How the "Dirty Dozen" ECMs Created a Need for a Risk Assessment Tool

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ABSTRACT

New technologies have emerged in the field of energy services that promise greater building performances by reducing energy consumption to lessen the carbon footprint, reducing water usage, and decreasing the amount of contributed green house gases. Major challenges when developing upgrades to increase a building's performance, are to effectively weigh the risks, benefits, and costs of implementing Energy Conservation Measure (ECM) investments.

In recommending an ECM, it is essential to minimize the risk that a technology will fail. This was not the case for the "Dirty Dozen," the name coined for new/emerging technology ECMs that did not perform as intended and actually caused equipment damage, higher energy costs, etc. The selections of these technologies were based on a point-in-time opinion, which applied judgment that was not typically consistent.

The lesson learned from the failed "Dirty Dozen" ECMs is that there is a significant need for a risk evaluation tool that minimizes arbitrary decisions or at least consistently standardizes the basis by which every evaluation of a new technology may be made. Such a tool is the Six Sigma™[1] Evaluation Tool (SSET), developed in an Excel format that extrapolates a final weighted score through ten calculations from five initial entries.

The SSET allows a systematic evaluation of potential ECMs to minimize arbitrary decision-making and to consistently rate, the risks and benefits related to potential savings, practicality, ROI, and risk management. Using the SSET on the "Dirty Dozen" would have produced low cautionary scores and therefore could have prevented their implementation.

Introduction

The field of energy services and technologies in the commercial and institutional building sectors has been experiencing incredible growth. This is due to multiple factors including rising energy costs and pressure to reduce carbon emissions. Increased awareness by building owners and operators of the cost savings and environmental benefits of green buildings is driving the demand for energy efficiency and resource management.

In light of these benefits, new technologies have emerged that promise greater building performance and peak demand reduction to achieve better demand-side utility management. A major challenge for utility-savings developmental professionals is to weigh the risks and benefits of conservation measure investments for their customers. New opportunities in supply-side management, automated meter reading technology, water conservation, billing documentation management, achieving ISO standard certifications and LEED Certification add to the complexity of choosing enhancements for greatest commercial viability and savings.

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[1] Six Sigma™, which was developed by Motorola, is a process that systematically eliminates defects and is now widely used throughout industries for Total Quality Management (TQM), LEED certification and to meet International Organization for Standardization (ISO) requirements. Six Sigma™ methodologies enhance the ability to develop solutions that achieve optimal cost, business and performance outcomes for buildings.

This paper is presented in two parts. Failed ECMs from the past that are presented in Part A, which support the need for an analytical evaluation tool (SSET) that minimizes arbitrary decisions or at least standardizes on how arbitrary decisions are addressed when determining the value of a new technology ECM. The SSET is discussed in Part B which covers how the SSET arrives at weighted values and is the main purpose for the presentation of this paper. Specifically, the use of the evaluation tool minimizes repeating a history of mistaken judgment. Part A examples only serve to support why an evaluation tool was needed. Had the SSET been available and applied to evaluating the ECMs in Part A, they most likely would not have been implemented. The results of applying the SSET to the failed ECMs in Part A are documented at the end of Part B, before the Case Study Example.

Part A --- Lessons Learned from Failed ECMs (the "Dirty Dozen")

In choosing Energy Conservation Measures (ECMs), it is essential to minimize the risk that a technology will fail. This was not the case for the "Dirty Dozen," the name coined by the Eastern Michigan Chapter of the AEE for 12 new/emerging technology ECMs that did not perform as intended and actually caused significant problems, such as equipment damage and higher energy costs. Selection of these technologies was based on an opinion, rather than measurement and evaluation.

Examining ECM technologies that did not perform as intended provides valuable lessons for what not to do and demonstrates the importance using a risk assessment analysis tool. The following is a list of the "Dirty Dozen" ECMs that failed and the lessons learned.

1. "On/Off" Duty Cycling of Large Motors (Greater than 80 HP)

ECM savings potential. This ECM technology was created with the idea that disabling running-operation of motors for 3 to 5 minutes during a 12 to 15 minute operational period would provide significant savings in kWh consumption. The saving assumptions were created because oversized motors run constantly even though the required run operation is less than 100 percent to meet design setpoint requirements.

Challenges. One problem that arose with this ECM was that if you started the motor when the demand reading occurred, you could reset the threshold of the maximum demand level. The timing depends on how demand was read from the utility and the sliding scale did not matter when load was allowed to operate. Therefore, 11-13 minute periods were selected, as it was not desirable for the load to start when the demand was read, which was the case when demand meter ratings were taken every 15 minutes.

The second problem with this use of duty cycling was that the greatest opportunity existed with a customer base that was on a high kWh rate billing structure and, unfortunately, these customers typically did not have many large HP loads that could be controlled. Therefore, the available target market was small. Typically, utilities offer reduced rates for customers with larger loads.

There is a saying that a good controls system creates or cures mechanical system and design problems. However, duty cycling loads On/Off amplifies and enhances existing system or design problems that may or may not have been known. Thus, the newest implemented control ECM is blamed for the problems.

Lessons learned. It was discovered that starting a motor more than three times per hour shortened its life. Furthermore, the inrush current on a warmed starter contactor typically welded the starter contactors closed. Because of how the demand usage was calculated by the utility, there was a high probability that any kWh savings would be wiped out by the increased demand charges.

2. Duty Cycling Small Refrigeration Units

ECM savings potential. Disabling the running-operation of compressor(s), and not the fan motors, for a 4 to 7 minute period, every 12 to 18 minutes, was thought to provide savings in kWh consumption. This ECM was created based on the assumption that refrigeration units are oversized and existing controls are typically severely out of calibration, therefore allowing a higher drift point and longer run time than necessary.

Challenges. The first problem was that to assume compressors are oversized and to force their operation Off could increase run time in non-optimum operating range, and therefore increase demand usage. Refrigeration systems are sized to run at optimum loading with box 80 percent full. Therefore, it is not uncommon to find compressors running about 85 percent of the time with a full box. Compressors could initially run 100 percent after a delivery, or if doors are left open for more than an hour, and part load typically sees compressors run 60 percent of the time. Thus, to force a compressor Off when it needs to operate compromises the system's ability to reach or maintain proper temperatures.

After this discovery, override thermostats were installed, which defeated potential savings by allowing compressors to run. Operation in the override mode could cause compressors to operate longer, trying to catch up to design box temperature. This inevitably caused additional consumption.

The second problem is that most refrigeration racks are located in a dirty operating environment, such as a loading/unloading area, outside in an alley or on the roof away from the front of the facility. This causes the coils to need cleaning which leads compressors to operate longer. Forcing compressors Off every 12 to 18 minutes contributed to box temperatures rising above desired operating temperature and in some cases, product loss.

The final problem was that the existing refrigeration system was often in need of repair or the box was loaded beyond original design specifications. The strain of duty cycling the compressor could accelerate the need for repair or emphasize the fact that the box is overloaded. Either way, the customer previously viewed the system as operating okay or enough to get by before the duty cycling ECM was implemented.

Adding a duty cycling control logic may not have caused the problem(s), but it forced the owner to fix them. By most laws, the last licensed contractor to work on the equipment is responsible for correct and safe operation and an Arbitration Board is most likely to side with the owner in a typical dispute.

Lessons learned. It proved to be problematic to implement duty cycling of the refrigeration compressors logic without conducting a study as to how the refrigeration box is loaded, what temperatures are maintained, how long the compressors operate, and without discovering any need for repair or for maintenance. This led to higher risk in being able to maintain the product temperature at a desired setpoint and increased energy consumption.

3. Powerline Carrier (PLC) Technology

ECM savings potential. The basis of this ECM was to use existing building 480/277/240/120 volt wiring to save on labor and materials normally required when implementing a new DDC network. The technology was intended to save on the expense of new wiring labor and materials by controlling loads with "On/Off," as well as injecting extremely high frequency signals onto existing building wiring through the use of a communication device to an interpreter-contactor/relay control device located close to the load being controlled.

The coupling communication device provides a low-impedance path for the communication signals and a high-impedance path for signals at conventional electrical power frequencies. Therefore, the injected signals operate independently of the supply power frequency and are not affected by voltage conditions. The high frequency signals also do not affect the line voltage distribution network.

It was assumed that existing wiring was in good operating condition without noise induced on the lines. Therefore, the line service had to be "clean" throughout the facility.

Challenges. The first problem was that the technology used devices that injected a 188 MHz to 194 MHz signal, which could be affected by frequencies used in the Marine radio or CB band above 5-watt power ranges. Although both these conditions were rare, there were cases of this happening.

The second problem was that noise on the power legs could override the injected signal command. To prevent this problem, the facility had to have clean power and, preferably, a stable, linear load profile.

Furthermore, in practice, this technology is best applied by Controls or Communications Technicians. Additional implementation costs were incurred when it was applied by electricians. The greatest problem occurred when crossing over transformers as supply leg 1 had to be bridged over the transformer and connected to outlet leg 1, supply leg 2 to outlet leg 2, etc. Electricians tended to think it was the voltage (and not frequency) being bridged, therefore connecting a 480 service line directly to a 120 volt line and they had "by-pass the transformer" by using the bridging devices, which costs time and damages. In addition, electricians typically did not adhere to the L1 to L1 rule.

The final problem with PLC technology was that feedback was relatively non-existent since communication signals were one direction, "On/Off" or Pulse Width Modulation. Thus, building operators had to depend upon a pseudo-verification of load operation as feedback of temperatures, current and psi was not possible with this technology. It turned out that the technology was good for scheduling or duty cycling loads only.

Lessons learned. With the personal computer entering the office environment along with magnetic ballasts, it became common for computer hotels, offices and schools to have a non-linear load profile, which is conducive to noise being induced on the supply voltage system.

Additionally, it was discovered that some high rpm motor loads induce a harmonics onto the line for a number of reasons. The harmonics were created by such factors as non-linear loading, ballast design, faulty ballast or motors creating a high frequency resonance. This injected “noise” onto the 60 cycle sine wave (evident by viewing through an oscilloscope), which interrupted or interfered with the correct operation of the PLC devices. This caused chillers and large motors to rapidly and uncontrollably duty cycle On/Off.

4. Digital Control Added to Process Controllers

ECM savings potential. This ECM attempted to minimize excessive control hysteresis and overshoot compensation by using the rapid and consistent attributes of a microprocessor for making logic based decisions to react instantly and controllably to digital/analog feedback signals. This was expected to lead to less equipment operation and less energy consumption. Additionally, the processor logic could be used in a predictive analysis, which would enable equipment to run in a smaller operating range. This would be possible by using the feedback response to last signal commands to aid in the determination of what point the equipment needs to start to satisfy the offset from setpoint control.

The ECM was created with the assumption that all mechanical control systems are reactive and have inherited “slop” causing drift past desired setpoints, known as overshoot or high hysteresis. A processor-based controller eliminates the mechanical wear points and excessive drift by operating with predictive logic and having less inherited hysteresis than electro-mechanical systems. It was intended to perform this way continuously and for a longer life cycle than electro-mechanical systems.

Challenges. One problem with adding digital controls to process controllers was that the sensor technology was not as developed as the microprocessor controller technology. This caused incorrect interpretation of feedback signals, which led to a failure in completing the loop logic.

The second problem was that Service Technicians did not know how to troubleshoot and properly service the systems. Since there was no training available, they had to learn on the job.

The final problem was due to the fact that if the process was critical, the microprocessor was often implemented as the master controller, while the existing electro-mechanical controls became a slave controller in case the master failed. This led to the master controller fighting the slave controller because the master utilized predictive logic and the electro-mechanical controls were always slow to be reactive to the initial master signals. Since the electro-mechanical controls were typically corrected prior to the slave reacting, the slave system would over compensate and the master would make a third correction, and so on. Essentially the challenge was that the two systems fought each other constantly for control.

Lessons learned. As time progressed, microprocessor technology advanced to more than 8 bit and included Token-passing protocol. With this method, time was saved and accuracy was increased with faster processor speeds and the ability to poll signals from sensors immediately that were out of desired parameters. Previously, signals were polled in series, whether or not the field device was in or out of desired settings. This led to the elimination of keeping electro-mechanical controls and in eliminating master-slave hierarchy logic.

5. Scheduling High-Mass, Low-Recovery Boilers Off

ECM savings potential. This ECM was creating to avoid energy uses through fewer run hours. The assumption was that boiler capacity was oversized for load and recovery time was being ignored. It was assumed that increasing steam pressure would heat the facility better, at less operating hours.

Challenges. The first problem that was created with this technology was that most high mass boilers require 4½ to 6 hours to build a full head of steam due to the amount of cast iron, steel and water in the vessel. The second challenge was that most high mass boilers have a greater thermal efficiency if pressure is lowered and allowed to run longer. The final problem was that existing heating anomalies and problems are magnified when the boiler is forced Off or the pressure is increased.

Lessons learned. The most important lesson learned from this ECM was that fuel consumption actually increases if the operation is curtailed. There exists a greater chance to thermally shock and damage the boiler if return water and outlet water exceeds design parameters. Furthermore, system leaks may occur at the increased steam pressure. Since a boiler only produces its rated capacity, the radiation units may get hotter at a higher pressure. Therefore, the burner ran longer to compensate for being Off. To compound this further, higher-pressure steam moves slower than low-pressure steam[2] so it will take longer for the radiation units to properly heat up, forcing the burner to run longer.

6. Installing T-5 Lamps in Cold Ambient Areas or in Large Temperature Swing Areas

ECM savings potential. This ECM was intended to reduce wattage consumption and provide longer lamp/ballast life. These savings were thought possible under the assumption that lamp/ ballast performances operate correctly at any temperature.

Challenges. The main problem was that operating temperatures less than 40°F and radical temperature swings over 50°F decrease lamp life.

Lessons learned. The lesson learned from this failed ECM was that T-5 technology should not be used in this environment. Rather T-8 or LED lamps should be used.

[2] For instance, let us say you wanted to move 200,000 BTU/Hr. out of a boiler into a three-inch main. A steam-velocity chart shows that at 0-psig pressure, the steam will be moving along nicely at 30.44 feet per second. Raise the pressure to 5-psig and the steam slows to 22.5 feet per second. Bring the pressure up to 10-psig pressure and the steam moves at just 18 feet per second. This happens because both the load and the pipe size are fixed. When you increase the steam pressure, you compress the steam. Since the load is the same, the steam moves more slowly.

7. Converting Diesel School Buses to Use Only LNG Fuel

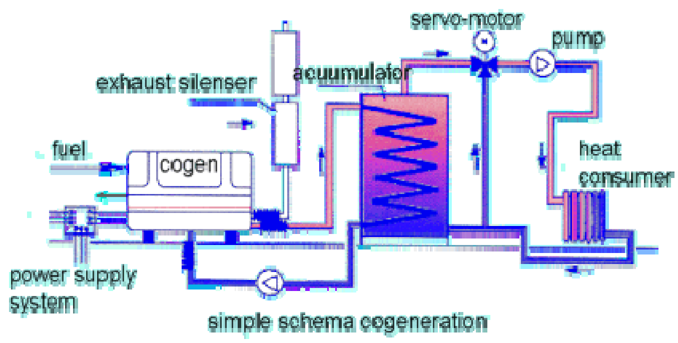
ECM savings potential. The intent of converting diesel school buses to use only LNG fuel was to lower the cost of replacement fuel and longer engine life. The assumption was the LNG fuel will remain plentiful, there will be substantial cost savings over diesel fuel, and operating LNG will not damage the engine.

Challenges. This ECM ended up not performing as intended because diesel fuel is a lubricant and LNG is not. Furthermore, an engine will not start on LNG alone.

Lessons learned. The main lesson learned from this failed ECM was that a mix of 7 to 15 percent diesel fuel needs to be consistently added to LNG for proper operation and to prevent engine seizure. Dependant upon manufacturer of engine, a higher ratio of diesel fuel needs to be used for startup, and then the LNG mix can be switched over for use.

8. Reciprocating Engine Co-gen Units without Supplemental Oil Lube Capacity

ECM savings potential. This technology was created with the assumption that oil within a crankcase is sufficient to lubricate the engine.



Challenges. In practice, excessive heat buildup and oil breakdown caused premature crank and then engine damage.

Lessons learned. The lesson learned was that a 200 to 500 gallon oil container needs to be included in the lubrication cycle.

9. Boiler Turbulators & Cooling Tower Ozone Systems

ECM savings potential. This ECM was created based on the assumption that turbulators increased combustion efficiency and that Cooling Tower Ozone treatment systems would reduce the amount of chemical treatment.

Challenges. The major problem was that both technologies became a maintenance nightmare. Additionally the turbulators created surface erosion on the tubes in some boilers.

Lessons learned. The lesson learned was that technologies should be used that Service Technicians already know how to install, calibrate and service.

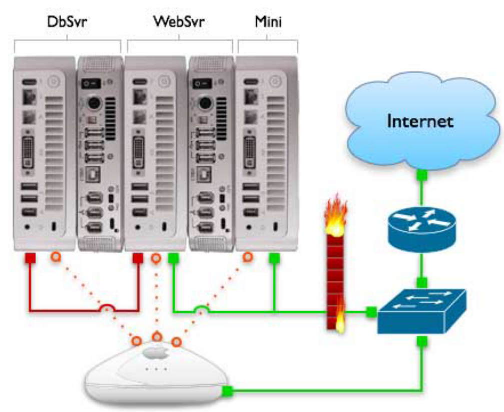
10. Sizing Combined Heating and Generating Plant (CHP) Unit for Electrical Load

ECM savings potential. The cost savings potential of this ECM was based on reduced grid load consumption, demand, and the use of a heat rejection unit to furnish HW/steam to processes. These processes included absorption cooling, boiler feed water, pool heating, etc. The assumption was that there would be a need for all of the electricity and heat generated by the unit, at all operating periods.

Challenges. The main problem encountered was that if the unit was sized for electric generation load then rejected heat had to be completely used. Otherwise, an additional and costly heat sink radiator had to be installed to remove generated heat.

Lessons learned. This failed ECM demonstrated that it is necessary to size the unit for the amount of heat rejection that you can consistently use and not for the electrical load.

11. Implementing a DDC Network Without a Qualified Operator or a Training Program



ECM savings potential. This ECM was created based on the assumption that once implemented, the new network would continue to operate correctly. Furthermore, it was assumed that the end user would understand how the systems are being controlled and that savings are being continuously generated.

Challenges. The first problem was due to site operating needs, schedules, facility usage and change in conditions. Personnel changes also posed a problem as employees with the relevant knowledge moved elsewhere.

Lessons learned. This failed ECM demonstrated that new controls always are blamed for field adjustments or from the results of not being properly maintained. This relates to a saying among Service Technicians that: "it is a fine-tuned DDC system that covers up design flaws and enhances mechanical system problems that proper maintenance should have caught." It was also found that including a dedicated BAS systems operator and a designated number of hours/years training in the project costs is necessary.

12. Majority of Savings Based on Operational Avoidances

ECM savings potential. This ECM was developed based on the concept of having the majority of savings based on operational avoidances. In this situation, the end user was not fully aware of the savings source(s). The assumption that this ECM would generate savings included an agreed amount based on cost avoidances or projected repairs not needed due to new replacement equipment. These were typically all budgeted items. The savings were operational or “soft” savings.

Challenges. The first problem with this ECM was that details of how the cost avoidances were arrived at are never properly documented and signed by the customer. Typically, the newly implemented ECMs are blamed for shortfalls. The second problem was that all or part of the involved parties would often move onward without leaving a paperwork trail as to agreements or how avoidances were arrived at. The final difficulty was that budget changes minimized projected avoidances.

Lessons learned. This ECM demonstrated the importance of documenting and clarifying information, as well as having more than one person at a high level on the customer’s side in the development and acceptance process.

Part B --- How to Minimize Repeating the “Dirty Dozen” through the Use of a Six Sigma™ Evaluation Tool (SSET)

Qualified ECMs are in high demand due to the potential long-term savings and environmental benefits. They promise greater building performance through such benefits as better demand-side energy management, opportunities in supply-side management, automated meter technologies and billing documentation management, as well as operation savings. Although the potential benefits of implementing ECMs are significant, systematic evaluation is essential before arbitrarily implementing any new or evolving technology (potential ECMs).

How Does the SSET Work?

There are several essential steps in evaluating new or emerging technology ECMs. Initially a decision has to be made based on limited information as to whether or not further time and resource effort should be spent on the technology. Specifically, does the technology seem to have cost-avoidance potential, does it have minimum risk for inclusion in a performance-based project and is it a potential ECM that is suitable for repeated applications?

Once the decision has been made to proceed based on the above three criteria, the first step is to seek detailed information on the ECM. This is accomplished through internet discovery, requesting third party testimonials from the manufacturer, reviewing case studies from the manufacturer, and then (if necessary) testing the technology in the field or in a lab environment. A Six Sigma™ Evaluation Tool (SSET) was developed in an Excel format to extrapolate a weighted score using standard questions, with each question being applied consistently to every ECM evaluation. The greater the score, the less risk (“defects”). From the discovery, testing and verification phase, each technology is entered in the SSET for scoring. The evaluations are based on:

1. **Savings Potential** ---------- does the potential ECM have a good payback and life cycle cost?
2. **Practicality** ----------------- is the technology reasonable and practical to implement?

3. **Commercially Viable** ----- is the technology something we want to sell and customers want to own?
4. **Risk Management** --------- is it easily provable and does it have a high degree of certainty over the life of the contract?
5. **Business Differentiator** --- is it attractive to the customer or fills their "Hot Button" needs?

Note that these inputs are the only selectable areas for numeric scoring. A weighted score is determined by entering in a value of 0 to 9 for the above criteria using a guideline where 0 is extremely difficult and 9 exceeds expectations. In the SSET, the entry would look like this:

SAVINGS POTENTIAL	PRACTICALITY Easy to Do? Well Supported?	COMMERCIALLY VIABLE	RISK MANAGEMENT	BUSINESS DIFFERENTIATOR aka: "Hot Button"
0=none/extremely difficult -- 2=min/somewhat difficult -- 4=some/min difficulties -- 5=good/no problems -- 9=exceeds expectations or easy				
enter 0~9 for Savings Potential	enter 0~9 for Practicality	enter 0~9 for Comm. Viable	enter 0~9 for Risk Managed	enter 0~9 for Business Differentiator

Part of the hidden extrapolation is weightings reflecting the importance of each area to both internal and external customers. The weightings have predetermined values entered for the five areas listed above. These predetermined values are multiplied by the entered selectable inputs in the previous clarification. See the following example for these hidden calculation variables:

Rating/Ranking of Importance to INTERNAL Customers				
9 -- Extremely Important	1 -- Low	7 -- High	7 -- High	7 -- High

Rating/Ranking of Importance to EXTERNAL Customers				
9 -- Extremely Important	7 -- High	1 -- Low	7 -- High	4 -- Medium

To quickly give a visual effect for understanding the level of risk should the technology be implemented, the weighted final scores have an answer field that is conditionally formatted like a Stop 'N Go traffic light. A green background means "Generally Best ECMs (should be recommended for most/all projects)". A yellow background means merit of "ECM is Probably Project-Specific (good for some but not good for others)". A red background means "Generally Worst ECMs (probably not good for many/any projects)". See the following for an example:

Technology/ECM Description	Rating/Ranking of Importance to INTERNAL Customers					Preliminary Assessment TOTAL Weighted
	9 -- Extremely Important	1 -- Low	7 -- High	7 -- High	7 -- High	
	Rating/Ranking of Importance to EXTERNAL Customers					
	9 -- Extremely Important	7 -- High	1 -- Low	7 -- High	4 -- Medium	
	SAVINGS POTENTIAL	PRACTICALITY Easy to Do?	COMMERCIALLY VIABLE	RISK MANAGEMENT	BUSINESS DIFFERENTIATOR aka: "Hot Button"	
	0=none/extremely difficult 2=min/somewhat difficult 4=some/min difficulties 5=good/no problems 9=exceeds expectations or easy					
Compressed Air Utility Management (Industrial)	9	9	9	9	9	531
Green Roofs (Plants)	9	4	4	9	9	451
River/Lake/Fountain Water	9	5	2	9	9	443
Well water	9	5	2	9	9	443
Paint Processing -- energy use/savings	9	5	2	9	9	443
Landfill/Methane Gas (See 2002 List Tab)	9	9	2	9	5	431
Load Shifting/Reduction Based on Hourly Electrical Costs	6	4	8	9	9	429
Recommissioning HVAC	9	9	5	9	9	499

Scores are given a percentage rating in addition to the numeric score so that one may quickly see the evaluation value besides the colored background. A green background represents a 76% to 100% score, a yellow background represents a 30% to a 75% score and a red background represents a 0% to a 29% score. See the following for an example:

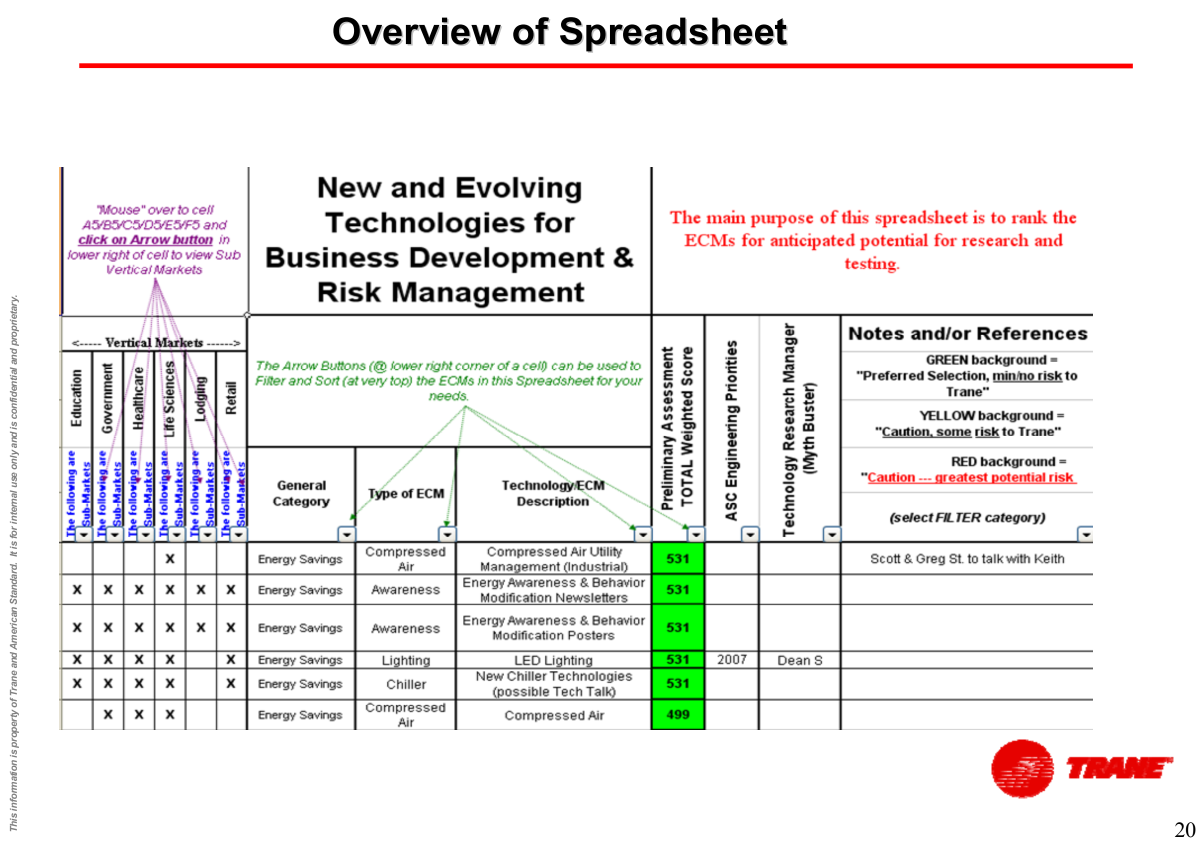
5	4	9	9	5	375	71%
9	9	9	9	5	487	92%

So Now that We Have this Database, What Do We Do With It?

The SSET allows us to filter ECMs by;

1. vertical markets --- education, government, healthcare, life sciences, lodging, retail
2. general category --- savings from comfort, energy, green, labor
3. type of ECM --------- alternative, automation, co-gen, compressed air, supply, envelope, etc.
4. specific type --------- glass, doors, walls, insulation, etc.
5. evaluation criteria – Savings Potential, Practicality, Commercially Viable, Risk Management,
6. weighted scoring total number
7. weighted scoring total percentage

for example:



Education	Government	Healthcare	Life Sciences	Lodging	Retail	General Category	Type of ECM	Technology/ECM Description	Preliminary Assessment TOTAL Weighted Score	ASC Engineering Priorities	Technology Research Manager (Myth Buster)	Notes and/or References
			X			Energy Savings	Compressed Air	Compressed Air Utility Management (Industrial)	531			Scott & Greg St. to talk with Keith
X	X	X	X	X	X	Energy Savings	Awareness	Energy Awareness & Behavior Modification Newsletters	531			
X	X	X	X	X	X	Energy Savings	Awareness	Energy Awareness & Behavior Modification Posters	531			
X	X	X	X		X	Energy Savings	Lighting	LED Lighting	531	2007	Dean S	
X	X	X	X		X	Energy Savings	Chiller	New Chiller Technologies (possible Tech Talk)	531			
	X	X	X			Energy Savings	Compressed Air	Compressed Air	499			

Note that applying a SSET evaluation today to each of the failed ECMs of the past would arrive at a cautionary rating with two in the advisory range; do not use without further detailed analysis. The following is an example of the SSET summary evaluation of the failed ECMs presented in Part A:

Technology/ECM Description	SAVINGS POTENTIAL	PRACTICALITY Easy to Do?	COMMERCIALLY VIABLE	RISK MANAGEMENT	BUSINESS DIFFERENTIATOR aka: "Hot Button"	TOTAL Weighted Score	Weighted Rating (% Value)
	0=none/extremely difficult	2=min/somewhat difficult	4=some/min difficulties expectations or easy	5=good/no problems	9=exceeds		
Duty Cycle large motors	5	4	4	4	2	232	44%
Duty Cycle Refrigeration racks	4	2	5	2	2	178	34%
Power Line Carrier	9	2	2	2	4	266	50%
DDC added to Process Controls	2	0	4	4	0	124	23%
Scheduling Hi-Mass Boilers OFF	2	5	5	4	2	194	37%
Placing T-5 lights in cold areas	5	5	5	2	0	198	37%
Installing Co-Gen units without supplemental oil reserve	5	5	5	2	0	198	37%
Boiler Turbulators & CT Ozone systems	2	4	4	2	0	128	24%
Sizing CHP for electrical load only	5	4	4	4	2	232	44%
Installing DDC network without dedicated operator or training	5	4	4	4	2	232	44%
Guaranteeing large amounts of Operational Savings	9	4	0	0	2	216	41%

Case Study Example

A project that Trane Energy Engineers recently worked on involving a potential ECM demonstrates the importance of risk assessment analysis and how the process can be used. The corporate support Energy Engineering group was approached regarding using reclaimed deep fryer oil to fuel a diesel cogeneration unit. The initial three evaluation criteria (has cost-avoidance potential, seems to have minimum risk, and can be applied in different regions/projects) helped to determine that the technology warranted further research. Therefore, personnel were assigned to conduct the research and development of a technical write-up for inclusion on the company portal in the Project Development resource area and web page.

After researching the ECM and conducting the necessary initial tests, the SSET was utilized. During the detailed evaluation of the ECM, the technology was rejected due to a concern that a long-term, continuous no/low-cost source of reclaimed oil would not be available. Therefore, it was determined that the savings potential, practicality, commercial viability and risk management all earned values of four on a nine point scale. The value for the ECM as a "business differentiator" was a two, on a scale of nine. The total weighted score for the preliminary assessment was 214, placing the potential ECM in the "yellow" or cautionary range, which rejected the recommended use of the ECM and requires further discovery on a case-by case basis. See below SSET summary:

Technology/ECM Description	SAVINGS POTENTIAL	PRACTICALITY Easy to Do?	COMMERCIALLY VIABLE	RISK MANAGEMENT	BUSINESS DIFFERENTIATOR aka: "Hot Button"	TOTAL Weighted Score	Weighted Rating (% Value)
	0=none/extremely difficult	2=min/somewhat difficult	4=some/min difficulties expectations or easy	5=good/no problems	9=exceeds		
Using Recaimed Deep Fryer oil for fuel	4	4	4	4	2	214	40%

Note that a confirmed ten-year source of reclaimed oil would have raised the scores and made this an acceptable ECM to implement on a Performance-Based project.

Conclusion

30+ years experience developing and implementing new technologies proved the Dirty Dozen ECMs failed. Applying the SSET (now) to evaluate each of the "Dirty Dozen" ECMs shows unacceptable levels of risk that precludes their use in a Performance-Based, Energy Services project. Using a tool like the SSET allows new technologies to be systematically evaluated, benefiting from by consistent judging criteria. Thus, lower risk and potentially better ECMs are identified that merit inclusion for project implementation and provide greater product offerings with optimal solutions at lower risk-management costs. Further, evaluation and recommendation results of potential new technology ECMs could be published on the internet for worldwide use. Any interested party anywhere may browse a technology and find the evaluated weighted score to determine if the potential ECM should be included for consideration during specific project development. Redundant efforts in rediscovery and elevated risks from not adhering to standard evaluation criteria as found in the SSET are virtually eliminated. Therefore, risk would be managed at a greater level that could lower costs.

About the Author

Dr. Keith Willis is an Energy Scientist and Engineer supporting Trane offices worldwide as a member of their Comprehensive Solutions corporate support team. He is responsible for research and development of new program work for risk management and for developing Energy Engineering solutions for new project work.

With more than 30 years experience with supply- and demand-side Management on more than 4,500 bundled-projects in 10 vertical markets, Dr. Willis is listed in Marquis' Who's Who in Science and Engineering, 5th thru 10th editions. He also has several certifications with the AEE including *Legend in Energy*®, Certified Energy Manager® (C.E.M.), Certified Business Energy Professional (B.E.P.), Certified Sustainable Development Professional (C.S.D.P.), and Certified Demand-Side Management Professional (C.D.S.M.).

Dr. Willis earned Doctorate and Master degrees in Engineering Management, a Bachelor degree in Aeronautical Engineering and an Associates degree in Direct Digital Controls and has held several Master Contractor's licenses, including Heating, Refrigeration, Steam, Water, Sheet metal and Electrician.