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Monitoring and Evaluating DSM and Energy Services Projects: A Success... and a Failure

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It has often been said that the "rubber hits the road" in Demand Side Management and Energy Services projects at the point of measuring the actual savings being achieved by a project. In the world of Demand Side Management, this is important because the various State Public Utility Commissions must be assured that the incentives paid to utility companies are justified by actual demand and consumption reductions and that those reductions are persistent, i.e., they will continue to occur over the life of the project. In the world of Energy Services, building owners need to know that the lease (or other) payments that they are making are being offset by reductions in energy use and cost.

This article presents the results of evaluations of two similar energy retrofit projects, both of which were done on a financed and guaranteed-savings basis. In one case the project was an unqualified success. In the other case it was a complete failure. This article describes the projects and their implementation methodologies, documents the projects' performance, and makes recommendations regarding the selection of Demand Side Management and Energy Services vendors and project implementation practices.

PROJECT NO. 1... A SUCCESS

Description of Project No. 1.

This project was the retrofit of a county administration building and courthouse complex. The administration building was built in the late 60's and is relatively modern in terms of its building construction, HVAC, and lighting systems. The courthouse building, by contrast, was built in the 1920's and shows its age in terms of its construction, the wide variety and age of its HVAC systems and the wide variety and age of its lighting systems. Each building was separately supplied with electricity and both buildings share a common central cooling and heating plant.

Through a competitive proposal process, the county choose a team to implement the project. This team consisted of a prime contractor (who was actually a local mechanical service contractor), a consulting engineer, and a financier. The steps to project implementation included the following:

- the completion of a very rigorous energy retrofit feasibility study including computer simulation of the entire facility to within 5% of its actual utility company invoices, performed collaboratively by the consulting engineer, the prime contractor and the owner's staff

- detailed review of the feasibility study by the owner, along with owner participation in selecting the final package of retrofit work to be performed—to suit their financial criteria, building maintenance and repair concerns, and other needs

- negotiation of a final turnkey retrofit contract

- completion of detailed final design, including such detail as point-to-point control wiring diagrams

- installation

- start-up and debugging of the project and training of owner's staff

The ultimate project implemented include the following features:

- the installation of an energy management computer for time-scheduling of virtually all HVAC equipment

- major modifications to the majority of the air handling systems in the two buildings including direct digital controls, conversion to variable air volume and the addition of outside air economizers on systems not so equipped

- extensive lighting fixture retrofit

Results of Project No. 1

The mechanism chosen by the parties to this particular contract for measuring the avoided cost produced by the project is a methodology generally referred as "stipulated calculations." In this methodology a series of formulas are developed which utilize energy factors which are agreed to by stipulation by both parties and which formulas also contain variables, such as equipment run-time and fluid temperatures, which are monitored and recorded by the building automation system.

These formulas are embodied in an automated spreadsheet which is used on a periodic basis by the energy services contractor and the owner (both parties possess the spreadsheet) to account for the avoided cost produced by the project. In addition, as a control mechanism, our firm was asked to prepare monthly cost avoidance reports utilizing comparison of monthly utility bills.

In this mechanism the units of energy used during the pre-retrofit base period is compared to the units of energy consumed after the retrofit is complete, and the difference in energy units is multiplied by the average unit cost of each type of energy consumed. These reports were generated on ERA's proprietary Energy Accounting Report System, which is described in the *Energy Engineering* annual "Directory of Software for Energy Managers and Engineers."

As can be seen in Figures 1, 2 and 3, the electrical use and natural gas use for the building complex departed from its normal pattern around June of 1990 and has essentially stayed that way since. As can be seen in Figure 4, which shows 12-month-long moving window totals, the long term trends in energy use are clearly down (we frequently utilize 12-month-long totals to neutralize seasonal effects in the data so trends can be more easily observed).

Figure 1. Admin. Bldg. Elec. Use: 1989-91

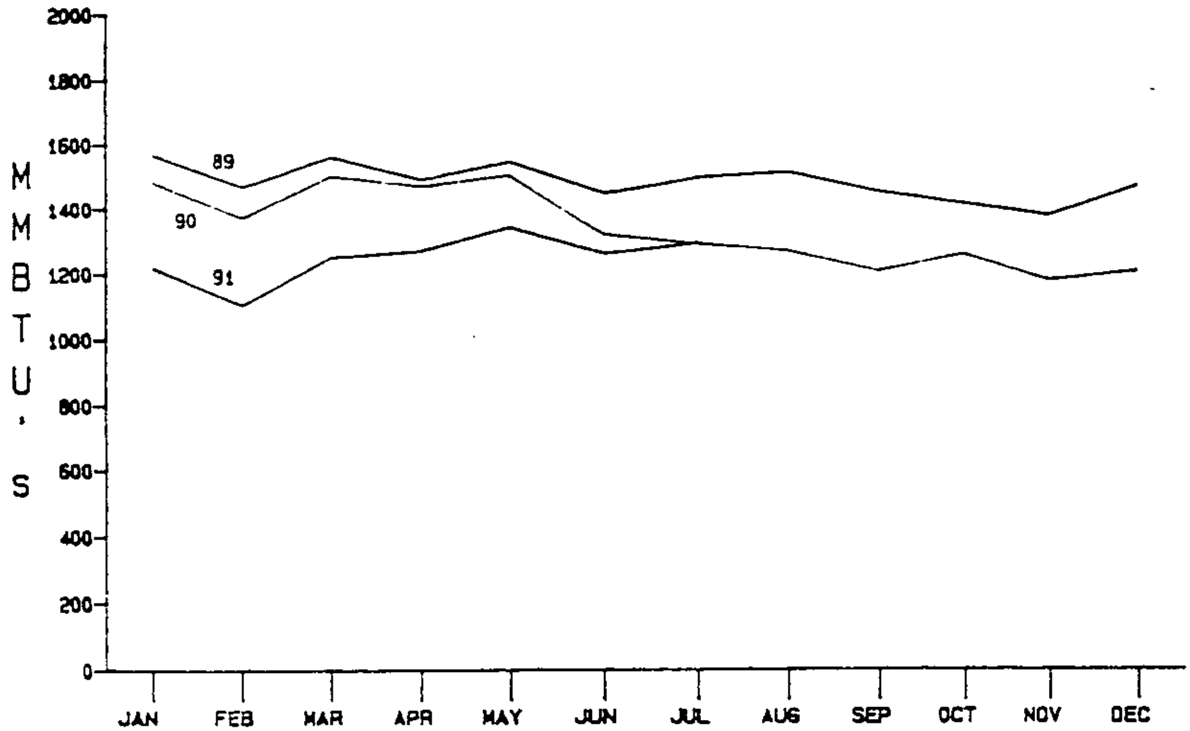


Figure 2. Courthouse Elec. Use: 1989-91

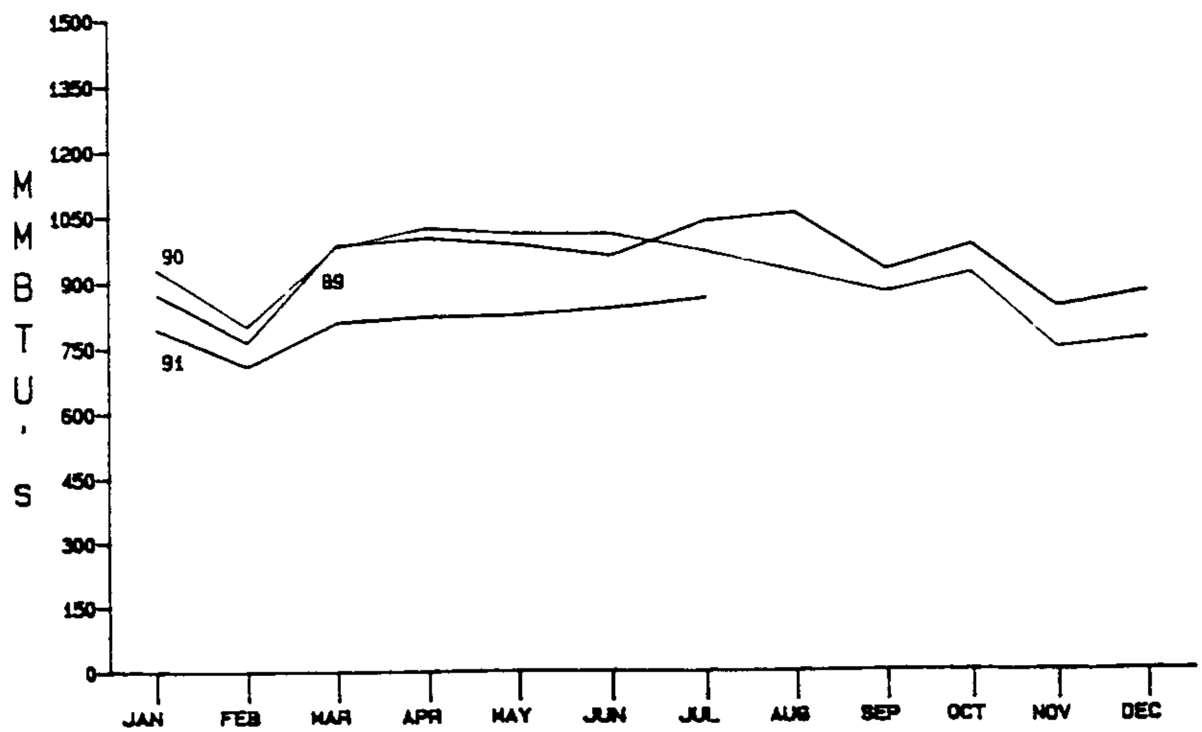


Figure 2. Court/Admin. Gas Use: 1989-91

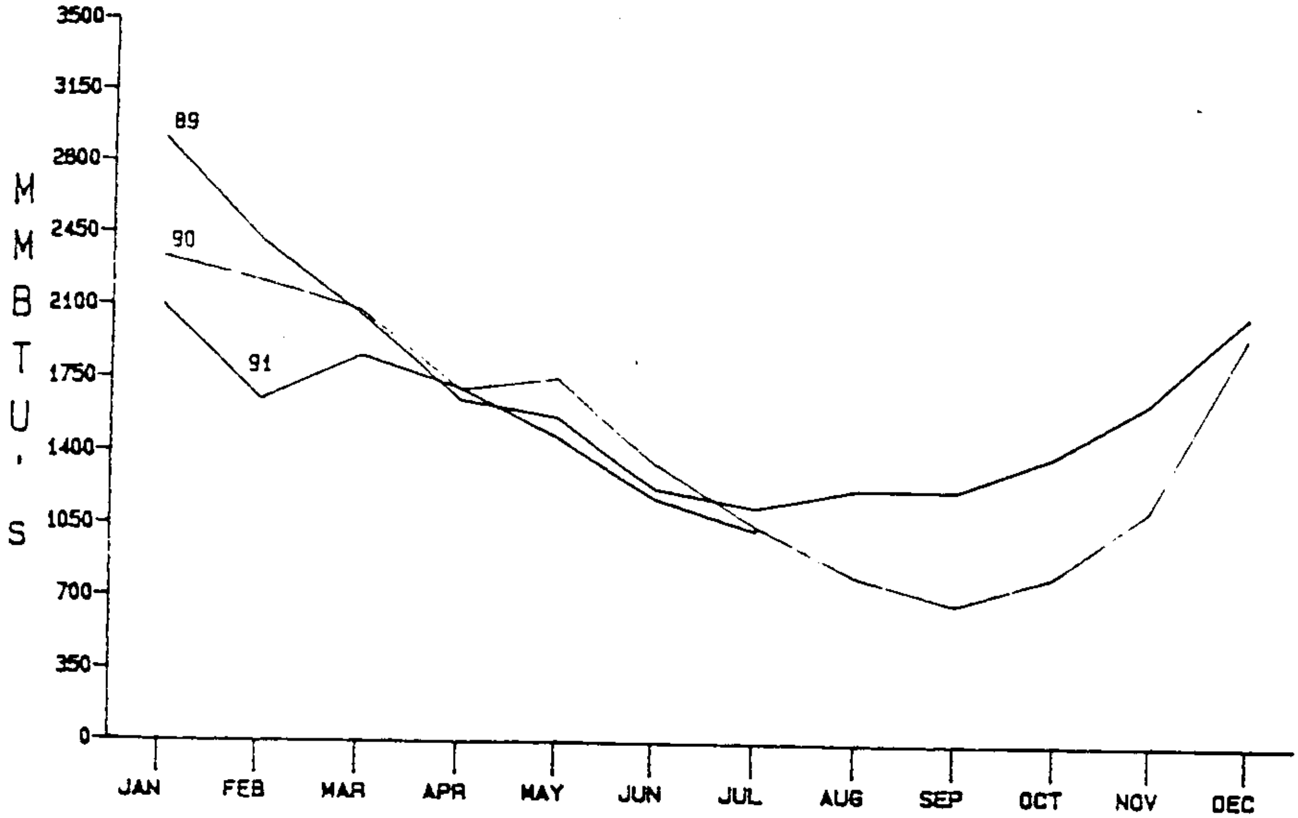
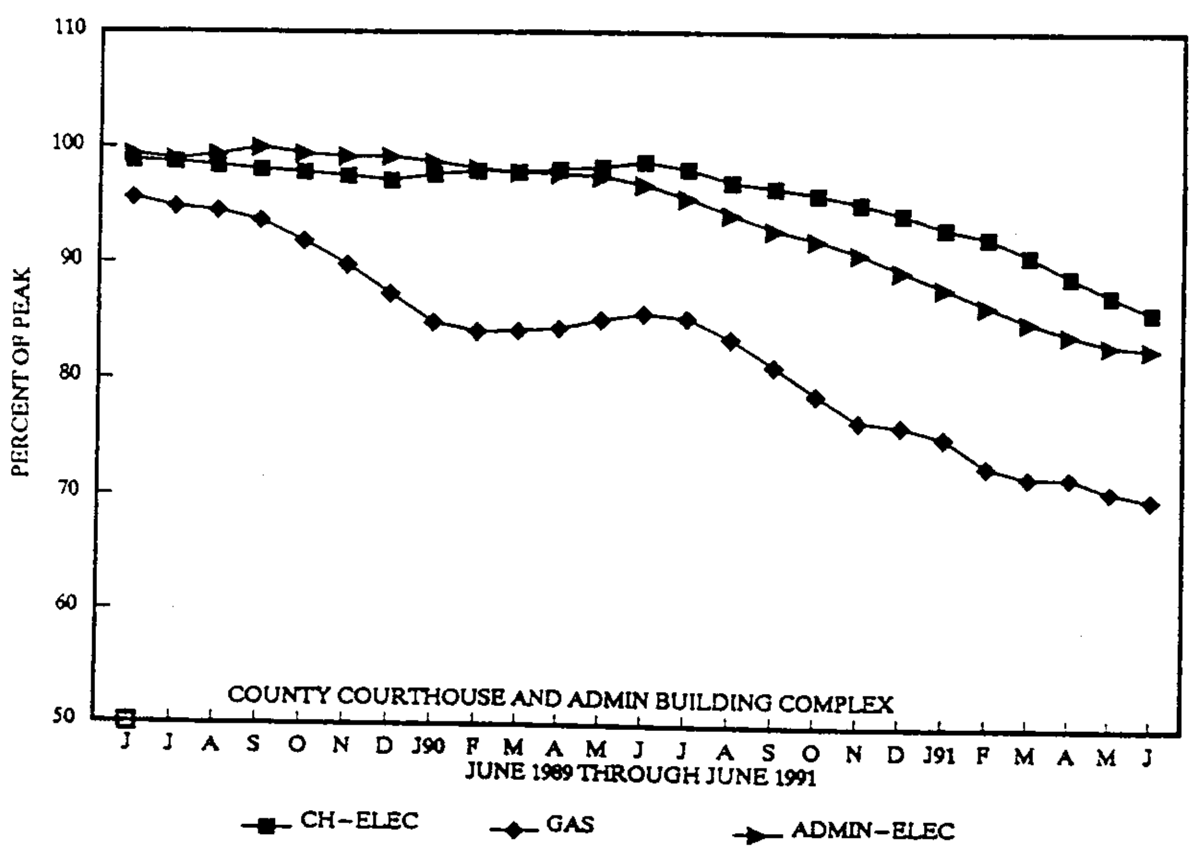


Figure 4. 12-Month Totals



PROJECT NO. 2... A FAILURE

Description of Project No. 2

The second case study project was a retrofit of a full service community hospital, also located in California. Similar to the administration building and courthouse complex, this facility was constructed in a multitude of projects spanning a number of decades. While fairly modern, this hospital possessed a wide variety of HVAC and lighting systems and, notably, had three separate central chilled water cooling systems prior to its retrofit.

The implementation steps used for this project were significantly different than that of the first project described herein. Specifically, the steps included the following:

- a preliminary assessment and outline proposal from the contractor (a large, nationally recognized controls manufacturer)
- performance of a cursory "energy audit" by the vendor's <u>sales</u> engineering staff, including <u>minimal</u> documentation
- preparation and presentation of a final proposal by the vendor
- contract negotiations and contract execution
- implementation of the project including <u>minimal</u> design documentation

The scope of construction for this particular project consisted of two basic components. The principle component was the installation of a new head-end computer on the existing building automation system. This computer was to provide automated scheduling of all equipment along with optimized control of chillers and their auxiliaries and optimized reset of the supply air temperatures of the majority of the air handling units.

The project also incorporated field hardware necessary to provide the automated supply air temperature reset. The second component of the project was the integration of the existing stand-alone chilled water systems. This work included interconnecting piping and the provision of automated shut-off valving for the various chillers.

Results of Project No. 2

As can be seen in Figure 5, no noticeable change occurred in the facility's use of electrical energy following the project implementation on or about November of 1989 (the year following the retrofit is shown as "1990" in the figure). In addition, Table 1, which shows monthly cost avoidance results, shows a <u>negative</u> cost avoidance, meaning that the facility's use of electrical energy has <u>increased</u> slightly since the completion of the project.

No natural gas savings was estimated for this project and therefore no natural gas data is presented herein.

Analysis of Project No. 2

As a result of its non-performance, a detailed audit of this project was conducted and produced a wide variety of observations, as described in the following:

1. The original energy "audit" identified savings of approximately $150,000.00 per year. Unfortunately, this audit was an "audit" in name only and, when examined in detail, revealed that little, if any,

Figure 5. Hospital Electricity Use: 1987-90

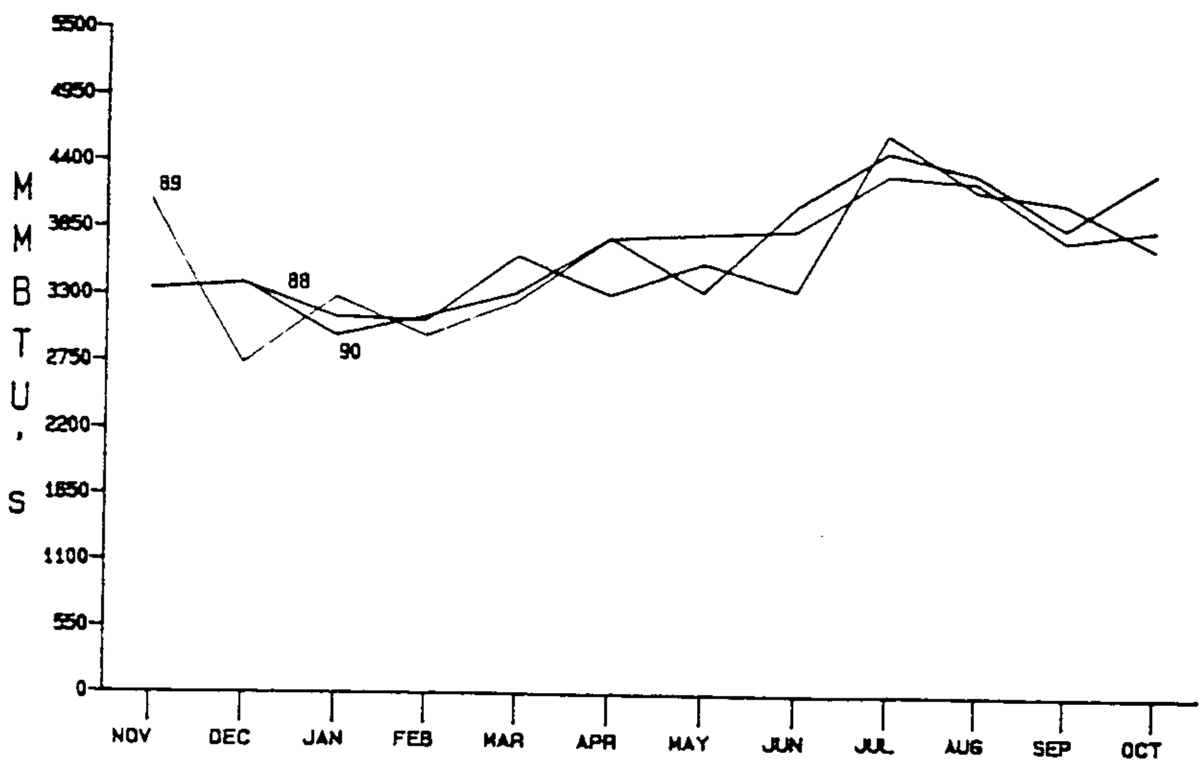


Table 1.
Cost Avoidance History

	Hospital (PV1) Month:	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Report for: Oct. 1990 Oct
89-90	Electricity	17312	-15215	7329	-3878	-1648	-157	11519	-6384	-6726	-2137	-3012	-11588
	Totals	17312	-15215	7329	-3878	-1648	-157	11519	-6384	-6726	-2137	-3012	-11588
88-89	Electricity	0	0	0	0	0	0	0	0	0	0	0	0
	Totals	0	0	0	0	0	0	0	0	0	0	0	0
87-88	Electricity	0	0	0	0	0	0	0	0	0	0	0	0
	Totals	0	0	0	0	0	0	0	0	0	0	0	0

Cost Avoidance History

Cost Avoidance Summary

From Nov 1989 to Oct 1990		From To (Transferred From Prior Report)		Program Total From Nov 1989 to Oct 1990	
Electricity:	-$14586	Electricity:	$0	Electricity:	-$14586
Total:	-$14586	Total:	$0	Total:	-$14586

factual information formed the basis for the savings calculations, and:

- the calculations were incorrectly performed in that incorrect units were used in formulas (e.g., degrees Fahrenheit versus enthalpy in Btu per pound of dry air)

- savings were double counted (e.g., cooling energy savings were counted at the air handling units and <u>again</u> at the chillers)

- values in the formulas such as air handling unit airflows in cubic feet per minute (cfm) appeared to have been guesses, as they did not correlate in any fashion at all to the airflow rates listed in the as-built drawings. (e.g., a 30,000 CFM guess, versus 10,000 CFM from as-builts)

Investigation indicated that no actual field measurements or detailed survey work had been performed. In addition, even the simple formulas that were used for estimating savings were misused in that formulas intended for calculating the savings from supply air reset on double duct HVAC systems were used for single zone, terminal reheat, and high pressure induction systems.

In short, the engineering feasibility study, or "energy audit," which was performed by the vendor was little more than a marketing ploy used to make the customer feel comfortable and thereby close the sale.

2. As the retrofit contract provided for a guarantee of savings, the contractor agreed to provide monthly audit reports which would document the avoided cost produced by the project. These reports provided simple tabulations of numbers which purported to show that the energy savings guarantee was being met.
   However, none of the formulas used in these audit reports were ever documented to the customer, but apparently embody the same erroneous formulas used in the original estimates of savings. Furthermore, the formulas were to employ variables such as the actual supply air temperatures at air handling units as reset by the automatic controls, and monitored by the building automation system. However, the audit reports simply show the same constant supply air temperature which was assumed for the original savings calculations. As a result, the monthly "audit" reports were little more than the original savings calculations presented in a new format.

3. Not only were the original estimates of savings erroneously wildly optimistic and the audit reports bogus, but further investigation of the modified building automating system ultimately revealed that, in fact, it was not working. While a new head-end computer was indeed installed, and the optimization software installed in this computer, the system had sufficient difficulties in its operation that the installing vendor ultimately removed the software and left the computer in place.
   This left the system in virtually the same condition it was prior to the retrofit. That is, reset of supply air temperatures, starting and stopping of chillers and pumps, etc. all had to be initiated by the system operators, as opposed to being automatic.

4. Because a detailed engineering feasibility study was not conducted and therefore a detailed technical plan for the project implementation was also not created, the project evidently went straight from sales to installation without really passing through a design stage. The results of this omission, for example, were such things as <u>two</u> air handling systems (one serving an interior zone while the other serves an exterior zone) having their supply air temperatures reset by means of a <u>single</u> control point from the building automation system!
   Clearly, the needs of these two spaces vary greatly and therefore it would be impossible to optimize the supply air temperatures simultaneously for systems having dramatically different cooling and heating needs. In the course of the audit of the project no documentation whatsoever was found for the modifications to the building automation system. Construction documentation was discovered for the modifications to the chilled water piping, valves, etc.. However, this documentation was found to be significantly inaccurate when compared to the actual installation.

CONCLUSIONS

The two projects exampled in this report are nominally the same. They were both financed and guaranteed turn-key energy retrofit projects. The difference between the two projects lie principally in the nature of the participants and the character of their approach to project implementation. To help our clients avoid the pitfalls chronicled above, our firm has established what we believe to be a good set of fundamental ground rules for the implementation of Energy Services or Demand Side Management projects, as follows:

1. The firm or team to do the project should be selected on the basis of their experience and qualifications, not just the financial underpinnings of the firm, optimistic (and admittedly enticing) savings projections, or a "rosy" sounding guarantee.

2. A detailed feasibility study is <u>always</u> required. There is simply no substitute for time spent in the field investigating systems and equipment, time spent in analysis of the building and its energy using systems and time spent performing detailed calculations of the potential energy savings that might be achieved by implementing certain energy conservation measures.

Generally speaking, computer simulation or other means to achieve an energy balance, i.e., a totalization of all the sources and uses of energy in the facility, is essential. In addition, estimates of savings should "spring-board" out of the comprehensive energy use model so as to prevent double counting or wildly optimistic estimates of savings. As a specific example, if a building only spent $60,000 per year operating its cooling equipment, an estimated annual savings of $50,000 for this function is probably not reasonable, even if the total annual energy bill is $500,000 or more. Each "piece of the pie" must be looked at individually instead of always being considered as a part of the total pie.

3. The engineering feasibility study, its source data and the bulk of the assumptions and calculations should be documented for review by all parties.

4. The intended energy conservation work should be identified by means of detailed scopes of construction work so that the installing company as well as the buyer can have a "yardstick" by which to measure whether or not the project has actually been implemented.

5. Extensive construction documentation should be developed, both to guide the installing contractor's craftsman, but also for the owner to see and concur with the detailed installation work planned, and to use as a troubleshooting tool once the work is complete and/or the contract term has run out.

6. Whatever means is agreed to by the parties for accounting for the avoided costs produced by the project, these means should be clearly defined and well documented and implemented in a way that both parties can track avoided cost when starting with the same periodically measured source data (unit costs of energy, system operating parameters, equipment run times, etc.).

There is great pressure from the various state legislatures and public utilities commissions to implement turn-key energy retrofit projects. Unfortunately many vendor firms are taking advantage of this business opportunity even though they are not truly competent in the field. Facility owners and utility companies should avoid being mesmerized by glossy corporate images and "no risk" guarantees.

Such purchasers should ask themselves the question: "do we want a guarantee... or a project that works?"

ABOUT THE AUTHOR

James P. Waltz, President of Energy Resource Associates, Inc., in Livermore, California, is a pioneer in the field of energy management. He has served as energy management program manager for the Air Force Logistics Command and the University of California's Lawrence Livermore National Laboratory. In addition he has worked as an energy management engineer for consulting and contracting firms. In 1981 he founded Energy Resource Associates for the purpose of helping to shape the then-emerging energy services industry.

Specializing in the mechanical, electrical and control systems of existing buildings, Mr. Waltz's firm has accomplished a wide variety of facilities projects, recently including a corporate-wide energy management program review for a major hospital chain, design of a replacement chilled water plant for a northern California hospital, on-site recommissioning of the entire building automation system for another large northern California hospital and audit and expert testimony relating to a failed energy services contract for a large southern California hospital.

Mr. Watz 's credentials include a Bachelors Degree in Mechanical Engineering, a Masters Degree in Business Administration, Professional Engineering Registration in three states, charter member of and Certified Energy Manager of the Association of Energy Engineers (AEE), member of the Association of Demand Side Management Professionals (ADSMP), Demand Side Management Society (DSMS) and the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE).

Mr. Waltz was recently nominated by the Bay Area Chapter of AEE for national Energy Engineer of the Year.

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