Starting Small Is Beautiful:
Using Incremental Energy Efficiency to Convince the Plant Manager

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ABSTRACT

For many if not most plant managers, it's a huge problem: how to control spiraling energy costs, after rising electric and gas prices have already taken a bite out of operating and utility budgets for the year.

Of course, both process and space (lighting, HVAC) loads chew up energy. Plant managers, though, know they're evaluated first on production – quantity and quality. They may thus be leery of energy efficiency (EE) improvements that -- in their minds, at least -- hold the potential of affecting that production. Sometimes this can stymie attacking the biggest energy-waste sources in the plant.

We illustrate several examples of starting with upgrading of lighting, cooling and heating equipment, in an incremental phased approach to convince the PM and his colleagues that there are ways to lower expenses without sacrificing (and sometimes even improving) performance. We will show how, then, to move on to process heating and cooling equipment, in adopting ECMs (energy conservation measures) -- in nearly all cases, short of buying new equipment -- that take into account sensitivities to process variables, product throughput, inventory control, and other critical manufacturing variables.

Examples are presented from the food, medical equipment, chemicals, and aluminum industries. We also discuss use of some of ENERGY STAR's financial analytical tools to calculate true cost and returns of these strategies.

The Problem: "Don't Mess With My Numbers"

Many corporations have set public goals for "sustainable" and "green" manufacturing, and for reduced corporate carbon footprints. Invariably, an attempt to take industrial processes in those directions must involve increasing energy efficiency.

As these laudable goals move to the manufacturing floor, however, they often encounter resistance from line managers whose major charge, in their minds at least, is maintaining monthly productivity and product quality numbers. And again in their minds, at least, energy efficiency proposals may initially seem to raise a flag of threatening one, or both, of these metrics on which they are judged. Adding to the "uh-oh" reflex, economic downturns and vast, generational feelings of job insecurity don't help matters. The former means less money for all activities, and the latter heightens the fear of making a mistake.

In fact, the technical answer is that more energy-efficient practices can actually improve both quality and productivity, and often both together, while still saving energy. Still, the "bad code" in many managers' heads is "'Energy efficiency' = less energy = less security of product quality + quantity = more risk". The problem, it seems fair to say, is thus more of psychology than of technology.

And it is a powerful and widespread one: many companies have turned away from virtually assured cost savings and process improvements from efficiency measures, even before pilot trials, due to fears that may only be vaguely framed. The internal programming in all of us, of "you can't get something for nothing", "there's a lot of snake oil out there", and so forth, can combine negatively with the manager's personal cost/benefit analysis. If the balance of:

> What do I get out of it if it (the energy efficiency measure) works? vs.
> What happens to me if it doesn't?

-- is viewed in the usual way, the industrial energy efficiency proposal may be quietly mothballed.

Magnitude of the Problem

Yet the issue of waste in industrial energy consumption is not only critical to competitiveness and job retention, but also is a key element in climate change mitigation. Using IPCC and IEA data, Lawrence Berkeley National Laboratory in 2008 estimated global industrial energy efficiency potential at <u>19%-32%</u> of industrial CO2 emissions, and <u>7%-12%</u> of total world CO2 emissions (Price, 2008).

Those are enormous numbers. But the inclination in industry (as industrial energy experts themselves note) is to look more kindly on a "growth" capital project (i.e., to make more product, or new product), with a 20% chance of meeting its projected – say -- 30% ROI, than on an equivalent-sized EE project with an 80% chance of hitting the same 30% ROI. This bias toward production capital expenditures can lead to a durable double bind: in good times, capital is routed toward producing more, vs. achieving operational cost reductions; and in bad times, there's no funding for operational cost savings, because sales are down. Why save more on product you're not selling?

Some Previous Research and Its Implications

This problem of psychological resistance to EE projects can be viewed, in organizational behavior terms, as a "process of influence". In this sense, fortunately, the same tools that can help in other organizational contexts can help with uptake of energy efficiency measures, by helping managers to change their attitudes and pre-assumptions. Schein describes a 3-part process for changing a manager's attitude in an organization (Schein, 1988):

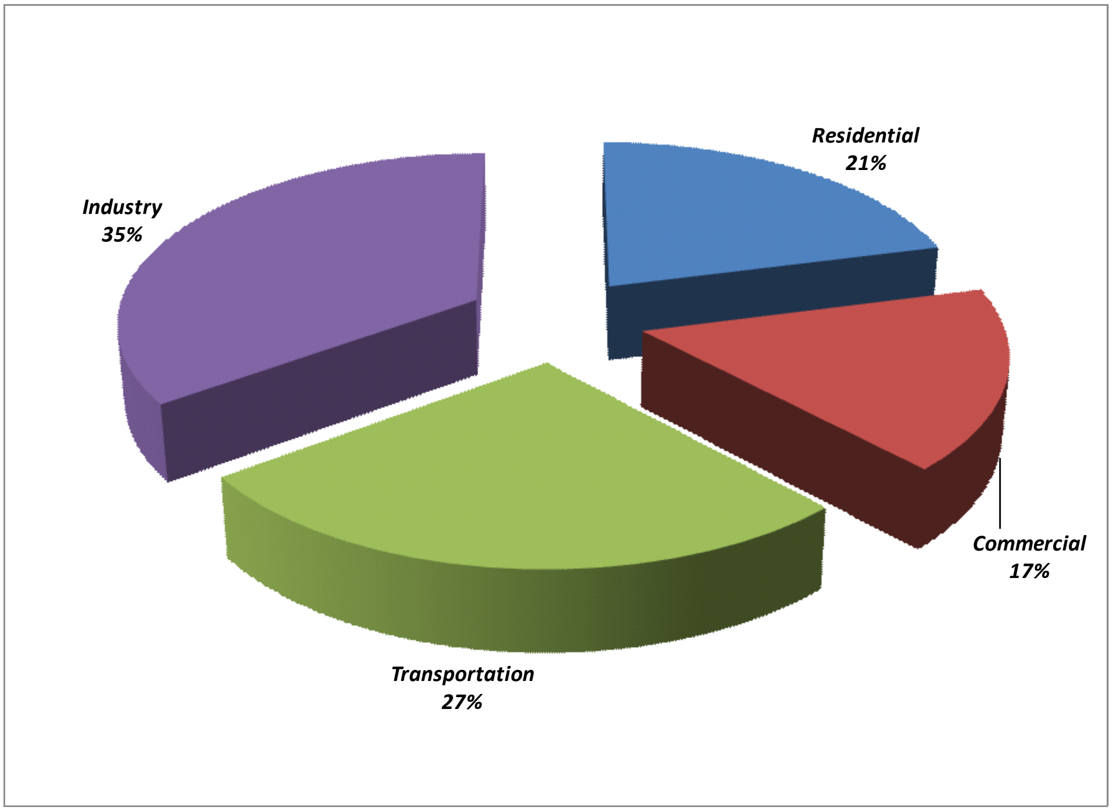
1. <u>Unfreezing</u>: Schein defines this first phase as "an alteration of the forces acting on an individual, such that his stable equilibrium is disturbed sufficiently to motivate him and to make him ready to change; this can be accomplished either by increasing the pressure to change or by reducing some of the threats of resistance to change."

2. <u>Changing</u>: In this second phase, new information is presented and the individual's attitudes are thereby changed.

3. <u>Reintegration</u>: Schein calls the third and final phase "refreezing", but "reintegration" seems a better term to describe the process of storing the new, revised attitude on the shelf with other attitudes, with the attendant necessary adjustments and justifications.

Moreover, with a large section of industrial energy efficiency, there is a way to "start small and safe" – a good idea in pilot design in all circumstances. In this, Amram and Kulatilaka are among several researchers who have pointed out a longtime "ignored opportunity" in EE program focus. While USEIA and other statistics often break energy usage out as Industrial, Commercial, Residential, and Transportation, as shown in Figure 1 below, a better way to portray usage is as Buildings, Industry, and Transportation, as shown in Figure 2.

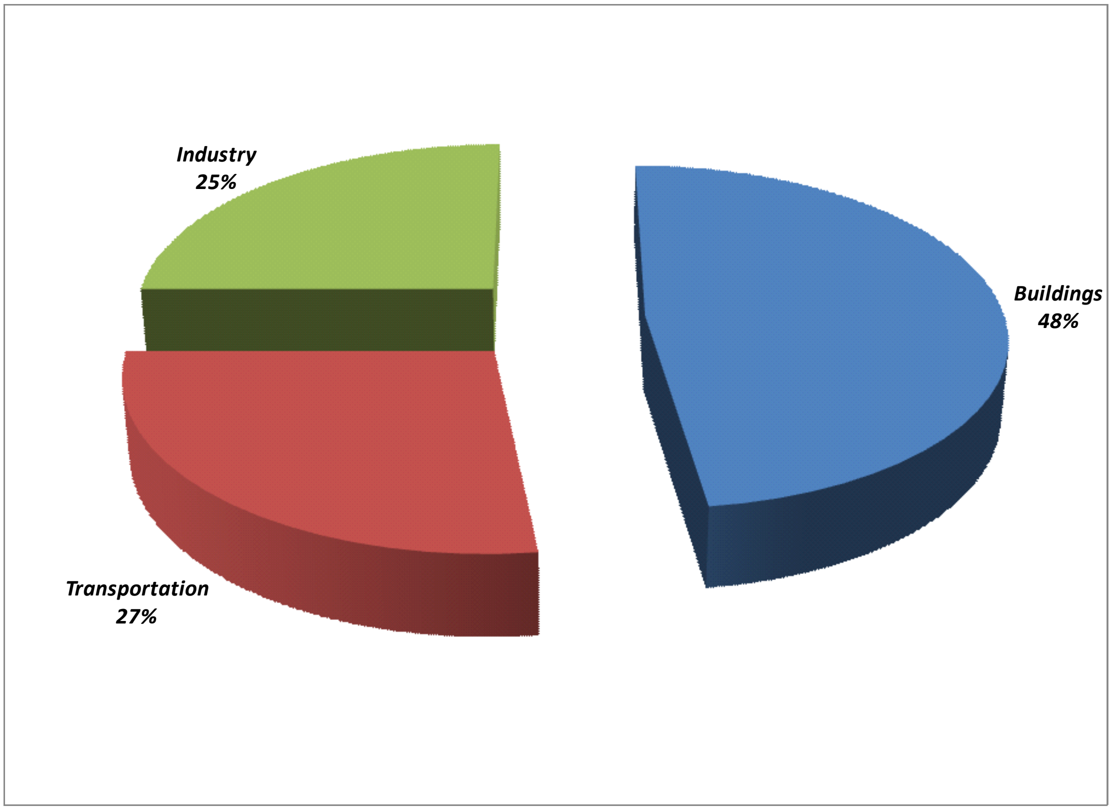
Figure 1. Typical US Energy Usage Breakout



Source: Amram and Kulatilaka, 2007

Figures 1 and 2 make clear, among other things, that a large proportion of "industrial" energy usage is, in fact, in the industrial building stock. In further reinforcement of this conclusion, according to a 2006 study, California industrial energy consumption had the components shown below in Table 1 (Shelton, 2006). In parallel with energy efficiency, "smart grid" initiatives targeting large opportunities for demand response (sometimes called "voluntary curtailment") should also take note of this aspect of industrial operations – i.e., that in addition to opportunities to shut down smelters, shift production schedules, etc. in order to reduce grid loading at critical periods, there can also be large opportunities for voluntary curtailment in industrial building lighting and HVAC operations.

Figure 2. An Alternative US Energy Usage Breakout



Source: Amram and Kulatilaka, 2007

Table 1. California Industrial Energy Consumption, 2006

Energy Source	Energy Use	%Total
Electric	Lighting	10%
	HVAC	11%
	Process Heating	11%
	Process Cooling	8%
Gas	Boiler	40%
	Process Heating	46%
	HVAC	7%

Source: Shelton, 2006

Table 1 above shows that industrial HVAC electric consumption levels in the survey were, interestingly, in the same general range as both electric energy consumption for process heating and process cooling: about 8%-11% of total electric usage. Importantly, however, the generally perceived risks of installation, startup, and operation with HVAC energy efficiency projects are considerably less than those typically perceived (or more precisely, feared) for a process heating or cooling project. In one case, as the thinking might go, people might get hot or cool for a while; in the other, products, or even equipment, might be damaged or ruined. As such, HVAC is a good place to start in EE, especially in industries where process heating and cooling and space heating and cooling are both important. Some examples are as follows:

- Manufacturing featuring clean room operations
- Food preparation
- Metals and metal fabrication
- Chemicals and pharmaceuticals

Examples from each of these industries will be discussed below.

Using ENERGY STAR Metrics

The ENERGY STAR for Industry program offers a number of tools for industrial concerns to use in establishing plant-level energy efficiency programs. The familiar 7-step “Guidelines for Energy Management” process, beginning with “Make Commitment” and ending with “Recognizing Achievement”, and then cycling around again, can easily incorporate the principles of process of influence as they are described above. Industry cost comparables and, in particular, calculating the “Cost of Doing Nothing” can be a big element in convincing skeptics that EE projects can be monetarily and competitively meaningful.

A Generalized Approach for Process of Influence in Industrial EE Programs

The following 4-step iterative process can be used to get an industrial EE program going:

1. <u>Set goals</u> and establish incentives, and communicate both. This is the “unfreezing” part of the process, whereby a new value system is communicated to line managers.

2. <u>Start small and safe</u> with analysis, selection, and implementation of lighting and space cooling and heating improvements. This starts the “changing” element in this process, in that managers start to see that in low-risk, less-production-sensitive situations, EE improvements can deliver significant financial rewards and no downside. As successes mount in the lighting and HVAC projects, managers’ attitudes toward EE, and even towards certain technology approaches, will in “reintegration” become more accepting of the win/win potential of EE proposals. In parallel path during this Step 2 --

3. <u>Analyze plant process heating and cooling operations</u> for size of EE opportunity, then <u>rank the opportunities</u> from lower to higher risk in terms of process tolerances. This step can continue the “changing” process, as managers now take a closer look and see opportunities with new eyes (a very common side-benefit, in general, of EE programs).

4. With the prioritized targets of Step 3, develop and implement a program to <u>fund and make the process improvements on a thus risk-adjusted, bang-for-buck basis</u>.

Regarding Step 3, a study of aluminum manufacturing in India, for instance, tabulated approximate sources and magnitude of energy losses through the manufacturing process. The largest amount of energy utilization is in the electrolytic Hall Heroult process, which accounts for about 34% of total energy usage, with energy for process steam and process heat at about 14% and 52%, respectively. The study team found heat losses during the wash and evaporation/drying step, and electrolytic resistance losses, were both high-magnitude energy inefficiencies that are also susceptible to fixing without much risk to production tolerances. Figure 2 below shows the energy values in 10^6 KJ/ton at each stage of the aluminum manufacturing process (Basu, Chaudhuri and Roy, 2005).

The iterative approach (Steps 1-4 above) will raise consciousness about energy as a cost. Schein clearly was contemplating both positive and negative reinforcement in his description of the steps, though probably the best goal is to have the explicit reinforcement be all positive: e.g., a bonus pool based upon EE cost savings, recognition in professional citations, etc.

Some Examples

Chemicals

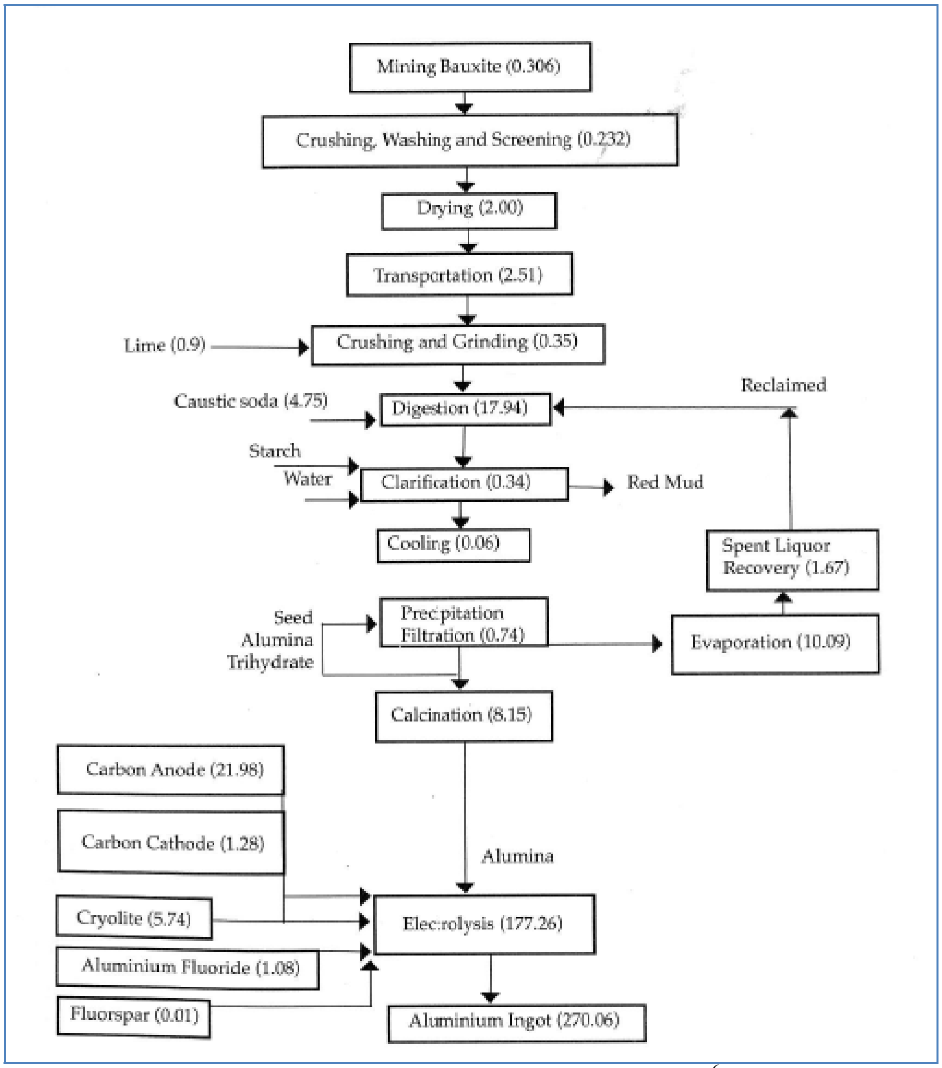
Parr has described DuPont's Energy Capital Set Aside program, an innovative approach that sets aside approximately 1% of the capital budget annually for EE projects.

DuPont's experience with this program suggests that this method -- in essence, adopting the old personal savings technique of "paying yourself first"-- is an excellent way to get around the abovementioned tendency in industrial capital budgeting, where "growth" (make more, or newer product) capital projects are funded instead of the EE project with similar or superior risk-adjusted dollar impacts.

The hurdle rate used by the energy efficiency project vetting committee set up by DuPont was 35% on an IRR basis, and with a "superior" project NPV. DuPont's initial results have been impressive: the 23 Energy Capital Set Aside projects implemented in 2007, for a total capital expenditure of $36 million, returned annualized pre-tax savings of $35 million, for an 81% ROI, as well as very significant related emissions reductions.

And importantly, the program has indeed apparently catalyzed an attitude change in production management. As Parr puts it, a public "willingness to fund" EE projects on DuPont's side has led in turn to a "willingness to find" deserving projects. Thus, DuPont stands as a successful example of a process of influence.

Figure 2. Energy Flow Diagram, Aluminum Manufacturing



Source: Basu, Chaudhuri and Roy, 2005 (values in 10^6 KJ/ton)

Table 2 below indicates some examples of the DuPont program's EE projects approved to date. As can be seen, most can be said to fit the "small and safe" categorization.

Table 2. DuPont Energy Capital Set Aside Program: Example Projects

Blowers to replace compressed air	Upgrade of steam turbine
Heat recovery from flash steam	Replace steam vacuum jets
Insulation of process vessels and piping	Laboratory fume hood alarms
Use waste gas to offset purchased fuels	Heat integration in distillation process

Source: Parr, 2009

Food

A large pizza manufacturing plant in the Midwest had large amounts of refrigeration and gas-fired heating equipment. Production schedules and tight budgets left plant managers concerned about larger process equipment changes in the name of EE. However, an ESCO working in collaboration with the plant's regular air conditioning and refrigeration contracting firm was able to propose and deliver a successful submetered pilot project, installing energy efficiency HVACR control retrofits on heating and small refrigeration (R410a refrigerant) equipment. It was important to the project's acceptance that the HVACR contractor, a trusted business partner, was involved with the proposal as well. Figure 3 shows a photograph of the plant's rooftop, with its large assemblage of ammonia refrigeration and freezing equipment. EE control retrofits of gas-fired package unit heating delivered 30%+ weather-normalized gas savings with excellent space temperature control, and the small refrigeration pilot also showed good efficiency gains.

Figure 3. HVAC Energy Project, Food Processing Plant

Source: PaceControls, 2009

As such, as a result of this piloting, the plant staff are working with their "greening committee" on analysis of large-scale process equipment, including large boiler and blast freezing equipment.

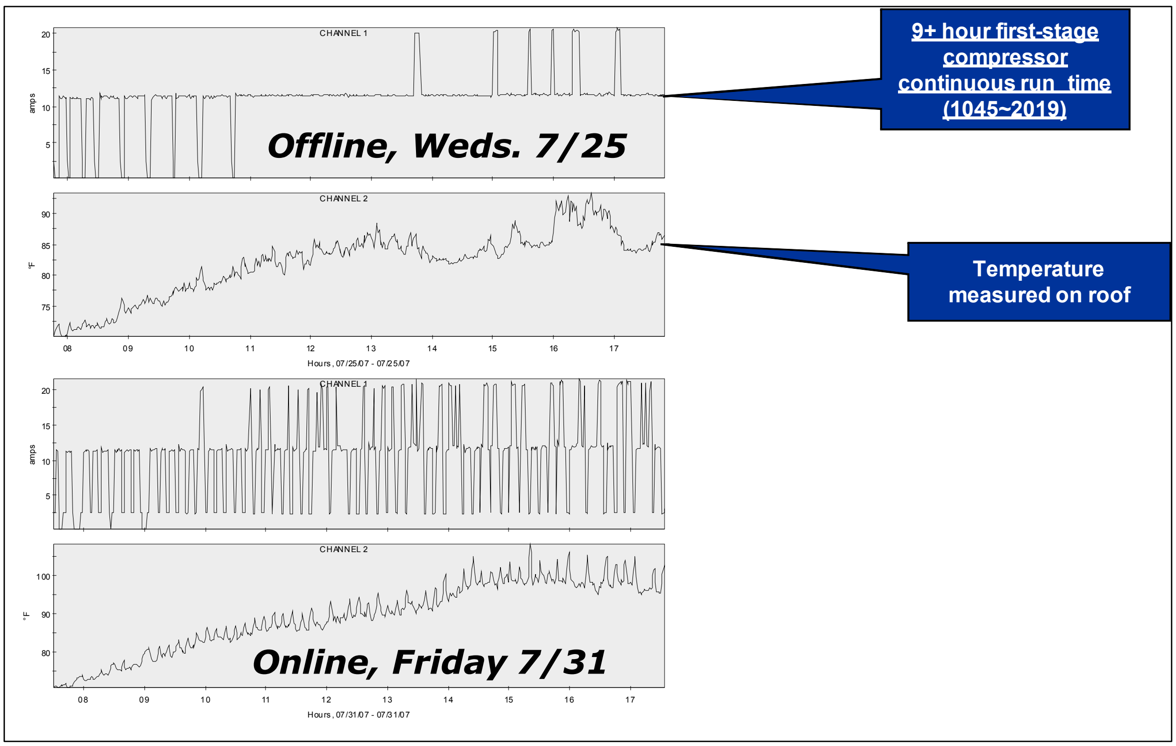
Medical Equipment

Another ESCO, working with a senior advisor to management of an international medical supplies manufacturer, proposed space conditioning EE projects for a distribution center. The distribution center, which had no manufacturing, received HVAC energy efficiency controls retrofits to the heating and cooling equipment.

Figure 4 shows current and rooftop temperature datalogging of one of the retrofitted package units at the distribution center. The 12.5 ton, 2-compressor package unit cools a lowerlevel area. "Offline" (control retrofits disconnected) compressor run time for the 12.5 ton unit, during the same 2 workdays of approximately matched weather, shows the first-stage compressor running continuously for 9+ hours, vs. optimized intervals of 1- and 2-compressor operation with optimizing control retrofits "online".

The total EE space conditioning project, which also included gas-fired unit heating in the warehouse area, paid for itself in under 1 year, in degree-day normalized utility bill analysis done by the manufacturer's corporate staff. As a result of this highly successful testing, the same products were incorporated into clean room manufacturing facilities, and on a national basis for this manufacturer. It is significant that the manufacturer was also greatly interested in the carbon-reduction benefits of these EE projects, as well as in the cash-flow benefits.

Figure 4. Datalogging of Air Conditioning Unit Operation
Medical Supplies Manufacturer Distribution Center



Source: PaceControls, 2007

Conclusions

"Starting small and safe" is a good and commonsense rule of thumb for most industrial piloting operations, no matter what the product or process. It is also a useful approach to take in helping managers to overcome attitudes of over-caution and concern about EE projects for the plant floor.

Starting with lighting and HVAC projects can achieve real-time savings, and quite possibly other benefits, while providing evidence that EE need not have inevitable negatives. It is critically important to take into account well-meant attitudes and reservations on the part of production managers, and the process of influence model can be a useful tool in overcoming negative attitudes.

As mentioned briefly above, an even newer field of application for this approach lies in the growing number of electric demand response (or alternatively termed "voluntary curtailment") programs. As utilities and demand response aggregators alike work with electric grid operators to refine their value propositions in this evolving industry -- with large potential benefits for all electric rate classes -- industrial customers, with their large electric demand profiles, are prized prospective clients for DR. While DR-oriented projects have not been addressed in this paper, they are a natural flange-up to energy efficiency programs, and the same educational process discussed herein can be helpful for DR as well.

References

Amram, Martha and Kulatilaka, Nilan. "Financial Innovations and Applications for Energy Services: Toward a Second Green Revolution". Policy Brief, Milken Institute, April 2007.

Basu, Navojit, Bimal Chaudhuri, and P.K. Roy. 2005. "Energy Management in Indian Aluminium Industries". *Energy Engineering* 102 (6): 7-25.

PaceControls, LLC. 2007, 2009. Unpublished metered demonstration reports.

Parr, Michael. "Investing to Improve Energy Efficiency: One Company's Path". PowerPoint presentation, presented at the ACEEE Market Transformation Symposium, March 30, 2009.

Price, Lynn, and Lawrence Berkeley National Laboratory. "Technologies and Policies to Increase Energy Efficiency in Industry". PowerPoint presentation, presented at the American Physical Society's Forum on Physics and Society, "Physics of Sustainable Energy", March 1, 2008.

Schein, Edgar. "Management Development as a Process of Influence". 1988. In *Readings in Managerial Psychology*, ed. Harold J. Leavitt, Louis R. Pondy, and David M. Boje. Chicago: University of Chicago Press.

Shelton, Jean. "Results from the California Energy Efficiency Potential Study – Existing Residential and Commercial". PowerPoint presentation, San Francisco, CA, July 27, 2006.