Systemic Impediments to Constructing Energy-Efficient Commercial Buildings

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ABSTRACT:

Exploring a systems-based view of the energy efficiency roadblocks faced by financiers, builders, owners, and tenants.

In 1992 Amory Lovins, founder of the Rocky Mountain Institute, wrote a paper entitled "Energy-Efficient Buildings: Institutional Barriers and Opportunities". In it, he detailed roadblocks to constructing energy efficient commercial buildings- from the fear of lenders to finance the unknown, to developers unmotivated to instill efficiency, to mechanical engineers specifying job-securing (and commission-increasing) safety margins when (over)sizing the apparati- every step of a commercial building's genesis is fraught with status quo and timidity.

Now, almost 25 years later, we will take a look at what has changed, what hasn't, and what areas still need incentivizing to get on a sustainable track towards efficiency. We model the systems to exhibit the persistent resistance to changes, the extraordinary pace with which some markets have embraced change, and the feedback mechanisms that can make efficiency both possible and profitable.

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INTRODUCTION

I. Why This Topic?

I have always been interested in efficiency of one kind or another. The prudent use of resources has no monetary base in my mind; it is simply how it should be- derive maximum benefit from minimal volume of resource. I am not advocating for a Spartan existence; only that the energy consumed should be the minimal of all available options to satisfy the need. Therefore when I began a home remodeling business, I focused on investing in materials, labor, design, and operations that would minimize the energy consumption and maximize the efficiency of the dwelling, while also maximizing the targeted effect of a resource's consumption on the intended recipient.

The topic of energy efficiency in commercial buildings was already the top contender for my thesis work when I came across Amory Lovins' paper "Energy-Efficient Buildings: Institutional Barriers and Opportunities"[i] during Harvey Michaels' "Energy Efficiency and Smart Grid Strategies for a Sustainable Future" Sloan offering. It was decided an update would make a viable and worthwhile endeavor. In the paper, Lovins talks about both commercial and residential, but because there are more efficiency-effectors in a commercial building, he concentrates on that market, and I focus solely on it.

II. Lovins' Assertions

He starts by talking about the financing and design realms, and how they are stuck in a stagnant reward loop of only doing what they know. This ensures repeatable execution of a business plan that works financially, even though it doesn't maximize its potential in net present value were efficiency part of the picture. There is more to be gained inside their vocational realms, and much more to be gained for the ecological realm as a whole, which benefits everyone.

Even after the design is done, Lovins talks about the builders capitalizing on the ambiguous and unchecked "or equal" contract phrase to install less efficient materials, and the operators of the new building not being trained in the new systems, which often perform worse than properly operated less efficient buildings. The occupants also never seem to get instruction on the operation of their building, and if they do, any feedback of their adjustments is rare, and usually delayed.

All these steps in a building's life present an opportunity to effect efficiency, and Lovins asserts that they're mostly mis-steps. He goes on to lay out the requirements necessary to correct these mis-steps by reinventing the building design, construction, maintenance, and operation processes. By restructuring fees paid to the designers, educating all the trades involved in the building's construction, and moving away from a passive "rule of thumb" modus operandi to a more active, results-driven, results-compensated model, the building process will have the emergent property of actually being efficient and operating as designed, while costing less to operate, thus paying back any upfront efficiency-related costs.

III. A Brief History of Efficiency

The Earth Day momentum from its inception in 1970 was mostly forgotten during the recession of 1975 – 1982. The materialistic excess that followed during the recovery did little to remind people of the effect they were having on the planet. Energy and resource use grew to fuel the economic recovery and the social trend of conspicuous consumption.

In 1990, the Earth Day organizers launched a massive marketing campaign for the 20th anniversary event. This came at a time when other social trends were also starting to change. Pop music went from diamonds and mirrors to flannel and jeans. Hippies became empty nesters and started re-thinking their values and returning to their roots. And many of the "haves" from the previous decade started realizing the effects of their ways. This marked a turning point in the environmental conscience of the OECD nations, one that has continued to gain momentum in many slices of the populace. However, turning such a giant ship around is a long and arduous process.

IV. Today and Beyond

Today, we have fuel-efficient cars, community recycling, certifications of raw material origin and purity, and energy ratings on appliances from programs such as Energy Star. "Save the planet", today mostly in the form of climate change, is on the mind of many consumers, and hence the producers, but this is mostly implemented only in two places – small consumer products where marketing and supply chains are already entrenched and can be slightly "greenified" at little expense, and in some B2B markets where the actual economic cost of efficiency is realized at the bottom line, as in fueling airplanes and cargo ships. It is still a very rare appearance in one very large energy sector- commercial buildings- largely because the provider of the energy-using components is often decoupled from the user of the energy. Hence, the provider has no incentive to offer energy-efficiency, and the users know not that they can ask for it. This is a huge untapped resource for long-term, positive-feedback energy savings. Lovins' paper touched on many of the processes necessary for the implementation of these efficiencies, and regulatory standards have been put in place at the federal, state and local levels, but the social and B2C aspects are still nascent. The tenants' ability to control their environment, and to have immediate feedback on the effect and cost of their actions, is still an extremely unusual occurrence, and yet is central to a building's efficient operation, as well as management-beneficial, long-term tenant retention. This lack of awareness needs to be instilled in the tenants' mindset so that the financier-designer-builder-owner ecosystem has an incentive to implement efficiency measures.

According to the US Energy Information Administration's 2012 Commercial Buildings Energy Consumption Survey[ii], there are now 5.6 million commercial buildings, comprising 87 billion square feet. While new construction needs to adhere to efficiency standards, half of these buildings were constructed before 1980. Because of the typical 2 year payback requirement for capital expense (CapEx) investments, expensive, disruptive, and time consuming energy retrofits are low on the to-do list of building owners and managers.

We will now explore Lovins' paper in detail; his assertions and suggested remedies, and we will lay out what has been done so far. Then I will give my own ideas of where we need to go, and how to get there.

BODY

I. Lovins' Issues

1. Project Origin and Financing

Developers and Investors build what the market, that is, the buyers/owners/managers, want- minimal Capital Expenditure (CapEx) per unit of Marketable Floor Space. Developers, a short term owner, seek maximize NPV which ends with resale. Operating Expense (OpEx) is a very minute factor, coarsely evaluated on the "coal or natural gas?" scale, not R values, tons/sf, U values etc.

The concept of lower CapEx for efficient materials is foreign to many owner-occupiers- efficient equipment *should* cost more. Lenders, unfamiliar with "new tech" and anxious to get the commission, may reject innovative designs that will require time and investigation to vet. The status quo gets passed and signed quickly, and quick turnaround means the next deal can be worked on sooner. Commercial appraisers rarely know about efficient designs, so even if the downstream players were to value the low OpEx building more highly, this value is not included in the appraisal.

2. Design Process and Method

Many players (developer, landscaper, site planner) lay down designs before the architect is brought in, therefore the architect is constrained in siting an orientation that would enable efficiency. Additionally, the architect themselves may not be compensated for the time involved in an efficient design, and can only realistically do what makes the client happy, which is much more a good first impression of aesthetics and comfort than long term efficiency or OpEx.

The architect often outsources mechanical systems to a consultant before the occupancy loads are known. The siting details aren't passed on, so the environmental loads are also unknown, therefore they can do nothing but design for the worst case. Each party involved in the chain does their own bit of rounding up, leading to oversized mechanicals.

The buildings don't undergo dynamic thermal simulations, so the thermal buffering of the building's mass also goes un-factored into the load calculations, adding to yet more oversizing.

Mechanical designers typically leave the equipment sizing to the manufacturers, a clear case of conflict of interest. And since most manufacturers bundle systems together in common packages, component optimization isn't exercised. And the absent manufacturer will also add in a bit of rounding up, just to be sure.

"Just in time" design necessitates a linear flow, with no feedback or collaboration, eliminating the possibility of inter-system discussion and matching up of intentions. There is also a social dynamic of not wanting to embarrass anyone by calling out their choices, lest you need that person for the next job. So when the mechanical engineer is last on site before the shell is closed, instead of pushing back on the architect that the proper sized ducts cannot fit where needed, they will be made to fit, somehow, despite the resulting restrictive flow that will unnecessarily consume energy for the entire life of the building.

3. Dis-integration of Design

There is no conductor for this orchestra. Every system is designed almost independently- the fenestration is not factored into the lighting needs, and the lighting load is not factored into the cooling load, the cooling load is not derived from the lab venting load, and so on. The individual players all speak different languages, so even if they did want to communicate, they can't. They all see the building through a different lens- a financial structure channeling money, a physical structure channeling energy, etc. As with the aforementioned mechanical engineer, the further down the design-build process things get, the costs of making basic efficiency changes increases steeply, while the effectiveness dramatically decreases. The architect, late to the game and saddled with being the point of contact, is now too overloaded to effectively make decisions within the time frame they're being compensated for, so items are prioritized by a logical and litigious order – safety, aesthetics, functionality. Efficiency is far down that list.

4. Design Sequence

Mechanical designers are also called in late, by (and hence, after) the architect, and now have to shoehorn a system into a "preordained three dimensional maze". This results in long, circuitous ducts with lots of resistance to flow, necessitating larger fans, poor access, and cost far more in time and money than it would have had they been involved in the initial design.

5. Design Incentives

Most designers, especially mechanical engineers, are given neither the time nor budget to learn to innovate. The trade groups do a good job of trying, but it's the manufacturers who impart most training, usually on a crisis their products can solve, not to advance the field. Architects' fee structures are not set up to allow for innovative mechanical design, or to inspect for efficiency afterwards. Litigation concerns are quickly and easily addressed by oversizing and conformity. Payback for efficiency is non-existent- bids are still evaluated on price, not qualifications, despite changes in ethics reform in the 1970s. And price is still a percentage of project cost, even though this *appears* to have outwardly changed. Designers' fees are supposed to be based on qualifications alone, yet that is often nullified by the post-selection negotiation process, where costs are evaluated and compared.

6. Substitution of Packaged Units for Design

The fast turnover of real estate has obviated any incentive for a custom-designed chiller setup, and manufacturers now supply pre-packaged units that can be easily and quickly dropped onto the roof. The trading of OpEx for CapEx has resulted in non-innovative "catalog engineering". Any designer that tries to innovate is quickly priced out of the market, or ends up losing their shirt. Occasionally, a forward-thinking client will demand a certain performance, but this is rare. Value is added not in engineering prowess, but in bang for the buck, quickly selected equipment. An oversized chiller will perform the job for $x, whereas designing a proper cooling system with a smaller chiller costing $0.8x would cost $3x in design fees, despite the long term operation of the smaller chiller saving $100x in operating costs.

7. Construction

Once the designs are in place, construction starts, but that doesn't mean the inattention to efficiency is over. The building contractors are under pressure to build to a schedule and cost, so when something isn't available, or is unfamiliar and might take time to learn to install, they revert to the "or equal" clause in the contact, allowing them to substitute sometimes unknowingly less efficient items for the specified ones. Inefficiencies are also added during construction because many things will be buried behind walls and never scrutinized, allowing for poor workmanship and improper substitution, especially if no one on the job site can reconcile a design question. Also, many contractors are not trained in the theories of how their actions affect efficiency, so even if they were motivated to do the right thing, they might not know how to do the thing right.

8. Commissioning

Once construction is finished and commissioning phase begins, there is usually a wave of urgency that has been building from time and cost overruns since the beginning. There is tremendous pressure on the commissioner to sign off on the building so tenants can get in and start generating revenue. Therefore any last minute issues are corrected as quickly and as bluntly as possible, often negating any efficiency process and controls that may have been snuck into the process. If the commissioning agent presses for issues to be resolved correctly, there is rarely any leg to stand on. Warranties are not usually offered and often unenforceable. Equipment such as chillers are rated either in a lab, or with "nominal" numbers like lumber.

9. Operations and Monitoring

At the end of this chain is the user. Either the individual tenant, or the building operator, has control over the operation of the building. And they both have little to no instruction on how to use the systems. Operators have no incentive to operate the efficiency aspects of the building if it takes more effort or if no one is complaining, and tenants have no knowledge of the options available to them. Or worse, complaining tenants who are sated cause even more tenants to complain and generate an opposite reaction. The buildings have no monitors or sensors, so the operator can't verify the conditions, resulting in the operators giving up and no one being comfortable, all while using more energy than would be used if everything were operated properly. With no post-occupancy evaluation or remote monitoring, the building never gets corrected, and everyone is unhappy.

10. Post-Occupancy Evaluation

Similar to operators, occupants are largely ignorant of how buildings work and how much they can influence the operations and management staff. Tenant satisfaction is rated by lease renewals, a narrow and imprecise measurement. Buildings today are made like American cars before Japanese competition dragged them forward. There is no tenant feedback and therefore no loop closure in the building ecosystem. Any system without feedback is doomed to fail.

11 Maintenance

Even in the best of worlds, where all efficiencies are designed and implemented and operated correctly, this necessarily unusual system will break down like any other system. The maintenance staffs are complaint-driven. Unless someone complains, the building can be operating well below its efficiency design and nothing will be discovered. Or, if disabling a complicated control addresses the complaint, often coming from a tenant who doesn't know that "good enough" is really much worse than the building can provide, the control will be disabled instead of the systemic issue being addressed.

12 - Suppliers

When an operator can't resolve a problem with a new, efficient/hi-tech system, the resulting service call and likely parts replacement is not going to be a timely, like-for-like job; it will be a confused tech looking at an unfamiliar system, requiring a part no one has in stock, and either the affected system is inoperative for 1-2 weeks while the part is sourced, or an "or equal" part is substituted to get the system up and running. Sometimes that "part" can be a substantial portion of the system. Much of the efficiency of that system is now eliminated, or worse, generates more inefficiency than would have been present in a typical system.

13 – Leasing and Sales

Commercial leases involve 3 parties- the landlord/owner, a broker, and the tenant. The landlord's energy costs will be paid by the tenant and buried in a gross use charge. The broker is there only to make the deal happen, and uses rule of thumb energy costs when writing up the deal. There is no incentive on anyone's part to enact any efficiency measures. Tenants are often ignorant or fatalistic about utility costs. Additionally, many leases allow for the tenant to modify the property, sometimes extensively, eliminating any control the owner/landlord might have over the efficiency of the building. In some places, landlords are allowed to mark up a tenant's utility bill, creating a profit center and a DIS-incentive to enact efficiency measures. It's worse in multi-tenant buildings, where tenants are charged a flat rate per square foot, penalizing the efficient.

Conclusion of Lovins' Statements

All these operators are part of a system that is coupled for speed and inefficiency, and coupled against effective design and positive feedback. Now we take a look at the state of the industry 25 years later and see if anything has changed.

II. Lovins' ideas on changes

1. Restructuring Design Professionals' Fees

Allow discussion of fees, or fee structures, to avoid DOJ issues. Educate clients to demand efficiency, perhaps by multiple scaled "options" with associated CapEx vs OpEx costs. This is a market based approach, no externalities. Utilities should pay rebates to designers for energy saved compared to a baseline, instead of to efficient equipment replacement only, and also pay them a portion of the actual energy saved over the years as compared to baseline.

2. Strengthening the Design Process

Design process needs to be re-integrated. Use a Design-Build method, involving all players from the start, aiming for the total present valued life cycle occupancy cost as their goal. Educate developers about the cost savings in CapEx by specifying smaller systems and the gains from occupant economic output from working in a more comfortable building – occupant salaries cost ~160 times as much as the operating cost of the HVAC system. HVAC costs are also 14% of a buildings operating income, so there is incentive to lower it.

Competition over lease costs can be as little as 0.10 / sf, yet the OpEx can be 10-35 times that high.

3. Educating Investors and Developers

Designers need to learn the leverage capability of efficient design up front vs. long run operational costs. Present-valued energy costs can be comparable to the building's entire cost. Marginal increases in CapEx can generate multiples of OpEx savings in both fuel, rent, and tenant productivity.

4. Professional Education

Trade groups like ASHRAE, ASME, AEE, IES all are good at small things but they need to dive deep and talk about integration and have rigorous efficiency standards. We need university level education, and AIA to reinstate some form of their defunct Energy Committee. We need a "Negawatt"[iii] university.

5. Rules-of-Thumb

They don't take into account the changing loads of efficiency measures such as low heat lights (LED, fluorescent), coated glazing, LCD monitors. They don't address the fact that smaller mechanicals equals more rentable space per floor, and more floors per total building height. They assume outdated costs of utilities and high discount rates on equipment that masks its electricity price signal by tenfold.

6. Design Tools

CAD needs to be improved to include efficiency. Tools like DOE-2, BLAST, and TRACE do not adequately simulate the detailed performance of systems.

7. Risk-Sharing and Flexibility

Publishers of standard reference materials such as R. S. Means and ASHRAE will need to revise their Rule of Thumb concepts. Good engineers' work is refused because know-nothing reviewer sees it doesn't comply with Rule of Thumb in the reference. Tenants and developers need to re-write lease terms, and ease liability concerns to enable designers to innovate. Engineers need to build in flexibility using collaboration and risk-sharing, such as HVAC pads and stub-outs for future load needs, instead of initial oversizing.

8. Design Support

Some utilities now provide design assistance, but it's usually topical – lighting OR heating, and is never implemented early, always too late. Effective time to implement design rebates works only if the utility is brought on early.

9. Marketing Support

Utilities have an opportunity to market efficient buildings directly to tenants and help close the disconnect. Feebates, points systems, or builder-brokered incentives for tenants can all be looked at.

10. Performance Contracting

Succeeds on the ability to align incentives and goals. Energy Service Companies (ESCOs) initially floundered because the cost of doing business often came close to or exceeded the value of the energy savings. Also tenant turnover created constant renegotiation costs. Utility Demand Response incentives paid to ESCOs helped alleviate that. Also, initial ESCO contracts focused on conservation, not efficiency, which led to incompatible interests. Same with lighting contracts- kwh saved instead of kwh/lumen-hour. Need to align incentives.

11. Other Contractual Issues

Ambiguous phrases like "high efficiency" and "or equal" phrase needs to be eliminated; it doesn't mean "equal or larger". Every component needs to be specified: wiring sizes, valve types and makes, etc., with sanctions for non-compliance, and contracts should provide for full commissioning to ensure compliance.

12. Operations and Maintenance Practices

Operations and Maintenance (O&M) needs to be revised. Poor design with good O&M will usually outperform good design with poor O&M. A bad user interface on controls and monitors can thwart the best O&M intentions, but most buildings have neither. Maximize sensor use and data collection, using e.g. ASHRAEs Building Automation and Control Network Protocol. Need replacement parts locally available. Need trained people.

13. Leasing Practices

Need lease terms reform. Current practice is to collect rent, which includes a flat fee per square foot for utilities, and pay utilities from that. Utilities should be separately annotated per tenant. Efficiency projects should benefit both tenant and owner, and implement equitable allocation of saved energy & maintenance costs. Eliminate free-rider tenants (must renegotiate lease terms or do like-for-like upgrade). Utilities should publish typical costs/area of buildings so lessees have a baseline to shop from. Revise lease provisions to require ASHRAE comfort standards using efficient numbers (such as 1w/sf for lighting instead of the antiquated 5 or 6).

14. Research Infrastructure

Few research facilities dedicated to efficiency, most are trade groups with limited funds and competing agendas. Something like the National Institute of Building Sciences, along with a "golden carrot" of first to market products, more are needed. More communication between groups and researchers, and more funding, is needed.

III. Actual changes as of today

With energy and climate issues achieving headline status weekly, there is no shortage of personal and corporate drive to "go green". The lack of education on the feasibility and methodologies of implementing it is now the greatest impediment, since there is still so much "old school" inertia in the way projects are thought out and done.

1. Restructuring Design Professionals' Fees

The utility-backed rebates as part of the restructuring of design fees are gaining momentum, and a few states' utilities have encouragingly comprehensive design-rebate programs in place. For instance, in California:

> *The Savings by Design program[iv], offered by PG&E, SCE, SDG&E, and SoCal Gas, as well as the Sacramento Municipal Utility District (SMUD), provides two incentive tracks for integrating energy efficiency measures into new construction and major renovations, the preferred whole building approach and the systems approach. The program offers building owners and their design teams a range of services, including design assistance, owner's incentives (up to $0.40 per annualized kWh and $1.00 per annualized therm savings), and design team incentives (up to $50,000, plus an extra $5,000 stipend for early collaboration). Owner Incentives include a separate 20% bonus for incorporating end-use monitoring and a 10% bonus for enhanced commissioning. The maximum total incentive per project is $150,000.*

The design team qualifies for an incentive when the building design saves at least 10% over the Title 24 Energy Efficiency Standards. Savings By Design also encourages a team approach to design, to incorporate synergies not present with individual system efficiency efforts. The rebates are on a sliding scale form $0.033/kWh for 10% over baseline, to $0.10 at 30%. Over 30%, the design team is eligible to receive 50% of the rebate upon design acceptance by the utility, vs. receiving it upon construction completion.

The Savings By Design program also offers design assistance by means of access to resources for efficient design, and owner incentives which are discussed later.

Arizona Public Service Company also has a design-based rebate program:

> *Our whole-building rebate encourages design teams, building owners and developers to design and construct buildings that perform at least 10 percent better than baseline.*
>
> *Building owners and developers may apply for a studies rebate to offset 50 percent of the cost of performance modeling—up to $10,000. Simulation modeling software must be used.*[v]

New York State Energy Research and Development Authority (NYSERDA) has a similar plan to the others, with not only design incentives, but also technical support rebates, low cost lending, and whole building design[vi]. Below is the schedule for their design rebates:

Design Team Support (For Whole Building Design projects)	
Designs 3% to 9% above designated baseline*	$25 per peak summer kW saved, maximum $3,400
Designs 9.1% to 16% above designated baseline*	$40 per peak summer kW saved, maximum $5,000
Designs 16.1% to 23% above designated baseline*	$55 per peak summer kW saved, maximum $6,700
Designs 23.1% to 30% above designated baseline*	$70 per peak summer kW saved, maximum $10,000
Designs 30.1% or more above designated baseline*	$90 per peak summer kW saved, maximum $15,000

The Department of Energy maintains a list of states with links to each top level energy efficiency program[vii]. The individual programs are quite varied and sometimes a bit of a morass to navigate, but never has the effort to consolidate them been more concentrated, especially with more programs available than ever before.

2. Strengthening the Design Process

The design process, long dis-integrated, is now largely, but not completely, re-integrated for commercial projects. The emergence and dominance of design-build contracts over the more decoupled design-bid-build provides a more integrated, communicative and systemic process where efficiencies of individual components are matched to provide a whole that is greater than the sum of the parts. According to one architect I interviewed, who works largely on public commercial new construction such as Department of Public Works buildings and police stations, LEED has been a large impetus for engendering the cohesive design process throughout the industry. This is evident in the proliferation of the design incentives of section 1, which often stipulate that a systems approach much be followed to extract the maximum synergy from the teams' cooperation.

In addition to design-build, another form of centralized construction management is Construction Management at Risk (CMR). In CMR, the client hires the construction manager on qualifications, and also the architect, who both collaborate, and the CM gives the client a set price for the project and then assumes all risk and hires all subcontractors. This method results in a faster project speed, greater cooperation of all involved, and greater transparency since fees are open and therefore bid shopping is eliminated.

According to the Design-Build Institute of America (DBIA), market share of combined DB and CMR projects increased from 35% in 2005 to just under 50% in 2013. If that data is inclusive of $10 million projects and above, that number is over 50%. The west coast leads the country with the state of Oregon at 70% of non-residential projects being design-build, California at 59% and Washington at 56%. The military is the highest by sector at 81%[viii].

At the 2010 DBIA conference, participants were asked to rank the benefits of design-build perceived by their clients. "Single point of responsibility" was chosen by more than a 2:1 margin over the next responses (fast delivery of the project, lower overall costs, greater focus on quality). When asked about the impediments to using an integrated design-build approach, the responses were unsurprising:

- Owner is unfamiliar with DB and finds it risky
- Owner perceives a loss of control
- Owner perceives a cost advantage from design-bid-build
- Utilization of design is difficult under current laws

Clearly the main impediment is again education, with policy change also a requirement (and policy change often requires education as well).

3. Educating Developers and Financiers

The first link in the chain of commercial construction is the investor. Traditionally, implementing energy efficiency was expensive, difficult to come by, and in the rare times it was viewed as an investment at all, suffered from an incorrectly calculated and shortsighted 24-month ROI requirement. However, word has begun to spread touting the benefits. In a 2004 Commercial Investment Real Estate (CIRE) magazine article, author Ken Pientka talks about investing in sustainable design[ix]. He mentions that tenants are starting to be attracted to the lower operations and maintenance costs brought on by efficient HVAC and lighting systems, and water-conserving fixtures.

> *"Green buildings first were promoted primarily for environmental reasons. Designs involved high initial capital costs, specialized teams, and uncommon equipment and building practices. Government agencies, universities, and nonprofit organizations were early adopters of sustainable design, using subsidies and grants to offset more-expensive building costs and recouping the return through long-term occupancies.*
>
> *Today, sustainable design is moving into the mainstream as more corporate tenants and owners, as well as speculative building developers, discover the value created when minor upfront capital costs and short payback times increase lease rates along with tenant attraction and retention. In short, sustainable design makes sense."*

He also addresses the afore-mentioned item regarding worker productivity in a more comfortable building, equating a 1% increase in worker productivity to the annual cost of the energy use by that employee and their space. "Because employee annual salary and benefit costs far outweigh a building's annualized energy, operations, and maintenance expenses, productivity gains can positively affect a business's bottom line." Happy employees tend to stay longer, reducing costs associated with talent search and sub-optimal headcount. There is also the customer satisfaction/impression aspect of a comfortable “green” building.

Also mentioned is the need to look long term at how reduced O&R costs affect the net operating income, and how that creates a higher valuation now, and how appraisers are catching up to realizing the present value embedded in efficient design and operation.

4. Professional Education

Professional Education via the rise in Energy Modeling. Building Energy Modeling (BEM) has been around since 1925, but was largely a niche field until the 1960s when some papers on heat transfer through walls were written by Mitalas and Stephenson. Since then the field has grown in step with the advancements in computer technology, on which it is heavily dependent. Since 2000, the field has seen, according to the Building Energy Modeling Book of Knowledge article on the History of Energy Modeling, “...remarkable growth in the BEM industry, primarily driven by more stringent building standards and a growth in voluntary certification programs.” Out of this field have grown many, many organizations related to the energy modeling field, most now with different and specialized agendas but still solidly in step with the spirit of energy modeling. The pertinent ones are listed here along with the breadth and depth of their educational efforts:

ASHRAE - American Society of Heating, Refrigeration, and Air-Conditioning Engineers (1959). Published Standard 90.1 – a building performance rating method requiring the use of computer simulation software, has become a US standard. They provide extensive training in 90.1 and general HVAC-R design and operation, utilizing classes, group, and self-directed learning. ASHRAE also publishes The Handbook, an industry reference manual continuously updated since 1922.

AIA – American Institute of Architects – this major trade group has AIA University, which offers classes to members and non-members on many topics including Building Science.

AEE – Association of Energy Engineers – founded in 1977, this field was small until recently, and now Energy Engineers are now not uncommon in new construction projects. They offer a suite of seminars in almost any real or virtual configuration.

ACEEE – American Council for an Energy Efficient Economy – around since 1980, they aren't a trade group per se, but a clearing house for all things efficiency. They offer a summer study series, as well as a slew of publications on many efficiency-related topics.

DBIA – Design Build Institute of America – Founded in 1993, they promote the use of a single contract between the project owner and the design-build team, ensuring an integrative approach to the project. They offer certifications as well as a plethora of training options, and are the trade advocate for a systems approach to construction.

IBPSA - International Building Performance Simulation Association – Promotes the science of building performance simulation with journals, student competitions, and regional chapters worldwide.

DOE – Department of Energy – the governmental entity that promotes and incentivizes efficient use of energy, with a wealth of resources from national labs to the Better Buildings Initiative, Building Technologies Office, as well as the Advanced Research Projects Agency – Energy (ARPA-E) which advances early-stage technologies. The DOE is a wealth of information regarding all aspects of energy use not only in commercial buildings, but in every field where energy is used.

USGBC/LEED – U.S. Green Building Council/Leadership in Energy & Environmental Design – founded in 1993 as to promote sustainability in the building and construction industry, it has grown phenomenally and created the LEED certification system in 2000 as a way to rate buildings' "green" performance according to a wide range of flexible criteria. Today they have one of the most recognizable certification suites and a wide availability of training to prepare for the certification tests, as well as lots of general information on sustainable building.

5. Rules-of-Thumb

Eliminate rules of thumb At least one company is referencing old rules of thumb[x], and despite a caveat on their website that users should always verify the values, they link to a Naval document CR 82.030 from 1982 entitled "Standardized EMCS Energy Savings Calculations" . However, this points to a lack of education on the part of the company, not a reflection of state of the art. With the trend in collaboration and design-build, coupled with the increase in design rebates from utilities for projects that employ a systems approach to building, the prevalence of contractors using obsolete rules-of-thumb is going down. The efficiencies won't be realized, and the group will suffer as a result, so there is an element of peer pressure to retire this method.

However, there still needs to be a method of quickly estimating energy use and mechanicals layout that is more accurate than the rule of thumb method, but faster than a detailed assessment of a space that isn't even designed yet. In 2012, ASHRAE addressed the catch-22 of needing to know the basic mechanicals size early on in the project, during the design-build competition.

ASHRAE had previously developed a few fast-calculation methods for cooling loads, and in 2001 merged them to create the Radiant Time Series (RTS). RTS "was derived from fundamental heat balance calculations while maintaining simple concepts and component-by-component results". In 2003 the ASHRAE Technical Committee prepared a real-world example of a quick load-calculation spreadsheet to use in their Handbook as an example. Originally intended for educational purposes, these spreadsheets have grown and been updated with glazing, orientation, and climate calculations, and now are a very useful tool to quickly estimate building loads during the RFP stage, when there isn't time to do a complete evaluation. These spreadsheets have also obviated the use of rules of thumb which no longer apply in today's complicated building environments.

6. Design Tools

Design tools have made great strides in not only being able to incorporate HVAC-R components into a structure plan, but also in calculating the energy use. The most significant of these is BIM- Building Information Modeling – a 3D representation and abstraction of all components of a building. Each component (a duct, a wall, a lighting fixture or complete wiring schematic) is an individual entry in a BIM file and can be added to a group of components, which can then be sent to the individual implementers (plumbing contractors, civil engineers, etc.). The components are also related to their environment, so that when the environment changes, the components' relationship to them changes with it. This requires BIM-capable software, which should be present in every commercial building contractor office if they want to bid on a project. BIM use extends throughout the life cycle of a building's construction and use, supporting cost, construction, and project management, as well as facility operation. [Wikipedia].

ENERGYPLUS (formerly DOE-2, BLAST) – DOE-2 and Building Loads Analysis and System Thermodynamics were both developed in the 1970s, coming out of the Department of Energy and the Department of Defense respectively. Created in 2001, EnergyPlus has taken the best features of both and merged them into one program, plus the addition of modern tools incorporating technologies that post-date the two older programs. This integration specifically addresses some deficiencies such as inaccurate prediction of indoor temperatures for undersized HVAC systems, free cooling using outside air, realistic system controls, moisture adsorption and desorption in building elements and radiant heating and cooling systems[xi]. In addition to modernizing the calculation engine with items such as coil fouling and zonal air infiltration and mixing, it has been converted from FORTRAN to C++, and added 64 bit versions for new computing platforms.

Also, the DOE maintains a Building Energy Software Tools Directory[xii] with, at this writing, 417 tools in various categories such as whole building analysis, codes & standards, materials, equipment, systems, economics, and pollution. They also offer links to training.

7. Risk-Sharing and Flexibility

Standards publishers been updating their references on an increasingly frequent basis. ASHRAE voted in 1999 to place what is now Standard 90.1 on continuous maintenance, allowing it to be updated several times a year. R. S. Means Co., the costing publisher, now has their products available in online format where they are updated quarterly. With the trend towards collaboration in full swing, these numerical data are available for all involved to see, creating an open atmosphere.

This atmosphere also promotes, as has been mentioned, the fostering of inter-component efficiencies, which in turn bolsters the right-sizing of equipment, making it much less likely a candidate for rejection because it didn't meet an outdated rule of thumb. This works well with technically adept top publishers, but care needs to be taken when using hardcopies such as textbooks, which aren't reprinted frequently due to their cost.

With single point of contact becoming a popular method of project structure, the liability fears of wrong-sizing equipment is removed from the owner and placed on the DB or CMR firm, and the oneness is on them to ensure the specified mechanicals will be matched to the load. The concept of engineering flexibility, or "real options"- using a chiller sized for current loads but installing pads and stub-outs for future possible increased loads, is cheap insurance against liability issues.

8. Design Support

Utilities have ramped up their design assistance, as has been stated earlier. A few are also taking a more active role, earlier, to enhance the efficiency components of new construction. One architect I spoke with who works on Massachusetts' town public buildings said the utilities call to talk about the project and offer advice and assistance on ways to cut energy use, ostensibly through efficiency. However most are still in a very reactive role, likely because of the expense and detective work involved in seeking out very early stage projects. They could conceivably coupe with the building permits departments and have their awareness triggered from that, but governmental agencies and utilities are both traditionally slow moving.

9. Marketing Support

Utilities have an opportunity to market energy efficient buildings, but they usually aren't in contact with the tenants until after the lease has been signed. There isn't a channel between utilities and _potential_ tenants other than a mass marketing to create a general social awareness that tenants should consider the efficiency as part of the lease considerations. However, this isn't to say that marketing in general hasn't worked. LEED, far more than any other entity, has exploded the marketing segment with their rating system. While this doesn't apply directly to utility marketing, it results in the same ends, and because the Green Building Association has marketing and efficiency branding as prime activities, it is much more focused on the efficiency target that a utility can be. Utilities may be coming around to selling efficiency first, energy second, but that is a very large ship to turn around. Meanwhile, utilities could likely do a better job of efficiency program outreach if they partnered with programs such as LEED, than trying to go about it on their own.

10. Performance Contracting

Energy Services Companies – ESCOs – have blossomed since the penning of the original paper. The business models have been mostly worked out and new ones are coming up as new technologies become available. They even have their own trade group – National Association of Energy Service Companies (NAESCO). On the Department of Energy's Qualified List of Energy Service Companies, there are over 100 ESCOs, from small companies to large energy-related companies such as Schneider Electric and Johnson Controls, to traditionally non-energy ones like Lockheed Martin Corporation.

In 2010 Lawrence Berkeley National Laboratory (LBNL) conducted a survey entitled "A Survey of U.S. Energy Service Company Industry: Market Growth and Development from 2008 to 2011".[xiii] The report looked into the growth trends, market segments and activity, and the implications for policymakers.

The estimated size of the ESCO industry in 2008 was $4.1B, achieving an annual 7% growth despite the economic turndown. While these were less than expected, the positive growth rate was a good sign considering the country's economic downturn. The 2011 revenues were projected to be $7.3B, a 26% annual growth rate. The largest market for ESCOs, at 69%, was the Municipal, University, Schools, and Hospitals (MUSH). Second largest at 15% was the Federal market, which actually shrunk from 22% in 2006, likely due to the growth in MUSH from 2006 at 58%. Roughly 75% of that revenue came from energy efficiency projects, and 70% of those EE projects were performance-based contracts. In addition to the typical ESCO business model of realizing and financing future energy savings in the present, these contracts were enabled by legislation and procurement requirements that allow long-term, performance-based contracts, something not seen in the private sector.

A 2011 article in Forbes talks about how the MUSH market was what sustained many ESCOs through the downturn, and in part specifically because of the downturn[xiv]. Cash-strapped municipalities embraced these performance-based investments in efficiency because of the guarantees provided by the ESCOs. The ESCOs, in turn, could provide these guarantees because of ARRA incentives embracing efficiency projects.

The LBNL article goes on to say that ESCOs are installing a more comprehensive mix of technologies, and they expect that trend to continue. Driving this is the increasing implementation of ratepayer-based energy efficiently program that fund comprehensive efficiency efforts, and continuing government initiatives. This increase will also drive up the size and cost of ESCO projects, increasing their bottom line, growing the industry as a whole, which will generate more awareness of ESCOs and the benefits they bring.

However, according to a 2013 Navigant report, since 2011 the ESCO industry has been in decline[xv]. Customers were concerned about the impact of performance contracts on their bottom line during the poor economy, and supportive policy measures that drove growth prior to 2011 dried up. They do predict that with the current rebounding economy, the ESCO market will pick up once again, especially for the ones that can capitalize on the growing demand for renewables and distributed generation/infrastructure. The ESCOs that can bring a mix of holistic, harmonic services will reap the most in terms of market share and economic growth.

11. Contractual Issues

The Energy Conservation and Production Act (ECPA) requires that whenever ASHRAE Standard 90.1-1989 (or successor) is revised, that within 12 months, the Secretary of Energy make a determination whether the new Standard would improve energy efficiency in commercial buildings. If it does, then all states need to update their codes such that they meet or exceed this new standard, within two years of the Secretary's affirmation. This is important, in that it gives the whole country a baseline on which projects are evaluated, narrowing, on the bottom end at least, the variance of how far the actual installed equipment can be from the intended performance.

One major fuzzy area, when it comes to implementation of a performance goal, has been the "or equal" phrase in specifications, and the wide berth given it when evaluating an installed system. Historically, it was interpreted through many lenses, resulting in lower efficiency than intended, or worse, conflict with other systems which were specified to optimally operate with the more efficient system, which subsequently perform more poorly than systems that would have been otherwise specified to operate with the less efficient component. Sometimes, in the rush to commission and populate a building, the systems were never checked at all if they provided the most basic levels of service.

Now that there's a baseline to follow, there need to be procedures in place to make sure they're followed. One way to ensure the owner's intent is met is by commissioning. According to the Whole Building Design Guide, "buildings delivered according to the owner's intent have fewer change orders, tend to be more energy efficient, and have lower operations and maintenance cost".[xvi] Commissioning would ensure that the installed mechanicals meet the desired performance levels, and avoid the ambiguity inefficiencies introduced by a casual or opportunistically inappropriate interpretation of the "or equal" clause.

Commissioning has three phases – Determining Requirements, Planning Commissioning Process, and Documenting Compliance and Acceptance. This both requires and informs a systems-oriented process, involving the building owner, designer, construction, and a commissioning agent. The earlier these professionals meet and lay out the required information, the more time consuming and expensive it will be to implement the owner's desires.

ASHRAE has their Standard 202-2013 – Commissioning Process for Buildings and Systems that standardizes the commissioning process, describing how to plan, conduct and document it. Commissioning isn't mandatory in many places, although some states have entities dedicated to the enabling of the process- California has the California Energy Commission whose Energy Efficiency Committee endorses a guide developed by the California Commissioning Collaborative, called the California Commissioning Guide. There is one guide for new buildings, and one for existing buildings (Retro-commissioning of never-commissioned buildings and Re-commissioning of previously commissioned ones).

12. Operations and Maintenance Practices

The more complex a building becomes, the more critical it is to have proper O&M, both because the systems are designed to work together, and because tolerances are smaller. An integrated building management system requires everything be functional to achieve its goal; when something isn't maintained, or is operated incorrectly, it not only performs poorly itself, but drags other systems with it. Modern building automation systems come with all the sensors and data one could want, but the user interfaces that present that data aren't always up to par. Many exist, some with proprietary protocols, some with IP-based communications, and some "open systems". Yet there is no "consumer reports" of "best BAS user interfaces". An internet search return no results, only the individual manufacturers touting their products. Until the UI of a BAS at least shows up on the internet, it isn't nearly prominent enough in the ecosystem of building management. Hopefully with the current trend of data analytics and visualization, the BAS UI will improve and even better, standardize, like the dashboard of a car, so that both users and operators alike will have instant feedback to their adjustments and clear signals to the operational state of the systems.

Proper commissioning also takes into account O&M and ensures it becomes an ongoing process, that operators are trained in the complex operation of the technologically advanced new systems. Maintenance is also a commissioning requirement, and is verified either directly from logs, or inferred indirectly from the state of the system during re-commissioning events.

The best run system in the world cannot continue that way if parts are unavailable. This balance of new vs. available vs. supportable exists in many industries, and is rooted in supply and demand economics. Only when the reinforcing loop of more efficiency acceptance -> cheaper operations -> greater NPV is realized, will the "new tech" replacement and support resources be locally commonplace. Until then, mandates such as code requirements, which lag, in the case of ASHRAE 90.1, by 3 years, are the only driving factor creating a large enough demand. Re-commissioning can catch incorrect but commonly available replacement parts, but that isn't a widespread practice, and is infrequent when it is, causing tears of inefficiency and degradation to other parts of the system before it's discovered.

13. Leasing Practices

There are two major problems in lease relationships, both related to the "split incentive", where benefits do not accrue to the person who pays for the transaction. The primary issue is the leasing terms related to energy efficiency retrofits. In New York City for example, the modified gross lease states that savings from energy retrofits are passed through to the tenants. Therefore the owners are not incentivized to implement efficiency measures, and no savings are realized for anyone. While the owners can pass through the capital expenses of the retrofit, it is amortized across the useful life of the equipment, and leaves tenants at risk for retrofits that underperform. In a survey done by the NYC Mayor's Office of owners or managers of > 300 million square foot spaces, 60% or commercial property owners who responded said that this split incentive issue inhibits their willingness to undertake efficiency retrofit projects.

In 2010, the Mayor's office met with several large tenants and real estate legal professionals and addresses these specific issues:

- Owners wanted an energy professional's savings prediction
- Tenants wanted protection from savings that might go unrealized

Basing the owner's cost recovery on predicted savings while tenants are protected from underperformance was written into the leasing language.[xvii] A mutually agreed-upon energy specialist will predict the savings, tenants are protected by a 20% "performance buffer" (since energy savings are typically within 20% of professional predictions), and owners CapEx is paid back in full, but the period is extended 25%. This applies to modified gross commercial leases and multi-tenant net office leases. While it does not apply to electricity used within non-sub-metered spaces, by 2025 all large commercial tenant spaces in NYC must be individually metered or sub-metered [Local Law 88]

The second is related to the tenants' actual energy use, and incentives to conserve, or properly operate efficiency devices. When a tenant's utility charge is bundled with their rent, they will use more energy. This has been documented in countless studies and seems to be human nature except for the ardently green thinker. This creates a reinforcing loop of increasing rents and subsequent increasing "retaliatory" or "justification-based" increases in energy use. Sub-metering, where the landlord/owner supplies the individual unit meters and typically bills retail rates to the tenants based on actual usage, is the only fair way to eliminate what really is a design flaw in human nature. While individual metering is perhaps the optimal way from the point of view of fairness and transparency, it is logically often un-implementable due to utilities' refusal to install individual meters in multi-tenant spaces, due to the cost, or the reduced ability to collect on overdue bills because of a typically transient population such as mobile home parks. The owner/landlord is charged a wholesale rate for their property's utility use, and the costs of sub-metering are recouped through this discount.

One problem with sub-metering is the tenant is now paying for the full cost of occupying an inefficient space, where with bundled utility costs, the rent was set at market rates and the owner was incentivized to implement efficiency measures to bring the rent down and be more competitive. If the pass-through cost of efficiency upgrades enacted by NYC were standard practice, the playing field would be level and the true cost of rent vs. utility would be transparent. But this again would require tenant education and enlightenment, awareness that they can and should investigate the energy OpEx of their space prior to signing a lease.

In 2010, the Building Owners and Managers Association published a "greenified" version of their 2008 Green Lease Guide: "Commercial Lease: Guide to Sustainable and Energy Efficient Leasing for High-Performance Buildings".[xviii] It includes enforceable tenant responsibilities, pass-through provisions, and green certification notations for Energy-Star, LEED, and GBI points. It also includes a supplement called "Working Together for Sustainability: The RMI-BOMA Guide for Landlords and Tenants", a joint publication with the Rocky Mountain

Institute. This publication outlines five synergistic steps that tenants and owners can employ together for greater energy savings.

14. Research Infrastructure

Since this paper was written, there has been explosive growth in the research of all energy fields, and efficiency, while not as glamorous as leading edge nanoscale materials, is vitally important. Research is abound in the educational sector. MIT itself has the MIT Energy Initiative, which among other things, is doing research into building efficiency. From "smart buildings" to codes, standards, financial incentives, and the all-important education, sensors, monitoring and simulation tools. Penn State's Consortium for Building Energy Innovation (formerly the Energy Efficient Buildings Hub) concentrates their research on deploying energy efficient solutions into the Small and Medium Sized Commercial Buildings sector, which makes up 95% of the current commercial building stock in the US. Notre Dame has 25% of their faculty at the Center for Sustainable Energy working on efficiency. Outside the US, RWTH Aachen University in The Netherlands has an Institute for Energy Efficient Buildings in their Mechanical Engineering department.[xix]

In the business sector, companies like United Technologies has their Research Center, with a division dedicated to Building Efficiency.[xx] They specifically use a systems engineering approach, resulting in "...assisting in the development of breakthroughs such as the GeN2 Switch by Otis—the only family of machine-room-less, fully VDI Level I elevators in the world, which operate using less energy than a microwave."

In the government sector, there are the National Labs. Most are engaged in energy research, many in efficiency. The widely known National Renewable Energy Lab (NREL) has a Buildings Research division which itself has a Commercial Buildings section with over 30 research staff[xxi]. In addition to doing their own research, the NREL commercial buildings team is available as consultant group to assist all commercial building players in solving their efficiency problems. The Oak Ridge National Lab has the Building Technologies Research and Integration Center, which concentrates on improved energy management during a building's operational phase[xxii]. The Pacific Northwest National Lab, noteworthy for their market transformation work in getting Compact Fluorescent Lightbulbs widely accepted, currently is leading the Department of Energy's Building Energy Codes Lab, which applies building science and whole-building energy simulation and analysis to the codes sector, enabling commercial buildings to achieve new efficiency standards with new technologies.[xxiii] PNNL also has two other areas of building research – Energy

Process and Materials, and Electricity Infrastructure and Buildings.[xxiv] The Lawrence Berkeley National Labs' Building Energy Efficiency department has a Commercial Buildings sector working on design tools that help intergrade the "...variety of isolated building technologies into complete systems that allow for compounded energy efficiency and an increased building life-cycle".[xxv]

IV. HOW TO CHANGE THE REST

Many of the issues addressed by Lovins have themselves been addressed at least in discussion, by the rising cost of energy, the threat of irreversible climate change, and just the desire for people to have less of an impact on their planet. There is some momentum in the industry, and a lot of government money and mandates pushing compliance and research forward. If all of Lovins' recommendations are to be implemented, this momentum needs to increase, feed on itself, driven by its own successes. Education of the general populace remains the major impediment. As with every movement, there are vocal subgroups actively resisting or politicizing science-based evidence of climate change. At the other end of the spectrum, there is the low income tenant who doesn't know to look at the efficiency of a space, because immediate, upfront costs trump complicated NPV calculations. The concept of efficiency, and what it can buy us, needs to be as prevalent as the other "green" movements of recycling, conservation, and renewable fuels. It needs to be in the social fabric if it's going to take a foothold in the everyday thinking of those who create and use commercial buildings.

I interviewed two architects for this paper, both personal friends, and purposely left anonymous out of deference to their privacy. Architect A works in Massachusetts, mostly on public projects for towns, such as Police stations and Department of Public Works buildings. Architect B works in Washington state and works on a variety of public projects. Their comments are listed here:

Architect A – Architect/Engineering fees are based on construction cost. The fee is set at the beginning of the project based on estimated construction costs. The Architect then negotiates the consulting/contracting fees with the engineering consultants and trades. Public projects usually specify mechanicals from specific companies, while private projects will specify a particular model of equipment. The desired efficiency level is set by the client (within codes of course).

Utility rebates to designers are not happening yet in her experience. The utilities will stay engaged on a project, and are willing to offer design and rebate assistance, but they need to be contacted first; they do not initiate contact by being connected to the permit department or any such closed loop systemic administration.

The re-integration of the design process, however, is happening. LEED has been a big pusher of this. The clients, mostly town managers and their personnel, need to be educated about the OpEx benefits of efficient design and materials, and also about OpEx vs. CapEx benefits. Their main resistance to new technology is that no one knows how to service it, so they specify "dumb" equipment. Every town is different, and there are some towns, not always the outwardly progressive ones, that are willing to try. It all depends on the town managers, and their ability to convince or override a sometimes ignorant and/or skeptical public.

The "or equal" phrase, when come across, is always vetted. Performance is adhered to. When first doing a rough first draft, estimates need to be done for mechanicals. For this Rules-of-Thumb are used, but during the design phase, they are refined.

Finally, on projects where there is a landlord/tenant relationship where the tenant pays the bills, the landlord will still balk on efficiency improvements.

Architect B – Pubic project fees are also set by a table, based on percent of construction cost. It states what is expected at each milestone and the percentage of the overall fee attributed to each development phase.

The public project/fee document does make note of involving all disciplines at each phase, and each phase has a small percentage called "collaboration fee". And while it is a design-bid-build process, there is a note under "exceptions" that allows for projects that are unusually slow or fast, and under fast is listed "Design-Build/Construction Manager at Risk.

Addressing the issue of oversized mechanicals, the story is mixed. In one instance, they sized an HVAC unit in a high school outdoor enclosed field house for the possible inclusion of bleachers at some point in the next 20 years. However in a boiler room at a different school, pads and piping were included to accommodate new boilers once some designated boilers were phased out in a few years, though this was part of a conversion from distributed heating to central heating, and no sizing design information about the boilers was mentioned. The net number of boilers remained constant.

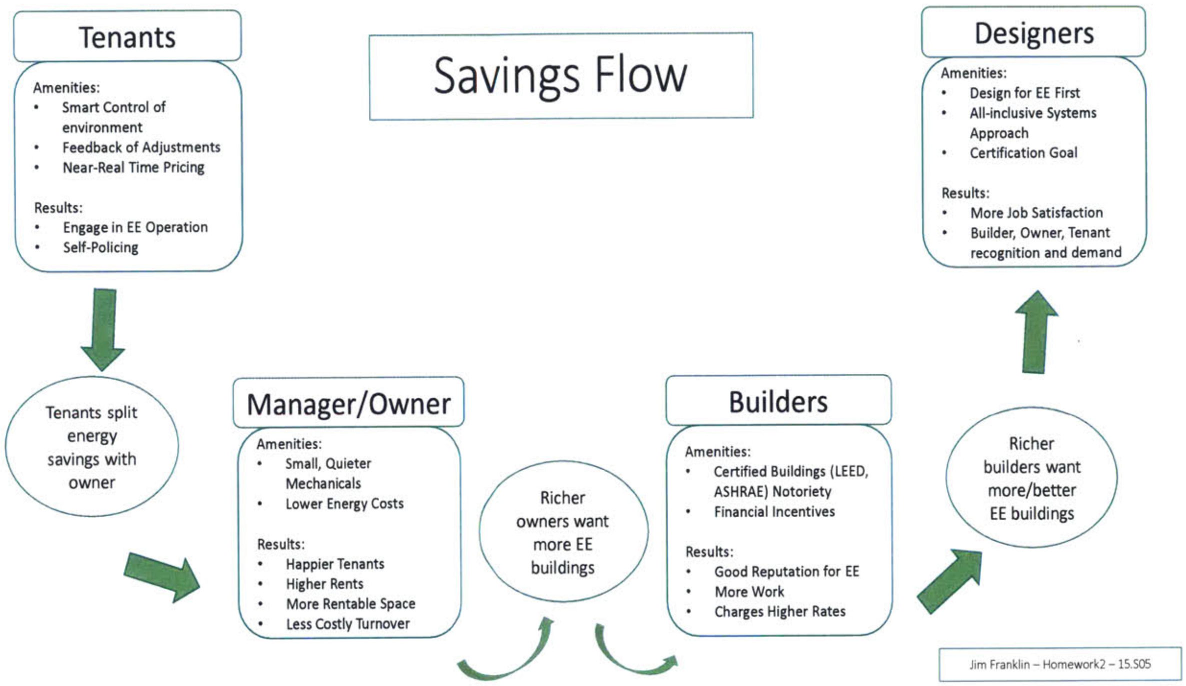
There is no financial incentive for the design team to specify efficiency, though there may occasionally be requirements that the owner hit some sustainability goals. However, the architecture/engineering team does make an effort to employ as much systemic design up front as they can, to the point that WA state revised the fee structure, moving 5% away from Construction phase and into Design phase, since the teams were losing money on Design hoping to make it up during Construction. One big driver of this over the past 25 years helping this is the incorporation of BIM. This is starting to move more coordination of building systems up to the Design phase, mitigating conflicts with the structural team and leading to better equipment choices as well.

As a very good example of how things are changing in some progressive places, MIT implemented its Efficiency Forward program. It formed a partnership with local utility NSTAR, who funded part of the efficiency push, and requires a re-commission 5 years in, to address the typical 10% degradation from occupant manipulation, interior readjustments, exterior readjustments, and degrading equipment.

Several cities have pushed efficiency programs along with a visible PR campaign, helping to spread awareness, namely Cambridge, MA's "Net Zero Task Force"[xxvi], and Boston, MA's "Green Ribbon Commission"[xxvii].

1. Where we still need to go

In an ideal world, everyone involved in the design-build-manage-occupy process would be concerned primarily with efficiency and conservation. The incentives for this would be the altruistic rewards of the system, not mandated externalities, and the cost savings from a well thought out system would be a nice economic side benefit. The following slide shows the current problem. Incentive to build efficiency should flow from right to left, but money flows from left to right, preventing the natural economic drive. None of the players is going to invest the additional time and energy to add efficiency if the player to their left isn't paying for it. Therefore, until tenants start demanding efficiency, and realizing the economic benefits to doing so, this system will remain stagnant without external influence.


Savings Flow
Tenants
Amenities:
Smart Control of environment
Feedback of Adjustments
Near-Real Time Pricing
Results:
Engage in EE Operation
Self-Policing
Tenants split energy savings with owner
Manager/Owner
Amenities:
Small, Quieter Mechanicals
Lower Energy Costs
Results:
Happier Tenants
Higher Rents
More Rentable Space
Less Costly Turnover
Richer owners want more EE buildings
Builders
Amenities:
Certified Buildings (LEED, ASHRAE) Notoriety
Financial Incentives
Results:
Good Reputation for EE
More Work
Charges Higher Rates
Richer builders want more/better EE buildings
Designers
Amenities:
Design for EE First
All-inclusive Systems Approach
Certification Goal
Results:
More Job Satisfaction
Builder, Owner, Tenant recognition and demand
Jim Franklin – Homework2 – 15.S05

2. The Externalities

Many elected and appointed officials, both on their own and through lobbying and other information channels, have enacted legislation across the whole spectrum of the energy using infrastructure, from local building codes to federal law. Trade groups have bolstered their relevance and advanced their members by creating codes that enable the legislated efficiency measures to be implemented. ASHRAE 90.1-2013 is now a requirement for states to adopt, or match, by September of 2016. Start-ups in the energy field, inspired by global awareness of the energy issues, have superseded the technical status quo and forced all industry players to keep up or fail. This system of improvement has enabled the continuing progress of efficiency and education, yet as I witnessed during an ASHRAE commissioning Q&A session recently, there are still plenty of disconnects between trades, planners, and designers, and no one there had a solution. Since the players internal to the system can't seem to champion or evangelize the systemic benefits to an architecture that supports reinvestment, and the bountiful return on that investment, the fastest way, ironically, to get past the hump of resistance and into awareness is with more externalities in the form of legislative mandates.

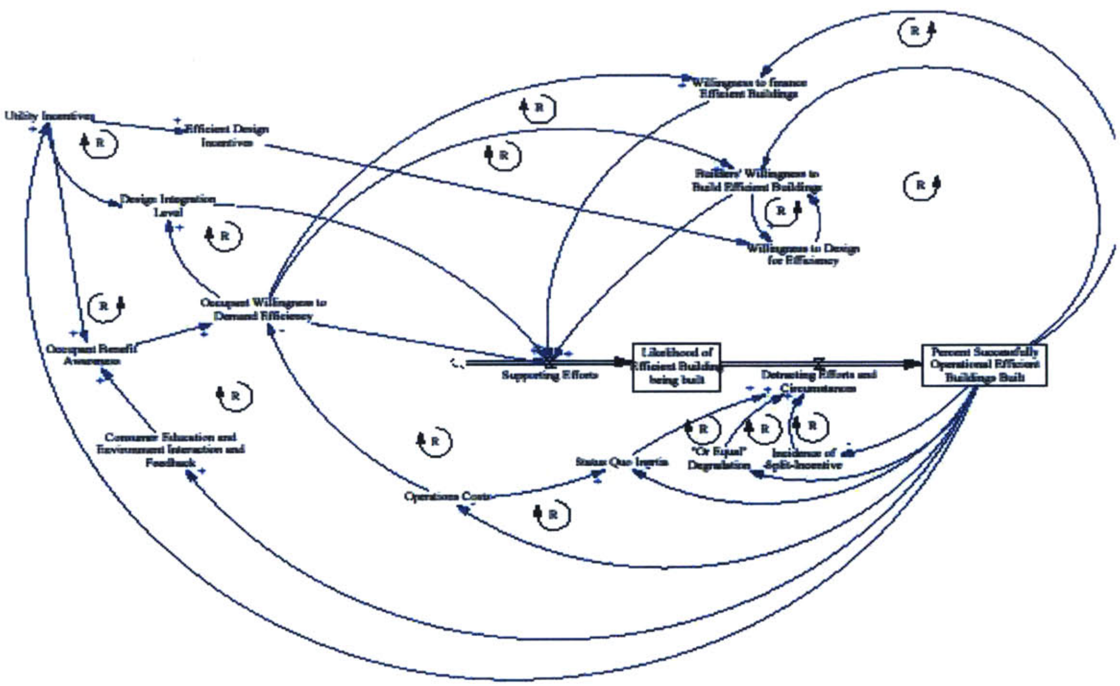
To craft these mandates, the legislative bodies need to meet with industry leaders and progressive thinkers and enact a viable plan that meets goals but is also achievable. It needs to be a combination of efficiency goals that exist in current code, standards, and guidelines, and also of new procedural requirements:

- All actors in a construction project must meet regularly
- Efficiencies from that collaboration must be documented
- Lack of emergent efficiencies must be defended
- A method of post-occupancy accountability for not meeting efficiency goals needs to be implemented and enforced, including putting licensing in jeopardy
- Periodic re-commissioning needs to be mandatory, and everyone held accountable for excessively rapid degradation of efficiency

3. Modeling the Dynamics

Below is a simplified version of the system's dynamics, showing all the feedback loops that detract from progress, but also enable the acceptance, of energy efficient building design, construction, and use. Once the tide turns and acceptance gains enough momentum, even if only in a few seemingly disconnected segments, the system picks up in intensity quite rapidly. Of course, the projects themselves often take years to complete, so “rapidly” needs to be taken in context. There are many more “secondary” elements and connection purposely not included, as modeling the actual system is complex enough to warrant it being a separate undertaking.

Model: C:\Users\jfranklin\Dropbox (MIT)\Thesis\ThesisModel.mdl View: View 1



Simplified Efficiency System Dynamics Thu Apr 23, 2015 1:55PM

CONCLUSION

This paper merely scratches the surface of the long-standing inefficiencies in efficient commercial construction and operation. Beyond the lack of collaboration, lack of initiative, lack of immediate use feedback, and lack of an enforceable reward/punishment system, are the secondary causes such as socio-political pressure to conform (passive pressure) and to not be a "greenie" (active pressure), short-term political schedules that reduce long-term planning and enable vacillating policies, and a lack of education at the most basic level on where our energy really comes from, and what it costs. The narrow-minded thinking that pervades most earthly inhabitants about their effect on their environment needs to be eradicated, by educating our youth via a mandatory curricular edict. The real cost of energy, unsubsidized, needs to be passed along to consumers, real-time, so that the monetary impact of, for instance, leaving the incandescent office lights on over a hot summer night, isn't buried in a monthly bill sent to a faceless accounts receivable in another state, but is felt by the immediate pass-through of that tenant in their daily itemized energy bill.

Someone recently bemoaned, on a social media website, how their children wouldn't have a "real" sports car to drive by the time they grew up. A respondent astutely replied that they won't care. They won't have grown up with them, and will be happy to have an autonomous or mass transit seat to their destination while concentrating on their personal technology device. Sea changes like this can happen in a generation; sweeping changes in the commercial building industry can be largely implemented in a generation if we start the environmental education now, so that to not be efficient will have the same awkwardness that vocalizing for efficiency still seems to have today. The incredible prevalence of LEED is an example of this. Not even a generation old, and there are over 50,000 LEED certified projects globally. That may not sound like much in the vast arena of global construction, but taking into account the number of people involved in that sum of projects lends a hint to the rapidity of information spread possible.

I am confident that despite all the resistance inherent in human nature, we will implement the forces needed to turn this ship around, and start realizing the inherent positive feedbacks available when buildings are viewed as a system of interacting parts, rather than a disparate, or conflicting, collective of autonomous competitors.

Acronyms and Abbreviations

ACEEE - American Council for an Energy-Efficient Economy

AEE - Association of Energy Engineers

AIA - American Institute of Architects

ASHRAE - American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

ASME - American Society of Mechanical Engineers

CAD - Computer-aided design

DOE - Department of Energy

DOJ - Department of Justice

ESCO - Energy service company

Feebates - a self-financing system of fees and rebates that are used to shift the costs of externalities produced by the private misuse of public goods onto those market actors responsible

IBPSA - International Building Performance Simulation Association

IES - Illuminating Engineering Society

LEED - Leadership in Energy & Environmental Design

R value - a unit thermal resistance for a particular material or assembly of materials

U values- describes how well a building element conducts heat (inverse of R value)

USGBC - U.S. Green Building Council

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