Energy Conservation Measures (ECMs): Which Projects Should We Select?

Robert K. Hoshide, CEM, CLEP, CDSM
Energy Management Consultant

Completing an energy audit of a facility should provide us with various candidate energy conservation measures (ECMs). "Which Projects Should We Select?" is often asked. ECMs selected will be based on your requirements, wants, needs and benefits.

This article discusses critical methodologies and procedures during our selection process. Key steps include correct engineering and economic analyses. The much used simple payback is shown to be a very poor economic decision guide. If these analyses are not properly accomplished, inappropriate equipment and systems will be bought and installed. The result will lead to dire consequences. Information is provided to help energy managers and building owners make the right decisions for selecting appropriate, cost- effective ECMs.

ECM SELECTION

Our ECM selection process is usually based on reducing energy consumption and energy cost. We want to meet or exceed the goals and requirements of the National Energy Policy Act of 1992 (EPAct), Executive Order 12902, Clean Air Act and others.

We want to become more energy efficient so our energy bills are reduced. Other wants include reducing our operation and maintenance (O&M) costs. We may also want to improve our workplace environment.

Meeting or exceeding the requirements and fulfilling our wants do require certain needs. They include training of the facility staff so they

are able to properly operate and maintain the newly installed ECMs. We need to also monitor our equipment and facility to verify that the estimated energy savings are obtained and continue to be realized over time.

There are numerous other benefits that may be obtained whenever we make our facilities and equipment more energy efficient. Some of these benefits may be very important in our ECM selection decision.

Benefits include:

1. Improving health, comfort and safety
2. Improving productivity & efficiency
3. Reducing errors and rejection rates
4. Improving mental well-being & morale
5. Reducing impacts on our environment including acid rain, global warming, ozone holes, air, water & ground pollution
6. Reducing depletion of our natural resources
7. Reducing O&M costs
8. Improving service life of our facility and equipment
9. Installing state-of-the-art equipment
10. Eliminating archaic & obsolete equipment
11. Providing a safe work place
12. Standardizing equipment thus reducing stores inventory

Occupant comfort requires proper temperature, relative humidity, indoor air quality, acoustics and air distribution around people.

Project selection must be based on engineering and economic analyses. Decisions based on only one or the other will surely prove that Murphy's Law is alive and well.

ECM CATEGORIES

Engineering analysis requires knowing the different ECM categories. We need to be able to differentiate between mutually exclusive, interactive (interdependent) and independent ECMs. Typically, we install different ECM category types. Knowing how to analyze these different ECM types is very important.

The three ECM categories are described below.

1. Mutually Exclusive ECMs: Selection of one excludes acceptance of others. Examples are whether to use single-, double- or triple-glazing for windows; or R 19, R 30 or R 38 level of insulation.

2. Interactive or Interdependent ECMs: Selection of one will impact or interact with another. Examples are when installing energy efficient lighting or adding ceiling insulation will reduce the cooling load and therefore the size of the chiller. When evaluating interdependent ECMs, their interaction must be included in the energy and economic analysis.

3. Independent ECMs: Selection of one will not impact or interact with another. Examples are when replacing energy inefficient components like chillers, boilers & electric motors with efficient ones.

ECM ENGINEERING ANALYSIS

Proper operation and maintenance should be performed prior to analyzing for estimated energy cost savings of proposed ECMs. By not doing this, unreasonable energy cost saving estimates may be credited to the proposed ECMs. Your engineering and economic analysis is only as good as your estimated energy cost savings. If your O&M procedures are not "up-to-snuff," the benefits of installing energy efficient equipment will disappear in due time. We want to obtain energy savings that are realistic and are based on sound engineering decisions.

When incorporating multiple ECMs, we should have them checked for interaction. If interaction exists, the analysis must account for it, otherwise energy saving estimates will be wrong (higher). I have seen energy management reports showing 200% annual energy savings (twice as much energy as was used the previous year)!

If interaction exists, the following sequence should be used:

First: Calculate system loads (lighting, service water heating, internal equipment, heating, etc.)

Second: Distribution loads (air handling, pumping, etc.)

Third: Generation loads (chiller, boiler, cooling tower, etc.)

Selection of inappropriate ECMs and/or oversized or undersized equipment will be avoided. By not following this sequence, you could be putting the cart before the horse. One may end up with an energy efficient chiller that is oversized. Operation at low load will be the norm and the chiller efficiency will be low compared to a correctly sized one operating mostly at its design point.

Capitol investment will be less for a smaller properly sized chiller than a large oversized one.

It is good that the Environmental Protection Agency (EPA) has come out with their Energy Star Buildings Program. This program obtains commitments from building owners as partners to invest in economically sound energy conservation opportunities (ECOs). They have requested that the partners complete ECOs in five stages. They are:

1. "Green Lights": Install energy-efficient lighting systems
2. Building Tune-Up: Update O&M, test and balance, recalibrate controls, expand ECOs
3. HVAC Load Reduction: Building envelope, internal load reduction
4. Fan System Upgrades: Air handling system, VAV, AFD, downsizing fans & AC units
5. HVAC Plant Upgrades: Lower HVAC loads permit new, smaller energy efficient systems. This methodology of the Energy Star Buildings Program for HVAC follows the sequence that is recommended for interactive type ECMs.

ECM ECONOMIC ANALYSIS

Some of us are still selecting ECMs based on simple payback (SPB). ECMs that have the lowest SPB are the ones that are usually funded and completed. Economic analysis should utilize life-cycle cost analysis (LCCA). The Federal Government uses this methodology for estimating and comparing life-cycle cost (LCC) of ECMs. The 10 CFR 436, subpart A directs them to use LCCA for determining cost effective ECMs.

Life-Cycle Cost Analysis

It is used to calculate the LCC of a building system or combination of interdependent systems

1. It includes the total cost of owning, operating, maintaining & disposing of the system over a given study period
2. All costs are adjusted (discounted) to reflect the time value of money
3. Generally, all future costs are discounted to their present-value (as of the base date)
4. It is useful when compared to other mutually exclusive design alternatives
5. Alternatives must use the same study period, base & service dates & discount rate
6. It helps select one alternative based on the lowest LCC

Supplementary Analysis Methods

Other analysis methods that may be used include: net savings, savings-to-investment ratio, adjusted internal rate of return, simple and discounted payback.

Net Savings (NS):

1. NS can be used in place of the LCC method to determine the most cost-effective mutually exclusive option
2. The option with the highest NS will have the lowest LCC
3. Options must use the same study period and discount rate
4. Positive NS (cost effective) occurs when the LCC is lower than the base case

Savings-to-Investment Ratio (SIR) and Adjusted Internal Rate of Return (AIRR), Both:

1. Must be calculated with respect to a designated base case
2. Useful for evaluating an alternative project compared to its base case, or for ranking independent ECMs
3. Must use the same study period (except independent ECMs)
4. Must use the same discount rate
5. Should not be used for evaluating mutually exclusive alternatives
6. SIRs greater than 1.0 are cost effective
7. An ECM is cost effective when its AIRR is greater than the discount rate

Simple Payback (SPB) & Discounted Payback (DPB), Both:

1. Estimate how many years it takes to recover initial investment cost

(Fish Bait technique)
2. Useful only as a rough guide for accepting or rejecting projects
3. Not recommended for selecting mutually exclusive alternatives
4. Not recommended for ranking independent projects
5. DPB includes the time value of money

Typical Capitol Investment Decisions We can separate ECM capitol investment decisions into five categories. They are:
1. Accept or reject an ECM
2. Select optimal ECM efficiency levels
3. Select optimal ECM from competing alternatives
4. Select optimal combination of interdependent (interactive) ECMs
5. Ranking independent ECMs Note: "Optimal" means the most cost-effective choice.

These capitol investment decisions are further discussed below:

1. Accept or Reject an ECM
   a. Alternatives must be evaluated against a base case (the "do nothing" alternative)
   b. Example: install storm windows over single-pane windows; install vestibule at doorway; *or,* replace an electric water heater with a gas-fired one
   c. Economic analysis indicators: LCC of ECM < LCC of base case; NS of ECM > 0; SIR > 0; AIRR > the discount rate

2. Select Optimal Efficiency Level
   a. The objective is to determine which efficiency level is the most cost-effective
   b. Examples (mutually exclusive ECMs): insulation R-value for roof, wall or floor; single, double, or triple glazing for windows; the efficiency of a furnace or boiler; the COP of a chiller or heat pump
   c. All ECMs require the same study period
   d. Economic analysis indicators: Minimize LCC; Maximize NS; Don't use SIR or AIRR

3. Select Optimal ECM Type
   a. The objective is to determine which ECM type is the most

cost-effective

b. Example: HVAC system type (e.g. electric, gas, heat pump); wall construction type (masonry, wood frame); or water heater type (e.g. gas, electric, solar)
c. All ECMs require the same study period
d. Economic analysis indicators: Minimize LCC; Maximize NS; Don't use SIR or AIRR

4. Select Optimal Combination of Interdependent ECMs
   a. Requires simultaneous energy analysis to account for interaction among ECMs
   b. Analyze only for practical alternatives
   c. Remember to use your engineering judgment & follow the proper load sequence (system/distribution/generating)
   d. Requires the same study period
   e. Economic analysis indicators: Select combination with the lowest LCC; Maximize NS (compared to base case); Don't use SIR or AIRR

5. Ranking Independent ECMs
   a. The objective is to rank two or more cost-effective ECMs because of limited funding
   b. Economic analysis indicators: Use declining order of their SIR or AIRR for ranking ECMs; Don't use LCC or NS
   c. ECMs can use different study periods

Table 1 summarizes the use of LCCA for ECM(s) capitol investment decisions.

It is suggested that the National Institute of Standards and Technology (NIST), Building Life-Cycle Cost (BLCC) software program be utilized for your LCCA. For information contact: Energy Efficiency Renewable Energy Clearinghouse (EREC), P.O. Box 3048, Merrifield, VA 22116, Phone: (800) 363-3732 (Help Desk).

SUMMARY

Selecting viable, technically feasible and economically sound ECMs should be based on energy savings, energy cost savings, other

cost savings and on other benefits that are obtained. ECM interaction must be analyzed and accounted for whenever multiple ECMs are proposed.

All selected ECMs should at least meet or preferably exceed the requirements and efficiency standards set forth in EPAct, Executive Order 12902, ASHRAE/ES 90.11989 (and revision), the Council of American Building Officials Model Energy Code and others.

These ECMs must maintain or improve the health, comfort and safety of your occupants. If occupant health, comfort or safety is compromised by the project, don't do it.

Projects should be economically analyzed based on life-cycle cost analysis, *don't use simple-payback* Correct economic analysis methods must be used for each ECM category type.

Since much of our work are retrofit projects, we need to select them correctly, the first time. Redoing a retrofit is not what any of us ever wants to do. We need to do what needs to be done, and not just think about doing it.

Table 1. Summary of LCCA for ECMS

Capital Investment Selection Decisions	Economic Analysis Methods				
	LCC	NS	SIR	AIRR	Payback
Accept/Reject ECM	Minimum	> 0	> 1.0	> Discount Rate	DNU
ECM Efficiency	Minimum	Maximum	DNU	DNU	DNU
ECM from Competing Alternative	Minimum	Maximum	DNU	DNU	DNU
Combination of Interdependent ECMs	Minimum Combined LCC	Maximum Combined NS	DNU	DNU	DNU
Ranking independent ECMs	DNU	DNU	Descending Order	Descending Order	DNU

DNU = Do Not Use

ABOUT THE AUTHOR

Bob Hoshide, CEM, CLEP, is an energy management consultant. He retired after 37 years with Rocketdyne and is now known for his professional development workshops for energy management personnel. He has presented 45 energy management training courses, in 18 states and Washington, DC. Key areas covered include the importance of energy efficiency, starting an energy management program, energy auditing and monitoring, analysis and selection of energy efficiency projects, life-cycle cost, cost estimating, installation, commissioning, operation and maintenance, technical engineering information and staying on top of technology.

From 1982 to 1994 he provided technical assistance to 27 states for the Institutional Conservation Program (ICP). He technically evaluated and monitored numerous energy efficiency projects and conducted building energy load analysis including on-site energy auditing and technical monitoring. He co-authored the *Energy Management Guide for Government Buildings* textbook and has presented numerous papers at various conferences. Mr. Hoshide has worked with the BPA, WAPA, PNNL and FEMP.

Robert K. Hoshide, Energy Management Consultant, 58483 Spring Creek Road, Montrose, CO 81401(970) 240-8227