the Engineering Advisory Council for the University of Michigan's College of Engineering, so he was familiar with Jeffrey Liker's research on the Toyota Production System.

DTE Energy's CI initiative enjoyed strong connections with MIT's Leaders for Manufacturing (LFM) program and with Peter Senge's Society for Organizational Learning (SoL). Many of the CI initiative's progenitors were LFM alumni: Steve Nagy (LFM '94), Shawn Patterson (LFM '94), Jamie Flinchbaugh (LFM '98), Tony Kramer (LFM '97), and Jason Schulist (LFM '97). Dave Meador, Shawn Patterson, and Jason Schulist, during different periods, served as members of the Council of Trustees for SoL.

These leaders of DTE Energy's CI initiative benefitted from the best advice by leveraging their social and professional networks. Their advisors in industry included Jamie Bonini (LFM '92), who was first at Chrysler and later at Toyota; Dennis Pawley at Chrysler; and Paul O'Neill at Alcoa. From academia, their advisors included Steve Spear at MIT, Kent Bowen at Harvard Business School, and Jeffrey Liker at the University of Michigan.

Despite these advantages, one of DTE Energy's senior executives admitted, "Since we started this initiative, we're probably guilty of every [CI] implementation error there is." I related these implementation errors in my case study of DTE Energy's CI initiative in

Chapters 2-4 and in Appendix B. But why did DTE Energy's employees make these errors?

I argue that these "errors" occurred for three reasons. First, DTE Energy's CI personnel — and their advisors in industry and academia — were unsure what was the best recipe for implementing a CI initiative at a regulated utility. Consequently, they had to adapt, experiment with, and learn from different approaches and tactics. This process of experimentation and learning was time-consuming and not always successful, slowing the growth trajectory of the CI initiative.

Table 10 lists the various tactics that DTE Energy's CI leaders used during the various phases of the CI initiative. The CI initiative gained traction in phases 3, 5 and 6, when the CI personnel aimed various tactics at all three levels of the company hierarchy. In addition to these tactics, DTE Energy's CI personnel had planned several more. They had begun developing CI Champion training for the senior executives and a CI basics training (a "White Belt") during the end of phase 3, but these were aborted because of the PEP initiative in phase 4. Interestingly, Jason Schulist and Bob Hemrick considered reviving the plan for these courses in late 2009 (phase 6) because they perceived that the CI skill of DTE Energy's employees was still insufficient. Similarly, Schulist and Hemrick also planned on reviving the learning lines tactic from phase 3 because they perceived that the swarm events of phase 6 could not achieve results commensurate with the Black Belts' CI project results.

	Wave 1		Wave 2		Wave 3	
	Phase 1	**Phase 2**	**Phase 3**	**Phase 4**	**Phase 5**	**Phase 6**
	1998-2000	**2000-2001**	**2001-2005**	**2005-2006**	**2007-2008**	**2008-2009**
SE	Executive training		Executive training			Executive training
					Executive TSSC workshops	
					CILWs for executives	
MM						CILWs for managers
					Performance Leadership sessions	Performance Leadership sessions
FL	UMP teams					
	Kaizen events	(Kaizen events)				
			Train OS Specialists	(Train OS Specialists)	Train OS Specialists	Train OS Specialists
			Learning lines			
						Swarm events
BB	Train kaizen facilitators					
			Train OS Experts			
			Demo projects			
			Train and certify Black Belts	Train and certify Black Belts	Train and certify Black Belts	Train and certify Black Belts
			Hire Black Belts	Hire Black Belts	Hire Black Belts	Hire Black Belts
			BB projects	BB projects	BB projects	BB projects

Table 10. CI Initiative Tactics by Phase

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The second reason for DTE Energy's CI implementation problems was its three organizational crises. These crises significantly distracted employees at all levels from the CI initiative. DTE Energy's CI leaders, in the midst of experimenting to find what worked, were forced to reformulate the CI initiative in response to other organizational actions intended to alleviate DTE Energy's (mostly financial) pressures in the short term. The most prominent example of this reformulation was the supporting role that Black Belts assumed during the PEP initiative, helping DTE Energy's business units survive "after the [budgetary] ax had fallen".

Third, I perceived that DTE Energy's CI initiative took on "a life of its own". After Shawn Patterson and Steve Nagy were successful in their lobbying to create the CI department, the leaders of the CI initiative found it easier to gradually expand the number of centralized and decentralized CI positions under its umbrella. With the backing of a few key senior executives like Dave Meador, Bob Richard, and Steve Kurmas, it would have been difficult for detractors to successfully eliminate the initiative in a single action. The CI initiative's persistence through the PEP cost-cutting initiative supports this assertion.

This institutionalization of the CI department and its associated positions in phase 3 had an important consequence. After they formally adopted Six Sigma, I believe the CI initiative's leaders became complacent during this period. John Weiss did not experiment with different tactics the way Shawn Patterson had before him in phase 1 and the way Jason Schulist did after him in phases 5 and 6. The senior executives, for their part, were content to simply monitor reported savings rather than involve themselves in building organizational capabilities for problem solving and process design. Jason Schulist's efforts to foster such senior executive involvement in phase 5 is evidence that it had been lacking previously.

8.2. Implications for Managers

Steve Spear's main point in *The High-Velocity Edge* (2009) is that high-performing companies have developed the capabilities to continually improve what they do, especially their core value streams. Companies need stable, predictable processes, of

course, but those stable processes may be inefficient, may produce low quality, and may be maladapted to external requirements. Consequently, companies need mechanisms to identify and correct these flaws. Companies usually attempt to fix these flaws individually as special cases — by bringing in consultants or by relying on the professional skills of their managers (such as they are). But such an *ad hoc* approach is itself inefficient, error-prone, not always successful, and does not promote organizational learning. A better alternative is to foster a stable, consistent, reliable procedure for fixing problems and reexamining process designs. The main goal of a CI *initiative*, in contrast to the main goal of CI *activities*, should not be to make specific improvements or to save a certain amount of money. Instead, the main goal of a CI initiative should be to institutionalize codified improvement procedures and to develop the skills at all levels of the hierarchy to enact them properly.

The main finding from my policy optimizations in Chapter 7 is that companies seeking to improve their performance with CI tools and methods should create and maintain positions solely dedicated to it. Black Belts deliver the highest financial payoff when they are highly skilled and work on CI projects full-time. Many of the certified Black Belts at DTE Energy were also engineers. This finding suggests that companies in any industry, not just in manufacturing, should hire industrial engineers to explicitly design and redesign their work processes. It takes too long for front-line employees, working on CI projects part-time, to accumulate enough skill to deliver results fast enough to sustain upper management's enthusiasm for CI.

This recommendation runs counter to the approach advocated by Toyota (Liker, 2004; Spear & Bowen, 1999) and by Deming (1986). Front-line employees are the experts in their jobs because they perform those jobs every day. They understand what goes wrong, how often, and what workarounds are used to circumvent those problems. They often have inklings of what would make their jobs easier, more efficient, more reliable, less error prone, less frustrating, and less costly. Because they know their jobs the best, they are the best suited to improve those jobs by diagnosing problems and inventing countermeasures. In doing so, they should be coached by their supervisors. Front-line employees' direct engagement in such improvement work reduces their resistance to

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change because they helped bring it about.

Toyota's approach is a numbers game. If everyone improves their own jobs just a little bit every day, week, or month, then those small efforts, aggregated across hundreds or thousands of employees, add up to large gains in the company's performance over time. Toyota's theory for CI is that these activities are part of everyone's routine work, not "extra" tasks to be done only when employees have slack time available (or when managers compel them to do those tasks). Jason Schulist was trying to foster the adoption of this theory of CI at DTE Energy by continually emphasizing the idea of "problem solving at the point of activity."

My finding about the best role for Black Belts alters this conventional wisdom. First, Black Belts or industrial engineers have specialized training for facilitation, advanced data analysis, and problem solving. Training a Black Belt is expensive. Companies should use them sensibly by having them use their special skills, rather than having them return to their previous jobs with a certificate. They should work full-time within their business units, close to the core value streams. They should act like internal consultants. They are the best equipped to facilitate problem solving across functional boundaries and to enforce honesty in uncovering and scrutinizing the causes of problems.

Second, managers of front-line employees must always confront the problem of effort allocation, between improvement and throughput. This trade-off is called the *self-improvement dilemma* by Keating and Oliva (2000a, pp. 263-264) and the *capability trap* by Repenning and Sterman (2002, pp. 282-283). This dilemma is particularly acute for unionized employees, such as those at DTE Energy, and for healthcare personnel because their highly specialized professional skills make their attention to throughput far more valuable than their attention to improvement. If such front-line employees are going to perform improvement activities, they should adhere to the TPS model: fix local problems for processes that are already well functioning. Work processes should already be clearly defined, standardized, and predictable. The mechanisms for signaling errors and escalating them to upper management's attention must also be in place and well functioning.

Third, managers should make process "reengineering" the responsibility of their

company's Black Belts. Often, processes have not been explicitly designed but have simply evolved over time. Consequently, costs can be reduced and efficiencies increased by "engineering" them in the first place. As specialized resources, Black Belts are best suited for cross-functional, capital-intensive, or way-out-of-the-box process redesign. Of course, they should include front-line employees as appropriate in such work, as experts and as the recipients of the new process.

These points have several implications. First, the Black Belts require a matrix-style organizational structure. Each Black Belt should be attached to a particular business unit, to ensure he or she is close enough to the front-line to understand processes and problems, and to develop good working relationships with the front-line employees in that unit. However, one of DTE Energy's Master Black Belts observed that it is beneficial for a company's Black Belts to officially report also to a centralized CI department. Such an official reporting relationship helps the Black Belts maintain their objectivity (not getting pulled into business-unit cover-ups), ensures that they are not appropriated as "extra" resources for the business unit's non-CI projects, and furnishes them with a support network should they need assistance.

Second, executives and managers need a system to compile improvement ideas from all sources, whether from employee suggestions or from strategic priorities. They would use such a system to review and sort these improvement ideas by priority and resources required, and then assign them to Black Belts or to front-line teams.

Improving a process involves two stages. The first stage is to stabilize a process by designing it explicitly. After the process is running smoothly, the second stage is to continually and iteratively refine its design. The segue from the first stage to the second is an important transition. It is likely that a Black Belt needs to direct the first stage, but he or she might not be needed in the second stage. Black Belts should train front-line employees on-the-job during the process-design stage, so they are well prepared and inclined to perform the ongoing process refinements when the Black Belts move to other projects. This combination of Six Sigma Black Belts and front-line employee problem solving is what DTE Energy's CI leaders mean when they call their CI initiative "Lean Six Sigma".

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This approach avoids front-line employee disenchantment that occurs when large numbers of them are forced (and often they *are* forced) through an introductory CI crash course with no immediate follow-up. The pro-CI managers or Black Belts throughout the organization are too few in number to involve every newly trained front-line employee in some kind of improvement work. Such a push for broad training is wasteful at best and creates a "disillusioning machine" at worst (see, for example, section 6.1, p.257).

Keating and her colleagues (1999) claim that long-term sustainability of a CI initiative requires an organization to make a transition from managerial push for CI work to employee pull for CI work, but they do not provide an argument for this claim. After all, why couldn't managers simply keep up their normative pressure? Perhaps Keating and colleagues thought that persistent managerial push was practically unlikely or structurally infeasible. Annual budgeting as a control mechanism, however, is a counterexample; there is no employee pull for it, yet organizations continue the practice. An alternative theory is that managerial incentives keep employees enacting CI behaviors until those practices become institutionalized as taken-for-granted social norms. In such a scenario, employees do not need to believe in those practices; they need only to become habituated to using them routinely.

My case study and simulation analysis of DTE Energy's CI initiative confirms Repenning's (2002) finding that managers need to stay the course. Repenning, also using a formal System Dynamics simulation model, illustrates how the reinforcing feedback processes of convincing from results and from word of mouth operate initially in a downward, reversionary direction (i.e., they boost the disillusioning rates). Managers' push for CI work is needed to get workers over a "motivation threshold" beyond which these reinforcing feedback loops operate in an upward, regenerative direction (i.e., the convincing rates exceed the disillusioning rates). CI implementation failure occurs when managers' push for CI work is too weak or is withdrawn too early to swtich these reinforcing feedback loops from their initial vicious direction to their potential virtuous direction. Repenning emphasized the "motivation threshold" because it explains how a CI initiative can fail even with employees achieving early successes. The simulation results in Chapter 6 validate Shawn Patterson's belief that the 6-month phases of the first CI

implementation plan should have been 2- to 4-year phases (see section 3.2, p.45). Such persistence is required to convince enough employees and to build their skill to a degree where they are achieving results that convince others.

8.3. Model Limitations and Implications for Further Research

The biggest flaw in my simulation model is the lack of a sector representing DTE Energy's finances. Even though my model includes labor costs and variable operating costs, it lacks enough detail of DTE Energy's revenue and cost structure to enable an endogenous formulation of a few important aspects of the CI initiative. Specifically, senior executives' belief in CI is required to allocate money to CI consultants, training activities, and positions. The allocation of monies to each of these elements exhibits a different amount of inertia: spending on CI consultants and training were increased and decreased quickly, positions for CI personnel were adding and eliminated slowly. My model is missing the cost of CI personnel, including the instructors for the Green Belt training program and the Master Black Belts. (It does include the wages for Black Belt program participants.) Modeling the dependence of training capacity for Black Belts and Green Belts on senior executives' belief in CI would raise the stakes on convincing them early and quickly. The optimal policy scenarios in section 7.4 (p.291) already include such aggressive convincing of the senior executives.

My lack of a fully elaborated financial model sector means that I had to define financial stress as an exogenous time series (see section 5.6, p.165). Financial stress in the model, therefore, does not participate in any feedback loops; it is not alleviated by employees achieving CI savings or by the lowering of labor costs through downsizing. For simplicity, I modeled changes in financial stress drastically; for example, it jumps from zero to 100 percent at the beginning of the PEP initiative in August 2005 (see Table 5, p.255), which implies that DTE Energy's senior executives immediately demanded 32 hours of nonroutine work, on average, from every employee. An endogenous formulation for financial stress would not exhibit such unrealistic swings.

When I simulated the scenarios in Chapter 6, I assumed for simplicity that Black

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Belts were dedicated to CI activities full-time. Although some of DTE Energy's Black Belts were dedicated to CI full-time, in actuality most were dedicated to CI only part-time. The part-time Black Belts could readily curtail their CI activities or even drop out of the Black Belt program entirely (by simply halting their CI activities) without much notice paid by their supervisors or by other managers. My model assumes constant dropout rates for Black Belts, Black Belt trainees, and Black Belt candidates (see section 5.12, p.203). The Black Belts' dropout rate was zero except for the period between the start of the MichCon merger's trouble in April 2000 and the start of the OS Experts training in July 2002 (see Table 5, p.255). Instead, Black Belts should drop out based on their assessment of the CI initiative's health, although it is an open empirical question how they would make such an assessment.

I represented the variable *Boss Push for CI Work* as a pressure ranging from zero to 100 percent, which employees translate into a certain number of work hours spent on CI work per month (see section 5.6, p.165). In actuality, however, DTE Energy's managers also pushed their subordinates to achieve a certain amount of CI savings or to attend CI workshops of certain durations. DTE Energy's OS Experts and full-time Black Belts, in particular, were expected to meet CI savings targets. My model omits the processes by which those targets for CI savings or for participation in CI activities were set. More importantly, it also omits increases in the Black Belt dropout rate when Black Belts judge their savings targets as unreasonable.

In my simulation model, CI work is always nonroutine work, added on top of every employee's routine workload. My model does not accommodate the possibility that CI work becomes institutionalized as part of everyone's job such that employees will enact CI behaviors even if they or their managers no longer believe in CI. It is not certain how much nonroutine work DTE Energy's executives and managers intended their subordinates to perform for a given degree of push for cost reductions. I assumed a fixed maximum nonroutine work fraction of 20 percent of an employee's work month (see section 5.6, p.169), but such a fixed maximum is unrealistic. I think it is plausible that employees at all levels learn, via a hill-climbing heuristic, how much nonroutine work is acceptable or desirable, given the other pressures they feel. Additionally, employees and their bosses

can both form opinions about how much nonroutine work those employees should perform — and these opinions do not have to match (and probably won't).

I make a similar assumption on the employee-pull side. My simulation model yields the result that CI believers experience more schedule pressure than do the neutrals and skeptics. The reason is believers *want* to engage in CI work in addition to their regular routine work (see section 5.6, p.164). My model reflects the strong assumption that managers allow their believer subordinates to engage in CI work to the extent they want. My model omits the structure of Repenning and Sterman's (2002) capability trap in which managers can increase or decrease the time they permit their subordinates to engage in CI work based on their own pressures for throughput (accomplishing the routine work).

As I explained in the Methods section 1.2 (p.18), I formulated a DTE Energy-specific simulation model prior to building the more generalizable version that I present in Chapter 5. For parsimony, I excluded from my final model some formulations of my precursor model. One of these exclusions was Black Belts' need for front-line employees' expertise and participation in their CI projects. Without such front-line participation, Black Belts find it much harder to achieve and sustain improvement results. Anecdotal evidence from DTE Energy suggests that Black Belts might require as much as double the amount of time to solve a problem without front-line employees' participation.

Another element in my precursor model that I excluded from my final simulation model was DTE Energy's CI workshops: the *kaizen* events of phase 1, the learning lines of phase 3, the CI Leadership Workshops (CILWs) of phase 5, and the swarm events of phase 6. I assumed instead that person-hours expended in CI workshops was equivalent to person-hours expended on CI projects or, in the case of CILWs, to senior executive training hours. But I believe a closer examination of the differences among these types of workshops and from CI projects would be fruitful. Learning lines (when conducted properly) and CILWs in particular were effective at convincing all participants, regardless of their level in the company hierarchy, in part because they were learning together on the front lines. In contrast, DTE Energy's kaizen events were unsuccessful because they represented CI work being delegated to front-line employees with no management support, inadequate training, and inadequate coaching. Swarm events suffered from being

viewed by some managers as a quick fix for any problem, even those problems that could not possibly fixed within a swarm event's 1-week duration (or shorter).

The aspects of CI implementation that I perceive would benefit the most from further research are (1) how senior executives and middle managers perceive the CI initiative's results, (2) how those perceptions shape their beliefs, and (3) how they translate those beliefs into specific directives or pressures down the company hierarchy. The interaction of these pressures with employees' beliefs and incentives at each level of the hierarchy is also important. For example, my simulation model demonstrates how a strong senior executive push for CI work from the top of the hierarchy may amount to very little pressure for CI savings on the front lines after the CI contribution rates for middle managers and front-line employees are reduced by their low skill and low effort earnestness (see section 5.7, p.172).

In my DTE Energy case study, I perceived what might be two different types of managerial belief in CI or two different points along a spectrum of increasing belief in CI. On the one hand, a manager or executive can believe that CI is beneficial for the company but think that there is no problem delegating the responsibility for enacting CI to his or her subordinates. On the other hand, a manager or executive can believe that CI is beneficial for the company only when he or she is personally involved in orchestrating it. Most senior executives at DTE Energy, with the exception of Bob Richard, exhibited only the first type of belief in CI until Jason Schulist's introduction of CILWs in 2008.

At all levels of the hierarchy, employees' perceptions of the CI initiative were shaped primarily by how much savings were reported (or not reported) under a CI label rather than by what means those savings were achieved. Also, employees did not pay attention to whether such work boosted the company's capabilities for the long term or simply reduced its costs in the short term. For example, CI methods properly applied under the rubric of the PEP initiative were not considered by many managers and executives as CI work. But DTE Energy's senior executives continued to support Black Belt projects in phase 4 because they could produce short-term gains efficiently. It is no wonder then that many front-line employees — having only heard about CI through word of mouth — believed that the PEP initiative was simply the next incarnation of DTE Energy's CI

initiative.

The results of simulation scenario 4 in section 6.4 (p.266) raise the question whether managers can correctly perceive, or tease apart, the factors contributing to an overall decrease in operating costs. My model assumes that they cannot do so. In scenario 4, managers engaged in downsizing and in cutting the scope of their subordinates' work, which created financial gains that were commingled with CI savings being achieved. It possible that they misperceived the CI initiative to be more beneficial or less beneficial than it actually was during different periods.

As I describe in section 5.10 (p.189), I adopted the assumption from the Analog Devices model that employees are convinced by the (continuous) rate of improvement in their variable of interest — time per task for front-line employees, CI savings for upper management — instead of absolute improvements made over a certain time period. This assumption makes CI results a derivative controller for the convincing rate. It is an open empirical question whether this derivative controller accurately describes how employees would respond to diminishing returns to a constant CI work rate (or even if they have the ability to perceive those returns diminishing at all).

My handling of the downsizing rate is simplistic. DTE Energy's senior executives discontinued their attempts at downsizing with layoffs after they observed the damage that these attempts made to employee commitment and morale. This causal mechanism is missing from my model. I also assume unrealistically that downsizing can persist at a constant fractional rate, rather than at a diminishing rate as the number of total employees approaches a theoretical minimum. (This theoretical minimum depends on the minimum monthly routine work that employees must perform to keep DTE Energy in business.)

Finally, the other pressing need for further research is investigating how much support from their managers and how much coaching from CI experts front-line employees require. My simulation analysis in Chapter 6 suggested that both support by managers and coaching by Black Belts always fall short of the amounts required by front-line employees, given DTE Energy's average span of control and a Black Belt target of 2 percent of the total workforce (see sections 6.4, p.266, and 6.5, p.271). This imbalance is not as severe as it seems, however, if a company's executives do not expect *all* its

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employees to make CI part of their jobs. It is not clear what fraction of a company's workforce should comprise the target audience for CI to become "the way we do things around here."

8.4. Conclusion

Companies do not attempt to train their employees to do their accounting. They hire professional accountants instead. They view these accountants as a necessary part and cost of doing business. No return-on-investment calculation is needed to hire an accountant (assuming, of course, that there is enough accounting work to be done). Yet non-manufacturing companies take this tack when it comes to the design of their work processes. They either assume their middle managers can do it adequately, or they train a handful of employees to do it on a part-time basis. Or, worse, they hand the responsibility over to the IT department as it attempts to "automate" the company's processes with computer systems. The alternative is to hire professional industrial engineers or full-time certified Black Belts. The findings from my policy optimization analysis in Chapter 7 suggest that this approach has merit. I cannot see how the design of a company's work processes is any less important than the accounting of its cash flows.

"Top-down" and "bottom-up" are adjectives commonly used to describe approaches to CI implementation. I argue that these terms refer to a false dichotomy. Any successful implementation must and does include both, like precipitation and evaporation in the water cycle. The process of CI implementation is governed by a positive feedback loop: from results to perceptions, to beliefs, to policies and other managerial actions, to front-line employee actions, and back to results. A company's CI leaders might choose to emphasize top-down incentives or bottom-up demonstration of results, but nobody can separate either one from this overarching feedback process.

While conducting my fieldwork for this study, I also attended BP's Global Operations Conference in late 2008. BP's executives had dedicated a large portion of this conference to BP's CI initiative, which was relatively new at that time. Andy Inglis, CEO of BP's extraction and production business unit, stated that their implementation strategy is

not top-down or bottom-up, but a blend of both. He explained that BP's upper managers should expect their subordinates to do improvement work, by applying standard CI tools and procedures, but they would not prescribe exactly how to go about it. Inglis intended for each business unit to experiment locally, to adopt so-called "best practices" from other business units, and to spread its own findings to others.
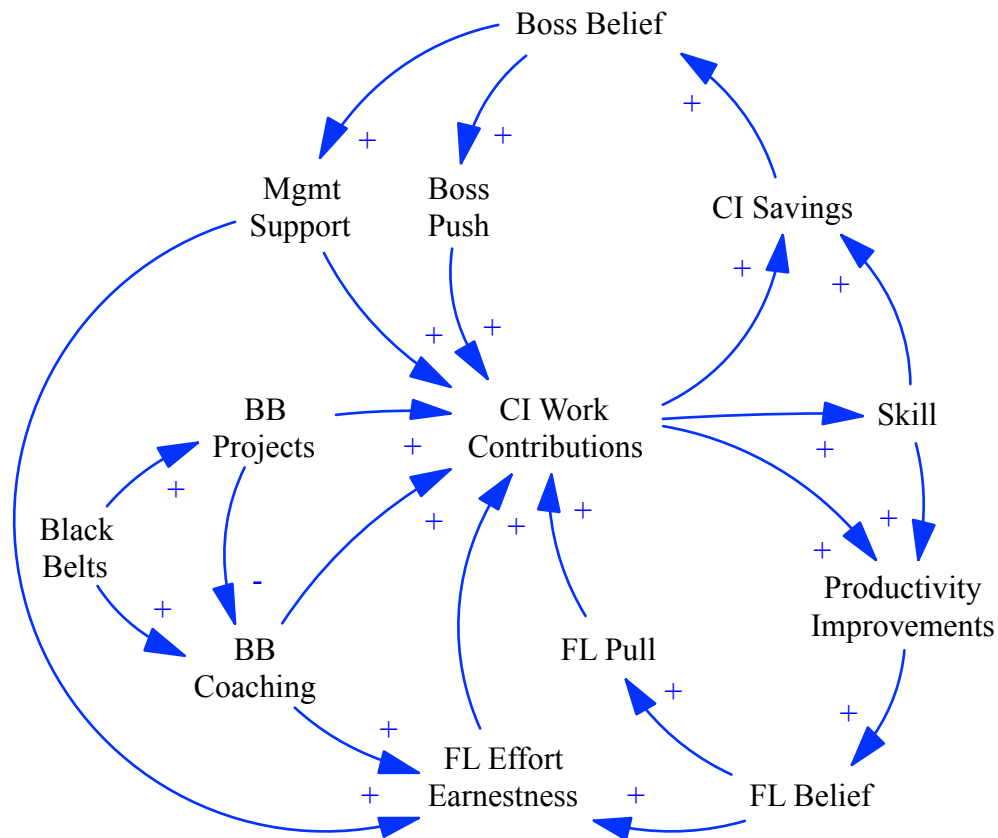
Figure 91. Summary of Reinforcing Feedback Loops

My case study of DTE Energy shows that growing a CI initiative involves more than managerial support, local experimentation, and sharing best practices. For employees at any level of the company hierarchy to believe that CI work is worthwhile, they must be convinced. But the results that convince the front-line employees are of a different type from those that convince upper management. Achieving results depends also on employees' accumulated skill and effort earnestness, both of which are initially low regardless of senior executives' enthusiasm for the CI initiative. It is for this reason that Black Belts' CI projects and coaching are so crucial to building and maintaining necessary

levels of employee belief. As Figure 91 shows, Black Belts' CI activities resolve the chicken-or-egg problem created by the interlocking reinforcing feedback loops between the front line and upper management.

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Appendix A: Timeline of Events

1994

- (March) Tony Earley leaves Long Island Lighting Company (LILCO) and joins DTE Energy as COO.

1995

- Following the failure of their 1992 contract negotiations, DTE Energy and UWUA Local 223 adopt an interest-based bargaining (IBB) approach. They agree to their first 4-year contract.

1997

- David Meador leaves Chrysler after 14 years and joins DTE Energy as controller and treasurer.
- Steve Nagy is hired from Chrysler for his experience working on the Chrysler Operating System.

1998

- (August) Tony Earley succeeds John Lobbia as DTE Energy's Chairman and CEO.
- Steve Nagy hires Lean consulting firm Achievement Dynamics to run *kaizen* events.

1999

- (June) Senior executives visit the U.S. Army's Center for Army Lessons Learned (CALL) in Fort Leavenworth, Kansas, and subsequently adopt the practice of After-Action Reviews (AARs) as an organizational-learning tool (Darling, Meador, & Patterson, 2003).
- Steve Nagy hires Jamie Flinchbaugh from Chrysler and Shawn Patterson from GM as the first full-time employees of the nascent CI initiative.
- Shawn Patterson becomes manager of DTE Energy's new Center for Continuous Improvement (CCI). He expands Nagy's *kaizen* program.
- DTE Energy and UWUA Local 223 negotiate a 5-year contract. The Office of Labor

Management Partnership (OLMP) is created to oversee the new Union Management
Partnership (UMP) initiative.

- (October) DTE Energy announces plans to merge with MCN Energy Group, parent
company of Michigan Consolidated Gas Company (MichCon).

2000

- DTE Energy's merger with MCN Energy dominates senior executives' attention.
- (June) Michigan governor John Engler signs Public Act 141 into law, requiring DTE
Energy to implement the Electric Choice program by January 2002.
- (October) DTE Energy and IBEW Local 17 negotiate a 5-year contract.

2001

- (January) DTE Energy begins implementing the Electric Choice program mandated by
the Michigan Public Service Comission (MPSC).
- (May) DTE Energy and MCN Energy formally close their merger.
- (November) The Operating Council, formed to oversee post-merger integration,
formally charters the creation of the DTE Energy Operating System.
- (December) CFO Larry Garberding retires and is succeeded by David Meador.

2002

- (May) Shawn Patterson becomes director of DTE Energy's new Operating System
Strategy Group (OSSG) and leads the creation of a 2-year strategic plan for the CI
initiative.
- Patterson hires Lean expert Michele Hieber to design the OSSG's training courses.
Hieber creates the OS Expert course.
- MichCon's approximately 1,000 members of SEIU Local 80 vote to become members
of UWUA Local 223.
- (September) CEO Tony Earley hires Signet Consulting to facilitate AARs by the
executive committee to identify and assess lessons from the merger (Darling et al.,
2003).
- (November) CEO Tony Earley conducts an executive-committee AAR, without

consultant assistance, on a substation fire adjacent to DTE Energy's Detroit headquarters (Darling et al., 2003).

- (December) DTE Energy sells its high-voltage transmission subsidiary, International Transmission Company (ITC), to private equity firms Kohlberg Kravis Roberts & Co. (KKR) and Trimaran Capital Partners for approximately $610 million in cash.

2003

- Michele Hieber creates the OS Specialist course.
- Bob Richard leaves Bethlehem Steel as vice president of operations and process improvement and joins DTE Energy as vice president of Fossil Generation. Richard brings Six Sigma to DTE Energy, having previously become a Six Sigma Master Black Belt during a 13-year tenure at GE.
- John Weiss is hired from Florida Power & Light (FPL) for his Six Sigma expertise. He starts a Black Belt training and certification program within OSSG.
- Frank Wszelaki leads the development of a periodic outage handbook for Fossil Generation's power plants.
- (August) Failure of the electricity distribution network in northeastern and mid-western states and Canada, causing the largest blackout in U.S. history.

2004

- DTE Energy's first Master Black Belt is hired from Ford to lead the Black Belt program.
- (Spring) Marcia Jackson leads a 3-month learning line at Coolidge service station, improving service-call productivity by 42 percent.
- (Summer) A second learning line is attempted at Broadway service station.
- (June) Gerry Anderson is promoted to president of DTE Energy.
- (July) DTE Energy and UWUA Local 223 negotiate a 3-year contract.
- Shawn Patterson and John Weiss lead the creation of a new 2-year strategic plan for the CI initiative. Weiss becomes director of OSSG when Patterson moves to Distribution Operations.

2005

- A statistician from DTE Energy's marketing department runs the Black Belt program for a few months only.
- (April) MISO's day-ahead and real-time energy trading markets go live.
- (Summer) Gerry Anderson becomes COO and hires McKinsey to design a cost-cutting and organizational restructuring initiative called Performance Excellence Process (PEP).
- A new group called Enterprise Performance Management (EPM) is created to orchestrate the PEP initiative.
- DTE Energy and IBEW Local 17 negotiate a new contract.
- (October) The MPSC orders DTE Energy to explain why its administrative and general expenses compared unfavorably to Michigan utility Consumers Energy.
- (November) Planned layoffs as part of a project at Pontiac service station poisons the learning-line approach to CI.

2006

- (March) The MPSC orders DTE Energy to argue why its electric rates should not be reduced.
- (June) The unions successfully resist PEP's proposed layoffs, but employee morale suffers. Hundreds of non-represented employees take voluntary buy-outs.
- DTE Energy installs new IT systems SAP and Maximo for administrative processes. The project costs over $250 million.
- (October) Steven Kurmas, former executive vice president of Energy Distribution, replaces Bob Richard as the head of Fossil Generation. Bob Richard becomes senior vice president of Gas Operations (MichCon).

2007

- (January) Jason Schulist replaces John Weiss as director of OSSG. He reemphasizes Lean concepts and tools in the CI initiative.
- Jason Schulist hires four new CI managers for DTE Energy's business units.
- (July) Gerry Anderson acknowledges at an upper-management retreat the damage that the PEP initiative caused to employee morale, marking a return to the CI initiative.

- (October) DTE Energy and UWUA Local 223 negotiate a 3-year contract.
- (October) Fossil Generation's managers restart a training initiative for power plant employees called Performance Leadership.
- Jason Schulist takes several senior executives to 5-day executive courses on Lean.
- (November) DTE Energy's fourth head of the Black Belt program quits, leaving the Master Black Belt position vacant for the next 6 months.

2008

- (February) Jason Schulist begins CI Leadership Workshops (CILWs).
- (May) Jason Schulist hires a new corporate Master Black Belt, who revives and restructures DTE Energy's Black Belt certification program.
- (July) At an upper-management retreat, 62 percent of DTE Energy's managers believed that the CI initiative would be displaced by a new initiative within 5 years.
- (August) Patti Poppe launches a culture-change initiative in Fossil Generation, called Trade Up Culture, and adds it to the Performance Leadership training.
- (September) Jason Schulist hires Bob Hemrick from Dana to be co-director of OSSG.
- (October) Credit crisis hits the U.S. economy.
- (November) Gerry Anderson formulates DTE Energy's economic-crisis response (ECR) and guarantees employment security for employees. DTE Energy cuts contractors instead.
- (Autumn) Jason Schulist teaches Gerry Anderson CI via one-on-one tutoring. Anderson completes his CI practicum at Trombly cable plant.
- (December) Detroit Edison president Bob Buckler retires and is succeeded by Steve Kurmas. Paul Fessler becomes Fossil Generation's new vice president.

2009

- (January) Deborah Meyers joins the OSSG from the HR department's Organizational Learning group to develop new CI materials.
- (Spring) Jason Schulist teaches Tony Earley CI via one-on-one tutoring. Earley completes his CI practicum at Southfield service center. He presents his project to DTE Energy's board of directors.

- Jason Schulist and Bob Hemrick heavily promote swarm events to teach Steven Spear's Four Capabilities (C1-C4) and OPCA.
- (April) Chrysler files for Chapter 11 bankruptcy protection.
- (June) General Motors files for Chapter 11 bankruptcy protection.
- (July) Leaders of all 11 divisions of UWUA Local 223 attend a CILW on the union grievance process.
- (October) The Conference Board's Council for Six Sigma Executives visits DTE Energy to learn about its CI initiative.

2010

- (January) DTE Energy wins the "Best Improvement Program" category of the Process Excellence Awards given by the International Quality and Productivity Center (IQPC).
- (April) DTE Energy hosts a event jointly organized by the Michigan Lean Consortium (MLC) and Oakland University's Pawley Lean Institute. DTE Energy's executives present their CI initiative to MLC members and other Michigan companies.

Appendix B: Assessment of CI Activities

While I was researching the history of DTE Energy's CI initiative, my interviewees were also communicative about the various types of CI activities used at DTE Energy. Their assessments of these CI activities augment our understanding of how the events of DTE Energy's CI initiative unfolded, yet these assessments remain somewhat tangential to the main history. For this reason, I have included these sections in an appendix. I did not exclude this material entirely, however, because I realized that these assessments are of equal — if not greater — importance and interest to practicing managers looking to learn from DTE Energy's experiences.

Voicing their frustrations with and perceived shortcomings of these CI activities seemed to be cathartic for many interviewees. We all love to complain, of course, when we have an ax to grind and an interested yet neutral listener. But this fact may worry readers concerned about bias: To what extent are these criticisms broadly representative, rather than the views of a disgruntled minority? My purpose for including these assessments was to provide a comprehensive list of shortcomings, as perceived by my interviewees, so that managers at DTE Energy and elsewhere may be aware of them. Bias and non-representativeness, therefore, aren't a problem: If these shortcomings were judged by my interviewees as significant, then they have the potential to hamper or derail any company's CI initiative. Forewarned is forearmed.

On the other hand, DTE Energy's employees achieved some remarkable successes with all of these activities — Black Belt projects, CILWs, and swarm events. To balance out the criticisms presented in this appendix, I have endeavored to provide examples of these successes both in the main history in Chapters 2-4 and in the sections below.

The last section on employee engagement addresses what I consider to be one of the most important challenges of implementing a CI initiative. This examination of DTE Energy's efforts with employee engagement is topical rather than chronological, so it did not fit my narrative structure of Chapters 2-4. I emphasize, however, that my relegating this section to an appendix does not reflect my opinion of its relative importance.

B.1. Black Belt Program

As DTE Energy's population of Black Belts grew between 2004 and 2009, the fraction of certified Black Belts hired — rather than trained internally — was consistently about one-third (see Figure 4, p.91). These Black Belts were hired from companies like GE, Ford, Visteon, Johnson Controls, and Lear. Because most of these companies had hired Six Sigma Academy to launch their Six Sigma programs, Black Belts from these companies were critical of DTE Energy's home-grown Black Belt program. The shortcomings that they reported follow.

1. Black Belt candidates were (sometimes) selected poorly.

Black Belts should not only work on projects, but promote structured and rigorous ways of approaching operational problems among all employees. For this reason, consulting firm Six Sigma Academy (SSA) recommends that companies select their best employees, those with energy and promise for advancement, to become their Black Belts. Ford hired Six Sigma Academy and followed this recommendation, at least initially. One of their former Master Black Belts, who later joined DTE Energy, said, "They were extracted from the operations, which was painful for us because they were our strongest teammates. However, they were the right people to forge a new path. You need strong people with strong skills to bump up against the culture and resistance to change. Our earliest Black Belt waves were some of our best practitioners." The OSSG personnel followed this approach with DTE Energy's first few Black Belt cohorts.

Over time, however, DTE Energy's senior executives gradually abandoned this strategy of training and promoting Black Belts as change agents. A manager complained, "DTE will train any Tom, Dick, and Harry who signs up for the Black Belt course, as long as they have their vice-president's approval. ...There's a pretty healthy percentage of people whom DTE made the investment in, went to the Black Belt training, and never did anything with it. That's wasteful. ...Why are you training all these people and certifying them if there is no expectation after they certify? They melt back into the [organization] and they're gone — but they got a plaque on their desk."

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Fortunately, DTE Energy's senior executives did not adopt GE's practice of requiring Black Belt certification for promotion to management positions. (Bob Richard came closest to this policy by stating that Black Belt certification was a factor, but not a requirement, in Fos Gen's promotion decisions between 2004 and 2006.) A CI manager who had worked at Ford described Ford's attempt with such a policy: "Ford experimented with that. It had only short-term success because it encouraged some unexpected behavior. The focus of the new Black Belt candidates shifted from deploying and using the methodology to how quickly they were eligible for promotion or stock options. That didn't work out well."

Middle managers sometimes sent their subordinates to Black Belt training for reasons other than acquiring skills for CI work. A few directors who joined DTE Energy from companies with strong Six Sigma cultures, like GE, encouraged all of their immediate subordinates to earn their Black Belt certifications. I perceived that these directors created disproportionately large clusters of Black Belts in their departments for shared language, concepts, and ways of thinking. Employees felt compelled to attend Black Belt training only because their bosses were Black Belts. Also, several CI managers reported a few instances of managers using the Black Belt program as a way to address conflicts with subordinates. For example, a few employees caused trouble when they felt that they weren't advancing as they thought they deserved, so their managers sent them to Black Belt training as a way of "throwing them a bone" (as one CI manager put it). These managers implied that Black Belt certification would open doors to new opportunities. Consequently, a few Black Belt candidates were seeking a merit badge for their resumes, rather than skills for doing CI work.

2. DTE Energy's Black Belt training was like Green Belt training elsewhere.

When one of the CI managers began grooming his replacement in late 2006, he wanted her prepared to mentor Black Belt candidates. Consequently, he asked her to attend the OSSG's classes to become familiar with their content, even though she had already earned her Black Belt certification at Ford. She was unimpressed: "I was surprised this was their Black Belt class, because the training that they were providing at the time

was less than Green Belt level training." MichCon's CI manager agreed: "I probably had better Green Belt training at Johnson Controls than [the training] they certified those initial Black Belts with." An externally trained Black Belt felt it was a mistake to omit the Green Belt prerequisite for Black Belt certification. She said, "We didn't even provide Green Belt level training and we were certifying people as Black Belts. I brought that up as a concern when I was a Project Lead." She also felt this lack of rigor hurt the Black Belts themselves: "We're not doing the right thing here. You're providing people a Black Belt certification and if, for whatever reason, they go outside [DTE Energy] and try to pursue a Black Belt type of job, they will be at a real disadvantage — and the person hiring those individuals will be at a disadvantage too — because it's not what a true Black Belt is supposed to do." A MichCon manager confirmed this feeling, saying he wouldn't hire many of the DTE-trained Black Belts for a Black Belt position. Another MichCon manager agreed: "There are a lot of people who really want to make this company better and we're sending them out to solve problems without the necessary skills." Another Black Belt, trained at Ford, believed strongly that DTE Energy's poor Black Belt training was causing more harm than good to the CI initiative as a whole:

> We have talented people over there in OSSG that know Lean really well [or] know other tools really well. Rather than training new Black Belts formally, they could work projects with small teams and teach through direct experience. When those projects are successful, there will be a demand for more. [Those projects'] team members [would be] new practitioners who have project experience.

> ...Sending people through an ineffective training program is damaging to DTE's continuous improvement goals because you send people out as representatives of that methodology who don't know what they're doing. When they fail, the people they were trying to help lose faith in the program.

Several CI managers agreed that ill-trained Black Belts failing at important projects created negative perceptions of CI among front-line employees. One Black Belt felt that these negative perceptions were so bad that she dissociated herself from the OSSG: "I purposefully avoid the CI network and the special language. When I talk to teams, I don't tell them I am a Black Belt. I just offer to help them with their process using only the tools that help us solve the problem."

3. DTE Energy's Black Belt candidates were mentored poorly.

The corporate Master Black Belt position in the OSSG was the only one at DTE Energy. This Master Black Belt was responsible for the design, content, and delivery of the Black Belt training course and for mentoring all of DTE Energy's Black Belt candidates as they worked to complete their projects. With about 140 candidates on the roster as of early 2009, the Master Black Belt was stretched thin. This ratio at DTE Energy contrasts with Ford's ratio of one Master Black Belt mentor for every five or six Black Belt candidates.

4. Most Black Belts did not work on CI full time.

The OSSG personnel chose to situate Black Belts within DTE Energy's business units, to place them closer to operational problems. "Embedding them in the business units, they get to know the [business unit] people, live with the people, they know the real problems that are bothering them," said an OSSG manager. This choice reflected other companies' experiences with Six Sigma. A service center manager hired from the automotive industry said: "Johnson Controls, as their continuous-improvement efforts evolved, came to the realization that if the operations manager owns continuous improvement [personnel], things are probably going to happen. If [Black Belts] are functioning as separate camps, then [CI] is just these guys that keep coming over, bugging me (as the ops guy). They're just an annoyance at that point. If the task and the expectation is squarely the responsibility of the ops manager, then he's going to get things done."

In contrast to other companies' practices, however, DTE Energy's managers generally did not put their Black Belts to work on CI full-time. (The one exception was Bob Richard creating positions in Fos Gen and MichCon for Black Belts to work as full-time internal consultants.) Both Johnson Controls and Ford required two years of full-time CI work from their newly certified Black Belts. Most of DTE Energy's Black Belts kept their operational jobs, both during and after earning their certifications. An OSSG manager explained the problem with this practice:

One of the problems we've seen here is whenever we certify Black Belts, they've got another job. They're going through the learning process and doing their two projects, [but] tacking that on to their regular jobs. They've [already] got a job that consumes a hundred percent of their time. Because they want this on their resume, they're willing to tack on an extra twenty-five percent, work some extra hours, to get this certification.

But the business units rarely pull them from that operational role and put them in the role of a hundred percent CI: "Now you're going to do continuous improvement for me, because you're one of the best problem solvers I've got." They don't see that. They say, "Do this job better. Do this the way a Lean person would do it, or do this the way a Six Sigma person would do it." I would say we've probably got two hundred people in the organization that have a CI title. Probably eighty of them are doing it three-fourths of the time. There's always something else you need to do. That's traditionally what we see.

One of DTE Energy's service center managers agreed: "They had a full-time job before they started going to class. And after the dust settles, they've still got a full-time job. They look at things a bit differently, they understand the tools better, so it's good for them developmentally. But it doesn't do much for the business."

Several Black Belts confirmed how difficult they found trying to juggle their CI projects and their regular job duties. One Black Belt said, "It was just a continuing-ed thing where you took your class, you became a Black Belt, you went right back to your old job. Then you would try to do projects: You applied some of the tools and you tried to work within a very odd, awkward, 4-Gate 9-Step [process] that wasn't quite effective, or efficient, or well-managed. And you still had all your day-to-day stuff to do on top of it."

Even worse, some managers had no expectation that their Black Belt subordinates would continue to work on CI projects after they earned their certifications. In these cases, these subordinates entered the Black Belt program with the assumption that Black Belt certification was only personal professional development. DTE Energy's only return on the cost of training these particular Black Belts was whatever gains they produced with their two certification projects.

5. Black Belt projects were selected poorly.

At an OSSG staff meeting in mid-2008, the CI managers agreed that many Black Belt projects were not connected to DTE Energy's strategic objectives, so Black Belts needed better project-selection criteria. When front-line employees at Johnson Controls or other automotive companies encountered intractable or resource-intensive problems in their local CI activities, they would typically submit these ideas to a database of possible Black Belt projects. DTE Energy tried to maintain an employee-suggestion database, but it was not the same type of repository of scrutinized Black Belt project ideas.

Black Belts were paid by their respective business units, not by the OSSG, so they took their marching orders from their business-unit managers. It was sensible for Black Belts to address their business units' priorities. However, several Black Belts highlighted the need for DTE Energy's managers to understand what was an appropriate project for a Black Belt to attempt. One Black Belt said, "A lot of our projects aren't on processes, they are on just a metric. You know, this metric has to go from here to here and that's it. You miss the whole process approach." A Black Belt at MichCon recalled a project that his director asked him to do that he said was typical: "It wasn't a project at all; it was run the numbers and make sure I saved some money. Well, that's not a project, that's a financial analysis. How do you gate that? How do you put any improvements around that, or validate it, and how do you sustain that over the long term?"

Managers who had worked with Black Belts at other companies thought that selecting projects properly was not mysterious or hard to understand; DTE Energy simply lacked a structure to do so. A manager who joined MichCon from another company explained the criteria: "[Black Belts] would be assigned things that have already been tried and failed several times — [problems] sitting in the queue with nobody able to fix them. ...It's not something that can just be fixed [with] the obvious answer, it's not what the executive wants to do [as] a pet project — it actually takes study. Those were probably the biggest criteria. I'm sure cost, timing, and scope of project are part of that too — anything that's longer than a six-month project, [requires] dedicated time, or you need a cross-functional team to apply itself. The Black Belt projects were the way to get those done."

Sometimes Black Belts selected improvement projects poorly out of desperation to meet annual savings targets. "You've got Black Belts doing incredible things, getting stressed out about saving five hundred thousand dollars every year to pay for themselves — in a vacuum, with very little help, support, and probably a whole lot of the opposite of those," said a MichCon employee. As a result, he said ill-trained and unsupported Black Belts resorted to "financial-shenanigans projects where numbers become difficult to prove.... Lots of 'soft' savings."

Several employees felt that many of the poorly chosen Black Belt projects underway in 2009 should be discontinued, rather than perpetuate the sunk-cost fallacy. One of MichCon's Black Belts said:

> Projects should be eliminated that aren't going to work much sooner. [For example, those projects] that the finance guys can't figure out what the savings are. [Or] the difficult ones where there's low-hanging fruit that needs to be solved first. [Or those projects that are] an eternal quagmire of issues that a Black Belt [employee] can't solve and shouldn't be fussing with...[such as] union-issue projects like attendance. There's always a project trying to improve attendance. It comes down to union...negotiation items that can't be argued at a Black-Belt level.

6. Black Belt projects were managed poorly.

Many employees thought that DTE Energy's 4G9S project-management process was too cumbersome and bureaucratic. Many Black Belts, especially those trained elsewhere, greatly preferred Six Sigma's standard DMAIC process as simpler to teach and to use (see Glossary for both *4G9S* and *DMAIC*). An OSSG manager reported that a committee debated the 4G9S-versus-DMAIC question almost every year since the Black Belt program's inception and each time they decided to keep their home-grown 4G9S process. Black Belt candidates were required by the OSSG's Master Black Belt to use 4G9S for their certification projects, but all other project teams tried to avoid it if they could. The CI mangers reminded their Black Belts repeatedly that "all the steps should still be there" even if they weren't using the 4G9S template formally. Without the rigor of a formal procedure, several managers complained of projects with scope creep and unintended consequences, just like the *kaizen* events of 1999 had.

Several employees said that improvements from projects were often short-lived for lack of process owners or other mechanisms to keep them in place. DTE Energy managers' approach was to publish or revise Standard Work Instructions (SWIs), but adherence to these SWIs could be hit-or-miss. One Black Belt said: "If you can't sustain whatever you think is the improvement for more than three months — if you can't prove that sustainability through process controls and proper metrics — it's susceptible to being lost in the next hot-potato game. Any gains you did make are gone when the winds change. We don't get to the validation piece at all unless it's just by accident that something sticks. But I've never seen anything validated with a set of SWIs, controls in place, the new process [design], communication [such that] this process is self-sufficient without the Black Belt being involved again. That's very rare here."

Managers and Black Belts agreed that DTE Energy needed better project management to fix these problems. "We need to go back to a rigorous way of gating the projects, eliminating projects that are incorrect, getting [projects] to a Black-Belt level, [and] getting those projects pushed through timely. A lot of those things have challenges," said a MichCon Black Belt. "Getting back to the process of walking through a project on time, in steps with proper inspection, would certainly get us to the path quicker." In late 2008, an OSSG member said that managers of several business units wanted the OSSG to become a project-management department because business-unit employees managed their improvement projects so poorly.

7. Sometimes Black Belts did not appropriately engage front-line employees in their CI work.

Black Belts should engage front-line employees in their CI work because front-line employees' expertise is vital. Ignoring this expertise raises the risk of unintended consequences and of poorer outcomes, and creates resistance among front-line employees. A Black Belt reported in mid-2009 that "one of the backlashes that's going on a bit in DO right now...is that supervising engineers and principle engineers feel that they're playing second fiddle to CI people. They resent that because, in some cases, they feel they have better training and are more experienced." An OSSG manager related the

following anecdote from Fos Gen:

> They had an outage at…Belle River or St. Clair, I can't remember which. Bob Richard had called his Black Belts and said, "This plant's down. I want you up there. I want you to figure it out. I want you to take over the conference room. I want you to go up there and do a bang-up job and fix this." He called them on Saturday morning or something.
>
> These couple of Black Belts showed up there. They had a team of about five or six. They took over the conference room where they had had some sort of training planned for that week; they had to cancel that. They put up a map on the wall. They were trying to map out the way the process is today, doing a current-state map, and they were using sticky notes. In the midst of all this — when the unit's down and it's not working — I think it took them about three days to map the "is" state, figure out what was going on, and getting it fixed.
>
> The people who were in the control room and the maintenance people think that they could have had it up and running in twelve hours. But (a) Bob Richard got involved, and (b) the Black Belts came. So they had a tremendous stigma against them. And they still do today. It's hard to go into the plants. To say you're a Black Belt is not a good thing, so you typically don't say it. That was slightly before PEP. The good thing is PEP came along and then everybody turned their wrath on McKinsey and took the heat off the Black Belts.

8. Black Belts were not held accountable for achieving verifiable results.

Many companies, like Ford, required a financial analyst to verify project results before a Black Belt received credit for the work. This type of verification was used during the PEP initiative on cost-reduction projects, so Schulist's new CI managers, unsurprisingly, began imposing this requirement on their business units' Black Belts in 2007 and 2008. Until then, it was up to each Black Belt to calculate and report his or her own project savings. About the new policy, DO's CI manager said, "We had *lots* of wrangling, it created a lot of tension, and people didn't like it because we were not allowing the old games to get played anymore."

9. DTE Energy's Black Belts were overpaid.

DTE Energy's Black Belt salaries were mostly in line with the national average — a survey conducted by the website iSixSigma.com found the average Black Belt salary in North America in 2004 to be about $79,000 (LeVeque, 2004) — but other DTE Energy

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employees perceived them as too high for two main reasons. First, Black Belts had difficulty demonstrating that their efforts were worthwhile: They were either not working on high priorities or could not quantify their projects' savings believably. Second, they were not exhibiting the same degree of initiative as similarly paid managers with lots of subordinates. A former plant manager for Johnson Controls, now a station manager at DTE Energy, said:

> I was surprised how much we are paying our Black Belts. Our Black Belts are making between eighty-five and a hundred and five thousand dollars. I wouldn't hire many of the Black Belts on the list here — certainly not for that wage. Two Black Belts at a [Johnson Controls] plant saving two and a half, three million dollars a year, really hitting it out of the park? I was paying those guys sixty thousand dollars.
>
> I think that has [caused] some frustration in the organization. Some of that frustration is they have Black Belts that are making more than station managers with a hundred and twenty people working for them. These guys have no direct reports and...they weren't yielding anything concrete that you could say, "Yep, I get it. I understand."

In summary, the consensus among the externally trained Black Belts was that DTE Energy's poorly trained Black Belts were working part-time on poorly selected projects for managers who didn't understand CI well, yielding disappointing results. "You've got people that aren't given the time to apply themselves. Once you have a Black Belt, you're back to your old job. If you're not one of these sharp people, the best of the best, you lose any ability to apply it, because now you've got a boss who doesn't know it telling you what to do," said a Black Belt trained at Johnson Controls. "Pretty soon, you're left with a bunch of people taking the class, putting a feather in their hats, walking out, and not having a clue. ...Now you're wasting millions of dollars in training and that's not cool. You're not recouping your costs, because now you're not getting any value."

The OSSG leaders' decision to decentralize DTE Energy's Black Belts averted some problems, but created others. The Black Belts were better placed to address problems with countermeasures that were less likely to be resisted. But without a formal structure for selecting, prioritizing, and supporting project work, Black Belts' efforts were directed by the whim of their managers. A Master Black Belt from Ford reported that Ford

experimented with many organizational structures for its Black Belt program, none of which were clearly preferable. She explained her personal preference for a matrix reporting structure: "Black Belts should report directly to the Master Black Belt because that gives the CI team some autonomy. The Master Black Belt has a leadership role to make sure their resources are being used appropriately. When the Black Belts don't have a core manager who can help direct their work, they can become extra people for those operational teams, rather than working on focused projects. ...In addition, sometimes you need some political autonomy. Suppose the Black Belt discovers a process failure that the business owner finds professionally embarrassing. The business owner may not want the Black Belt to reveal the process [problem] or even correct it. The Master Black Belt has the overall company goals as a priority and can step in to support both the Black Belt and the business owner to resolve the conflict. It isn't appropriate to put the Black Belt — especially a new Black Belt — in that position."

In May 2008, Schulist hired a new corporate Master Black Belt from EDS after the position had lain vacant for six months. Like his predecessors, this new Master Black Belt immediately revised the Black Belt training course. He and Schulist promulgated tougher certification requirements in August 2008 aimed at improving the expertise of new Black Belts. These requirements included the following:

1. Each Black Belt candidate must complete two projects within 18 months.

2. Each project must save $250 thousand (or make substantial improvements in safety, customer satisfaction, or environmental impact). Each project's benefits may be earned over a 5-year period (i.e., $50 thousand annually).

3. Each Black Belt candidate must attend a "panel defense" at which she presents her two completed projects and demonstrates her expertise before a panel of examiners.

These reforms enabled the OSSG personnel to begin reducing the sizable backlog of uncertified Black Belt candidates by imposing new project deadlines. (One manager complained that some of her Black Belt candidates had been in certification limbo for four years.) Schulist reportedly cut about 100 people from the candidate roster by the end of 2008.

In February 2009, MichCon senior vice president Bob Richard complained to the

OSSG personnel about certain Black Belt candidates who were not showing progress with their projects after three or four months. He wondered if they were ill-suited for the program. In response, OSSG managers conducted focus groups to solicit opinions about the Black Belt program, particularly its coaching and mentoring (or lack thereof). The problems raised by focus-group participants indicated the need for new policies, for better communication, and for mentor training. Consequently, OSSG managers enacted additional reforms intended to clarify the Black Belt certification process and fix several additional shortcomings. They flowcharted, redesigned, and published the Black Belt certification process, from candidate nomination through panel defense. This document, intended to clarify expectations among Black Belt candidates, their managers, and their senior executives, included these additional expectations:

4. Black Belt candidates are required to identify five areas of potential improvement themselves.
5. Black Belt candidates should dedicate 30-50 percent of their time to CI work.
6. After they are certified, Black Belts are expected to mentor other candidates.

Many Black Belts said that DTE Energy's front-line employees did not welcome them initially. A Black Belt hired from Johnson Controls reported that some improvement projects were resisted by front-line employees because past work on those problems was abandoned before the problems were fixed: "Gosh, we've been through this before! We've *done* all this. Why are we...? It didn't work the first time." That Black Belt continued, "New people at the company, myself included, come in and ask old questions, [which] frustrates the long-time employees: 'New flavor of the month. You're asking the same questions. I'll answer the same way and we'll be back to doing it the same way I always do, getting the work done however I see fit, when I see fit, as efficiently as I can do it.'" However, another Black Belt reported a gradual improvement in front-line employees' willingness to consider the different views of these Black Belts: "I can honestly say I've felt the difference and it is starting to work. ...I've seen in my own organization where the response to that kind of questioning or new ideas has changed over time. ...Certainly, that's embedded, front-line culture change."

Some of DTE Energy's most successful use of Black Belts has been when they

constituted a whole department dedicated to long-term projects spanning several years. To illustrate, I present an example from each of DTE Energy's main business units, Fos Gen, Customer Service, and MichCon.

Fos Gen's Revenue Sufficiency Guarantee Project

A Black Belt candidate spearheaded a multi-year project in Fos Gen's Generation Optimization group to reduce the Revenue Sufficiency Guarantee (RSG) fines that DTE Energy pays MISO. Each utility must meet the hourly electricity-generation forecasts that it submits to MISO's day-ahead market. Deviations above or below a forecast that are not requested by MISO result in fines, a mechanism necessary to clear the real-time electricity market. "It's like a speeding ticket," explained one of the group's managers. "After we get all done with the market, there's this huge thing called settlements. Trust me, it's like your Visa bill multiplied by a million. It's huge. They're nasty." The Black Belt candidate analyzed DTE Energy's historical data and discovered the most troublesome — and therefore the most expensive — times of day: seven to ten o'clock in the morning and six to ten o'clock in the evening. "She found out," said the manager, "the worst times we get penalized is when the load's picking up in the morning, the rate of change is drastic, and in the afternoon when all of a sudden people start cooking and stuff when they come home." The project team used Six Sigma tools to improve load forecasting, communication, and coordination among Fos Gen's plants to meet the day-ahead targets. DTE Energy's RSG charge for 2006 was $13.2 million. Over the next few years, this project cut the fines to $5.3 million in 2007, to $3.2 million in 2008, and to $2.9 million in 2009.

Customer Service's First-Contact Resolution Project

The Customer Service (CS) business unit had a department called Customer Commitment Management Process (CCMP) dedicated to improving DTE Energy's retail processes. Seven of CCMP's employees were Black Belts and all of the rest were OS Specialists. One of CCMP's biggest projects was first-contact resolution (FCR), attempting

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to resolve a customer's request or complaint during that customer's first contact with CS. DTE Energy's FCR percentage was in the 60s and CCMP was working to bring it up to the 80s. The manager said, "This project is a hundred percent CI: multiple iterations and lots of tool use. I am proud that my group does the actual improvement implementation, not just tracking and facilitation." Another CCMP project involved implementing a system to defer billing customer accounts whose usage is below a certain threshold, rather than automatically bill all accounts every month.

MichCon's Lost Gas Project

MichCon personnel had been trying to reduce lost and unaccounted-for gas for several years. MichCon's losses were about eight billion cubic feet (Bcf) per year, costing DTE Energy about $60 million annually. The main sources of lost gas were theft, transmission losses, leaks, and billing problems. For example, a MichCon manager estimated that between five to ten thousand of MichCon's 1.2 million customers' meters were broken and therefore were not billing correctly. But these sources of lost gas were obscured by variability introduced by MichCon's accounting practices. For example, if MichCon personnel could not read a meter one month, the billing system would estimate the usage based on historical data. When that meter was read next, any discrepancy between the estimated and actual gas usage was resolved. (In some months, MichCon had as many as 16 thousand "net-negative" invoices — those invoices where the corrections were such that customers received a credit.) Similarly, the billing system estimated the portion of customers' monthly usage for which they had not yet been billed. Resolving these estimates for "unbilled volume" is bothersome month-to-month, but those that spanned fiscal years dramatically affected MichCon's year-end performance numbers. If MichCon's billing system over-estimated customers' usage by 0.5 Bcf in December 2008, then MichCon's measured lost gas for the year is 0.5 Bcf too low (the total volume of gas purchased by MichCon for the entire year is a known quantity). When these unbilled-volume estimates are corrected in January 2009, MichCon's 2009 fiscal year begins with 0.5 Bcf of lost gas that had actually occurred in 2008.

After Bob Richard became MichCon's senior vice president in October 2006, he created a department of Black Belts to address the lost gas problem with Six Sigma. Richard hired three externally trained Black Belts to lead efforts in the three major problem areas: theft, meters, and the accounting measurement system. When these lost-gas personnel discovered that the amount of theft was larger than anyone had expected, DTE Energy's senior executives approved expanding the department. These additional employees made good progress reducing theft in 2008 and 2009.

Fixing MichCon's measurement system for lost gas required a leap of faith by the senior executives, because it was an expensive yet necessary prerequisite for making improvements. Catherine Stafford, the Master Black Belt (with a PhD in economics) hired for the job, explained: "There was some resistance to spending time on the measurement system. I was asked, 'Where's the money in that? How does measuring it better reduce lost gas?' In the short term, it doesn't. That can be a hard thing for an executive team to invest in when the problem is costing a hundred and fifty thousand dollars per day. There's an element of trust required when I explain that if I can measure it appropriately, I can understand it, know where the defects are, and really fix it." Stafford said that MichCon's senior executives, after years of periodic interventions, were frustrated with lost-gas unpredictability and obstinacy, so they committed the necessary resources to the problem. Stafford related how it took time to change how the company thought about the problem:

> The first year I was here, I struggled to help some managers understand that measuring the problem is relevant. Our goal is to reduce lost gas but we weren't measuring it appropriately. ...We could have had a two-and-a-half-Bcf loss in January or we could have "found" lost gas in January. The lost gas report felt like a random-number generator. Our measurement system was inaccurately measuring lost gas. However, we would still react to the monthly report because we didn't have anything else to use to monitor it.

> I could sense the frustration from the leaders. They had invested in our team to help them remedy the lost-gas problem and they weren't seeing any results. In spite of the urgency, they continued to support the effort of improving the measurement system. But they also invested in more resources to address theft. This was one area we knew caused a significant portion of the lost gas.

We started working with Business Analytics to improve the unbilled estimate and we developed a second method for calculating lost gas that is slightly more correlated to weather. We still have unexpected volumes but the process helped us understand some of the things that can cause the variation.

B.2. CI Leadership Workshops

The direct involvement of senior executives in CILWs made these events highly visible within their respective business units. This emphasis on CILWs, however, diminished attention paid to other forms of CI during 2008 (except Black Belt candidates' projects for certification). One of the OSSG's union representatives perceived that CI was "happening only in pockets" outside of CILWs. A few other problems with the CILW approach gradually came to light:

1. Senior executives were not the best teachers for CILW training.

The promotion of the CI initiative via the use of CILWs by DTE Energy's senior executives highlighted a chicken-or-egg problem. Steven Spear's fourth rule of the Toyota Production System is: "Any improvement must be made in accordance with the scientific method, *under the guidance of a teacher*, at the lowest possible level in the organization" (Spear & Bowen, 1999, p. 98; emphasis added). According to Spear, these teachers should be a company's executives and managers (Spear, 2004a, 2009). But how can a company's executives and managers inculcate the principles and methods of CI in their subordinates when they are learning the same material themselves? "If the intention [of CILWs] is to teach basic problem solving, you can lay a good foundation in three days," said a Black Belt hired from outside DTE Energy. "However, this requires teachers who are experts in problem solving. Our executives are excellent leaders, but most of them are not experienced continuous improvement experts. Asking them to teach the workshop is a disservice to the executive and the students. It is taking [the principle of] leaders as teachers too literally."

2. CILWs were not intended to include front-line employees.

Senior executives and middle managers were the target population for CILWs, not front-line employees. The CI personnel who facilitated CILWs in the business units,

however, quickly realized that excluding the front line was a mistake. Front-line employees knew the details of work processes better than their managers, so their expertise was crucial to efficiently diagnosing process problems and developing effective solutions. CI personnel in some business units, therefore, included front-line employees in their CILWs as subject-matter experts.

Additionally, by defining CILWs as management only, the OSSG personnel were inadvertently reinforcing a barrier to union involvement in CI activities that they were trying to overcome. One manager believed that Schulist's intention of having CILW-trained managers and supervisors coach front-line employees was likely to fail because of DTE Energy's poor labor relations (in some areas).

3. CILWs were used as vehicles for making improvements.

During a week-long CILW, attendees divide into two teams, each of which works on a problem. Hemrick had explained to the OSSG personnel that CILWs were intended to teach CI concepts and skills, so these problems should be selected for their educational value, not for their potential effect on operations. Significant improvements to a process during a CILW should be viewed as a beneficial side effect only, not as a necessity.

In practice, however, business-unit personnel did not follow Hemrick's guideline. The temptation to exploit the attention of a senior executive and all the relevant middle managers and subject-matter experts assembled for a week was too great to ignore. Many business-unit leaders would convene CILWs for the purpose of making operational improvements. A Black Belt hired from outside DTE Energy objected to this use of workshops: "I don't believe you can develop sustainable solutions to difficult problems just by putting all the relevant people in a room for three to five days. Data analysis and process mapping often require several iterations to determine the root cause. It is, however, quite productive to have all the players in a room for two or three hours during different steps of the problem-solving process; for example, [during] initial process mapping or [for] brainstorming when the problem is well understood with data."

A few CILWs exhibited one exception to this Black Belt's criticism: The CILW created a forum in which front-line employees could tell their executive about their

frustrating workflow barriers — some of which had simple solutions — that their managers had previously ignored. For example, commercial customers routinely wanted to pay multiple accounts' bills on a single credit card. Both call-center representatives and customers were frustrated that the IT system would wipe all credit-card information after each account's bill was entered, requiring tedious retyping. Because an executive was leading this CILW in Customer Service, he had the authority to order the IT department to fix the system almost immediately (Wilhelm, 2009, p. 39). Another instance occurred during a CILW involving the IT help desk. Every employee's computer login would automatically expire after 10 minutes of inactivity, a policy designed to protect everyone's information. The work of the help-desk support personnel, however, was both computer-intensive and punctuated by frequent interruptions. Consequently, each support technician would log in dozens of times every day. Even though they complained, their login timeout wasn't increased to 30 minutes until the problem was raised during the CILW.

When Steve Kurmas (still executive vice president of Fos Gen at the time) ran CILWs for the power plant directors and managers, he deviated from the OSSG's CILW template. Instead of having these managers learn CI skills by implementing 50 countermeasures over five days, he had them pick important projects in their respective areas to work on over the following three months. Fos Gen's CI manager was assigned the task of monitoring the progress of each project to ensure that the managers were using the tools correctly.

4. Countermeasures implemented in CILWs were not managed to ensure their longevity.

CILWs were an improvement over DTE Energy's early *kaizen* events in that participants implemented countermeasures instead of leaving the workshop with long to-do lists (that were usually never completed). Because CILWs were designed to teach, however, nothing in their design ensured that these countermeasures would stick.

To correct this problem, the CI manager for Corporate Services began audits of the CILW countermeasures a few weeks after each workshop to assess which had been sustained, abandoned, or improved. She explained, "We've taken our countermeasure

worksheets...gone back out, looked at all the problems we identified. We decided on a green-yellow-red scheme because it's the easiest thing to look at in terms of visual management. ...It's green if you go out there and you had evidence that it's still there and it's being used. It's yellow if you see evidence of what was done, but it's not being used, or it's not updated, or whatever. It's red if it was gone, disappeared. Or it could be red if we didn't implement [it]." From these post-CILW audits, she learned to insist that her CILW teams implement only those countermeasures aligned with the area's priorities.

More subtly, however, CILW teams attempting to brainstorm, implement, and test 50 countermeasures in a week hindered employees' learning about their processes. They were trying too many changes in too short a time. A Black Belt said rhetorically, "Which of those [countermeasures] had any impact? If you have another problem just like it, you would have to implement all fifty countermeasures because you don't know which one [worked]. That sounds like the firefighting-style problem solving that I was trained to avoid."

5. CILWs created unrealistic expectations.

One manager observed that CILWs created what many employees called "leadership engagement" in the CI initiative very quickly, but this enthusiasm sometimes led to unrealistic expectations. Some middle managers would demand a lot of CI activity from their subordinates without first building their subordinates' ability to make improvements effectively. Other managers would insist on having a Black Belt or other CI expert assigned to projects, even if those projects required minimal use of CI tools, such as flowcharting a process.

6. Some CILWs were isolated events with no lasting influence.

While many veteran DTE Energy employees reported that CILWs were better than CCI's early *kaizen* events in design, some had little or no influence on the business unit for the same reason: As an isolated event, a CILW or *kaizen* does not in itself alter managers' daily routines. A CI manager for one of the business units said, "[T]he folks that we trained initially have gone back, but they haven't shared with their folks, haven't taught their folks, haven't put out an expectation for their folks."

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Despite these problems, many employees perceived that CILWs were beneficial. At the 2008 management retreat, a manager said, "For the first time we are speaking the same, common language and using the same terms." The OSSG personnel were able to convince the 11 division leaders of Local 223 to attend a CILW in the HR department on the union grievance process in July 2009. Around this time, a former consultant working in the OSSG felt that DTE Energy had succeeded with the CI initiative's training plan where other companies had not. She said:

> Being a consultant in [CI], I have seen different companies try this cascade approach where the vice presidents teach the directors, the directors teach the managers, and so forth. This [approach] has worked better here than other places that I've seen it. I don't know why it is. Maybe it's because [DTE Energy] is a smaller organization — there's only nine thousand of us. It was really difficult to make it happen at Chrysler. It was really difficult to make it happen at Ford. We tried it also at Johnson Controls — we had around thirty-five thousand [employees]. You couldn't really make the organization move, whereas I think it's happening here. This has been an exciting place to be for anyone who's been doing Lean since 1991. ...I'm delighted that I got to be here at this time and see this happen because I hadn't seen it anywhere else.

B.3. Swarm Events

The majority of DTE Energy's CI activity in 2009 consisted of swarm events, for two main reasons. First, almost all of DTE Energy's senior executives had received an introduction to CI in a CILW. The logical next step was for these executives and the OSSG personnel to extend such hands-on CI training to middle managers and front-line employees with swarm events. Second, the senior executives expected DTE Energy's ECR plan to be accomplished with CI methods. Swarm events were the obvious choice for coordinating the cost-reduction efforts of middle managers and front-line employees.

DTE Energy's front-line employees did not resist participating in swarm events the way they had resisted CI activities before the PEP initiative. Managers cited several reasons for this change of behavior. First, because of the economic crisis, they understood the need to improve their work processes. This imperative was strong enough to overcome their fear of being scrutinized. Before, front-line employees would typically ask, "Why do you want to know my business?" Second, with the ECR plan's employment

guarantee, they were not afraid of improving themselves out of a job. Third, they saw managers begin to support, or even personally lead, these swarm events to a greater degree. Fourth, they saw swarm-event results that benefitted them directly.

The OSSG personnel were happy to emphasize swarm events. Unlike CILWs, they had designed swarm events specifically to engage front-line employees in CI activity. By 2009, they had subscribed to Jeffrey Liker's opinion that a CI culture should be built by using new procedures to change beliefs rather than the reverse: "It's not as simple as this, but the bottom line is that we're more likely to change what people think by changing what they do, rather than changing what people do by changing what they think. If we want people to understand and buy into the assumptions of lean manufacturing, let them experience it firsthand. Direct experience, with on-the-scene immediate coaching and feedback, will change behavior over time. On the other hand, trying to change what people believe through persuasive speeches, interactive video learning courses, or classroom training will not cut it. They might begin to say the right things, but it will not deeply impact beliefs or behavior" (Liker & Meier, 2006, p. 455).

Swarm events were a better way of training a large number of employees on basic CI concepts and tools, including the Four Capabilities and OPCA, than the OS Specialist course. Swarm events were held on-site, not in a classroom at headquarters or at an off-site retreat, which was more convenient for the front-line employees and less disruptive to operations. Consequently, front-line employees were able to immediately apply the CI concepts and tools to real problems and, hopefully, achieve improvements. The OSSG personnel and business-unit managers continued to replace the automotive examples in the training materials with DTE Energy examples, making the concepts easier to grasp. To a limited extent, some managers also tailored the content of their swarm events to their local contexts, making the material more relevant to their front-line employees. A director in Fos Gen said, "We can do a C1-C4 overview teach in less than two hours. We don't want to lose the opportunity to show them the tools, show them the [Four] Capabilities, and having them start understanding the language and stuff, because then they can problem solve better."

More importantly, swarm events provided a forum for front-line employees to

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collaborate with each other and with their managers on fixing process problems — exactly the desired behaviors for a CI culture. Swarm events at the power plants provide good illustrations. All of Fos Gen's managers attended a CILW in 2008, so they were equipped to facilitate swarm events in 2009 (albeit at different levels of proficiency). Fos Gen's senior executives, per Earley's directive, expected all of their subordinate managers to be always working to improve one or two areas. At Monroe power plant, director Frank Wszelaki assembled his managers in late 2008 to brainstorm areas for swarm-event improvements in 2009. "We're trying to get to where the guys in the field are naturally doing it or they're bringing the ideas back to us," said Wszelaki. "Then we go work on stuff that we think is practically meaningful..." regardless of who suggested the improvement idea. Fos Gen's plant managers taught their front-line employees either in these formal swarm events or during CI projects. "We haven't scheduled everybody to go," Wszelaki explained. "The plan is to catch the people as we can. There's really no training record on it as to how many we've done. The objective is to have everybody exposed to the process over a period of time."

Swarm events were particularly useful for redesigning processes with hand-offs from one functional group to the next. One director remarked, "The tougher ones were when you had to have multiple work groups that didn't naturally interface come together in a room. Those are really tough ones to do. They say, 'I hand it off to this organization and then it gets handed off to this [group].' You get those organizations in a room and they sometimes didn't like each other. Sometimes they didn't even know what each other did to know *why* they didn't like each other! So it was like: 'Okay, let's sit down and figure it out. How busy are you? Where's the hand-off going to take place? How do we communicate that hand-off?' Just talk about it. It's been tough. It's been a road. It's communication."

Despite swarm events being an improvement over the CI initiative's past *kaizen* events, they still exhibited problems in content, in execution, and in use. Schulist admitted that, over the years, DTE Energy's CI initiative has suffered many of the pitfalls that Liker and Meier describe in Chapter 19 of *The Toyota Way Fieldbook* (2006). DTE Energy's problems with swarm events match Liker and Meier's generalized observation:

"The *kaizen* workshop approach has gotten a bad name in many quarters. Jim Womack used to laughingly refer to it as 'kamikaze *kaizen*,' or 'drive-by *kaizen*.' The implication was that you swoop down fast and furiously, solve some problems, and swoop back up, or drive by, take aim and fire, and you're done. The problem is not that *kaizen* workshops are inherently bad, but that many companies turned their entire lean process into a series of *kaizen* workshops along with a *kaizen* promotion office to administer, support, and monitor *kaizen* events. They may even count *kaizen* events as a key performance metric" (Liker & Meier, 2006, p. 396; italics added). I elaborate on DTE Energy's problems with swarm events below.

1. Tracking counts of completed swarm events engendered a check-the-box mentality that undermined their purpose.

Senior executives required each of their departments to conduct a certain number of swarm events in 2009. Executives could count swarms easily because they were discrete events. A CI manager explained that the danger in DTE Energy's practice of tracking the CI initiative with counts — of swarms, of countermeasures implemented, of people trained — is "then it becomes all about just ticking off the box." One middle manager said that this compliance mindset can detract attention from achieving results: "It's good we're teaching people, but I think there's a bit less accountability than should be there.... I have checked that box and now I can move on — politically, I'm a good guy, right?"

Several managers reported struggling to keep their subordinates' attention on CI's purpose — fixing problems and redesigning processes — rather than on complying with short-term executive mandates. One of MichCon's Black Belts suggested that the executives could have tracked the 6-month retention rate for swarm countermeasures instead, but he acknowledged that such measurement would be much harder.

A Black Belt in DO perceived "the culture of the organization slipping back" to the pre-PEP practice of not quantifying CI savings. A former CI manager agreed: "If you do too much of just the fuzzy, feel-good stuff, you've got too many gamers out there who can get around it and make it look like they're doing things — and Gerry [Anderson] doesn't catch them until two years later when he looks backwards at the budgets and finds out

that we really didn't save anything." This worry was not lost on the OSSG either. An OSSG manager said:

> The pendulum swings. [During PEP], we were trying to put dollars and cents to absolutely everything so that we could prove to Gerry Anderson that we saved money.
>
> Now the pendulum has swung to the other side. These swarms — they don't even talk about money. ...[S]ome of the vice presidents, when they're teaching this, have said, "We don't have to have dollars-and-cents savings on this. We're just looking at how many ideas you come up with. We want you to implement ideas."
>
> ...Somewhere in between the two extremes Gerry Anderson may reverse direction and move toward asking us to prove that money has been saved.

2. Middle managers and Black Belts exploited the enthusiasm for swarm events by using them as political tools.

With DTE Energy's senior executives hyping swarm events in 2009, some middle managers used them as a convenient excuse. If an executive was upset about a particular problem, in a few cases the responsible middle manager would announce his or her intention to hold a swarm event to address it. These executives accepted their subordinate managers' plans without much scrutiny because, by then, conducting swarm events was considered a legitimate response.

Black Belts also sometimes misused swarm events. One of the CI managers reported that a few Black Belts, working on 4G9S projects, were unable to secure resources or managerial support for the interventions that they wanted to make, so they convened swarm events to get the managerial attention they needed. OSSG personnel objected to this practice, because they believed swarm-event participants should work to solve problems, not merely implement a "solution" handed to them.

3. The content of swarm events varied widely, outside of the OSSG's control.

In early 2009, OSSG co-directors Schulist and Hemrick were concerned about the variation in how business-unit personnel were conducting their swarm events (and CILWs, to a lesser extent). Most departments followed the OSSG's plan for promoting a CI

culture: Managers attended CILWs to learn the skills and knowledge that they passed along to their subordinates in swarm events. But a few middle managers bypassed CILWs, "skipping ahead" to swarm events. These managers, and a few others, delegated their swarm events to their Black Belts or — even worse, in Schulist and Hemrick's view — to non-Black Belt personnel. Some facilitators trimmed the teaching portion of their swarm events, cutting topics or exercises from the OSSG's teaching materials that they judged unnecessary. CI managers reported business-unit personnel creating 6-hour, 4-hour, and even 2-hour versions of the training presentation. (An OSSG manager joked that these could be called 'mini-swarm,' 'micro-swarm,' and 'nano-swarm'.) Schulist and Hemrick thought that it was important for swarm-event training to be delivered consistently across the company. By mid-2009, therefore, they restricted access to the training materials on the OSSG's internal website and they implored the CI managers to help them manage revisions centrally. But ultimately they had no mechanism to monitor and control swarm events closely.

4. The mismatch between the OSSG's intention and business units' use of swarm events created detrimental tension and frustration.

The OSSG personnel had initially designed swarm events to train employees in solving problems rigorously on the front line with the scientific method. Their guiding principle for swarm events was Spear and Bowen's fourth 'DNA rule' of the Toyota Production System: "Any improvement must be made in accordance with the scientific method, under the guidance of a teacher, at the lowest possible level in the organization" (Spear & Bowen, 1999, p. 98). To aid employees with this process, the OSSG personnel developed a step-by-step countermeasure worksheet (see Glossary).

CI personnel in the various business units, however, began to shape the content according to their own perceptions of how their managers or the OSSG wanted them to facilitate their swarm events. These perceptions often diverged from the OSSG's original intent, creating confusion and erroneous beliefs among front-line employees about the purpose of swarm events. For example, swarm events, like CILWs, appealed to middle and upper managers as vehicles for organizing improvement effort because they

effectively focused everyone's attention on the problems at hand. When middle managers received targets for cost reductions and for a number of swarm events to be held, it is not surprising that they tried to combine the two — reduce costs via swarm-event interventions — even though the senior executives did not (necessarily) intend that connection. (DTE Energy's senior executives wanted employees' to make lasting cost reductions with their new CI skills, but I do not believe they cared whether these reductions were made within swarm events or not.)

Another pervasive misperception was that swarm participants should categorize and attempt to implement countermeasures for as many (possible) causes of their problem as they could. Some swarm event facilitators overemphasized teaching the OPCA framework (see Glossary). Many employees, however, had difficulty categorizing process elements according to OPCA. One of the OSSG's trainers had observed that participants in the OS Specialist course often struggled with OPCA categorizations, yet they did not have difficulty making process improvements in swarm events. Similarly, an OSSG manager acknowledged that OPCA corresponds to the elements of a proper swimlane flowchart for process design, but she thought that teaching Toyota's Seven Wastes (Ohno, 1988, pp. 19-20) was a less confusing and more effective way of mobilizing front-line employees to improve processes (see *Seven Wastes* in the Glossary). A MichCon manager agreed: "[OPCA] is rigorous process mapping…[but] we spend a lot of time debating whether [something] is an output or an activity. Who cares? We don't tell them what to do with this information." Other swarm event facilitators mistakenly thought that something must be done with every brainstormed potential cause. This misperception was reinforced by some managers calling CILWs "fifty-in-five" events. A Black Belt, who attended several swarm events as a participant, described how the facilitator's training script conflicted with the aim of making substantial process improvements:

> I don't support the concept of a swarm as I have seen it used at DTE. Come up with as many possible ideas as you can think of; label them as an O, P, C, or an A; tell me what your countermeasure is; and tell me when you're going to implement it.

> …I had to go to these meetings. The last one I went to [had] eighty action items. I informed the group that I was not going through eighty causes and

guessing a solution to each of them. I will go through the three or four that we think have the biggest impact. If we need help figuring out which items, let's look at the data and figure out what is causing the problem. ...Why would we implement "improvements" when we have no idea whether they would fix the problem? Why would we change things that may not be causing a problem? ...It's insanity. ...In their defense, they are doing what they were trained to do.

5. Swarm-event facilitators found it difficult to make employees properly follow the problem-solving process.

CI managers gave three reasons why employees resisted following the scientific method in swarm events to solve problems. Many engineers at Fos Gen's power plants regarded the CI training as "a waste of time" because they were confident they already knew how to solve problems systematically. Some front-line employees who were coerced into attending swarm events were skeptical of CI's value. Hemrick said that the CI personnel at Dana ensured that their swarm events always included a few swarm alumni (sometimes from other business units), because a facilitator would have a hard time overcoming the collective skepticism of a group comprised entirely of novices. (Despite this insight, however, DTE Energy did not adopt this practice.) Also, swarm-event participants felt uncomfortable following a formal process. "When I led workshops," said Emmett Romine, DO's former CI manager, "the classical failure with the scientific method is they would see an issue and they would jump to the conclusion and skip over the steps." Getting participants to not skip steps "was like pulling teeth," and getting them to make a quantitative prediction about the effect of implementing a countermeasure was even more difficult.

6. Swarm events were not connected to each other or to a larger strategy for improving core processes.

An infrastructure is needed for both swarm events and for Black Belt projects: to collect improvement ideas, to vet and prioritize them, and to assess their connection to the company's core processes. Within DTE Energy's business units, however, managers often held swarm events haphazardly and sometimes for firefighting (reacting to unanticipated problems that demand quick resolution). A Black Belt explained, "[A

swarm] is just a little thing that happens. What happens after and before it? Nothing. There's no build-up to a swarm, except some excitement about something that happens and someone says, 'Swarm it!' So they do. And they're done. It happened. On to the next swarm! Where does it tie in? ...[O]n Friday, you presented to the executives, then you forgot about it. No one really knows if it worked." He continued, "There's no planning for the swarm, so there's very little focus on good process identification. For a swarm, you should have your process mapped out first, so people can come in and fix it, or adjust it, or whatnot. We don't have that except in rare cases. There's no...circling back to where did that last swarm leave off and how did that affect the plan? Swarms aren't connected to anything."

Other aspects of a swarm-event infrastructure missing from DTE Energy were mechanisms to ensure that each swarm event met its objectives and that countermeasures implemented were retained. From his experience at Dana, OSSG director Hemrick said that sometimes front-line employees need to make more problem-solving iterations than is possible over the few consecutive days of a single swarm event. Depending on the time required to assess the effects of their countermeasures, front-line employees may need to attack a problem over weeks or months with a series of swarm events. After efficacious countermeasures are implemented, managers and front-line employees need to standardize the new process design. "There's nothing to sustain those fixes," said a Black Belt. "If you go out and put in fifty ideas, we have to make sure those fifty ideas stick." Otherwise, he said, "[swarms] end up just being flavor of the month, quick hits and that's it."

7. Swarm events were not connected to the Black Belt program.

According to Toyota's ideal, employees working on the assembly line solve problems either as they occur — when someone pulls the *andon* cord — or in weekly QC circles in their areas. Toyota managers expect such regular problem solving to yield incremental improvements that add up over time. (A manager at TMMK put it this way to David Meier (Liker & Meier, 2006, p. 462): "Dave-san, our job is, every day, little up. Then, over time, we up!") But Toyota does not expect its front-line employees to redesign

core processes that span functional boundaries. All companies, Toyota included, need specialists to (re)design processes that had only evolved over time. (This need for radical process redesign enabled the Business Process Reengineering (Hammer & Champy, 1993) management fad to differentiate itself from the incrementally oriented TQM fad.)

Many automotive companies that adopted both Lean and Six Sigma used their Black Belts to redesign the processes that front-line *kaizen* teams selected for fixing. DTE Energy's CI initiative did not include a mechanism for making such a connection. A MichCon Black Belt perceived that DTE Energy's enthusiastic concentration on swarm events in 2009 diminished attention on equally important elements of the CI initiative: ensuring that "things coming out of [swarms]...cross over into Black Belt projects" and get fixed using the 4G9S process, which he viewed as "the core of this improvement [initiative]."

8. DTE Energy's processes were not yet designed well enough for employees to use swarm events as the OSSG intended.

DTE Energy's front-line employees could not routinely enact triggered problem solving because their work processes did not include embedded tests in their designs. A MichCon Black Belt said, "We're putting emphasis on the process because our processes don't exist. We spend a lot of time building the process and arguing about the process." Instead of improving operational measures "to the next level" as in manufacturing, he said, "Here it is much more ground level: 'What's your process? You say it's this — let's write it down.' Much more mapping and study of it."

Processes must also be stable and reliable enough, otherwise the problems that arise are too frequent and too large to be addressed by the front line. A Black Belt said, "Our processes aren't good enough to implement a reaction plan to the occasional defect, because we're producing defects all the time. We have to get our processes in better shape [before] we could implement that type of problem solving. We're just not ready for it." OSSG Lean expert Michele Hieber said, "[Toyota has] a nice escalation process. We have none of that. That's why for most companies, when you go down, Toyota will 'open the kimono' and...tell you everything. They know...you can't do it because you don't

have this structure, you don't have an escalation process, you don't know how to solve problems. 'Sure, we'll tell you everything. It won't do you any good, but we'll tell you what it could be if you ever got there.' That's where we're at right now. I know the directors and the managers know this is a problem, that we don't have the embedded tests, the way to pull the *andon* cord, and get it escalated up. We don't have that thought process. Changing the whole culture to that [thought process] is going to be a longer journey for us."

DTE Energy's CI managers, aware of some of these problems, tried to impose additional guidelines on the swarm events in their business units. In general, their guidelines reflected the OSSG's stance that swarm events — at least at this stage of DTE Energy's CI initiative — were intended primarily to train front-line employees rather than to organize serious process-improvement work. One manager insisted on these guidelines:

1. Have pre-swarm-event meetings to ensure good problem statements.
2. Ensure swarm-event participants are working from good swimlane process maps.
3. Because swarm events are for training, pick processes that are "visible" (some departments have many processes that are "invisible").
4. Teach OPCA with DTE Energy examples, not automotive examples.
5. Continually emphasize the need to implement, not just identify, 50 countermeasures during the swarm event.
6. Pick measures that can show improvement within the swarm event's 5-day duration.

Despite the many problems enumerated above, some departments' swarm events were very successful. For example, a swarm event in Fos Gen's Generation Optimization group yielded multiple benefits: reduction in cycle time for MISO market submissions from 3.5 to 2.5 hours, reduction in staff from 18 to 15 people, increase in time available to double-check submissions to avoid mistakes or accommodate unexpected surprises (like computer-system failures), and an increase in employees' enthusiasm for using CI to improve their work processes. A manager in the group recounted the story:

> There are some processes that are pretty rock-solid, like our day-ahead submittal process. But we reviewed it. We had people who were skeptical.

They were mad at us: "Why are you looking at my process? It's perfect!" We found it was taking them between three and a half and four hours to get the offers in. We start right at seven-thirty in the morning. Eleven is the target. You have to have your offers in to MISO before eleven o'clock [otherwise] whatever is in there from yesterday gets defaulted. Our target is to get them done by ten-thirty and then do any last-minute tune-ups.

We get them done by ten o'clock now. Instead of having a half hour of panic if something happens, you've got an hour. Believe it or not, [because of] that extra thirty minutes, everybody's more relaxed. [Before], it was a nightmare: "Woah! I've got to get stuff in!" You don't have that [now]. It has added some serenity to the group. I mean, they're not all [Zen] Buddhists now, but you've built in some extra room there. Sometimes the computer goes down. I can tell you, it happens ten minutes to eleven. You get caught. But you can at least get a little more flexibility. Plus, you can take a little more time, to look at it and see if something doesn't look right.

...Now with the new market that they've added, you've got another complexity. Guess what? Before we were participating in two markets. Now we're participating in four markets, all in the same time. We're doing more work but in that same timeframe. It was a real plus. Even they are seeing it now. They're saying, "God, can we swarm this again? Maybe there are other things we can pick up." ...Instead of having eighteen people for the real-time staff, we condensed it to fifteen. More efficiencies there. That wasn't popular but we did it with normal attrition and some selective redeployments.

B.4. Front-Line Employee Engagement

Before DTE Energy's senior executives formulated the ECR plan for 2009, front-line employees' participation in CI activities was limited. An OSSG manager said, "It was like buckshot. It was out there. There were little pockets of where stuff was happening, but it wasn't really coordinated. It wasn't really aligned to business needs." DTE Energy's only certified Black Belt member of Local 223 said that front-line employees' world consists of their co-workers and their supervisors: "Until you can change that world, [CI] really doesn't mean anything to them." He said that front-line behavior depends on local relationships and cues. Putting a CI culture in place requires that supervisors and co-workers reinforce those behaviors after the CI experts have left; otherwise, a CI project, workshop, or swarm event is just an isolated event.

Many CI managers reported difficulty engaging middle managers and front-line

employees in CI activities between the start of the PEP initiative in 2005 and the economic crisis in 2008 because of production pressures. This phenomenon is called the *self-improvement dilemma* by Keating and Oliva (2000a, pp. 263-264) and the *capability trap* by Repenning and Sterman (2002, pp. 282-283): Front-line employees work hard to overcome workflow impediments but they feel they cannot "waste" time removing those impediments with CI because of their managers' throughput targets. In the cases when problem solving was unavoidable, several managers admitted that everyone tried to resolve problems as quickly as possible, even if the root causes were not fixed.

DTE Energy's leaders did not include a gainsharing program as part of their CI initiative, perhaps because the unions' contracts did not accommodate year-end bonuses or other financial incentives. (Initially, MichCon's union employees participated in a gainsharing program, but they traded it in contract renegotiations to keep their level of benefits.) One of the OSSG's union-member CI experts asked rhetorically at a staff meeting, "Why should the workers and union leadership participate in CI? What's in it for them?" Schulist discussed this question with Local 223 president Jim Harrison in mid-2008. They agreed that union members with CI skills are (potentially) more valuable employees, thereby justifying employment security and, perhaps, comparatively higher wages in the long run. Safer working conditions, fewer frustrations, and better coordinated work processes were also incentives for union members. But DTE Energy's senior executives did not broadly publicize these benefits of CI.

Middle managers in DTE Energy's business units were better at articulating the CI initiative's win-win proposition for front-line employees. For example, improving periodic-outage durations at Fos Gen's power plants was unambiguously in everyone's interest. Line restoration following weather storms was the same way for DO employees. Emmett Romine, DO's former CI manager said, "'Pride in DO.' ...We ended up using that in the strategy as well: being proud in your work. When was the last time we said we were proud of our work? That one fits really well in the union environment...." One of his Black Belts added, "To most people, [electricity] is a commodity. It's not something that you even think twice about, except when it's not there. ...[Customers] want price competitiveness and high availability. How do you get proud about that? ...The only time

that you have the opportunity to be proud is when the lights aren't on and then you put them back on. Storms were the opportunity to shine." One of Fos Gen's middle managers said, "I've never run into people yet where somebody comes in in the morning and says, 'You know, when I go to work today, I'm going to do a real crappy job. I'm just not going to put out today.' I don't see that. I think everybody's on the same page: Everybody understands the economic situation we're in, they understand our customers. There's a few people who are resistant to change, but they still want to do a good job."

Managers and CI personnel working in every business unit agreed that front-line employees need to see CI methods work firsthand before they "buy in" to the initiative. Naysayers and skeptics tended to be those employees who did not perceive any incentives for CI and were fixated on the countervailing pressures instead. One of MichCon's Black Belts explained how she won people over by appealing to their self-interest:

> As you're trying to manage this change, you pick projects where you can be successful from the business team's perspective. Impact the work day of the working-level employee. For example, suppose that your employees often complained about how long it took to complete their time card. If your Black Belt improved that process, [if] the employees found the process better, it would impact every employee every month. In addition, all of those employees now have a positive experience with problem solving and will offer more ideas and support for future projects.

> We took the ground-up approach while we were still trying to go from the top down. I need people to understand how it works, to not be afraid of this program, and get value out of it. Once you do projects that help people do their job better or easier, you don't have to work so hard at convincing people to work with you. "Can you please try this new program that you didn't ask to participate in?" People don't have a lot of time for that. They need you to help them be more productive. If you can do that, they'll invite you back all day long. Go for the pain. Find the pain and see what you can do about it, even if it's something tiny.

> ...That's the strategy that's worked well for me. ...Small, successful, sustainable projects that take the pain away from people doing the work. That's how you move forward. That's how you change people's understanding of their role in continuous improvement.

CI events like learning lines and swarm events generally helped convince skeptical employees. Former CI manager Emmett Romine said that DTE Energy's employees "need

to start experiencing what a well-run process feels like." Another manager said, "Skepticism dwindles for people who have been on a [CI] team." Marcia Jackson, who had success leading the learning line at Coolidge, said, "Now my whole attitude around anything for continuous improvement is: 'Okay, when I show up, they're not going to like it, but I'll win them over in the end!' If you show them the right way, if you care about them — and I do, I care about the work — that shows up with you, no matter what." Others echoed this need for CI personnel to care about the work that front-line employees do. A Fos Gen manager said:

> Once you do a swarm event and they see, "Oh, it does make my job easier!" Or better: When you say, "Gee, you used to do fifteen steps to get to the same outcome. We've gone through and analyzed it, we can get it in four. And not only that, you can get more of your work done quicker. Same output, same [effort], same accuracy, but I made your job better." That's when they buy in. They [say], "Wow, this stuff works!" ...You connect on that base level. I made that guy's job easier, not harder. I haven't eliminated his job [and] he's working smarter. People appreciate that, they absolutely do. If I put a little embedded test in...and it helps them troubleshoot, find an error themselves, [then] people take ownership from that. They like that. That's a good thing. ...When people do get it, it's like that little light bulb comes on on top of their head. You actually sometimes see it. The people who say, "Leave me alone!"? Very few. I don't run into them and I'm all over the organization.

CI experts made progress appealing to front-line employees' self-interest, but several managers said that their subordinates also understood the company's financial plight in 2009. DTE Energy's front-line employees were more willing to engage in cost cutting and process improvement if they perceived managers working just as hard, helping them to do so. An OSSG manager said that the CI initiative needed to be orchestrated properly:

> It's all in how it's presented to them and orchestrated. If I'm going to make one of their jobs easier, they're all for it. If I'm going to take this nagging defect that they have been putting up with for years — that they've been squawking about to their supervisor and nobody fixed it — and I fix it, they're going to be on-board.

> If I take a bunch of information from them, to tell them I'm here to help — "Give me all your problems" — and I do nothing, they're going to not trust me or my methodology.

People have common sense. People support improvements and improvement initiatives. And they even support better, faster, cheaper. They appreciate the fact that we're trying to save a hundred and fifty million dollars company-wide and make it labor neutral. They see some of our peer companies laying off five, six hundred people to affect the cost structure that way, so they get it. They're on-board. It's all in how it's managed. If it's managed effectively, it's going to be successful. If it's not, it's going to fail.

Proper orchestration of the CI initiative meant the way in which middle managers engaged their front-line subordinates. One effective way was managers soliciting employees' ideas in CILWs and swarm events. Detroit Edison president Steve Kurmas said, "What I hear most often is that everybody knows what needs to be done to improve their process, and has suggested it in the past to management or through suggestion programs, only to see their idea get lost in the bureaucracy. We gave them the opportunity to suggest something, then to try it, test it, implement it almost in real time, assuring that the changes were in fact moving us in the right direction. There was a whole fountain of opportunities as they realized that their suggestions might get implemented right away and make us...more successful as a company..." (Wilhelm, 2009, p. 36). A middle manager in Fos Gen confirmed the effectiveness of this approach: "That's where you really get the buy-in, where somebody says, 'Hey, they listened to me! Somebody took my idea — and maybe didn't do exactly what I said — but at least listened to me and made it better.'" As we have already seen, however, some managers — like Baum at MichCon's Michigan Avenue service center — were reluctant to "open the floodgates" before they were prepared to handle a deluge of problems and ideas.

DTE Energy had a poor track record trying to implement employee-suggestion computer systems. (DTE Energy called these "corrective action" systems; see *CAR* in the Glossary.) The IT department and Fermi 2 nuclear power plant each had their own specialized systems, but the rest of the company had experimented with several off-the-shelf and home-grown databases for many years. Employees thought even the latest attempt, built in 2008 as part of DTE Energy's new SAP system, was overly cumbersome and bureaucratic. Consequently, employees avoided using it. At the power plants, for example, employees brainstormed ideas or raised problems and kept track of them on

butcher paper hung on walls.

Front-line employees, especially union members, also avoided formally submitting improvement suggestions for other reasons. From past experiences during the PEP initiative, they believed that managers would ignore their suggestions, perhaps because cost savings were not apparent, or would use their suggestions against them by trying to reduce staffing levels after improvements were made. A few front-line employees admitted that they would not make suggestions that did not benefit them directly. But one manager said that very few union members used the terms of their contract as an excuse not to participate in CI activities.

Managers and CI personnel in every business unit also agreed that the involvement of middle managers, especially the directors, was crucial for engaging front-line employees. They said that middle managers can provide the rationale for using CI tools and can foster the right kind of collaboration for problem solving. The section called "Stuck in the Middle" from *The Toyota Way Fieldbook* was even distributed to everyone at one OSSG staff meeting: "Their jobs are to turn the great ideas of the people at the top into concrete action and results. ...They must deliver daily production, be accountable for quality and service, and deal with all the 'experts' management sends along to 'help' them do their jobs better. ...[M]iddle managers have the power to either get things done or stonewall" (Liker & Meier, 2006, p. 433). Monroe power plant director Frank Wszelaki described the finesse that he sometimes needed to bring people along: "Probably one of the biggest challenges we had in this company is [the front-line employees] get especially annoyed that CI comes in and says, 'You're not going to do this in thirty days; you're going to do it in twenty.' You get the people saying, 'I can't believe...' It's how you show them and work with them in the process."

Finally, managers and CI personnel must pay attention to front-line employees' trust. I conclude this section with two examples of CI projects with different outcomes. Neither of these projects was designed to appeal to front-line employees' self-interest, but they were both successful at winning them over with skillful engagement and good results. The difference in ultimate outcome was attributable to how the CI personnel handled employees' trust.

Trombly Cable Plant

In the past, Trombly cable plant had a reputation as a demoralizing place to work. Employees viewed being assigned to Trombly as a punishment. Gradually, CI work at Trombly turned it around — and employee attitudes about it. Upper management approved repainting the floor, which made a big difference to the atmosphere. Working with CI experts, the Trombly employees cleaned up the yard of cable reels, reduced inventory (especially the short cable pieces left over when the reels were depleted), increased the cycle time for returning empty reels to their vendors (thereby earning larger rebates), and experimented with various reel-layout schemes for better efficiency. They also redesigned work processes and installed whiteboards to visually track order statuses, work performance, and OSHA events. A Trombly supervisor said that they had no arguments with the union over revising work procedures. Persistent effort over several months increased productivity 100 percent.

These improvements permitted DTE Energy's managers to reduce the cable-plant personnel from 16 to 9 people. Unfortunately, they handled this reduction badly. The union workers, proud of what they had accomplished, presented their improvement results to upper management. Only after the presentation were they told that seven employees would be involuntarily redeployed elsewhere in the company. Feeling betrayed, the front-line employees stopped their improvement efforts. Employees at other locations also began resisting CI efforts when they heard what happened at Trombly.

Warren Service Center

Black Belts Shujaa Smith and Jennifer Johnson led a CI project at DO's Warren Service Center warehouse. At first, the front-line warehouse employees complained that they had "been through these flavor-of-the-month improvement efforts before." Smith told them, "Don't tell me it's Groundhog Day[8]. I know you think nothing changes, that today is the same as every other day. Let's put that aside. I promise you that something will be different. Tell me when you see something that indicates it's not Groundhog Day." Smith

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[8] Smith is referring to the 1993 Bill Murray film; see Glossary.

and Johnson worked with the front-line employees to create a shared understanding of the 32 core processes of the warehouse: inbound processes like receiving and replenishing; inventory processes like cycle counting; and order-fulfillment processes like wave planning, releasing, picking, loading, and shipping. Smith said, "The people there couldn't believe that we cared enough to understand what's going on in these three areas." They laminated posters of the final process diagram for the warehouse personnel.

Smith and Johnson had no problem gaining union support and involvement in the CI project. Smith said they won over the warehouse employees with interest and respect for their work and expertise. He emphasized the following division of responsibility: CI people bring the methods and the front-line employees bring their subject-matter expertise. Smith told them, "Leadership is not based on [shoulder] stripes; it's based on topic. Whatever the outcome, we want to get your voice in the process." They also ensured that the front-line employees were given enough time away from their regular job duties to participate in the CI project.

Smith chose to concentrate on the order-fulfillment cycle time. The cycle time for non-expedited orders was about two days because of batch processing: Orders received after shipping time were held to the next day with no preparation or picking done ahead of time. Smith said, "Nothing was broken; the process was just set up to work this way." They set an improvement target of 8-12 hours. After flowcharting the process, they engaged the warehouse employees in redesigning the 11 process steps, cutting the number of hand-off pathways from nine to three, and revising policies. Before, the pickers were assigned to specific sections of the warehouse. Smith introduced cross-training and a rotation system to make the pickers more flexible. These changes, implemented over a period of only 9 weeks, boosted productivity 40-45 percent. To achieve the cycle-time target, however, they needed to eliminate in-process waiting time, so they examined how to make the shipping schedules more just-in-time. They also installed a 6-foot-by-5-foot whiteboard to visually display the status of all trucks and work teams.

Smith and Johnson earned the warehouse employees' trust by tapping their knowledge, by soliciting their opinions, and by striving to be transparent in everything they did. They were careful to communicate the same information to all three shifts.

Johnson reported that the warehouse employees began giving them improvement ideas voluntarily. They collected a large number and entered them into a database for future swarm events. The change in employee perspectives at Warren was such that a few managers created a short film for DTE Energy's board of directors about this project.

Appendix C: DTE Energy Operating System

The initial development of the DTE Energy Operating System was started in November 2001 and took about 4 months. OSSG personnel have released two major revisions (and several minor revisions) since 2002.

The first version of 2002 emphasized the "DTE Operating Principles" and enumerated all of the CI initiative's tools and practices on a PDCA-cycle diagram (see Figure 92, p.367).

The first major revision, in 2005, reflected the addition of Six Sigma tools to the CI initiative, represented by the "Operating System Toolbox" (see Figure 93, p.369).

The second major revision, in 2009, incorporated Steve Spear's Four Capabilities, or C1-C4, and trimmed the Operating Principles to reduce the amount of text (see Figure 94, p.371).

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DTE Energy

Operating System Framework

DE 963-5254 09-03

Vision: *We, the employees of DTE Energy, excel as partners founded on trust, respect, & shared responsibilities in pursuit of business excellence & success.*

Vision → Principles → Actions → Results

Putting our principles into action will yield our anticipated results

DTE Operating Principles

Operate consistently with DTE Energy Way, Pathways to Partnership, and the People Strategy

- Ensure safety of our employees, customers and general public
- Measure success by how well we meet and exceed customer expectations
- Communicate honestly and effectively
- Hold each other accountable and reward success
- Drive decision making to the point of activity
- Gain high agreement on what and how by standardizing all activities and processes
- Create a learning environment where all employees are engaged in organized reflection and knowledge transfer
- Optimize enterprise wide focus through internal collaboration and partnership
- Understand current reality through fact based measures, articulate the ideal state, & understand the gap
- Surface problems quickly, engage everyone
- Identify and eliminate waste
- Improve processes by focusing on activities, connections and flows

Anticipated Results

People:
- Employee engagement
- Improved employee skills
- Safe work environment
- Diversity
- Pathway to Partnership Implementation

Financial:
- Cash Flow
- B/U Earnings growth
- Shareholder value creation

Customer & Stakeholders
- Customer satisfaction
- Reliability
- Environmental improvement
- Corporate citizenship
- Institutional success of unions

Competitive Position
- Improved throughput
- Industry efficiency leadership
- Superior benchmarking performance

Operate Consistently
Develop a standardized work environment with high-performing, robust processes
- Standard work instructions
- Error-proofing
- Process management
- Problem-solving (people, technology & processes)
- Workplace organization
- Visual management
- Predictive / Preventative Maintenance

Measure, Learn & Analyze
Continually assess the current state to identify opportunities for improvement
- Quality assessment
- Waste elimination
- Control point audits
- Benchmarking
- Balanced measures

Develop People
Build the right skill sets so that every employee can contribute
- Inclusive decision-making
- Leader development
- Reward systems
- Employee development and training

Plan & Engage
Develop clear goals, objectives and methods & ensure everyone is engaged, empowered and committed to change
- Integrated Planning Process
- Project / program management
- Change Management and Case for Change
- Gallup Survey / Feedback
- Clear Governance and decision-making structure

Continuously Improve
Maintain systems that engage all employees in identifying and implementing opportunities to promote safety, quality & consistency in our work
- Corrective action procedures & problem-solving mechanisms
- Operational Reviews (e.g. daily huddles)
- After Action Reviews
- Process improvement workshops

The PDCA Cycle

Revised 3/15/2002

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DTE Energy

Operating System Framework

Vision → Principles → Actions → Results

Vision: Working in partnership with all of our employees and the unions to establish DTE Energy as the premier regional integrated energy company by providing sustained earnings growth.

What We Get

Corporate Goals

People Effectiveness:
- Safe Work Environment
- Gallup - Employee Engagement
- Pathway to Partnership Implementation
- Diversity Commitment

Process Excellence:
- Operating System Savings
- DTE2 Implementation Readiness
- Sarbanes-Oxley Compliance

Customer & Stakeholder Focus:
- Customer Satisfaction Index – Electric & Gas
- Institutional Success of the Unions

Financial Stability:
- Net Income from Non-Regulated Business
- Cash Margin Loss from Choice
- Headcount
- Regulated & Corporate O&M Spend
- Capital Expenditure
- Cash Flow
- Net Cash from Sale of Synthetic Fuel Interest

How We Work

Develop People
Build the right skill sets so that every employee can contribute

Plan & Engage
Develop clear goals, objectives and methods & ensure everyone is engaged, empowered, and committed to change

Operate Consistently
Develop standardized work instruction environment with high-performing, robust processes

Measure, Learn & Analyze
Continually assess the current state to identify opportunities for improvement

Continuously Improve
Maintain systems that engage all employees in identifying and implementing opportunities to promote safety, quality & consistency in our work

Operating System Toolbox

- Lean Operating Tools
- Standard Work Instructions
- Change Management Tools
- Employee Evaluation & Talent Planning Tools
- Statistical Problem Solving Tools
- Corrective Action & AAR Tools
- Employee Engagement Tools
- Project Management Tools

How We Think

DTE Operating Principles

Operate consistently with DTE Energy Way, Pathways to Partnership, and the People Strategy

- Ensure safety of our employees, customers and general public
- Measure success by how well we meet and exceed customer expectations
- Communicate honestly and effectively
- Hold each other accountable and reward success
- Drive decision making to the point of activity
- Gain high agreement on what and how by standardizing all activities and processes
- Create a learning environment where all employees are engaged in organized reflection and knowledge transfer
- Optimize enterprise wide focus through internal collaboration and partnership
- Understand current reality through fact based measures, articulate the ideal state, & understand the gap
- Surface problems quickly, engage everyone
- Identify and eliminate waste
- Improve processes by focusing on activities, connections and flows

Revised 3/3/2005

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OPERATING SYSTEM FRAMEWORK

OUR PURPOSE: We energize the progress of society. We make dreams real. We are always here.

How We Think   +   How We Work   =   What We*Achieve

TRUE NORTH (Ideal State)

OUR CORPORATE PRIORITIES

FINANCIAL PERFORMANCE

CONTINUOUS IMPROVEMENT

EMPLOYEE ENGAGEMENT

VALUE CREATION

REGULATORY STRATEGY

*All stakeholders: customers, suppliers, employees, unions, shareholders

OUR CORE VALUES & GUIDING PRINCIPLES

CORE VALUES

SAFETY

RESPECT

INTEGRITY

LEARNING

CUSTOMER SERVICE

BUSINESS SUCCESS

GUIDING PRINCIPLES

IDENTIFY AND ELIMINATE WASTE

BE DATA DRIVEN

BE ACCOUNTABLE

BUILD COLLABORATION

Derived from Pathways to Partnership, consistent with the DTE Energy Way and the Energy Model/

Central Diagram

CAPABILITY 1 — Design work to see problems as they occur.

CAPABILITY 4 — Leaders develop engaged employees through teaching, coaching and mentoring.

CAPABILITY 3 — Share new local knowledge across the enterprise.

CAPABILITY 2 — Countermeasure problems rapidly at the point of activity.

PLAN AND ENGAGE

OPERATE CONSISTENTLY

MEASURE, ANALYZE, LEARN

CONTINUOUSLY IMPROVE

ENGAGED EMPLOYEES

CONTINUOUS IMPROVEMENT METHODOLOGIES

People Focus | Project Focus

Swarming | DNA Building | 4 Gate – 9 Step | Just Do It

Lean/Six Sigma

Additional information on Continuous Improvement and OSSG is available on the Operating System Web site on Quest, keyword search: CI

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Appendix D: CI Tools

The "tools" that the OSSG considers part of DTE Energy's CI initiative as of early 2009 are shown in the following list. The name(s) used at DTE Energy is (are) listed before the semicolon; I have provided other common names after the semicolon. Japanese terms are set in italics.

- 4-Block
- 4-Gate 9-Step Project Management (4G9S); DMAIC (Define, Measure, Analyze, Improve, Control)
- 5S Workplace Organization (Sorting/Sifting/*Seiri*, Straighten/Set in Order/Simplify/*Seiton*, Shine/Sweeping/*Seiso*, Standardize/*Seiketsu*, Sustain/Self-Discipline/*Shitsuke*)
- A3 Summary
- After Action Review (AAR)
- Assessment Data Collection
- Attainment Chart
- Benchmarking
- Box Plot
- Business Plan Deployment (BPD); Quality Function Deployment (QFD), Policy Deployment, *Hoshin Kanri*
- Cause & Effect Matrix
- Cause Map, Root Cause Analysis
- Check Sheet
- Control Chart
- Control Plan
- Control Point Audit
- Corrective Action Request (CAR)
- Countermeasure Worksheet, Scientific Method
- CT Tree, Voice of the Customer

- Decision Analysis
- Design of Experiments (DOE)
- Embedded Test, Human Performance, Error Proofing; *Poka-Yoke*
- Escalation; *Andon*
- Failure Mode & Effects Analysis (FMEA)
- Fishbone Diagram, Cause & Effect Diagram; Ishikawa Diagram
- Gantt Chart
- Go-and-See; *Genchi Gembutsu*
- Histogram
- Hypothesis Testing
- Improvement Workshop, *Kaizen*
- Individual Skills Chart
- Knowledge Sharing, C3; *Yokoten*
- OPCA (Output, Pathway, Connection, Activity), Process Design, C1
- Pareto Chart
- Problem Anticipation Planning
- Problem Solving, PDSA Cycle (Plan, Do, Study, Act), C2
- Process Mapping, Swim-lane Flowchart; Deployment Flowchart, Cross-Functional Flowchart
- Project Management
- Project Scoping Document
- Project Selection Matrix
- Radar Chart
- Regression Analysis
- Replenishment System; *Kanban*
- Run Chart
- Safety Cross
- SIPOC (Suppliers, Inputs, Process, Outputs, Customers)
- Situation Analysis
- Standard Work Instruction (SWI)

- Storyboard
- SWOT (Strengths, Weaknesses, Opportunities, Threats)
- Trend Chart
- Value Stream Mapping (VSM)
- Visual Management
- Waste Template, Seven Wastes
- Weibull Analysis
- Y=f(x)

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Appendix E: Peer Utilities

DTE Energy defines its own peer group of utilities for comparing stock performance and other operational measures. These utilities were selected for their similar generation portfolios and because they are publicly traded. Fos Gen's metrics are compared to other peer-group parent companies, but metrics for DO and MichCon are compared to peer-group distribution and natural gas sub-units, respectively.

In 2008, DTE Energy's peer group of utilities were as follows. I have listed them in stock-symbol order and provided the states in which the utility does substantial business. The utilities marked with an asterisk (*) are members of the 15-utility group that constitute the Dow Jones Utility Average index.

*AEP - American Electric Power Company Inc. (Arkansas, Indiana, Kentucky, Louisiana, Michigan, Ohio, Oklahoma, Tennessee, Texas, Virginia, West Virginia)

CMS - CMS Energy Corp. [Consumers Energy] (Michigan)

*CNP - CenterPoint Energy Inc. (Texas)

*ED - Consolidated Edison Inc. (New York City, northern New Jersey, eastern Pennsylvania)

DPL - DPL Inc. [Dayton Power and Light] (Ohio)

GXP - Great Plains Energy Inc. (western Missouri, eastern Kansas)

LNT - Alliant Energy Corp. (Wisconsin, Iowa, southern Minnesota)

*NI - NiSource Inc. (electricity: northern Indiana; gas: northern Indiana, Ohio, Pennsylvania, Virginia, Kentucky, Maryland, Maine, Massachusetts, New Hampshire)

NST - NSTAR (Massachusetts)

NU - Northeast Utilities (Connecticut, New Hampshire, western Massachusetts)

NVE - NV Energy Inc. [formerly Sierra Pacific Resources] (Nevada, eastern California)

*PCG - PG&E Corp. [Pacific Gas & Electric] (central and northern California)

PGN - Progress Energy Inc. (North Carolina, South Carolina, west-central Florida)

PNW - Pinnacle West Capital Corp. (Arizona)

SCG - SCANA Corp. (South Carolina, southeastern Georgia)

*SO - Southern Company (Alabama, Georgia, Florida, Mississippi)

TE - TECO Energy Inc. (Florida)

TEG - Integrys Energy Group Inc. (electricity: Illinois; gas: Illinois, Michigan, Minnesota)

VVC - Vectren Corp. (Indiana, Ohio)

WEC - Wisconsin Energy Corp. (Wisconsin, Michigan upper peninsula)

WR - Westar Energy Inc. (Kansas)

XEL - Xcel Energy Inc. (Colorado, Michigan, Minnesota, New Mexico, North Dakota, South Dakota, Texas, Wisconsin)

Appendix F: Scenario Parameters

In this appendix I provide the parameter changes files that I used to simulate the scenarios in Chapter 6. These parameters are also summarized in Table 4 on page 253. Vensim's parameter changes files usually have a '.cin' file extension and include parameter settings that differ from the default values defined in the model.

F.1. Parameter Changes File for Scenario 1

```
Excel File Scenario Name :IS: 'scenario1'
INITIAL TIME=0
FINAL TIME=180
SE Training Start Date=12
Merger Close Date=180
BB Training Change Date=180
GB Training Start Date=180
BB Certification Start Date=180
Constant BB Coaching Start Date=27
Constant BB Coaching Fraction=1
Constant BB Coaching Duration=180
Downsizing Start Date=180
Downsizing Duration=0
Work Scope Increase Start Date=180
```

F.2. Parameter Changes File for Scenario 2

```
Excel File Scenario Name :IS: 'scenario2'
INITIAL TIME=0
FINAL TIME=180
SE Training Start Date=12
Merger Close Date=52
BB Training Change Date=180
GB Training Start Date=180
BB Certification Start Date=180
Constant BB Coaching Start Date=27
Constant BB Coaching Fraction=1
Constant BB Coaching Duration=180
Downsizing Start Date=180
Downsizing Duration=0
```

```
    Work Scope Increase Start Date=180
```

F.3. Parameter Changes File for Scenario 3

```
    Excel File Scenario Name :IS: 'scenario3'
    INITIAL TIME=0
    FINAL TIME=180
    SE Training Start Date=12
    Merger Close Date=52
    BB Training Change Date=66
    GB Training Start Date=76
    BB Certification Start Date=90
    Constant BB Coaching Start Date=27
    Constant BB Coaching Fraction=1
    Constant BB Coaching Duration=39
    Downsizing Start Date=180
    Downsizing Duration=0
    Work Scope Increase Start Date=180
```

F.4. Parameter Changes File for Scenario 4

```
    Excel File Scenario Name :IS: 'scenario4'
    INITIAL TIME=0
    FINAL TIME=180
    SE Training Start Date=12
    Merger Close Date=52
    BB Training Change Date=66
    GB Training Start Date=76
    BB Certification Start Date=90
    Constant BB Coaching Start Date=27
    Constant BB Coaching Fraction=1
    Constant BB Coaching Duration=39
    Downsizing Start Date=108
    Downsizing Duration=72
    Work Scope Increase Start Date=180
```

F.5. Parameter Changes File for Scenario 5

```
    Excel File Scenario Name :IS: 'scenario5'
    INITIAL TIME=0
    FINAL TIME=180
```

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```
SE Training Start Date=12
Merger Close Date=52
BB Training Change Date=66
GB Training Start Date=76
BB Certification Start Date=90
Constant BB Coaching Start Date=27
Constant BB Coaching Fraction=1
Constant BB Coaching Duration=39
Downsizing Start Date=108
Downsizing Duration=12
Work Scope Increase Start Date=180
```

F.6. Parameter Changes File for Scenario 6

```
Excel File Scenario Name :IS: 'scenario6'
INITIAL TIME=0
FINAL TIME=180
SE Training Start Date=12
Merger Close Date=52
BB Training Change Date=66
GB Training Start Date=76
BB Certification Start Date=90
Constant BB Coaching Start Date=27
Constant BB Coaching Fraction=1
Constant BB Coaching Duration=39
Downsizing Start Date=108
Downsizing Duration=12
Work Scope Increase Start Date=141
```

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Appendix G: Optimization Parameters

     In this appendix I provide the Vensim files for optimization control and parameter changes that I used to simulate the policy scenarios in Chapter 7. Vensim's optimization control files usually have a '.voc' file extension. Vensim's parameter changes files usually have a '.cin' file extension and include parameter settings that differ from the default values defined in the model.

G.1. Control File for Policy Optimizations A1 and A2

```
:OPTIMIZER=Powell
:SENSITIVITY=Parameter Percent=10
:MULTIPLE_START=Off
:RANDOM_NUMER=Linear
:OUTPUT_LEVEL=On
:TRACE=Off
:MAX_ITERATIONS=1000
:RESTART_MAX=0
:PASS_LIMIT=2
:FRACTIONAL_TOLERANCE=0.0003
:TOLERANCE_MULTIPLIER=21
:ABSOLUTE_TOLERANCE=1
:SCALE_ABSOLUTE=1
:VECTOR_POINTS=25
0<=Constant Target BB to Workforce Ratio=0.02<=0.1
12<=SE Training Start Date=12<=180
12<=GB Training Start Date=12<=180
12<=Work Scope Increase Start Date=180<=180
0<=Maximum Fractional Work Scope Increase Rate=0.1<=1
0<=Regular Employee Maximum Nonroutine Work Fraction[SE]=0.2<=0.5
0<=Regular Employee Maximum Nonroutine Work Fraction[MM]=0.2<=0.5
0<=Regular Employee Maximum Nonroutine Work Fraction[FL]=0.2<=0.5
0<=BB Nonroutine Work Fraction=1<=1
12<=Constant BB Coaching Start Date=12<=180
0<=Constant BB Coaching Duration=0<=180
0<=Constant BB Coaching Fraction=1<=1
0<=Maximum BB Coaching Fraction=0.5<=1
12<=BB Training Change Date=12<=180
12<=BB Certification Start Date=12<=180
0<=Constant BB Hire Rate[FL]=0.54<=1
0<=Initial Master Black Belts=1<=5
0.1<=MBB Training Relative Weight=1.1<=10
0.5<=BB Shortfall Correction Time=24<=180
```

```
0<=BB Trainee MM Odds Ratio=0.125<=2
0<=BB Trainee SE Odds Ratio=0<=2
0.5<=GB Training SE Target Completion Time=24<=180
0<=GB Training Maximum Capacity=100<=400
0<=Maximum SE Training Rate per Person=4<=12
1<=Work Standard Increase Time=2<=1000
1<=Work Standard Decrease Time=12<=1000
1<=Operating Cost Standard Adjustment Time=3<=1000
0.5<=Improvement Perception Time=1<=3
0<=BB Fractional Promotion Rate[MM]=0<=0.01
0<=BB Fractional Promotion Rate[FL]=0.0046<=0.01
0<=Downsizing Start Date=180<=180
0<=Downsizing Duration=0<=180
0<=Productivity Improvement Work Fraction=0.5<=1
```

G.2. Parameter Changes File for Policy Optimization A1

The worksheet 'scenario1' in the Excel file defines exogenous time series for no organizational crises. The MichCon merger does not occur. The other changes below set as constant the Black Belt target, the Black Belt program start date, the Black Belt hiring rate, and the Black Belt program dropout rate (at zero). I skip the period of kaizen facilitators.

```
Excel File Scenario Name :IS: 'scenario1'
INITIAL TIME=0
FINAL TIME=180
Merger Close Date=180
Constant Target BB to Workforce Ratio Switch=1
BB Target Start Date=12
Constant BB Hire Switch=1
Constant BB Hire Avg CI Experience Switch=1
Constant BB Hire Avg CI Experience=4160
Constant BB Fractional Dropout Switch=1
Constant BB Fractional Dropout Rate=0
First MBB Training Work per Course=0
```

G.3. Parameter Changes File for Policy Optimization A2

The worksheet 'policy4' in the Excel file defines exogenous time series for all three organizational crises: the period of merger trouble, the PEP initiative, and the ECR initiative. The MichCon merger closes in May 2001. The one other difference between this scenario and Policy Optimization A1 is the exogenous time series for BB dropouts

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which define dropouts during the period of merger trouble (only).

```
Excel File Scenario Name :IS: 'policy4'
INITIAL TIME=0
FINAL TIME=180
Merger Close Date=52
Constant Target BB to Workforce Ratio Switch=1
BB Target Start Date=12
Constant BB Hire Switch=1
Constant BB Hire Avg CI Experience Switch=1
Constant BB Hire Avg CI Experience=4160
Constant BB Fractional Dropout Switch=0
First MBB Training Work per Course=0
```

G.4. Control File for Policy Optimization B1

```
:OPTIMIZER=Powell
:SENSITIVITY=Parameter Percent=10
:MULTIPLE_START=Off
:RANDOM_NUMER=Linear
:OUTPUT_LEVEL=On
:TRACE=Off
:MAX_ITERATIONS=1000
:RESTART_MAX=0
:PASS_LIMIT=2
:FRACTIONAL_TOLERANCE=0.0003
:TOLERANCE_MULTIPLIER=21
:ABSOLUTE_TOLERANCE=1
:SCALE_ABSOLUTE=1
:VECTOR_POINTS=25
6<=BB Shortfall Correction Time=24<=180
0<=SE Training Start Date=12<=180
12<=Work Scope Increase Start Date=90<=180
0<=Maximum Fractional Work Scope Increase Rate=0.1<=0.1
0<=Regular Employee Maximum Nonroutine Work Fraction[MM]=0.2<=0.2
0<=Maximum BB Coaching Fraction=1<=1
1<=Initial Master Black Belts=1<=20
0<=Maximum SE Training Rate per Person=4<=8
0.5<=Improvement Perception Time=1<=3
0<=BB Fractional Promotion Rate[FL]=0.0046<=0.01
0<=Productivity Improvement Work Fraction=0.5<=1
```

G.5. Parameter Changes File for Policy Optimization B1

Policy Optimization A1 searched for the best values of some policy parameters that I subsequently set as constant in this optimization scenario. As before, there are no

organizational crises and the MichCon merger does not occur. The Black Belt program starts at the earliest point, only front-line employees become Black Belts, certification projects are not required, and Black Belts do not provide any coaching to front-line employees. There is no downsizing and the Green Belt training starts concurrently with the Black Belt training. Finally, the largest fraction of their work month that senior executives and front-line employees devote to nonroutine work is limited to 20 percent.

```
Excel File Scenario Name :IS: 'scenario1'
INITIAL TIME=0
FINAL TIME=180
Merger Close Date=180
Constant Target BB to Workforce Ratio Switch=1
BB Target Start Date=12
Constant BB Hire Switch=1
Constant BB Hire Avg CI Experience Switch=1
Constant BB Hire Avg CI Experience=4160
Constant BB Fractional Dropout Switch=1
Constant BB Fractional Dropout Rate=0
First MBB Training Work per Course=0
BB Trainee MM Odds Ratio=0
BB Trainee SE Odds Ratio=0
BB Training Change Date=12
BB Certification Start Date=180
Regular Employee Maximum Nonroutine Work Fraction[SE]=0.2
Regular Employee Maximum Nonroutine Work Fraction[FL]=0.2
GB Training Start Date=12
Constant BB Coaching Start Date=180
Constant BB Coaching Duration=0
Downsizing Start Date=180
Downsizing Duration=0
```

G.6. Control File for Policy Optimization B2

```
:OPTIMIZER=Powell
:SENSITIVITY=Parameter Percent=10
:MULTIPLE_START=Off
:RANDOM_NUMER=Linear
:OUTPUT_LEVEL=On
:TRACE=Off
:MAX_ITERATIONS=1000
:RESTART_MAX=0
:PASS_LIMIT=2
:FRACTIONAL_TOLERANCE=0.0003
:TOLERANCE_MULTIPLIER=21
:ABSOLUTE_TOLERANCE=1
```

```
:SCALE_ABSOLUTE=1
:VECTOR_POINTS=25
6<=BB Shortfall Correction Time=24<=180
0<=Constant BB Hire Rate[FL]=0<=0.54
12<=BB Certification Start Date=12<=180
0<=SE Training Start Date=12<=180
12<=Work Scope Increase Start Date=12<=180
0<=Maximum Fractional Work Scope Increase Rate=0.1<=0.1
0<=Regular Employee Maximum Nonroutine Work Fraction[SE]=0.1<=0.2
0<=Regular Employee Maximum Nonroutine Work Fraction[MM]=0.1<=0.2
0<=Regular Employee Maximum Nonroutine Work Fraction[FL]=0.1<=0.2
0<=Maximum BB Coaching Fraction=1<=1
1<=Initial Master Black Belts=1<=20
0<=MBB Training Relative Weight=0.1<=100
0<=Maximum SE Training Rate per Person=2<=8
0.5<=Improvement Perception Time=1<=3
0<=BB Fractional Promotion Rate[FL]=0.0046<=0.01
0<=Productivity Improvement Work Fraction=0.5<=1
1<=Work Standard Increase Time=12<=1000
1<=Work Standard Decrease Time=2<=1000
1<=Operating Cost Standard Adjustment Time=12<=1000
```

G.7. Parameter Changes File for Policy Optimization B2

The parameter settings for this optimization scenario are mostly a blend of the settings for Policy Optimization A2 and Policy Optimization B1. As for Policy Optimization A2, the three organizational crises occur, Black Belts drop out during the period of merger trouble, and the MichCon merger closes in May 2001. The rest of the parameter settings match those for Policy Optimization B1 except I do not set as constant the maximum fraction of nonroutine work that can be done by senior executives and front-line employees.

```
Excel File Scenario Name :IS: 'policy4'
INITIAL TIME=0
FINAL TIME=180
Merger Close Date=52
Constant Target BB to Workforce Ratio Switch=1
BB Target Start Date=12
Constant BB Hire Switch=1
Constant BB Hire Avg CI Experience Switch=1
Constant BB Hire Avg CI Experience=4160
Constant BB Fractional Dropout Switch=0
First MBB Training Work per Course=0
BB Trainee MM Odds Ratio=0
BB Trainee SE Odds Ratio=0
```

```
BB Training Change Date=12
GB Training Start Date=12
Constant BB Coaching Start Date=180
Constant BB Coaching Duration=0
Downsizing Start Date=180
Downsizing Duration=0
```

G.8. Control File for Policy Optimizations C1 and C2

```
:OPTIMIZER=Powell
:SENSITIVITY=Parameter Percent=10
:MULTIPLE_START=Off
:RANDOM_NUMER=Linear
:OUTPUT_LEVEL=On
:TRACE=Off
:MAX_ITERATIONS=1000
:RESTART_MAX=0
:PASS_LIMIT=2
:FRACTIONAL_TOLERANCE=0.0003
:TOLERANCE_MULTIPLIER=21
:ABSOLUTE_TOLERANCE=1
:SCALE_ABSOLUTE=1
:VECTOR_POINTS=25
0<=SE Training Start Date=12<=180
0<=Regular Employee Maximum Nonroutine Work Fraction[MM]=0.1<=0.2
0<=Maximum SE Training Rate per Person=4<=8
0.5<=Improvement Perception Time=1<=3
0<=Productivity Improvement Work Fraction=0.5<=1
```

G.9. Parameter Changes File for Policy Optimization C1

I defined this optimization scenario by starting with the parameters from Policy Optimization B1 and adding a few more parameters set as constant. I set the Black Belt shortfall correction time to a realistic minimum and set the initial number of Master Black Belts. Black Belts are never promoted. And employees' scope of work is increased as fast and as soon as possible.

```
Excel File Scenario Name :IS: 'scenario1'
INITIAL TIME=0
FINAL TIME=180
Merger Close Date=180
Constant Target BB to Workforce Ratio Switch=1
BB Target Start Date=12
Constant BB Hire Switch=1
```

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```
Constant BB Hire Avg CI Experience Switch=1
Constant BB Hire Avg CI Experience=4160
Constant BB Fractional Dropout Switch=1
Constant BB Fractional Dropout Rate=0
First MBB Training Work per Course=0
BB Trainee MM Odds Ratio=0
BB Trainee SE Odds Ratio=0
BB Training Change Date=12
BB Shortfall Correction Time=6
Initial Master Black Belts=1
BB Certification Start Date=180
Regular Employee Maximum Nonroutine Work Fraction[SE]=0.2
Regular Employee Maximum Nonroutine Work Fraction[FL]=0.2
GB Training Start Date=12
Constant BB Coaching Start Date=180
Constant BB Coaching Duration=0
Maximum BB Coaching Fraction=0
BB Fractional Promotion Rate[FL]=0
Downsizing Start Date=180
Downsizing Duration=0
Work Scope Increase Start Date=12
Maximum Fractional Work Scope Increase Rate=0.1
```

G.10. Parameter Changes File for Policy Optimization C2

The parameter settings for this optimization scenario are a blend of the settings for
Policy Optimization A2 and Policy Optimization C1. As for Policy Optimization A2, the
three organizational crises occur, Black Belts drop out during the period of merger trouble,
and the MichCon merger closes in May 2001. The rest of the parameter settings match
those for Policy Optimization C1.

```
Excel File Scenario Name :IS: 'policy4'
INITIAL TIME=0
FINAL TIME=180
Merger Close Date=52
Constant Target BB to Workforce Ratio Switch=1
BB Target Start Date=12
Constant BB Hire Switch=1
Constant BB Hire Avg CI Experience Switch=1
Constant BB Hire Avg CI Experience=4160
Constant BB Fractional Dropout Switch=0
First MBB Training Work per Course=0
BB Trainee MM Odds Ratio=0
BB Trainee SE Odds Ratio=0
BB Training Change Date=12
BB Shortfall Correction Time=6
```

```
Initial Master Black Belts=1
BB Certification Start Date=180
Regular Employee Maximum Nonroutine Work Fraction[SE]=0.2
Regular Employee Maximum Nonroutine Work Fraction[FL]=0.2
GB Training Start Date=12
Constant BB Coaching Start Date=180
Constant BB Coaching Duration=0
Maximum BB Coaching Fraction=0
BB Fractional Promotion Rate[FL]=0
Downsizing Start Date=180
Downsizing Duration=0
Work Scope Increase Start Date=12
Maximum Fractional Work Scope Increase Rate=0.1
```

G.11. Parameter Changes File for Policy Scenario D1

The parameter settings for this simulation scenario comprise the optimal parameter
values found by Policy Optimization C1 added to its parameter changes file.

```
Excel File Scenario Name :IS: 'scenario1'
INITIAL TIME=0
FINAL TIME=180
Merger Close Date=180
Constant Target BB to Workforce Ratio Switch=1
BB Target Start Date=12
Constant BB Hire Switch=1
Constant BB Hire Avg CI Experience Switch=1
Constant BB Hire Avg CI Experience=4160
Constant BB Fractional Dropout Switch=1
Constant BB Fractional Dropout Rate=0
First MBB Training Work per Course=0
BB Trainee MM Odds Ratio=0
BB Trainee SE Odds Ratio=0
BB Training Change Date=12
BB Shortfall Correction Time=6
Initial Master Black Belts=1
BB Certification Start Date=180
Regular Employee Maximum Nonroutine Work Fraction[SE]=0.2
Regular Employee Maximum Nonroutine Work Fraction[MM]=0.2
Regular Employee Maximum Nonroutine Work Fraction[FL]=0.2
GB Training Start Date=12
Constant BB Coaching Start Date=180
Constant BB Coaching Duration=0
Maximum BB Coaching Fraction=0
BB Fractional Promotion Rate[FL]=0
Downsizing Start Date=180
Downsizing Duration=0
Work Scope Increase Start Date=12
Maximum Fractional Work Scope Increase Rate=0.1
```

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```
SE Training Start Date=6
Maximum SE Training Rate per Person=8
Improvement Perception Time=0.5
Productivity Improvement Work Fraction=0.34
```

G.12. Parameter Changes File for Policy Scenario D2

The parameter settings for this simulation scenario comprise the optimal parameter values found by Policy Optimization C2 added to its parameter changes file.

```
Excel File Scenario Name :IS: 'policy4'
INITIAL TIME=0
FINAL TIME=180
Merger Close Date=52
Constant Target BB to Workforce Ratio Switch=1
BB Target Start Date=12
Constant BB Hire Switch=1
Constant BB Hire Avg CI Experience Switch=1
Constant BB Hire Avg CI Experience=4160
Constant BB Fractional Dropout Switch=0
First MBB Training Work per Course=0
BB Trainee MM Odds Ratio=0
BB Trainee SE Odds Ratio=0
BB Training Change Date=12
BB Shortfall Correction Time=6
Initial Master Black Belts=1
BB Certification Start Date=180
Regular Employee Maximum Nonroutine Work Fraction[SE]=0.2
Regular Employee Maximum Nonroutine Work Fraction[MM]=0.2
Regular Employee Maximum Nonroutine Work Fraction[FL]=0.2
GB Training Start Date=12
Constant BB Coaching Start Date=180
Constant BB Coaching Duration=0
Maximum BB Coaching Fraction=0
BB Fractional Promotion Rate[FL]=0
Downsizing Start Date=180
Downsizing Duration=0
Work Scope Increase Start Date=12
Maximum Fractional Work Scope Increase Rate=0.1
SE Training Start Date=6
Maximum SE Training Rate per Person=8
Improvement Perception Time=0.5
Productivity Improvement Work Fraction=0
```

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Appendix H: Glossary

<u>**-#-**</u>

4-Block — A 1-page project summary report comprising four different charts arranged in a grid: a trend or control chart, a Pareto chart, a Paynter chart, and a list of tasks assigned to people.

4G9S (4-Gate 9-Step) — A project-management procedure used at DTE Energy instead of Six Sigma's DMAIC, usually for Black Belt projects or their equivalent. Each phase gate is a progress checkpoint at which a decision is made to continue, rework, suspend, or cancel the project. The gates and steps are as follows:
1. Identify potential project
2. Form team & refine scope
3. Assess & analyze current reality
Gate 1: Assessment
4. Define desired outcome / ideal state
5. Identify project gaps and countermeasures
6. Create master plan for implementing solutions
Gate 2: Design
7. Test, refine, and implement project solutions
Gate 3: Implementation
8. Measure project progress & sustain goals
9. Acknowledge team, reflect, and communicate results
Gate 4: Results

4P — A mnemonic for Jeffrey Liker's (2004) four categories of elements that constitute the Toyota Production System: (1) philosophy, (2) processes, (3) people and partners, and (4) problem solving.

50-in-5 Event — See *CILW*.

5S — A practice of the Toyota Production System for organizing a work area and keeping it clean such that employees always know where materials and tools are located. (Following the adage: "A place for everything and everything in its place.") Each of the original five Japanese 's' words — *seiri*, *seiton*, *seiso*, *seiketsu*, *shitsuke* — has a few corresponding English equivalents (translated only roughly to keep them all beginning with 's'): (1) sorting, sifting; (2) straighten, set in order, simplify; (3) shine, sweeping; (4) standardize; and (5) sustain, self-discipline.

7 Wastes — See *Seven Wastes*.

-A-

A3 Problem Solving — Toyota's problem-solving process based on the Deming-Shewhart PDSA cycle. According to Sobek & Smalley (2008), this process consists of the following steps:
1. Grasp the current situation
2. Identify the root cause
3. Devise countermeasures and visualize the future state
4. Create implementation plan
5. Create follow-up plan
6. Discuss with affected parties
7. Obtain approval
8. Execute the implementation plan
9. Execute the follow-up plan
10. Establish process standard

A3 Report — A short management report developed by Toyota, consisting of no more than two pages, that summarizes succinctly the results of a problem-solving process like A3, PDSA, or DMAIC. According to Sobek & Smalley (2008), an A3 report consists of the following sections:
1. Report Theme
2. Background
3. Current condition & problem statement
4. Goal statement (target condition)
5. Root-cause analysis
6. Countermeasures
7. Effect confirmation (and implementation plan)
8. Follow-up actions

ACSI (American Customer Satisfaction Index) — A customer satisfaction scale, ranging from 0-100, based on a complicated econometrics model (which supposedly adjusts for customer dissatisfaction from recent price increases). It was developed by the National Quality Research Center at the University of Michigan.

AMI (Advanced Metering Infrastructure) — Meters that automatically send their readings to DTE Energy, eliminating the need for "manual" reads by employees.

AMO (Asset Management Organization) — A part of Fossil Generation's central organization comprising four departments: outage management, project management, reliability, and implementation/building-trade work. AMO had a north-area group and a south-area group.

Andon — An integral part of the Toyota Production System used at Toyota's assembly plants consisting of a board, displaying each assembly line's status, and a stop cord running the length of the line through every work area. If a worker cannot solve an emergent problem within the line's *takt* time, he or she pulls the cord to stop the line and request assistance from his or her coworkers and supervisor. See also *takt* time.

AVA (Activity Value Analysis) — A structured five-phase process used by McKinsey as part of the PEP initiative to cut costs.

-B-

Balanced Scorecard — A performance-monitoring tool for executives that was developed by Kaplan & Norton (1992). A balanced scorecard comprises a (small) set of goals and performance measures in each of the following four categories:
1. Financial perspective — How do we look to our shareholders?
2. Customer perspective — How do our customers see us?
3. Internal business perspective — What must we excel at?
4. Innovation and learning perspective — Can we continue to improve and create value?

BAMA (Bluegrass Automotive Manufacturers Association) — Originally a consortium of suppliers to TMMK in Georgetown, Kentucky, through which they learned TPS, but its membership has broadened since its founding in 1989.

Beachhead — Jason Schulist's reinvention of the learning-line concept in late 2008, in which a CI coach from the OSSG works intensively with the personnel at a particular facility to figure out how to make CI work effectively in that context. None had been attempted by the end of 2009.

Black Belt (Six Sigma) — A certification that someone is a qualified Six Sigma expert. Requirements typically consist of the following: four weeks of training on process-improvement concepts and methods, statistics, and other tools; an examination; and the completion of two projects each yielding $250 thousand in benefits.

BPA (Business Process Assessment) — A tool used by MichCon's improvement department prior to its merger with Detroit Edison. It specifies four levels for how much a process is prespecified and documented: (1) no documentation; (2) process flowchart with specified activities, pathways, and cycle times; (3) analysis to determine efficiency and staffing; and (4) favorable performance comparison to other companies (benchmarking).

BPD (Business Plan Deployment) — GM's term for *hoshin kanri*, Quality Function Deployment (QFD), or policy deployment, brought to DTE Energy by former GM employees.

BPR (Business Process Reengineering) — A management fad advocating the radical redesign of a company's process (Hammer & Champy, 1993), often starting from a clean slate. BPR contrasts with TQM, the preceding management fad emphasizing incremental improvement.

-C-

C1-C4 — Four capabilities posited by Steven Spear (2009) to be characteristic of "operationally outstanding" organizations: (C1) process design, (C2) problem solving, (C3) knowledge sharing, and (C4) leaders develop people (via coaching and mentoring).

CAIDI (Customer Average Interruption Duration Index) — Reliability index = average restoration time = SAIDI/SAIFI = sum of all customer interruption durations divided by total number of customer interruptions over a rolling 12-month period.

CAIFI (Customer Average Interruption Frequency Index) — Total number of customer interruptions divided by total number of customers who had at least one interruption over a rolling 12-month period.

CAR (Corrective Action Request) — DTE Energy's employee suggestion system, run formally like an IT problem-ticket system. It worked poorly because the process was overly bureaucratic and several versions of its IT system were notoriously difficult to use. The name was later shortened to Corrective Action (CA).

CCMP (Customer Commitment Management Process) — A department of Customer Service responsible for the FCR improvement program. See *FCR*.

CILW (CI Leadership Workshop) - A 4- or 5-day workshop consisting of training and hands-on practice of improvement concepts and tools, led by a senior leader of the business unit and a CI expert (usually a CI manager). Attendees of a CILW divide into two teams, select a problem area, brainstorm possible countermeasures, and proceed to test/implement as many of the countermeasures as possible. The OSSG required the results of every CILW to be summarized in an A3 Report. Some managers also called these workshops "50-in-5 events": implementing 50 improvement ideas in 5 days. Jason Schulist originally intended CILWs to train business-unit leaders. In practice, however, some leaders used them to focus attention, resources, and action on making operational improvements. See also *A3 Report*.

Complex Change Model — A model for managing organizational change, based on Knoster and colleagues' (2000) adaptation of an earlier model by Ambrose (1987). This model was used at DTE Energy in the early years of the CI initiative. It posits six necessary conditions for organizational change, each intended to overcome an impediment:
1. Case for change — to overcome the inertia of the status quo
2. Vision — to avoid confusion
3. Skills — to avoid anxiety
4. Incentives — to promote rapid instead of gradual change
5. Resources — to avoid frustration
6. Action Plan — to avoid false starts

Countermeasure — An intervention intended to fix the root causes of a process problem. According to Spear & Bowen (1999, p. 104), Toyota prefers the term 'countermeasure' over 'solution' to emphasize that interventions are never permanent: They should be replaced when conditions change or when a better approach is discovered.

Countermeasure Worksheet — A problem-solving template created by DTE Energy's OSSG to help employees fix process problems by following the scientific method: diagnose the problem, and then invent, test, implement, and monitor countermeasures. Similar to Six Sigma's DMAIC model. See *DMAIC*.

-D-

DCS (Distributed Controls System) — A system of instrument controls in a power plant that enables remote monitoring of operations.

DMAIC — The standardized problem-solving process of Six Sigma comprising the following steps: Define, Measure, Analyze, Improve, and Control.

DNA Building — The OSSG's term for employees enacting new behaviors by using CI tools, thereby changing DTE Energy's culture. Employees sometimes used this term to refer to using CI tools outside of swarm events, JDIs, and 4G9S projects.

DOTWIMP — A mnemonic for the *Seven Wastes*: (1) Defects, (2) Overproduction, (3) Transporting, (4) Waiting, (5) Inventory, (6) Motion, and (7) Processing.

-E-

EAF (Equivalent Availability Factor) — The fraction of a power plant unit's full-time, full-power output that it has available to generate electricity, if required, over a certain period.

EAS (Employee Appraisal System) — DTE Energy's name for each employee's annual performance review and goal-setting for the following year.

EBS (Enterprise Business Systems) — DTE Energy's name for its linked implementations of SAP and Maximo computer systems.

ECR (Economic Crisis Response) — DTE Energy's term for its 2009 plan, consisting of no employee layoffs and a cost-reduction target of $130-150 million. Furthermore, executives wanted 80 percent of these cost reductions to be permanent.

Electric Choice — A program mandated by Michigan's Public Act 141, signed into law in mid-2000, to allow DTE Energy's customers to purchase electricity generated by other suppliers (but still distributed by DTE Energy). DTE Energy reached full implementation of the program by January 1, 2001.

Employment security — An employer's assurance, if not guarantee, that employees will not be laid off but will not necessarily keep the same duties. See also *job security*.

-F-

FCR (First-Contact Resolution) — An improvement program within Customer Service to increase the number of customer requests that can be resolved with only one contact.

Forced Outage — A power plant's unit taken out of service involuntarily, not as part of a planned periodic outage. See also *Periodic Outage*.

Foreign Labor — power plants and other locations must budget for labor expense associated with full-time-equivalent support employees who are members of DTE Energy's corporate departments, such as finance, IT, human resources, security, and central engineering.

Four Capabilities — See *C1-C4*.

-G-

Genchi Gembutsu — A practice of the Toyota Production System (TPS) in which any employee or manager seeking to understand a work process goes to the "actual place" (*genchi*) and personally observes the actual situation, materials, or products (*gembutsu*, also sometimes transliterated as *genbutsu*). Liker (2004) defines this practice as one of twelve principles of TPS. See also *Go-and-See*.

Go-and-See — DTE Energy's version of Toyota's practice of *genchi gembutsu*: To properly diagnose process problems, employees and managers should go and observe the processes personally and speak to the front-line employees working in those processes. Also used to refer to managers visiting other departments to see first hand how those departments' employees made improvements. See also *genchi gembutsu*.

Groundhog Day (1993) — Popular film in which arrogant and egotistical TV weatherman Phil Connors (Bill Murray) relives February 2 over and over again with his producer Rita (Andie MacDowell) in Punxsutawney, Pennsylvania, where he is covering the annual Groundhog Day festivities.

-H-

Hard Savings — Cost reductions or benefits from improvement projects that directly lower expenses, such as increasing inventory turns or reducing equipment, required maintenance, downtime, overtime, part replacements, or prices.

Heat Rate — A measure of power plant efficiency (how much heat is lost).

-I-

IBEW (International Brotherhood of Electrical Workers) — Local 17 is the second-largest union chapter at DTE Energy with about 500 members. Its members are overhead linemen, underground cable workers, some dispatchers, and some crane and elevator operators.

INC — An abbreviation for instrumentation and controls (in a power plant).

-J-

JDI (Just Do It) — A process-improvement approach to be used when a problem's cause is well understood, and its remedies are clear and can be implemented with minimal risk and disruption. JDIs were used often to avoid the bureaucratic hassle of the 4G9S process. See also *4G9S*.

Job security — An employer's assurance, if not guarantee, that employees will not be laid off and will retain the same duties. See also *employment security*.

-K-

Kaizen — The Japanese word for 'improvement' that has been used outside of Japan to mean 'continuous improvement' or even the entire management philosophy of CI.

***Kaizen* (event)** — Typically a 3- or 4-day workshop consisting of some teaching of CI concepts or tools and hands-on practice trying to improve a process. Such events focus attention, resources, and action on making changes quickly, usually intended to demonstrate the effectiveness of CI tools to both management and employees. See also *Swarm Event*.

Karate Kid, The (1984) — Popular film in which a bullied teenager Daniel LaRusso (Ralph Macchio) befriends the handyman of his apartment complex, Kesuke Miyagi (Noriyuki 'Pat' Morita). Daniel learns karate from Mr Miyagi and wins a tournament by beating the bullies.

Kepner-Tregoe (KT) method — A set of four (common-sense) procedural guidelines, which Kepner & Tregoe (1965) call Rational Processes, intended to help managers rationally and systematically assess a situation, problem, decision, or opportunity (or potential problem).

-L-

Learning Line — A practice adopted from Lean manufacturing in which one of several "production lines" is made the focus of experimentation to see what innovations in process/work design can be found and implemented. A learning line involves front-line employees working on that production line and is led by a CI expert for an extended period of time (weeks or months). Also called a *model line*. See also *beachhead*.

LFM (Leaders for Manufacturing) — A 2-year, cross-disciplinary, dual-degree program at MIT in which students earn a Master's degree both from the Sloan School of Management and from one of eight departments in the School of Engineering. The program was renamed Leaders for Global Operations (LGO) in June 2009.

Lost and Unaccounted-For Gas — The difference between the gas procured by a utility and the gas billed to its customers. The main sources of lost gas are leaks and theft.

-M-

Master Black Belt (Six Sigma) — A certification that someone is qualified to teach, mentor, and certify Black Belts. See *Black Belt (Six Sigma)*.

Maximo — An asset-management software application developed by MRO Software (subsequently acquired by IBM in August 2006). DTE Energy uses Maximo as a work-management and MRP system.

MBWA (Management by Walking Around) — A practice advocated by Bill Hewlett and Dave Packard as part of their management philosophy at HP, The HP Way (Packard, 1995). Managers, especially executives, should visit the front lines to (1) know their subordinates, (2) understand the work their subordinates do, and (3) make themselves visible and accessible to their subordinates. Dave Packard brought this practice to HP from GE, but its name was coined by an HP manager. See also *Go-and-See* and *Genchi Gembutsu*.

MISO (Midwest Independent Transmission System Operator) — The regional organization, established in 2001, that operates and monitors the electrical transmission system for 13 mid-western states and the Canadian province of Manitoba, encompassing 135,000 megawatts of generation capacity from 4,700 units run by 25 utilities. MISO has operated real-time, day-ahead, and futures markets for electricity and natural gas since April 2005. MISO has headquarters in Carmel, Indiana, and an operations center in St. Paul, Minnesota.

MPSC (Michigan Public Service Commission) — Michigan's government agency that regulates utilities, telecommunications, and transportation services. The MPSC is led by three commissioners appointed by the governor. In 2008, the MPSC had 167 full-time employees.

-O-

Opacity — The amount of light obscured by particulates in the emissions from power plants' stacks. Opacity is a performance indicator for power plants' particulate control systems.

OPCA — The four major components of process design according to Spear & Bowen (1999): output, pathways (who is responsible for which activities), connections (hand-offs between pathways), and activities (process steps).

Operating Principles — The set of twelve principles developed for the DTE Energy Operating System (2002 and 2005 versions), intended to guide how DTE Energy's employees think and approach their work.
1. Ensure safety of our employees, customers, and the general public.
2. Measure success by how well we meet and exceed customer expectations.
3. Communicate honestly and effectively.
4. Hold each other accountable and reward success.
5. Drive decision making to the point of activity.
6. Gain high agreement on what and how by standardizing all activities and processes.
7. Create a learning environment where all employees are engaged in organized reflection and knowledge transfer.
8. Optimize enterprise-wide focus through internal collaboration and partnership.
9. Understand current reality through fact-based measures, articulate the ideal state, and understand the gap.
10. Surface problems quickly, engage everyone.
11. Identify and eliminate waste.
12. Improve processes by focusing on activities, connections, and flows.

OS Expert — Someone who had completed the OSSG's in-depth training course in Lean concepts and tools. The course consisted of four weeks of classes over four months. It was developed in 2002 and was superseded by DTE Energy's Black Belt training course in late 2003.

OS Specialist — Someone who had completed the OSSG's introductory course in Lean concepts and tools. The course consisted of four days of classes (six days at first) over three weeks. It was developed in 2003 and was intended for front-line employees who would participate in CI activities part-time only.

OSHA (Occupational Safety and Health Administration) — The federal agency, part of the U.S. Department of Labor, whose mission is to prevent work-related injuries, illnesses, and occupational fatality by issuing and enforcing standards for workplace safety and health.

Outage — See *Periodic Outage* and *Forced Outage*.

Outage Pockets — The percent of customers who had three or more outages over a rolling 12-month period.

-P-

Paynter Chart — A chart developed at Ford showing Pareto-chart bars (counts of defect types) for multiple time periods.

Patrol — Operations personnel making rounds of a power plant to observe, inspect, and verify the functioning of the equipment.

PDSA Cycle — An iterative problem-solving process adapted and refined by Deming (1986, 1994) from an earlier cycle by Shewhart (1939). (Note: Sometimes the third step is called 'Check' instead of 'Study' due to an erroneous translation of Deming's cycle back into English from the Japanese version.) The steps according to Deming (1994, p. 132) are as follows:
P: Plan a change or a test, aimed at improvement.
D: Do carry out the change or test (preferably on a small scale).
S: Study the results. What did we learn? What went wrong?
A: Act. Adopt the change, or abandon it, or run through the cycle again.

PEP (Performance Excellence Process) — A cost-cutting initiative designed by McKinsey in 2005 and implemented in 2006.

Periodic Outage — Taking a power plant unit off-line for planned maintenance or upgrade, the objective of which is to minimize the unit's forced-outage time. A unit's outages typically alternate between major and mini outages, at intervals of 2-4 years. A major outage usually requires 8-12 weeks of work; a mini outage requires 4-5 weeks. See also *Forced Outage*.

PMO — An acronym for project-management office.

-Q-

QC (Quality Control) Circle — A group of front-line employees who meet regularly with their supervisor to discuss their performance, any emergent problems, and ideas for improvement. The group engages in problem solving to test and implement countermeasures.

-R-

RASCI — A project- or change-management method for assigning roles and responsibilities, particularly for planning communications. The acronym letters denote the following roles: responsible, accountable, supportive, consulted, and informed.

REC (Renewable Energy Credit) — Also called Renewable Energy Certificate. Certificates used to trade credit for 1 megawatt-hour of renewable energy (already produced) to meet state-mandated targets. These credits expire after 3 years.

Regulatory Lag — The duration from the time a utility files a rate case with its state's regulatory agency until the date a final decision is issued. Michigan's 2008 energy legislation imposed a maximum lag of 12 months on the MPSC. Previously, the MPSC's regulatory lag was one of the worst in the country at 18-20 months.

ROF (Random Outage Factor) — The unplanned fraction of time a power plant's unit is unavailable: the total duration of all forced outages divided by total service hours in a reporting period.

RPS (Renewable Portfolio Standards) — Also called Renewable Energy Standards. State-specific targets for the fraction of energy produced from renewable sources by a certain deadline. Each state has its own definition of what energy sources count as "renewable".

RSG (Revenue Sufficiency Guarantee) — A mechanism that fines electricity generators for over- or under-producing and electricity distributors for over- or under-forecasting demand relative to their commitments in MISO's day-ahead market.

-S-

S1 — DTE Energy's term for each business unit's 5-year strategic plan.

S2 — DTE Energy's term for each business unit's budget and performance targets for the next fiscal year, based on its S1 plan.

SAIDI (System Average Interruption Duration Index) — Average outage duration for each customer served = sum of all customer interruption durations divided by total number of customers served over a rolling 12-month period.

SAIFI (System Average Interruption Frequency Index) — Average number of interruptions that a customer would experience = total number of customer interruptions divided by total number of customers served over a rolling 12-month period.

SCCORE — The dimensions of the balanced scorecard used in Fossil Generation: safety, customer focus, cost, organizational efficiency, regulatory compliance, and environment.

Seven Wastes — The Toyota Production System's seven types of *muda*, or non-value-adding activity (usually translated as waste), as defined by Taiichi Ohno (1988): (1) overproduction, (2) waiting, (3) transporting, (4) inappropriate or over-processing, (5) unnecessary inventory, (6) unnecessary or excess motion, and (7) rework or correcting defects. For a mnemonic, see *DOTWIMP*.

SIPOC — A Six Sigma tool used in process mapping to ensure that all relevant aspects of a process are considered before improvements are attempted. SIPOC is an acronym and a mnemonic: suppliers, inputs, process, outputs, and customers.

Soft Savings — Cost avoidance or benefits from improvement projects that allow one to resist or delay incurring expenses or price increases. Soft savings are usually intangible and difficult to estimate. By contrast, see *Hard Savings*.

SQCDM — The dimensions of the balanced scorecard used in most of DTE Energy's business units: safety, quality (customer focus), cost, delivery, and morale.

STAR — An acronym and mnemonic that Fossil Generation uses to promote workplace safety: Stop, Think, Act, and Review.

Sustainability (for countermeasures) — To describe different levels of countermeasure permanence, DTE Energy uses the following analogy sequence: hold, tape, clamp, bolt, weld. The OSSG personnel adopted this analogy sequence from research on the Toyota Production System (see Spear, 2004a, p. 83). See also *countermeasure*.

Swarm Event — A problem-solving workshop for fixing front-line problems quickly as they occur. Swarm events are intended to mimic the on-the-spot problem solving by Toyota's assembly-line employees and team leaders after an *andon* cord is pulled. Each swarm event should include personnel from the functions and levels necessary to identify root causes, and to design and implement countermeasures. A leader or CI expert teaches basic CI concepts and tools, as needed, during the swarm event. (The OSSG initially intended six hours of training during a swarm event.) The OSSG replaced the name '*kaizen*' with 'swarm' to eliminate Japanese words from DTE Energy's CI initiative and to avoid association with the previous *kaizen* program's poor results. See also *Andon*, *Kaizen (event)*, and *CILW*.

SWI (Standard Work Instruction) — DTE Energy's standardized procedures for how particular jobs or tasks are expected to be done.

SWOT — A situation-assessment tool. SWOT is both an acronym and a mnemonic: strengths, weaknesses, opportunities, and threats.

-T-

Takt **Time** — The desired pace of production in the Toyota Production System (TPS), which should match the (near-future) pace of sales in the market. In practice, it is often calculated as the total regular operating time available in a period divided by the total production requirement for that period. Arguably, *takt* time is one of the most important organizing concepts in TPS, because it emphasizes rates of flow — suggesting Just-In-Time — instead of emphasizing inventory stocks. The term comes from the German *taktzeit*, meaning cycle time.

Theory X — According to McGregor (1960, pp. 33-34), the assumptions about employees underlying a management style of direction and control:
1. The average human being has an inherent dislike of work and will avoid it if he [or she] can.
2. Because of this human characteristic of dislike of work, most people must be coerced, controlled, directed, threatened with punishment to get them to put forth adequate effort toward the achievement of organizational objectives.
3. The average human being prefers to be directed, wishes to avoid responsibility, has little ambition, wants security above all.

Theory Y — According to McGregor (1960, pp. 47-48), the assumptions about employees underlying a management style integrating individual and organizational goals:
1. The expenditure of physical and mental effort in work is as natural as play or rest.
2. External control and the threat of punishment are not the only means for bringing about effort toward organizational objectives. [Employees] will exercise self-direction and self-control in the service of objectives to which [they are] committed.
3. Commitment to objectives is a function of the rewards associated with their achievement.
4. The average human being learns, under proper conditions, not only to accept but to seek responsibility.
5. The capacity to exercise a relatively high degree of imagination, ingenuity, and creativity in the solution of organizational problems is widely, not narrowly, distributed in the population.
6. Under the conditions of modern industrial life, the intellectual potentialities of the average human being are only partially utilized.

Tracker — A formula approved by the MPSC for changing rates as needed, obviating repeated applications for such changes. One of DTE Energy's approved trackers is for storm expenses.

Trade Up Culture — Fossil Generation's initiative to change its culture, particularly to change assumptions about managing people. Started in August 2008, it was based on the books *Joy At Work* by Bakke (2005) and *Trade Up!* by Sharpnack (2007).

TSSC (Toyota Production System Support Center) — Toyota established the Toyota Supplier Support Center in 1992 to teach the Toyota Production System to TMMK's suppliers and other affiliated manufacturers in North America. Toyota spun off this center in 2002. It was renamed in 2009 to better reflect its mission, but retained the abbreviation TSSC. It's headquarters are in Erlanger, Kentucky.

-U-

UWUA (Utility Workers Union of America) — Local 223 is the largest union chapter at DTE Energy with about 4500 members. It has eleven divisions.

-V-

VA/VE (Value Analysis/Value Engineering) — An analysis technique like QFD in which the rows of a matrix divide the cost of product components among desired functions and and the columns divide the value of desired functions among the product components.

VSB (Voluntary Separation Bonus) — An incentive payment made to an employee who agrees to leave the company willingly. DTE Energy used these bonuses during the PEP initiative to minimize layoffs.

VSM (Value-Stream Mapping) — An approach to process design and improvement in which a process is flowcharted and the cycle times of each step are measured and usually divided into value-added time (like production) and non-value-added time (like waiting).

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