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Advantages and Disadvantages
of the French Nuclear Power System

Anthony J. DiBella

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ADVANTAGES & DISADVANTAGES OF THE FRENCH NUCLEAR POWER SYSTEM

Anthony J. DiBella

Nuclear power plants are presently operating in 30 countries. How the nuclear power system in each of these countries functions is a result of political, institutional, and cultural factors. Each country's system is a unique combination of characteristics which facilitate and constrain the safe and efficient production of electricity. This essay examines the advantages and disadvantages of the French system. It is written under the assumption that there is no one correct way to manage nuclear power and that each system of production has certain costs and benefits attached to it.

I. ADVANTAGES OF THE FRENCH SYSTEM

Of the 57 nuclear power plants now operating on French soil, 54 are solely owned and managed by EDF. The other three plants, including the Phenix and Super Phenix fast breeder reactors, are joint ventures managed cooperatively, one with the French Atomic Energy Commission, the other two with European agencies. To talk about French nuclear power is to talk about EDF.

A. Standardization & Economies of Scale

By constructing series of identical plants, EDF is able to spread

fixed costs across a number of units. R & D, design, and construction costs per unit are lower than if plants were designed and built on an individualized basis. Building contractors can also realize cost reductions and pass them along as savings to EDF due to the recurrent use of capital intensive equipment in multiple projects. Experience feedback (retour d'experience) increases productivity thereby decreasing construction time.

These presumed economies of scale that result from standardization pertain, however, not only to construction, but to every phase of operations and maintenance. Fixed costs associated with developing employee training programs, operational procedures, and maintenance routines and equipment are spread across multiple units. Since the bulk of expenditures for nuclear operations stems from fixed costs, economies of scale are an important aspect of financial feasibility.

Cost savings also accrue from the decreased time required to reach plant start-up within an integrated company of standardized units compared to power companies in which units are individualized. In-house approval of designs shortens the time from initial conceptualization to final planning. On-going relationships with contractors reduces the time between preparing blueprints and beginning construction. Finally, close coordination with French safety authorities (DSIN - Direction de

la Surete des Installations Nucleaires) means that licensing procedures may be expedited.

B. Integration & Collaboration

EDF's corporate structure is an organizational umbrella which manages all processes required to design, build, start-up, operate, and maintain nuclear plants. This places a high demand on intra-firm communications. The French nuclear power system is also streamlined by the existence of several specialized contractor firms such as Framatome, Alstom, and Cogema. The effects are to reduce complexity and simplify EDF-contractor relationships by minimizing the number of inter-firm relationships. There is on-going communications among these firms and EDF both at headquarters and plant levels.

The limited number of organizational actors operating in the French nuclear industry is presumed to facilitate collaboration on projects of mutual interest. The French consider this important for safe and reliable operations. For example, one area where efficiency occurs is in licensing and start-up where there is close technical dialogue between EDF and DSIN (Direction de la Surete des Installations Nucleaires), the government agency responsible for plant safety. A significant result is that during a fifteen year period (1975-1990) EDF was able to place a relatively large number (53) of plants on-line.

C. Experience Feedback & Coordination of Learning

By having plants of the same design, EDF personnel quickly accrue operating experience. Given the probability of events, the combined experience of many plants produces a large number of actual events that have widespread significance. Every event may indicate that there are as yet undetected problems at other similar type plants. Thus events are opportunities for experience feedback and their analysis can be added to EDF's data base to enhance reliability.

The structure of the French nuclear industry is a network of resources that can be called upon to analyze an event and develop a solution. For example, headquarters staff (MC) of the Direction du Production Nucleaire (DPN) in La Defense communicate directly with plant staff, EDF design and R & D teams, and specialized research centers, like the Groupe des Laboratoires (GDL). EDF also collaborates with contractors, like Framatome, and government agencies, like the Commissariat a L'Energie Atomique, in resolving design problems that affect safety.

Through EDF's umbrella organization, news about a plant incident can be quickly shared with staff at other plants of the same configuration. Meanwhile, the Groupe Coordination du Parc can assign to appropriate DPN/MC staff the task of analyzing the problem and developing short or long term solutions. Once a

solution has been developed, DPN/MC can expedite on a national basis contractor assistance, as necessary, to make needed repairs or modifications. EDF also has the in-house capacity to follow-up and check that corrective action has been taken.

An incident that occurred during the summer of 1991 demonstrates how this feedback system works. On Saturday, June 22 during a routine test taken before start-up at Belleville, a rondier noticed water on the floor of the BAN, Batiment Auxiliaire Nucleaire. Further inspection indicated that the water originated from leaks on a nozzle weld on a safety injection system. Staff of the Mission Surete-Qualite at Belleville immediately notified MSQ staff at the seven other 1,300 MW plant sites and the on-call team at DPN/MC.

The following Monday, the Maintenance Department at DPN/MC initiated discussions with Framatome, which also has offices at La Defense, about the problem. The next day a temporary solution of placing a collar over the pipe with the poor weld was decided upon, and immediate arrangements were made with Framatome and Nordom to perform the modification. It was easy to contract the work out to these companies since both had participated in plant construction and had open work contracts with EDF.

Even as the problem at Belleville was being solved, DPN/MC personnel were identifying more than 70 similar nozzles on other

safety systems. Subsequent inspections indicated that the same problem existed at 13 out of the other 17 1,300 MW plants, and work teams from Nordom and Framatome traversed the French countryside to solve what had become a "parc" level problem. After the modifications had been made, staff from GDL inspected the new welds and a unit from DTG, the EDF division responsible for dams and hydraulic generated electricity, conducted tests on vibration levels.

Information about the "piquage" (nozzle) problem and its resolution was distributed by the head of the Groupe Coordination du Parc. Meanwhile, this staff group was coordinating further studies to determine whether 900 MW plants were also at risk. Staff from DPN and EDF's design and construction division engaged in discussions over the initial source of the defect and a long-range solution.

This case shows how a problem detected at one plant site is treated within EDF as a clue about the presence of similar problems at other plants. Even as site staff conduct tests to determine whether the problem exists elsewhere, staff at DPN/MC are studying possible solutions in collaboration with specialized contractors. By the time site staff has confirmed the presence of the defect, contractual arrangements may already have been finalized on how to correct the problem. For example, within two working days after a "piquage" problem was located at Alpha

plant, a work crew from Nordom began making repairs on site in accordance with specifications developed at DPN/MC (1).

D. Human Resource Policies & Synergies

With 120,000 employees EDF is France's fifth largest employer (2). Administratively, staff is organized into three categories of employment (execution, maitrise, and cadre) and are further divided into 19 functional groups. There are 35 pay levels and 10 steps within each level. This hierarchical system provides job security and many opportunities for career growth, especially when matrixed against the array of EDF divisions and departments into which staff may transfer.

Cadres, who form the most senior employment category, participate in a system of "mutation," or job rotation. To obtain experience in a range of tasks and functional areas, such as operations, maintenance, and inspection, cadres rotate between positions at DPN/MC and plant sites. The system presumably gives cadres the knowledge and skills necessary to advance into top management. However, the system also has the effect of creating a network of social relationships so that decisions about promotions and transfers can be made on the basis of personal knowledge. Job rotation also has a socializing effect that reinforces shared values and cultural understanding.

The breadth of EDF operations means that one organization must house the human resources necessary to operate or supervise all phases of nuclear power production. The result is a unique talent bank of personnel with the capacity for the organization to be self-sufficient in its human resources. In most cases contractors, through their specialized competencies, extend or supplement skills that are already present within EDF.

E. Uniform Standards for Safety and Quality

The nuclear industry has come to recognize the complexity of the man-machine interface and how even small lapses in attention or work quality can have major impacts on operations or safety. At EDF, one response has been the recent effort to create a "safety culture." The aim is to incorporate in every facet of operations and maintenance a similar attention to detail and work quality.

To facilitate the "retour d'experience" and create its safety culture, EDF staff try to maintain an organizational climate that recognizes rather than penalizes errors and incidents. Problems are viewed not as opportunities to blame individuals for poor performance but as occasions for learning. The objective in this approach is to have an open climate in which problems will be revealed rather than covered up. EDF's non-firing policy contributes to this objective.

Through its extensive training program and certification of staff and contractors, EDF strives for a standard level of performance throughout its network of plants. Knowledge about safe operations is built into role requirements and written into training, operations, and administrative manuals. These are duplicated and used throughout EDF plants so when staff transfer between sites, they can rely, to some extent, on the task behaviors performed elsewhere.

F. Facilitating Change

EDF's experience feedback system creates opportunities for learning which to be successful must be converted into some form of organizational or technical change. Change can be facilitated through the coordinated development of technical solutions to critical events. However, job rotation between plants also encourages the transfer of managerial ideas and techniques.

When problems or incidents arise that have long-term implications which may mandate some form of change, EDF relies heavily on its own internal resources to develop recommendations. A very common mode of work is the Groupe du Travail (GDT). A "pilote," or group leader, is selected by a department or permanent committee of the College de Direction, and EDF staff from DPN/MC and plants are designated to participate. Groups in which higher level staff participate are named commissions.

These groups study both technical and managerial problems and offer solutions. Some groups continue to meet to follow-up actions taken or to renew their inquiry should their proposed solution fail to correct the problem. For example, there has been a technical problem with faulty fire detectors on 1,300 MW plants that a GDT studied last year. A technical solution was implemented but the problem has continued. Soon many of the same participants will join a new GDT to restudy the issue and review the changes that were tried.

This approach to change, based on rectifying defects, has several advantages. First, by requiring plant staff to work with DPN/MC staff, GDTs become opportunities for site staff to enhance their analytical skills, to stay current in their fields of interest, and to break from the daily routine of plant operations. Second, by involving site staff in the development of technical solutions and getting them to participate in the process, there is a greater chance that those solutions will be accepted by plant staff. Finally, GDTs draw upon the technical knowledge that already exists among EDF employees and provide formal mechanisms to monitor change and the need for follow-up.

II. DISADVANTAGES OF THE FRENCH SYSTEM

France's reliance on one large organization to generate nuclear power has certain disadvantages. Some derive from the industrial

structure, others from the history and mere size of EDF, and others pertain to the policy decisions that have been made, such as standardization. The following is a brief discussion on some of these disadvantages and their impact.

A. Overcommitment to a Specific Form of Technology

Unlike in the USA where power plants come in a variety of types and sizes, EDF depends heavily on specific series of PWRs designed and equipped by a limited number of builders and suppliers. A major drawback to the French approach is that generic problems may occur that have widespread implications. For example, in 1989 stress corrosion problems on steam generators caused major delays during planned outages at 1,300 MW plants. The "piquage" problem in the summer of 1991 required shutdowns at 13 of the 17 1,300 MW plants.

The most recent development has been the discovery in the fall of 1991 of cracks in the heads of the reactor vessels at three CP-0, 900 megawatt plants. Estimates of the cost to correct this problem at each plant range from 58 to 75 million U.S. dollars (3). Depending on the type of solution chosen (repair versus replace the part), it may take up to three years before the problem has been completely rectified (4).

Generic problems often raise other questions and produce decision

scenarios that demand accurate risk assessments in order to ensure safety. For example: how long should a problem once detected go uncorrected? does the existence of a problem in an older unit necessarily mean that the same problem will subsequently develop in a newer plant of the same series? If so, should maintenance schedules be altered or the frequency of inspections be increased?

Correcting many defects simultaneously may require that serious trade-offs be made between safety and national security because of the impact on electricity supply. (It is important to note that France depends on nuclear power for 75% of its electricity supply and this should increase once plants currently under construction come on line.) There is a limit to the scale of this type of problem since French plants, although constructed with a standardized technology, belong to different series (paliers) and are of varying age. Thus generic problems do not affect all plants with the same urgency. Correcting generic problems must be done in close coordination with EDF's dispatching and grid departments and in consultation with French safety officials.

There are two other potential drawbacks to reliance on a specific form of technology and the resultant heavy investment in fixed assets. First, the environmental demands of a specific type or series of plants means that there will be a limited number of

sites that meet all the necessary criteria. This requirement restricts the actual number of standardized plants that may be built.

Another potential problem is the relative ability to take advantage of new technologies as they become available. EDF staff have calculated that 60 - 70 years will lapse between the time that the first plant of a given series is constructed and the last of its series is decommissioned (5). Given the rate of change in technology and regulatory requirements, there is a real danger that plants can become inefficient relative to newer technologies or be unable to meet rising safety requirements.

Management must decide about how best to address such potential deficiencies through increased maintenance, periodic modifications, or decommissioning. For example, by 1993 all five of EDF's graphite gas reactors, the first of which was connected to the grid in 1967, will have already been decommissioned. Another approach is to conduct periodical safety reevaluations at older plants where up-to-date safety features can be integrated through design modifications.

B. Perception that Critical Decisions Are Made in Paris.

When I asked staff about how certain changes has been decided upon, a common reply was that a decision had been taken in Paris.

One shift supervisor referred to the "le salon de Paris" as where decisions were made. The presence of centralized headquarters staff who review situations that affect "le parc" lead plant personnel to think that critical decisions are made in Paris. The result is staff alienation and abdication from decision-making.

For example, at Alpha there has been a recurring problem of faulty fire detectors for the primary pumps, a problem that is generic to 1,300 MW plants. Senior safety and operating staff at the plant decided to shut down the plant so that a replacement detector could be installed. However, operating room staff thought that the decision had been taken in Paris. A similar scenario pertained to the changing roles of control room staff. The effect is to give staff a feeling that decisions affecting them are beyond their own control which reduces their own initiative and motivation.

C. Inertia

The size and configuration of EDF's operations makes it difficult to alter established norms of practice. For example, the tradition of centralizing decisions in Paris reflects the low sense of responsibility among site staff for plant processes and outcomes. Once decisions have been centralized, it is hard to give responsibility back to site staff.

The current emphasis on change and making site staff take on more responsibility is being blocked by two major constraints. First, site staff continue to have the perception that Paris is ultimately in control, so they have significant doubts about how much authority they can really exercise without higher level interference. Second, staff have been socialized into behaviors that focus on the achievement of well-specified levels of performance rather than on independent decision-making and risk-taking.

D. Whose Problem Is It?

When outages occur due to generic problems, that is problems resulting from standard design, construction, or modification work, the downtime is attributed not to individual plants but to "le parc" as a whole. In effect, the staff located where the problem resides is not responsible for its occurrence. Designing a solution to generic problems is also not the responsibility of site staff but is coordinated through the staff and resources at DPN\MC. Yet once a solution has been selected, its implementation becomes the responsibility of both site staff and oftentimes contractors as well.

The result of this process is that for generic problems their source, solution, and resolution are not the responsibility of any one person or group but are split among a variety of actors.

The lack of integration among these aspects of a problem can lead to delays in getting problems resolved. In effect, no one really owns the problem.

For example, EDF may delegate problem resolution to a contractor such that site staff feel no responsibility for when the work is completed. Inefficiency results as contractors get frustrated over a lack of interest or cooperation from site staff in solving what they perceive as an EDF problem. In effect, the diffusion of the principal elements of a problem can lead to social loafing.

E. Who Knows "What" First ? : Lines of Communication Within EDF and Between EDF and Outside Agents.

At EDF, the traditional lines of communication involved direct contact between plant and headquarters staff. Formal communications with external agents and organizations were handled solely by headquarters staff. This network became increasingly complex as EDF added plants and new sites. Meanwhile, the demand from the French media and safety officials for current information and rapid response to events has also grown.

One reaction has been the new initiatives towards decentralization and transparency. Now when events occur, site

staff may directly contact safety officials even before staff at headquarters is aware of any problem. Yet DPN/MC staff still arrange for maintenance workers to correct generic defects without coordinating such visits with site staff. Site staff may learn of contractor visits only when they must process paperwork and security clearances to allow them access.

The result of this complicated web of relationships is that information about a subject may not be evenly distributed among those departments which have a vested interest or direct responsibility. There may be instances of embarrassment, frustration, or decisions based on insufficient information. For example, EDF headquarters staff may receive a phone call about an incident from government safety officials while the FAX from the plant is still in an in-basket. Plant staff have details about local conditions which if known to headquarters staff could make a contractor better prepared for visiting a site. These conditions result from the geographic fragmentation and specialization of organizational units.

F. Standardization and the Emphasis on Internal Learning May Reduce Learning from the External Environment

France's standardization policy ensures multiple opportunities to learn from internal events via EDF's experience feedback system. However, EDF's 57 plants represent only 10% of the world's total

number of plants (6). Operational experiences outside of France may not be readily transferable on the basis of technical or cultural differences. This constraint and the emphasis placed on EDF's own experience feedback system may overshadow other learning opportunities.

For example, incidents that derive from organizational or human factors would seem to have worldwide applicability and provide a basis for EDF to learn as well. To expedite the transfer of information and experience, EDF has developed links with organizations, such as INPO, WANO, and individual plants have formed liaisons with sister plants in other countries. However, how or whether learning from such sources can be translated into behavioral change at EDF and institutionalized remains an unanswered question.

III. IMPLICATIONS

EDF is a very large and self-contained organization. It has the human and economic resources to pursue its stated goals and operates in a social and political environment that is mainly supportive. France's concern for national energy independence is mirrored in EDF's relatively self-sufficient capacity to generate nuclear power.

Many work organizations must act on the basis of conflicting

goals, and companies that operate nuclear power plants are no exception. Perhaps the most critical tradeoff in the nuclear industry is between safety and on-line production. My sense in conducting fieldwork at EDF is that this trade-off is not something that is of major concern to plant staff and even in some ways to headquarters staff as well. The emphasis and concern seemed almost exclusively oriented towards nuclear or systems safety, not production and efficiency.

Is this a win/lose scenario? With increasing economic pressures from EDF's external environment, the concern for efficiency will likewise grow. However, if safety and performance are perceived as directly trading off with priority placed on safety, then where will EDF obtain the capacity to be more efficient? Will the organizational changes currently being implemented at EDF ensure that a balance is maintained so that operations are increasingly more safe and more efficient?

EDF's decision to utilize nuclear power as France's major source of electricity is rooted in a national energy and industrial policy. To weigh the advantages and disadvantages of the French nuclear power system is ultimately a matter for the French public. EDF's nuclear power infrastructure is a long-term investment whose ultimate value can only be considered over a similarly long period of history.

NOTES

1. Pseudonyms are used to ensure the confidentiality of visited sites.
2. Based on 1988 data.
3. EDF: La panne de l'hiver. Le quotidien, 15 November, 1991.
4. Cracking in vessel penetrations called EDF's "most serious" ill. Nucleonics Week, 21 November, 1991.
5. Giraud, Bernard; What makes a successful nuclear program? The French standardization policy. Manuscript.
6. Based on 1990 data furnished by the American Nuclear Society.

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