Metrics-Based Approach to Achieving Sustainable Energy Conservation

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ABSTRACT

Energy cost reduction can be achieved through one of three means--alternative energy sources, reduction in utility cost structures and efficiency of energy usage. Of these, only the third alternative is energy conservation. It improves energy efficiency and can often be the most cost-effective and reliable option, if implemented correctly. This presentation defines a fact-based approach to planning, achieving and tracking energy conservation initiatives with the use of best available meaningful metrics. The approach starts with investigating the key metrics for energy conservation by gathering data on the key volume and weather indicators that impact utility usage. By applying proven statistical methods and system models to study utility usage patterns and modes of operation, the calibrated baseline model guides energy conservation initiatives for predictable and successful outcomes. Using case studies, this presentation shows the importance of metrics to planning, achieving and tracking energy conservation initiatives using best available meaningful metrics. The fact-based approach very closely mirrors actual plant operations and therefore is a trusted model to achieve several objectives such as analyzing what-if scenarios, predicting the impact of operational changes, and tracking results

Sustainable Energy Conservation for Industries

Energy conservation is being increasingly addressed by industries seeking to maintain market leadership and profitability. The increased attention on energy is also due in part to deregulation, ever increasing costs for energy and concern for environmental regulation that could arise in the future. Alternative energy sources, competitive procurement to reduce unit costs for energy and improvement in energy efficiency are three paths for reducing energy costs. Improvement in energy efficiency can be the most cost effective and reliable option if implemented correctly. Often this can result in lower capital invested in utilities infrastructure and lower operating costs. Lower capital cost results from improved utilization of existing systems, elimination of inappropriate applications and right sizing of systems. Lower operating costs follow elimination of waste, efficient system design, reduced runtimes and improved operating procedures. The process for achieving sustainable energy conservation requires at a minimum:

- linking energy issues with corporate objectives and goals,
- systems thinking,
- ability to leverage technologies,
- process to empower and enhance team skills and
- meaningful metrics "feedback and controls" for managing energy.

Sustainable energy conservation is an energy management process that improves energy efficiency, drives down consumption and reduces energy costs while at the same time improving quality of the utilities, reliability and productivity. This paper describes the elements required for achieving sustainable energy conservation. There are no magic bullets in this process. The methods that are useful for energy management have a lot in common with ISO programs, six sigma, safety and quality initiatives.

Demand side initiatives to conserve energy must be implemented without compromising quality, reliability of service or throughput. This requires a balanced approach with the proper metrics: balanced in terms of executive commitment, technology, expertise and financial impact. The intent is to keep it as simple as possible, have the optimal level of attention on energy issues and focus on delivering the appropriate return on resources invested (manpower, finances and process management). For instance, one of our internal indicators is the percentage of project justifications written that are funded and implemented. Over the last four years, for us, this percentage has consistently been above 80%. We attribute this to a fact-based balanced approach.

This paper summarizes the experience gained in the process of developing sustainable energy conservation initiatives for industries. Industry sectors covered include food and beverage, manufacturing, plastics, printing, paper and allied products and chemicals. The focus has been on developing a sustainable energy conservation process and appropriate objective indicators to gauge progress on these initiatives.

Balanced Approach

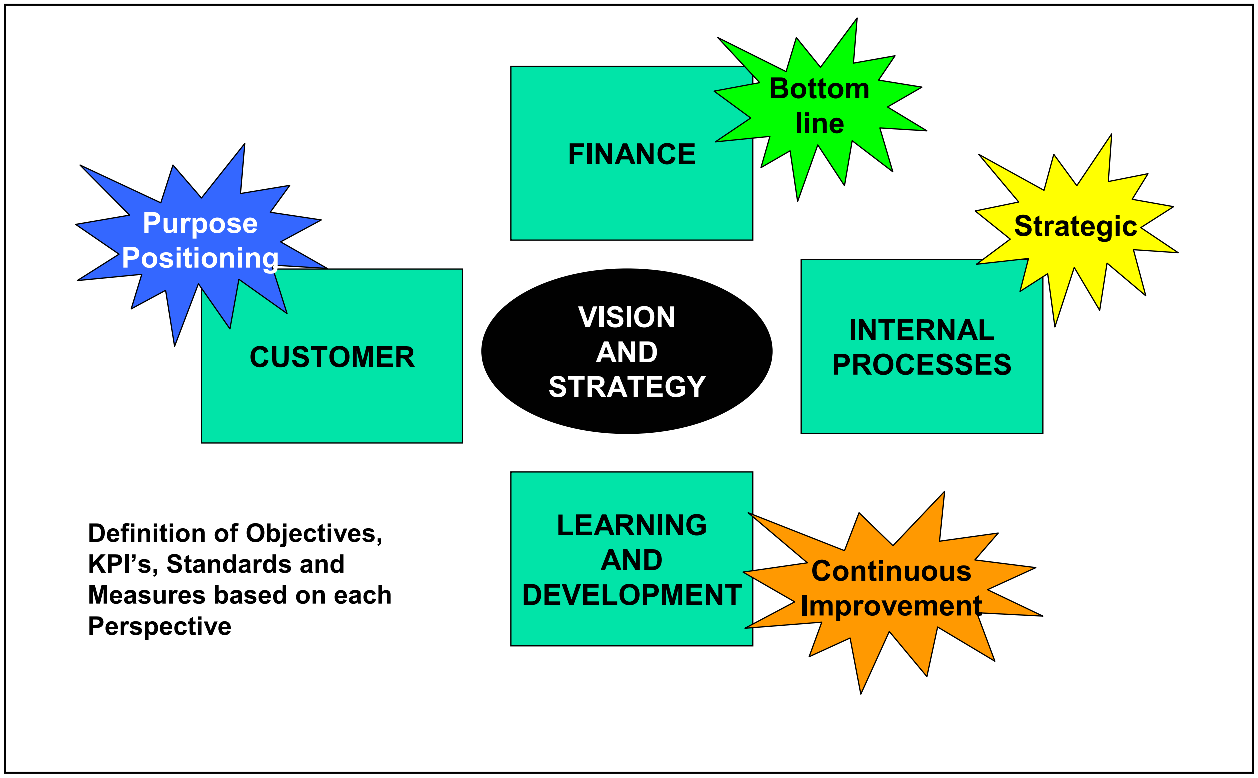
What is a balanced approach? A balanced approach takes into account all stakeholders in the success of the energy conservation program. This includes upper management, finance, production/operations and facilities (utilities/maintenance). Inadequate attention in any one of these areas often adversely impacts the ability to manage energy.

How would we know if we are taking a measured and balanced approach to energy management? There are various methods available such as ISO, six sigma, MSE 2000, safety programs, etc., that could be used as a template. We selected the balanced scorecard approach developed by R.Kaplan1 to energy management. The balanced scorecard is a structured approach to developing meaningful metrics for process and result management. For the metrics to be meaningful they need to be linked to and contribute to corporate vision and strategies. The balanced scorecard process allows for taking into account all stakeholders and provides both leading and lagging indicators for energy management. Bottom line results (such as "how much did we save?") are a lagging indicator because they are obtained after the fact. Variances from goals need to be investigated and may require corrective action or provide new insights into improving energy efficiency. Energy management process metrics such as number of energy procedures developed, training and awareness activities completed, quarterly energy review meetings and actions completed are examples of leading indicators showing the effectiveness of a sustainable program. Also, an objective energy management benchmarking tool (like the EnVinta One-2-Five2 program) can be used to provide a quantitative score for the process issues.

Figure 1 shows the elements of a balanced scorecard approach. The objective is to promote sustainable energy conservation in a manner that contributes to corporate vision and current strategies. There are a minimum of four perspectives to consider for a balanced score card:

1. Financial – "bottom line" – how does it contribute to the corporate goals and objectives?
2. Internal Processes – What are we doing? Who is accountable? Who is leading? What are we going to change?
3. Learning and Development – this is what is in it for the people that participate – How can we educate to get support for the initiatives?
4. Customer – How does this impact the customer? From an executive level this could be the external customer and the public relationship gain for the corporation on environmental stewardship or it could be an internal customer (the end user) who gains by the improved quality and reliability of the utility systems.

Figure 1 – Balanced Scorecard Approach



Executive Sponsorship

To achieve optimal results and develop a sustainable energy conservation program, it is important to have the proper level of executive sponsorship. Key functions for the executive in developing a sustainable energy conservation program are:

- Sign an energy policy or directive with specific goals and objectives for reducing energy costs.
- Set up a continuous improvement team for energy management.
- Assign an Energy Manager/Champion to facilitate/lead Energy Team activities.
- Fund metering and reporting initiatives required to get valid, accurate and timely information for managing energy initiatives.

- Establish financial criteria for energy project approval and set capital budgets for energy projects.

Our approach is to educate the executive level on the need for their participation in evaluating energy management as a valuable initiative for their plants. Success begins with gaining an executive level sponsor for energy. One of the tools we use to engage the management team is in a two-hour software2 facilitated energy diagnostic session utilizing the EnVinta One-2-Five program. Energy management benchmarking has been done as a part of the Ohio Department of Development Initiative for Industries3. The energy diagnostic session provides a method to comprehensively examine energy management processes and engage the management team to arrive at the best next steps. Like any software tool, it requires a thorough knowledge of the issues affecting industries, strong facilitation skills and a sound understanding of the concepts that define the various stages of development in the evolution towards sustainable practices. The process steps for successfully starting a sustainable energy conservation program can vary depending on composition of team and customer needs. However, there are common elements or milestones that need to be achieved for each customer as shown in Table 1 below. The start is a team approach to gain an understanding of current practices for energy management. Five key milestones (as shown in Table 1) on the path to sustainable energy conservation were tracked. It ends with a strategic energy plan that revises the short term plan with feedback from results and business objectives.

Table 1 – Sustainable Energy Conservation Evolution

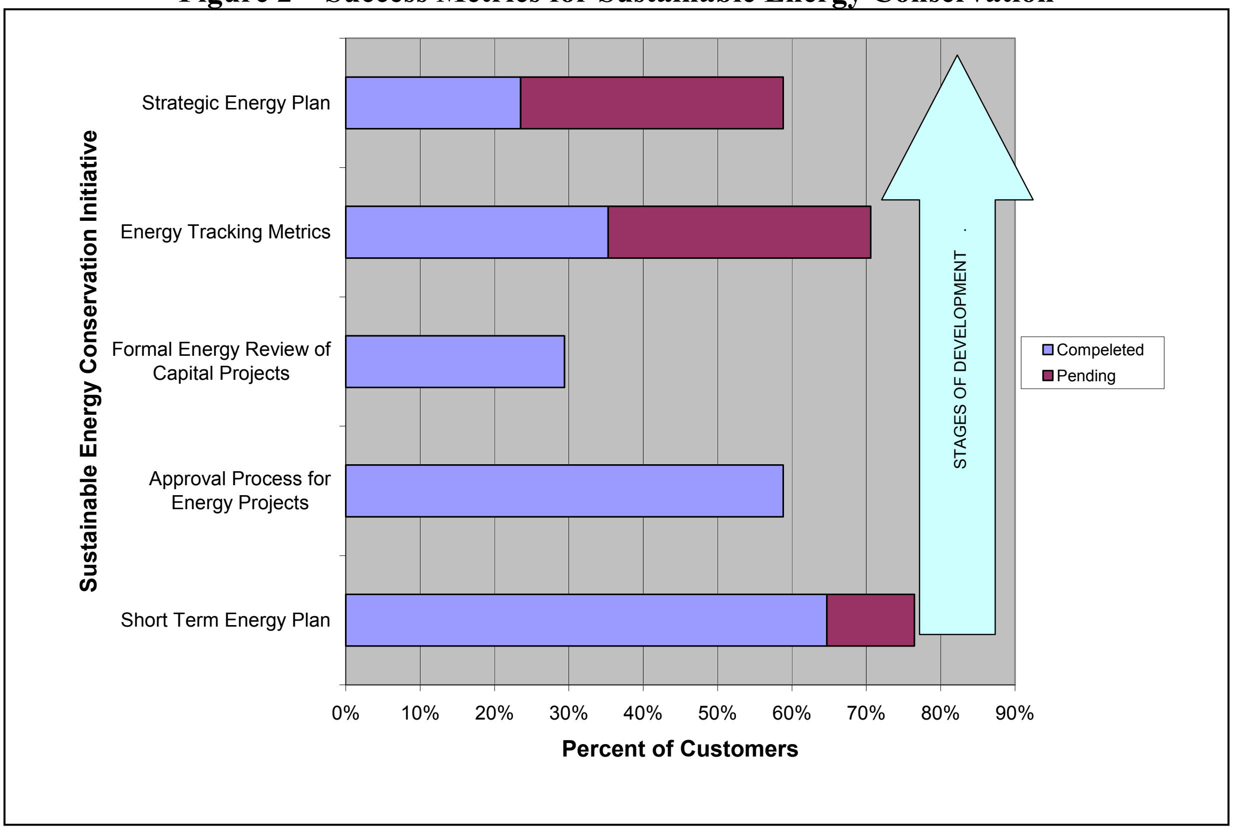
No.	Action	Result
Start	a) Energy Management Benchmarking	Consensus on where we are on energy management and possible actions.
	b) Validation / Planning actions required / Technical actions Required	Define actions required to develop an energy plan. Define technical efforts required for setting realistic goals.
1	a) Short Term Energy Plan	Define process, baseline and tracking metrics.
	b) Pilot Project Implementation	Develop first project and run through approval and implementation processes. Confirm financial requirements and document. Set up process for linking capital projects to energy efficiency.
2	Approval Process for Energy Projects	Financial requirements established. Approval process understood by team
3	Formal Energy Review of Capital Projects	
4	Energy Tracking Metrics	Implement tracking metrics and evaluate effectiveness. Revise based on lessons learned.
5	Strategic Energy Plan	Revisit plan and update Develop a two/three year strategic energy plan based on a sound understanding of current performance, opportunities and business goals.

The success rate for the above process is significantly greater than any that we have experienced historically for change management through consultative selling. Figure 2 below shows the success rate in developing sustainable energy conservation processes and is based on a database of seventeen industries that participated in this process over a four year time period. Of the seventeen plants that participated in the energy diagnostic session to explore energy management, over 75% committed to the development of an energy plan for their facility.

Sustainable energy conservation is a process that takes time to implement and promote. It typically took between one to three years for a plant to move from developing an energy management plan to developing a strategic energy plan with specific energy projects identified for the next two to three years. The metrics we track shows that only 58% of industries that started on the path towards energy management are at the point of developing strategic energy plans.

Another key characteristic of a sustainable energy conservation program is that they have well defined energy metrics. Over 70% of the participating industries have defined metrics to begin tracking energy achievements. Typically the energy metrics are understood by the team members and there are defined accountabilities for the team. Defined accountabilities are key performance indicators and are on the team member's personnel objectives for the year. At the management level this would include energy costs and energy usage, while accountabilities at the end user and operations level would be on energy usage and energy efficiency. Often, the energy tracking reports are easier to implement when they are incorporated into existing management processes and reporting formats.

Figure 2 – Success Metrics for Sustainable Energy Conservation



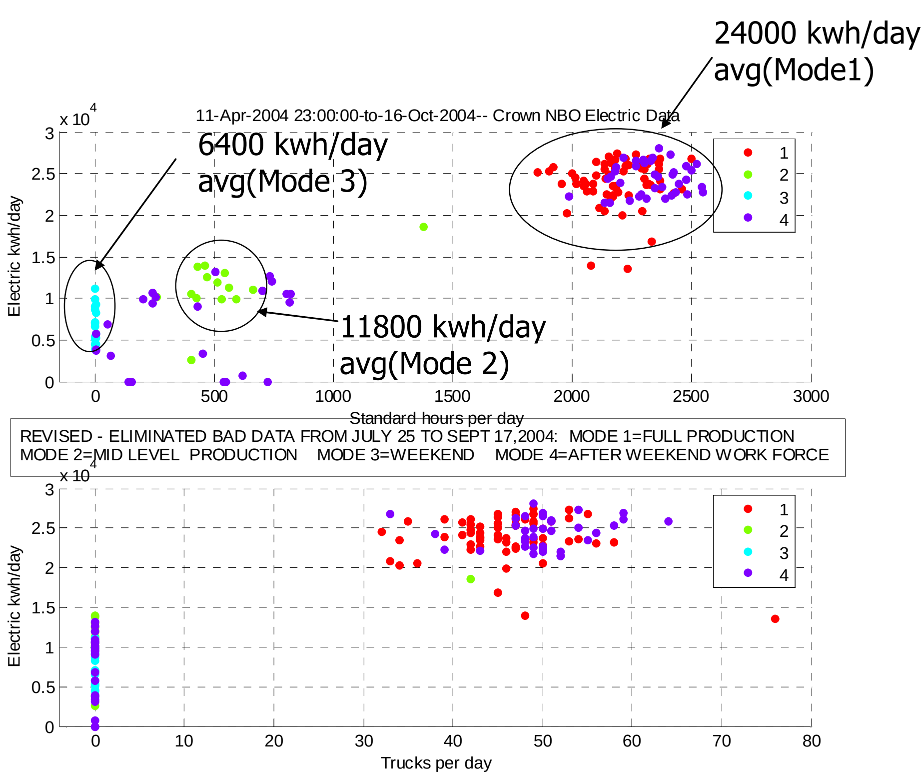
The development of a process for energy management requires technical expertise to set achievable goals and the ability to define measurement and tracking needs to provide the feedback necessary to manage energy efficiency. The process gains credibility and team support if it is fact-based, collaborative and vendor-neutral.

Fact-Based Vendor-Neutral Approach

Being fact-based requires an understanding of current energy usage patterns, definition of known operating modes and consensus agreement of meaningful indicators possible with the metered data available for the site. The importance of being fact-based is evident; however, experience indicates that tracking results of energy projects implemented or success of energy conservation programs remains difficult and elusive. Changing production process, people, weather, expansions, cutbacks … all affect energy usage and cost. In this environment, the credibility and the ability of energy conservation programs is often questioned by upper management. Energy data mining and analysis tools we have developed utilize the vast amounts of data being collected today to uncover usage patterns, to understand statistical correlations in stable operating modes and help develop meaningful metrics that account for key volume indicators, weather and other parameters.

In the case of Crown Equipment Corporation, the energy usage patterns for electricity were not statistically dependent on weather or number of widgets produced. Based on standard hours worked, there were three modes of operation – full production (Mode 1), mid level production (Mode 2) and weekend shutdown (Mode 3). Electricity usage in each of these modes was scattered around an average usage number specific to that mode (see Figure 3 below).

Figure 3 – Crown Equipment Corporation Energy Usage Pattern



For the Samuel Adams Brewery it was important to track results of energy savings initiatives. A comprehensive analysis of historical data was utilized to uncover usage patterns and statistical correlations. These relationships were used to evaluate historical results and develop an energy tracking score card (and are discussed in the energy metrics section below).

When it comes to energy consumption for industries, establishing meaningful metrics can be a challenge, but without metrics it is not possible to know where we are and what we can achieve. Metrics help in:

- benchmarking where you are;
- understanding how energy is used today;
- uncovering efficient usage patterns;
- facilitating training and awareness;
- setting achievable energy goals and targets;
- establishing a baseline against which progress can be tracked;
- providing for timely, accurate and meaningful energy information sharing;
- obtaining buy-in from team members and operations; and
- setting up a continuous improvement program.

The credibility of energy management programs depends on historical success and the ability to demonstrate results to upper management. Energy efficiency contributes to profitability and competitive advantage. For it to be implemented, it must also ensure that the upgrades enhance quality of the utility, reduce down time risks and/or improve production throughput/operations. Often proper linkage of energy management initiatives with capital projects results in lower capital invested in equipment (primarily through right sizing systems and elimination of inappropriate applications) and lower long-term operating costs (by accounting for design and part load efficiencies).

Process Metrics

Energy management process benchmarking tools are available to systematically evaluate current energy management practices, from simple diagnostic sessions conducted by an energy consultant to standardized software assisted energy diagnostic sessions.

Of these tools, only one tool, the One-2-Five program2 has quantitative and objective process benchmarking capabilities. The One-2-Five program also prioritizes the top five next actions to consider for implementation. The focus is on results, on leveraging limited resources, on having sound processes and on ensuring contribution to corporate goals.

In lieu of the One-2-Five process benchmark score, it is possible to develop simple metrics for ensuring sustainable energy management processes. For instance, we could have a responsibility matrix for executive, energy champion and manager, and the energy team member. This could include tracking weekly reviews schedule, energy audits completed, training completed and energy projects/action items completed. Often it is beneficial to incorporate these goals into existing performance management systems.

Energy Metrics

Quantitative metrics for energy should include procurement rates, rate structures and energy usage. On the demand side, changes in production operations, plant modifications, weather, maintenance and controls strategies all impact energy usage. How does energy vary with key production volume indicators, what are the usage patterns, are there any statistically significant correlations? What are the operating modes – by shifts, by product … ? These are the questions that need to be answered and understood prior to establishing quantitative metrics for managing energy. The criteria for establishing energy metrics should be to verify that they:

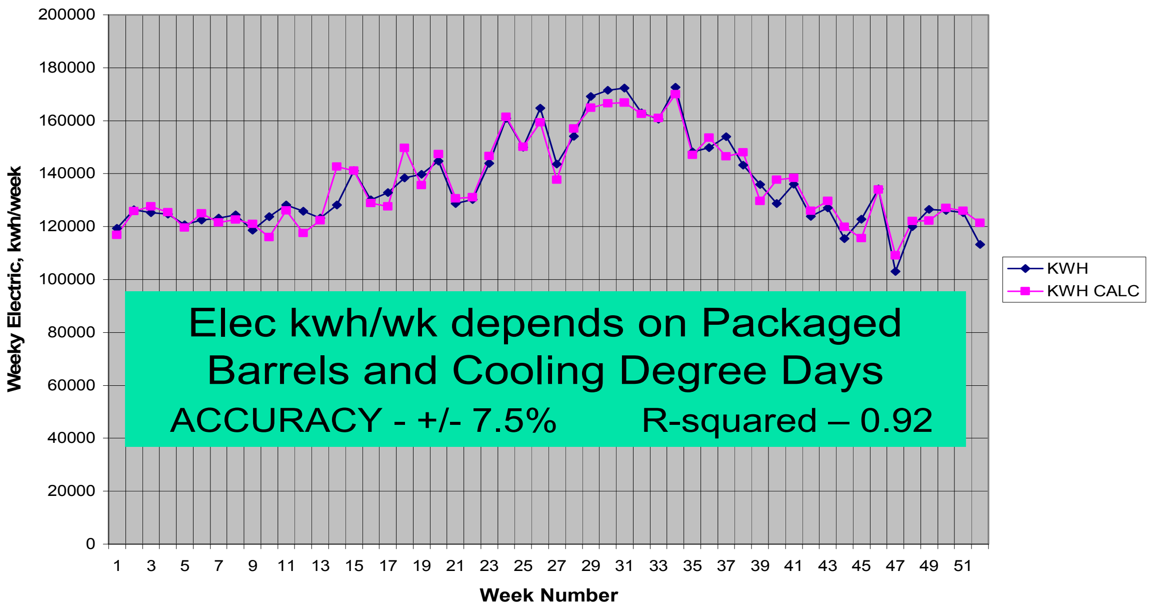
1. Are meaningful and easy to understand.
2. Are agreed to by the persons accountable for results.
3. Provide timely and accurate feedback for action.

Most industries collect information needed to analyze energy performance. Interval data for electricity and gas is usually available, production output data is captured in the production, financial and accounting systems and weather data is readily available from various sites. There is an information overload. However, current computing power, available software tools and advances in data mining techniques provide a unique opportunity for making sense of this information. Expertise in optimizing energy usage for utility systems, applying data mining tools and analyses helps in transforming energy data into knowledge and understanding. This understanding of critical requirements and usage patterns provides a sound basis for establishing continuous energy efficiency improvement programs.

Developing energy metrics requires a systematic approach to evaluating operating modes and energy usage patterns. At a basic level there is energy data, production data and weather data. We can create from these, secondary measures such as energy efficiency or energy use per unit output, throughput or production per hour, etc. Whenever there are multiple parameters that affect energy usage, the energy efficiency metric will depend on other parameters such as operating modes (such as days of the week, shifts…) and weather.

For the Samuel Adams Brewery in Cincinnati, Ohio we had production data including brewing and packaging barrels, weather data, electric data and gas data on a daily and weekly basis. There were issues with the accuracy of production and gas data on a daily basis. However, weekly data was collected in a consistent manner. Statistically significant energy correlations were found and validated for electric, steam and gas usage. The gas and electric usage depended on certain key volume indicators and appropriate weather parameters. For instance, weekly electric consumption could be predicted to +/-7.5% accuracy and it depended on packaged barrels and cooling degree days. The cooling degree days were based on 55°F which was the balance point temperature indicated by the electric and weather data. Figure 4 shows the validation of the statistical correlation.

Figure 4 – Samuel Adams Brewery Electric Usage Correlation – 2001 Data

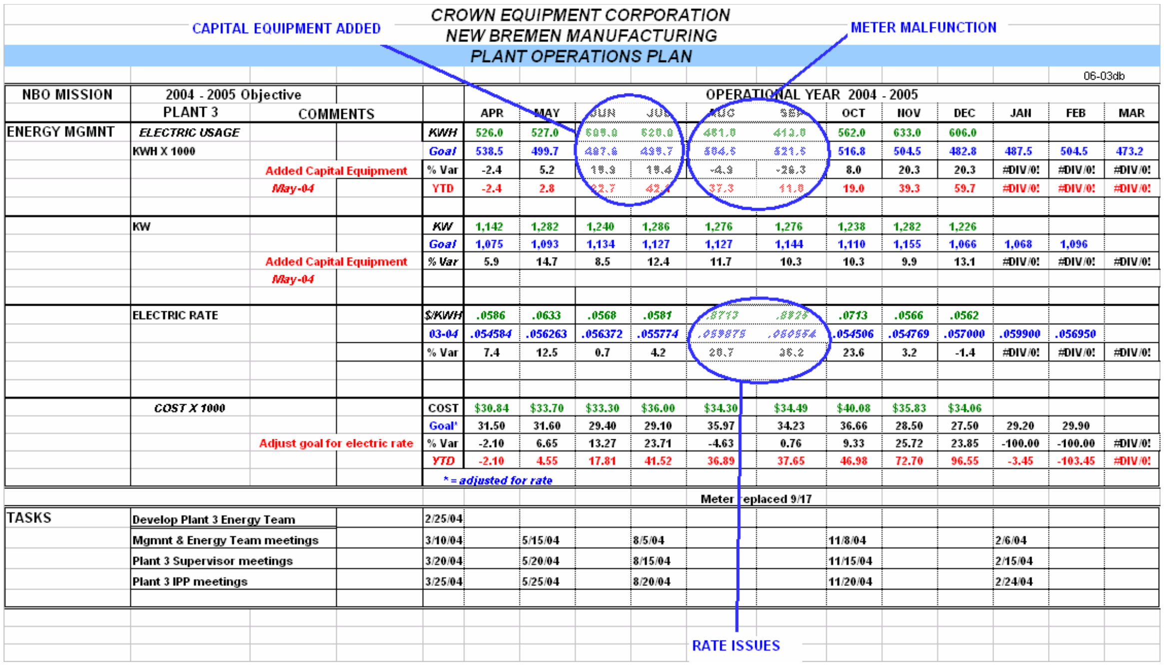


The above correlation for electricity adjusts for weather and key volume indicators to set the expected energy target under current operating conditions for that week. Comparison of the energy target against actual weekly energy consumption is then used to track energy savings relative to 2001 as the baseline. Weekly tracking has proven to provide immediate feedback on deviations in electric, gas, water and sewer usage. Based on the results, the plant is proceeding with the implementation of sub-metering of steam and electricity to engage end users in energy management. For 2004, annual utility cost savings were 12% relative to 2001 and represented a savings of $96,000 per year. The key benefits for Samuel Adams Brewery were:

- Systematic approach and confirmation of previous results.
- Energy targets and metrics provided improved budget setting for energy.
- Improved awareness and understanding of energy issues (senior management & operators).
- Buy-in from team members and operations.
- Ability to leverage expansion capital to enhance energy efficiency.

At Crown Equipment Corporation in New Bremen, Ohio the energy usage patterns were used to develop monthly forecasts for the 2005 energy budget. This was based on the holiday schedule for 2005, expected full production days, expected weekend workforce days and downtime. These targets were incorporated into the existing reporting formats for process management at Crown. A sample of the report and its results are shown in Figure 5.

Figure 5 – Crown Equipment Corporation Energy Goals Tracking For Electricity


CAPITAL EQUIPMENT ADDED

CROWN EQUIPMENT CORPORATION
NEW BREMEN MANUFACTURING
PLANT OPERATIONS PLAN

METER MALFUNCTION

06-03db

NBO MISSION	2004 - 2005 Objective			OPERATIONAL YEAR 2004 - 2005											
	PLANT 3	COMMENTS		APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
ENERGY MGMNT	*ELECTRIC USAGE*		*KWH*	526.0	527.0	589.0	520.0	481.0	413.0	562.0	633.0	606.0			
	KWH X 1000		*Goal*	538.5	499.7	487.6	439.7	504.5	521.5	516.8	504.5	482.8	487.5	504.5	473.2
		Added Capital Equipment	% Var	-2.4	5.2	19.9	19.4	-4.9	-26.3	8.0	20.3	20.3	#DIV/0!	#DIV/0!	#DIV/0!
		May-04	YTD	-2.4	2.8	22.7	42.4	37.3	11.0	19.0	39.3	59.7	#DIV/0!	#DIV/0!	#DIV/0!
	KW		*KW*	1,142	1,282	1,240	1,286	1,276	1,276	1,238	1,282	1,226			
			Goal	1,075	1,093	1,134	1,127	1,127	1,144	1,110	1,155	1,066	1,068	1,096	
		Added Capital Equipment	*% Var*	5.9	14.7	8.5	12.4	11.7	10.3	10.3	9.9	13.1	#DIV/0!	#DIV/0!	#DIV/0!
		May-04													
	ELECTRIC RATE		*$/KWH*	.0586	.0633	.0568	.0581	.0713	.0826	.0713	.0566	.0562			
			03-04	.054584	.056263	.056372	.055774	.059875	.060554	.054506	.054769	.057000	.059900	.056950	
			% Var	7.4	12.5	0.7	4.2	20.7	36.2	23.6	3.2	-1.4	#DIV/0!	#DIV/0!	#DIV/0!
	COST X 1000		COST	$30.84	$33.70	$33.30	$36.00	$34.30	$34.49	$40.08	$35.83	$34.06			
			Goal*	31.50	31.60	29.40	29.10	35.97	34.23	36.66	28.50	27.50	29.20	29.90	
		Adjust goal for electric rate	% Var	-2.10	6.65	13.27	23.71	-4.63	0.76	9.33	25.72	23.85	-100.00	-100.00	#DIV/0!
			YTD	-2.10	4.55	17.81	41.52	36.89	37.65	46.98	72.70	96.55	-3.45	-103.45	#DIV/0!
			** = adjusted for rate*												
								Meter replaced 9/17							
TASKS	Develop Plant 3 Energy Team		2/25/04												
	Mgmnt & Energy Team meetings		3/10/04		5/15/04		8/5/04			11/8/04			2/6/04		
	Plant 3 Supervisor meetings		3/20/04		5/20/04		8/15/04			11/15/04			2/15/04		
	Plant 3 IPP meetings		3/25/04		5/25/04		8/20/04			11/20/04			2/24/04		

RATE ISSUES

Energy tracking reports for the plant were initiated in April of 2004. The scorecard gained acceptance because of executive sponsorship and ease of use. Some of the immediate results were identification of new equipment added and their impact on energy, the fact that existing technical initiatives were well developed and opportunities for improvement were limited at this site, identification of meter failure in readings and uncovering rate structure issues to be resolved with the utility supplier. The key benefits for Crown Equipment Corporation were:

- The systematic approach (from the energy diagnostic session) provided corporate buy-in, facility awareness and opportunity for continuous improvement.
- Plant was managing energy very well.
- We now understand the magnitude of the opportunities and will budget resources accordingly.

Conclusion

This paper addresses the qualitative metrics "process" issues and the quantitative metrics issues that contribute to a successful energy management program. The data is based on experience at setting up sustainable energy conservation programs for industries. We believe a balanced approach is required for developing sustainable energy conservation. The process should be fact-based and vendor-neutral.

Success rates of over 75% are possible with a structure approach which engages senior management, establishes a fact-based process and provides the expertise and facilitation required to promote sustainable energy conservation. The set of metrics should include process and energy metrics. Computing power, energy data mining and analyses tools are available to convert the large amounts of information collected by existing systems into knowledge and understanding. Two case studies demonstrate the evolutionary nature of a continuous improvement program for energy.

A proven process is presented for consideration in developing sustainable energy conservation initiatives for industries.

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