The New Role of the Energy Manager

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ABSTRACT

Companies in the commercial and institutional fields are always looking for ways to reduce costs and increase profits. In recent years, top-level executives have asked energy managers to find ways to cut operating costs by improving the energy efficiency of their facilities. One stimulus for establishing energy management programs is the persistently increasing price of electricity experienced in many areas. The electric bills of a poorly managed facility can make a serious dent in corporate profits.

Furthermore, deregulation of the electric industry, which is occurring or being considered in many states, will make it more difficult for companies to forecast their energy expenses in the near term. This article reviews the new complexities with which energy managers must now work.

(**Editor's Note**)

What forces are compelling energy managers to reassess their expanding role? Why are they now required to engage in demanding new activities, more difficult than they have heretofore had to master? Mr. Panucci's article summarizes the new "energies" which are driving the growing responsibilities, and opportunities, which you now face.

(The author calls educational and religious facilities "commercial" which, strictly speaking, they are not. But doing this makes sense in the context of the parallel technical/economic systems with which energy managers work.)

Many technological advancements have emerged that provide a wide range of options to the energy manager to reduce the energy consumption and its corresponding cost. Highly efficient equipment and lighting, viable gas powered alternative equipment, and automated energy management control systems are a few examples of this technology. One might ask why, if the technology is available to significantly cut the energy cost of operating a commercial facility, changes are not made to facilities, or why are new facilities are built with less than the best energy management equipment.

The answer is that there are barriers to these changes, the most significant one being economic. Even when energy inefficient equipment and systems reach their end-of-life, the replacement systems are usually chosen based upon the lowest first cost rather than those which are the most energy efficient. This article focuses on the economic factors confronting energy managers and discusses strategies to control energy prices and to control energy usage to achieve the most favorable energy investment over the long run.

Energy management is playing an increasingly important role in the commercial industry. There are several reasons for this including: **1) the economic return and the corresponding competitive edge obtained, 2) the uncertainty in energy costs and services after deregulation, 3) the importance of reliability of commercial facility operations, and 4) energy efficiency regulations.**

It is no coincidence that the U.S. Department of Energy's Office of Energy and Efficiency and Renewable Energy recently solicited proposals for "innovative technologies that have the potential for significant energy savings in residential and commercial buildings" ("RFP")[1] with the intent of awarding approximately $5 million for the initial phase development. For commercial business owners, neglecting energy efficiency can have the same economic impact to the business as ignoring competition or losing customers.

I. COMMERCIAL INDUSTRY ELECTRICITY DEMAND

Energy companies serve customers in three major groups: residential, commercial, and industrial. Buildings owned and operated by commercial customers (emphasized in this article) include those used for education, food service, food sales, health care, lodging, mercantile, office, public assembly, and religion. According to the Edison Electric Institute, these facilities represent 11% of the electric utility customers and 32% of electric utility sales ("Profile").[2] The facilities with the largest energy demand per square foot of floor space are those used for food service and food sales, health care, and lodging, representing over one-half of the total energy demand of all commercial facilities.[3]

These high-demand facilities also require high levels of electricity reliability and electric power quality. Reliability means ensuring that the power required is available. Reliability problems result in power outages that can cost millions. In a recent poll of 800 commercial and industrial customers, an average of 15 outages occurred during a 12-month period resulting in a combined cost of more than $7 billion per year.[4]

Highly complex computer and communication systems used in an increasing number of commercial facilities require power free of significant voltage and power spikes or sags, interruptions, and harmonic distortions. While maintaining overall power quality does not solely depend on the electricity provider, energy managers should be concerned with the effects that restructuring could have on power quality. The new interdependence of the unregulated and regulated players and their ability to work together effectively coupled with price-cap regulation could adversely affect quality of the electricity delivered.[5]

II. DRIVERS OF ELECTRICITY COST SCRUTINY

A. Regulatory Drivers

The most significant regulatory drivers that influence investment decisions by energy managers in commercial facilities are 1) electric industry restructuring, 2) certain regulated programs, and 3) building codes and standards.

The restructuring of the electric industry is resulting in new pricing structures and new retail services in a competitive market. Current utility pricing structures involving peak and off-peak energy and demand charges will likely be replaced by real-time charges reflecting the actual costs to provide electricity on an hourly basis. While both schemes favor customers with flat, predictable load profiles that minimize consumption during peak demand periods, the price variations under real-time pricing will be much more dramatic making it more important to manage energy usage.

Electric utility restructuring will also result in deregulated retail services. While overall rate decreases are predicted by many, the reduction in some rates may result in an increase to others. Fox-Penner documents the basis for why many feel that small commercial customers may experience rate increases.[5] Specifically, small commercial customers cannot invest the time and money to research the best retail deals and will choose to stay with the utility distributor. The utilities will charge their captive smaller customers more so that they can offer better prices to the businesses that have the means to choose their retail service provider.

Improvements in energy efficiency was ordered in most states via demand-side management (DSM) programs executed by the utility companies. These programs are designed to reduce total energy consumption and, in doing so, help utilities avoid major investments in new power plants. DSM programs ease the financial burden of making energy efficient improvements through rebates, low interest loans, or performance contracting to name a few. Therefore, DSM is important to commercial building energy managers. As most states deregulate their electric utilities, the future of DSM programs becomes more uncertain because certain benefits of DSM programs are expected to be achieved via retail competition.

What is likely to happen after deregulation is that there will be a transition from utility-based to market-based DSM programs. For example, prompted by environmental and renewable energy advocates, the deregulation laws passed in California include over $1 billion in DSM program funding through the year 2001.[6]

Similarly, the Long Island Power Authority will spend $32 million per year through 2004 on programs designed to encourage energy efficiency, peak load reduction, and renewable energy technologies.[7] In other states, only those DSM programs that can be justified economically based on the new competitive retail market will survive.

Environmental programs such as renewable energy programs may cause rate increases in some regions of the country. Based on the concerns that deregulation will result in an increase in the use of cheaper and more environmentally unfriendly fuels such as coal, some regions may be forced to generate additional electricity via renewable energy. For example, future congressional actions may very well require that 2% of electricity production be from renewable energy generators such as wind, sun, and hydro. Currently, the Midwest production is less than half this amount. Imposing this requirement in the Midwest would require Gencos to build more expensive generators resulting in higher prices to the retail electricity customers.

Finally, building codes and standards are driving energy efficiency. In an effort to address the "sick building syndrome," indoor air quality (IAQ) in buildings is getting much attention. Buildings requiring air-conditioning upgrades are also required to meet code ventilation (outdoor air supply into the spaces) requirements. This results in additional air that must be cooled in the summer.

This requirement can easily result in a 15% increase in energy needed to air-condition the buildings. Codes also require the phase-out of certain refrigerants used for air-conditioning refrigerants—thus contributing to the global warming problem. After the year 2010, equipment using these refrigerants can no longer be manufactured or sold. This will likely cause the price of the refrigerant, still required for older equipment maintenance, to rise. Energy managers need to plan to replace this equipment as part of the facility energy management plans.

B. Market Drivers

The key market drivers influencing energy managers are the impressive advancements in 1) energy efficient equipment, 2) building automation system technologies, and 3) gas technologies. Energy managers are tempted now more than ever to invest additional capital dollars for these technologies since the energy savings can be significant.

A recent issue of *Heating, Piping, and Air-Conditioning*[8] (HPAC) identified the top ten 21st century building technologies. Among them are new generation direct digital controls (DDCs), thermal storage controls, load profiling, and managing energy by productivity (Thompson 6-22). The significance of these technologies is that they control energy usage better, use less human effort, and result in a more productive environment. Each technology provides significant economic benefit to the commercial business owner.

The manufacturers of these technologies put forth significant R&D investments to make them available to the commercial industry. These manufacturers are convinced that commercial facilities will invest heavily in these energy saving technologies in light of the rapidly changing electric utility industry. It is still early from a supply and demand standpoint for some of these technologies and as such, the investment required (for purchase and training) to upgrade a facility is still intimidating to the energy manager.

Planning for an effective energy management program can be a monumental challenge. Coordination of education planning, management training, employee training, and audit planning need to be done efficiently and cost effectively. This coordination issue and the ever present capital investment issue are the biggest barriers to implementation of these key technologies. Absent these barriers, "…**this country could possibly reduce its energy consumption by 50%….**"[9]

Another major market driver influencing energy managers is the efforts made by the gas industry to provide various gas powered building systems. Organizations like the Gas Research Institute (GRI) and the American Gas Cooling Center (AGCC) have hit the market hard to advertise the benefits of gas powered equipment. A recent publication from the AGCC expresses this point: "Our primary target is the building community—commercial and industrial customers. We want this market segment to receive a strong message about the benefits of gas cooling."[10]

The gas industry feels strongly that improvements in gas technology combined with changes brought on from utility deregulation will give facility managers very good reason to invest in gas powered equipment. Economic forces will make retailers join gas, electricity and other fuels and services. This convergence is one of the key reasons that gas technology will be more viable to the commercial industry.

The other key change is the likelihood that real-time pricing will be the norm. Natural gas prices are generally lower during the summer when electricity prices under a real-time pricing scheme can be very high during parts of the day. Facilities that install gas powered equipment become sufficiently flexible and can manage their energy usage based on the rates offered and their equipment load profiles, thus significantly lowering their total energy bill. It is this reduction in energy costs that is the primary motivation for additional investment in gas-powered equipment compared to the lower-cost electric powered alternative.

From a commercial building perspective, the key gas powered technologies that should be considered are microturbines, gas powered generators, fuel cells, gas cooling equipment, and cogeneration—the integrated building cooling, heating, and power (BCHP) systems. Microturbines and gas powered generators are the more viable distributed generation methods available to the typical commercial industry customer. Distributed generation at a commercial facility gives the owner the ability to control certain aspects of the electric services that become unbundled by utility deregulation.

Briefly, these services are **energy, capacity, reserve, reliability, and power quality**. With a distributed generation capability, the need for some of these services become less important which will afford the energy manager a strong negotiating position with electricity retail vendors.

BCHP cogeneration systems continue the energy savings process by using the waste heat from on-site power generators or heat-producing systems to drive building cooling, heating, or dehumidification systems. BCHP technology is currently best suited for high thermal use commercial facilities such as hospitals, health clubs, process industries, campuses, and laundries.

Large commercial franchises recognizing the benefits of this gas technology have begun to modify their standard designs to incorporate the gas powered systems. In the Midwest, NiSource developed a package system for Walgreen drug stores that has been operating since May 1999. It features a 30 kW microturbine to provide electric generation and space heating, a chiller (air or water cooling equipment) for summer air conditioning, and a dehumidification system. AlliedSignal has installed its 75 kW microturbine in McDonald's franchises.[11] The investment made by these mega-companies gives further emphasis to the need for the commercial industry to review the economics of gas powered technologies.

III. ECONOMIC STRATEGY FOR CONTROLLING ENERGY COSTS

If a commercial energy manager truly wants to gain corporate recognition, then saving significant costs that allow a company to become more competitive is the best avenue. To determine if there is a cost/benefit to an investment in energy efficiency or gas technologies, a plan must be developed to document three key strategies.

The first strategy addresses the method that will be used to control electricity usage on a daily and yearly basis.

The second strategy addresses the method that will be used to control the price paid for electricity in a deregulated environment.

The third strategy addresses the method used to finance the investment.

Electricity Usage Control Strategy

Before energy managers can begin to develop a strategy to control electricity usage, they must understand several key facts: How much power is used? When is it used? Where is it used? How much does it cost? Which loads are critical and which loads are flexible? Using this information, increase in control can be achieved using four different strategies:

1) **Load shedding**—curtails non-essential loads when electricity demand reaches a preset level,

2) **Load scheduling**—uses gas and electricity price forecasts to plan an operation strategy,

3) **Load shifting**—shifts portions of the electricity load from a peak time to an off-peak time, and

4) **Load switching**—involves using gas versus electric powered equipment when electricity prices peak during a given period.[8]

Not many commercial facilities are flexible enough to accommodate all of these strategies. Even if the commercial facility has a energy consumption profile that is fixed, there is much that can be done to control the electricity use profile for a given period. As mentioned in Section II, these strategies are now very realistic, thanks to the technological advancements in building energy management systems.

Traditional energy efficiency upgrades, especially those encouraged under the DSM programs of the past such as lighting retrofits and equipment upgrades, target reducing consumption. **In a deregulated market, the energy retrofit projects must also target reducing demand.**

The goal is to obtain an energy load profile that is as level and predictable as possible. The primary reason for this is that power marketers will view an erratic load profile as very risky in light of real-time wholesale prices. Few, if any, would be willing to negotiate favorable electricity pricing for this type of facility. Based on the assumption that many facility managers lack knowledge about the load profile of their facility, "in a competitive market, the mere possession of verifiable load profile data from revenue-grade metering equipment will provide significant negotiating leverage."[8] It is not likely that load profile knowledge alone will be enough to negotiate favorable prices with the power marketers in the competitive electricity marketplace.

For commercial facilities, there are several technologies that will help achieve level and predictable load profiles. The commercial industry currently consumes approximately 15 quadrillion Btu and about one-third of this is used for conditioning (cooling or heating) spaces and equipment. Another one-quarter of the energy is used for lighting and the rest is used to power equipment such as computers.[12] As mentioned earlier, in a deregulated and competitive electricity marketplace, controlling demand becomes as important as controlling total consumption.

To level a facility's load profile, it is likely that the biggest challenge is associated with space and equipment cooling loads. While it is important to have control over electricity usage during the shoulder periods, it is critical to control its usage during the peak demand periods.

Controlling space and equipment cooling equipment during these peak periods involves both load shifting and load switching strategies. A very effective load shifting technology for cooling is thermal energy storage (TES). With a TES system, the cooling equipment (usually chillers) run at night, when electricity is cheap, storing the cooling in ice or water. When the building needs maximum cooling, which occurs when electricity prices peak, the stored cooling is tapped, thus curtailing some or all of the electricity load used to operate the chillers. Many TES systems have been operated successfully in hospitals, public and private schools, airports, churches, government and private office buildings, and process cooling applications.

What usually intimidates energy managers is the first cost of a TES system. One possible compromise is to only size the TES system to level the demand profile during the day, rather than to completely shift load from day to night. A recent installation of a TES system in educational facilities near Princeton University is expected to result in a lifetime energy savings of $2.5 million.[12]

Load switching technologies can also have the same electric load leveling effect in cooling applications. The methods most recently offered to energy managers to load switch involve using a hybrid cooling plant or involve using on-site gas-powered distributed generation. A hybrid cooling plant uses both gas powered and electric powered cooling equipment to serve the facility. This allows part or all of the electrical equipment loads to be controlled. Again, gas-powered equipment (which has a larger first cost) does not have to be sized to substitute for the electric powered equipment, but can be sized to level the electricity load profile only. Rita Tatum concisely points out the averages of the hybrid cooling plant:

> Hybrid chiller plants enable facility professionals to take full advantage of fluctuating utility rates. A facility professional with the ability to choose between gas and electric cooling on a daily basis will have negotiating power in a deregulated environment. Gas cooling owners are attractive to gas companies because they use gas in the summer. Gas cooling customers are also attractive to electric companies because their load profile is flat. Flexibility in fuel sources gives a facility professional control and negotiating power in a deregulated environment.[13]

The economics of a hybrid cooling plant are discussed in more detail in **Section IV**.

Another load switching strategy is to install gas-powered electric generators at the facility. Running the on-site generator, which may be a microturbine or a gas engine, can curtail the electricity purchased off the grid during peak demand periods when prices are highest.

In Chicago, the building code will soon require emergency electric generators in certain types of buildings. Installing this "mandated emergency equipment" will afford the opportunity to add the infrastructure for microturbines (30-200 kW) or gas engines (50-5,000 kW). Many facilities that already have these emergency generators may be able to add on-site power generators at a lower first cost. The economics of on-site power generation depend on the first cost, running efficiencies, fuel costs, emissions, noise, and other factors.

A recent study completed by the Energy Resources Center for the University of Illinois at Chicago for the Museum of Science and Industry[14] demonstrates the load shifting capability of TES and on-site generation systems. The typical July load profile that normally has a peak electricity load close to 3000 kW during the peak daily demand periods (10:00 a.m. to 4:00 p.m.), could be leveled to a peak electricity demand of 1500 kW during this same period and result in a level and predictable load profile.

Based on the traditional ComEd rate plan that uses demand and energy charges, this study calculated an electricity savings of $45,000 (reduction of over 50%) for the month of July. The savings under a real time pricing scheme could be significantly greater. Of course, the total savings must consider the cost of the on-site generation and TES system which is discussed in more detail in **Section IV**.

While load shifting and load switching strategies provide a very significant electricity saving, load shedding and load scheduling strategies are also important. As mentioned earlier, various energy management system technologies will play a key role in the early 21st century. These technologies are needed due to the complexity of load shifting and load switching systems and are the backbone to the load shedding and load scheduling strategies. Energy management systems are programmed to minimize peak-hour demands by adjusting temperature settings in non-critical spaces or by shutting down non-essential loads. The submetering systems can isolate usage by floor, by department, by process, and by device, which is then fed into the building automation system.

The benefits of investing in any of these electricity usage control technologies depend on the existing load profile of the facility and the significance of the cost of electricity compared to other costs. However, the energy manager must have the knowledge of the load profile with and without the implementation of these technologies to negotiate electricity prices.

Electricity Price Control Strategy

Once an energy manager has a complete understanding of the facility's electrical load profile and understands the variations to the load profiles that can be achieved via system upgrades, he can plan a strategy to get the lowest price for electricity. There are several players that are involved in the process of buying and selling power. There are the local utilities, local utility affiliates, power marketers, power brokers, and buying agents. There are many title variations, but this list presents the point that buying electricity and associated unbundled services is rather complicated in the deregulated environment.

Thanks to competition, there are thousands of entities emerging to offer the commercial industry various energy services. This competitive environment puts the commodity of electricity in a form that energy managers are very familiar with—one that allows them to competitively bid for price and services using their competitive bid process via Request for Proposals (RFPs).

Prior to shopping for the best electricity services, the energy manager should determine if there are benefits by organizing with other energy users. Audin describes three types of groups: 1) Those groups buying energy as an aggregation, 2) Those acting as interveners in regulatory actions, and 3) Those previously existing affinity groups focusing on either or both of these pursuits.[15] Understanding the benefits of organizing with other energy users is an important electricity price control strategy.

As stated earlier, the winners in a deregulated market are large energy users because they are more attractive to marketers of electricity. Through aggregation, a small commercial facility can be part of a large purchasing group. Organized groups aggregating their power purchases should have the same goals. For example, is reliability more important than lowest price?

Also important are the load profiles. Facilities that group together should have a combined load profile that is level and predictable. Each member in the group should have a similar political agenda. For example, each member should have the same philosophy on the value of renewable energy and energy efficiency programs. Customers involved in these programs may pay a premium price to advance the generation of electricity using renewable fuels.

Another important step in shopping for electricity is to prepare an RFP that incorporates your goals. From reviewing RFPs and awards, Warwick identified a list of the desired outcomes as follows:

1) Save money,
2) Comply with competitive contracting requirements,
3) Consolidate electricity billing,
4) Consolidate utility purchasing,
5) Provide metering and data management, and
6) Integrate energy efficiency and procurement decisions (77-82).[16]

Clearly, energy managers are looking for energy management services in addition to low prices. These seem like practical ingredients to incorporate into the RFP. Warwick also identifies key lessons learned from reviewing some RFP process results:

1) Provide accurate load profiles,
2) Balance the benefits of the size of the aggregated loads with the administrative hassles associated with handling them,
3) Understand the net affects of a price discount,
4) Build a cushion into the contract to fund energy efficiency

projects, if practical,

5) Get multiple bids to instill competition, and

6) Consider the pros and cons of long or short duration contracts.

Once the competitive bidding process unveils the type of prices and services that are achievable, financing methods must be established. In the past, bank underwriters would typically view an energy efficiency project as new or innovative and consider it a bad risk, which is a barrier for the facility manager. As an alternative, the facility manager should review the performance contracting option. McClain describes the basics of a performance contract with energy service companies (ESCO):

> … the ESCO pays all up-front costs, including identifying building energy requirements, and acquiring, installing, operating, and maintaining energy-efficient equipment. The ESCO receives a share of the cost savings resulting from these improvements until the contract period expires—sometimes up to 25 years. At contract expiration, the agency retains the remaining savings and the equipment.[18]

Performance contracting finances energy efficiency projects and guarantees savings. No up front capital is required, and owners can finance energy efficient improvements for an extended period of time. Basically, the facility manager is buying new energy efficient systems and paying no more than she would have budgeted for utilities. Recently completed energy efficiency upgrades at several schools in New York were made by Sempra Energy Services under a performance contract. The annual energy savings from these upgrades are projected at $690,000 with projected annual maintenance savings of $48,500.[17] As mentioned earlier, the new energy management systems save energy and labor expenses due to increased automation.

If performance contracting is not appropriate for a particular energy efficiency upgrade, then other financing methods such as debt financing, tax incentives, grants, and leases can be pursued. Several advantages of leasing identified by McClain are:

1) the debt-to-equity ratios decrease,

2) payment schedules can be adapted to seasonal business cycles, and

3) a lease is an operating cost for tax purposes.[18]

Nurtured during the original DSM program era, energy efficiency financing programs for the commercial industry are taking off as the demand for them increase in order to manage the uncertainty of electricity retail prices after utility deregulation. **Section IV** discusses examples of economic payback analysis that are needed to justify the economics of an energy efficiency upgrade project.

IV. Economic Payback Analysis

Economic payback analysis is needed to determine when it is appropriate to spend more money now in order to save money in the long term. Two methods that will be illustrated are simple payback (SPB) and life-cycle cost analysis (LCCA).

SPB is used to determine the duration it will take to recover the initial investment and is usually used to compare an energy efficiency approach to the "do nothing" option.

LCCA compares the life-cycle costs of two or more approaches and includes investment, debt obligation, and maintenance and operating expenses over the study period.

Of course, the "do nothing" option (if applicable) could be considered one of the options. Payback analysis should be used to determine if energy upgrades are economically favorable. LCCA should be used to select the best upgrade out of all viable upgrade alternatives. For example, an upgrade might have a payback of two years and another upgrade may have a payback in three years. If both return periods are acceptable, does this mean that the two-year payback upgrade should be chosen? The answer is that you cannot be sure until you have performed the LCCA comparing both approaches.

Simple Payback

To illustrate SPB, an example of a load switching strategy using the real-time pricing scheme is presented. The load switching strategy involves the hybrid chiller plan alluded to earlier. The equipment performance assumptions, climate, and real-time price profiles given below will be taken from Stewart.[19]

Suppose that a commercial facility uses two electric chillers to handle the building cooling load. The chillers have reached their end of life and are also not in compliance with the current codes. The facility manager is considering the option of using a hybrid chiller plant, but the initial cost of the hybrid plant is $139,000 greater than using electric driven chillers.

Shown below are Stewart's Figures 1, 2, 3 and 4. The real-time pricing scheme, shown by Stewart's **Figure 1** assumes that during off-peak periods the price for electricity is $.03/kWh and that it ramps to a peak as high as $.45/kWh.

Figure 2 relates the real-time prices that occur as a function of the outdoor air temperature. The number of hours during the year that the outdoor air temperature will fall within a particular range are also shown in this Figure. **Figure 3** presents the calculation results of the operating energy costs for two electric powered chillers. **Figure 4** presents the calculation results of the operating energy costs for one electric and one gas powered chiller.

Stewart's results are that the annual energy cost for the electric-only equipment is $95,799 and for the hybrid plant is $57,247. These results indicate that based on an annual savings of $38,552, the SPB on the additional $139,000 investment is 3.61 years based on the assumed real-time pricing scheme.

In this example, the gas powered chiller is assumed to be operating during the peak periods. Of course, the SBP depends on the real-time pricing assumptions which is uncertain. Regardless, it is likely that there are numerous examples such as this one where the SPB occurs in a few years, after which, total operating costs for this equipment drop compared to the electric-only option.

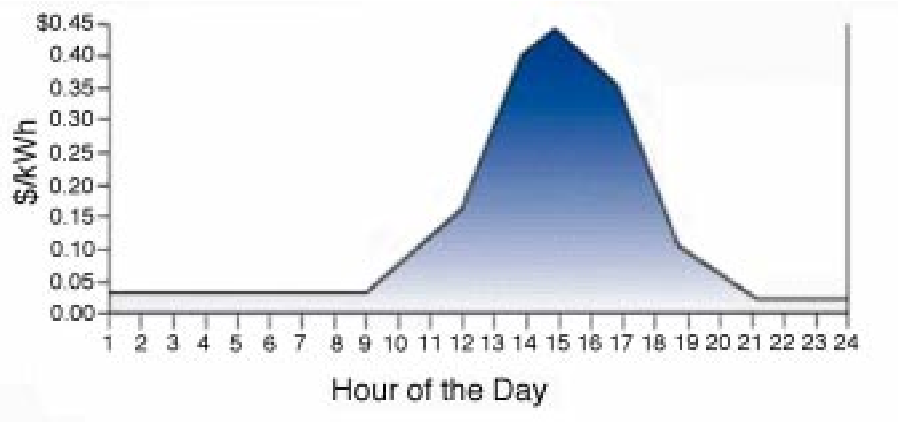

Figure 1. Simple RTP Schedule—Summer

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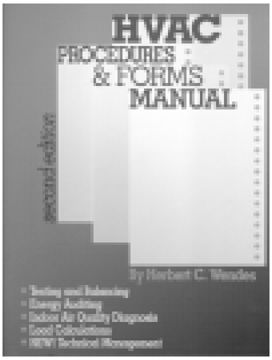

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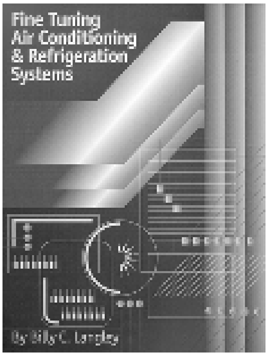

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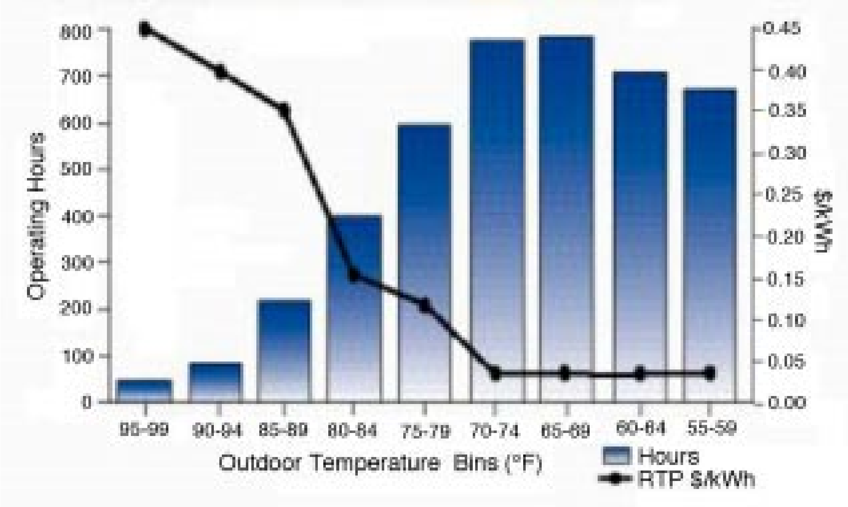

Figure 2. Temperatures, Hours, and Electric Costs

Temp B/N	Hrs	Tons Load	ECWT	kW/ton	kW Draw	kWh	RTP $/kWh	Cost of Operation
95-99	20	800	82	0.527	422	8,432	$0.45	$3,794
90-94	84	742	81	0.517	384	32.224	0.40	12,889
85-89	216	678	79	0.504	346	74,790	0.35	26,176
80-84	393	632	76	0.487	308	120,959	0.35	18.144
75-79	585	573	74	0.479	276	161,684	0.10	16,168
70-74	775	522	72	0.475	248	192,566	0.03	5,777
65-69	784	467	68	0.468	219	171,348	0.03	5,140
60-64	706	412	63	0.475	196	138,164	0.03	4,145
55-59	670	357	59	0.497	177	118,877	0.03	3,566
								$95,799

	Equipment Cost	Operating Cost
CH-1	$126,000	
CH-2	126,000	
Total	$252,000	$95,799

Figure 3. All-electric Plant
Two 800-ton Electric Centrifugal Chillers.

Figure 4. Hybrid Plant
Chiller #1: 500-ton Gas-engine-driven Centrifugal Chiller
Chiller #2: 500-ton Electric Centrifugal Chiller

Temp Bin	Hrs	Tons Load	ECWT	Gas Tons	Mbtu Hr	Therms/ Hr	Therms	Gas Price $/Therm	Cost of Gas Operation*	Electric Tons	kW Ton	kW Draw	kWh	RTP $/kWh	Cost of Electric Operation	Total Operating Costs
95-99	20	800	82	500	3,250	32.50	650	$0.35	$298	300	0.560	168	3,360	$0.45	$1,512	$1,810
90-94	84	742	81	500	3,100	31.00	2,604	0.35	1,205	242	0.540	131	10,977	0.40	4,391	5,598
85-89	216	687	79	500	2,925	29.25	6.318	0.35	2,967	187	0.590	110	23,831	0.35	8,341	11,308
80-84	393	632	76	500	2,725	27.25	10,709	0.35	5,124	132	0.620	82	32,163	0.15	4,824	9,948
75-79	585	577	74	500	2,600	26.00	15,210	0.35	7,371	77	0.690	53	31,081	0.10	3,108	10.479
70-74	775	522	72	0	0	0.00	0	0.35	0	522	0.475	248	192,161	0.03	5,765	5,765
65-69	784	467	68	0	0	0.00	0	0.35	0	467	0.464	217	169,883	0.03	5,097	5,097
60-64	706	412	63	0	0	0.00	0	0.35	0	412	0.455	187	132,347	0.03	3,970	3,970
55-59	670	357	59	0	0	0.00	0	0.35	0	357	0.456	163	109,071	0.03	3,272	3,272
																$57,247

	Equipment Cost	Operating Cost	
CH-1	$265,000		
CH- 2	126,000		
Total	391,000	$57,247	
Base Plant	252,000	95,799	Simple Payback
Delta	$139,000	($38,552)	3.61 Years

*Includes maintenance premium

The SPB method will help the facility manager convince upper management of the economic benefits of an investment of a new technology. However, the more detailed LCCA is needed to ensure the optimum alternative is chosen from an economic standpoint. A LCCA for the previous example would consider other costs incurred during the life of the equipment such as maintenance.

In the previous SPB example, the fact that gas powered chillers are more expensive to maintain was completely ignored. The more that gas powered chillers are operating, the greater the maintenance costs. It is possible that by running the chiller less, thus saving less on electricity, more savings will occur over the lifetime of the equipment. As mentioned before, the main goal for load shifting and load switching is to cause a level and predictable demand profile.

To compare and contrast result using both the SPB and LCCA methods, an example published by Arnold and Bahnfleth is summarized.[20] In this example, the authors evaluate the benefits of using a gas powered chiller to reduce the electrical demand (peak shave) when electricity prices are highest. Several different gas powered chiller sizes are reviewed since the initial investment and annual maintenance costs vary based on size.

Since there is a trade-off between savings and expenses when running the gas-powered chiller for longer periods, the duration of monthly operation is determined by maximizing the net savings associated with the electricity savings, gas costs, and maintenance costs.

The LCCA method must consider items such as discount rates, escalation rates for variable costs, and debt obligation payments. Arnold's and Bahnfleth's results are shown in Table 1. The life-cycle costs are actually the energy savings for each case.

It is interesting to note that the alternatives with the most life-cycle savings have the longest SPB. This is because the larger gas powered chillers cost more initially, but save more over time. The authors recommend the 600 ton chiller as the optimum choice which seems very reasonable because the life-cycle savings level off at this point.

Energy managers must perform this type of analysis to support the investment. Without this analysis, the lowest first cost 300-ton gas powered chiller would certainly have been chosen, allowing approximately $130,000 dollars of savings to be lost. This example also supports the motivation for only leveling demand versus reducing electricity usage further.

Table 1. Selected Figures from Arnold and Bahnfleth[20]

Simple payback and life cycle cost comparison of alternatives.

Gas Engine Chiller Nominal Capacity (Tons)	Incremental Cost ($)	Annual Electric Savings ($)	Annual Natural Gas Costs ($)	Annual Engine Maintenance Costs ($)	Simple Payback Period (Years)	Life Cycle Costs ($)
300	$85,520	$24,513	$1,751	$465	3.8	$218,472
350	$88,870	$27,754	$2,418	$630	3.6	$247,566
500	$156,920	$40,121	$4,634	$1,415	4.6	$305,842
600	$176,120	$47,674	$6,775	$2,068	4.5	$349,951
700	$210,000	$50,624	$8,031	$2,452	5.2	$332,915
800	$220,920	$58,280	$12,699	$2,807	5.2	$354,598
900	$254,540	$66,352	$15,331	$4,449	5.5	$370,205

CONCLUSION

The ability to influence investment decisions by controlling energy costs should present exciting possibilities to an energy manager in the commercial area. Various external drivers further influence these decisions and must be understood by all involved when making upgrades to commercial facilities, or when designing new ones. The electricity component of energy costs has been made even more confusing due to the restructuring of the electric utility industry. Strategies outlined in this article will benefit energy managers on their quest to reduce the electricity cost component of the commercial facility's total energy bill.

Cost savings can be modest or dramatic, depending upon the dynamics of the competitive electricity retail market. There is no doubt that a commercial facility achieving a level and predictable electricity load profile will achieve savings compared to one with a more unpredictable load profile that contains varying peaks of electricity usage. There are many decisions to be made, but the process is beginning to take shape. Economic analysis will allow savings to be predicted and can help investments that yield the lowest costs, in the long run, even if the first cost of implementing the new technology is not the lowest.

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