SASKATCHEWAN
ENERGY MANAGEMENT
TASK FORCES

TECHNICAL GUIDE

A GUIDE FOR THE SELECTION OF ENERGY EFFICIENT TECHNOLOGIES

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1. INTRODUCTION

Investing in energy efficient products and services can help reduce operating costs, improve the work space environment and contribute to increased productivity. On the income statement this means lower expenses and increased profits. For the operations manager these investments can help balance a reduced budget, save jobs and possibly create new employment opportunities. This guide will provide the reader with the information required to evaluate energy efficiency options and provide a guideline to decide which projects should be undertaken to reduce energy costs.

2. ESTIMATING ENERGY SAVINGS & COSTS

Selection of an energy efficiency option or choosing between several such options should be done on the basis of cost effectiveness (the costs versus the savings) and reliability and durability.

The first step is to properly estimate the saving and cost of each option. When we talk about energy efficiency, the cost of the energy efficient technology or service represents the investment, and the savings in energy bills and other costs represents the return on that investment.

The cost of an energy efficient technology is the incremental cost of the more efficient technology over the cost of a conventional one or the full cost of an added technology or measure.

Savings resulting from the use of energy efficient technologies and measures consist of several parts.

- direct energy and demand savings from the energy efficient technologies or measures.
- indirect energy savings from the reduction in other loads.
- capital savings from smaller systems.
- maintenance savings.

Direct Energy Savings

In its broadest sense, energy efficiency means "the same for less". An energy efficient technology or measure is one that uses less energy to provide the same service as a conventional technology or measure, or which uses a cheaper form of energy to provide the same service.

Energy efficiency can therefore cover a wide variety of measures:

- replacing an inefficient product with a more efficient one
  - a high efficiency boiler uses less gas to provide the same amount of heat
  - a compact fluorescent lamp requires a lower wattage to provide the same amount of light

- replacing equipment that uses an expensive fuel with one that uses a cheaper fuel[1]
  - a natural gas water heater costs less to operate than an equivalent electric water heater

- reducing the energy load that a technology is required to meet
  - using high efficiency windows reduces the heating and cooling load in a building
  - adding covers to food freezer cases reduces its refrigeration load
  - using occupancy or daylight sensors to control lighting systems shortens the length of time light is needed

- matching the size of the technology to the service required
  - reducing light levels to match the task can be achieved through de-lamping or using lower output better quality lighting
  - if cooling load itself has been reduced by use of other energy efficiency measures, chillers can be down-sized and more precisely to match the cooling load of a building

- improving operating procedures
  - optimising control systems reduces equipment run times
  - regular maintenance and cleaning increases the effectiveness of systems

- reducing or shifting peak electricity demand
  - - installing capacitors improves power factor
  - - thermal storage reduces daily heating or cooling peak demand
  - - optimising use of large pieces of equipment minimizes peak demand

In each case, there is a direct savings in energy costs, and in the case of electricity, demand savings as well2.

Indirect Energy Savings

Sometimes an energy efficient technology or practice will provide greater savings than first appears. Reducing energy consumption in one end-use can often indirectly save energy in other systems due to interactive effects among end-uses.

For example, the cooling load in a building includes the heat generated by the lighting system. Other factors also contribute to the cooling load: lighting, office and food service equipment make up 40% of the load, the heat brought in from outside in the ventilation accounts for an additional 40%, and the solar heat gain through the windows makes up the remaining 20%. Using efficient lighting, lowering light levels, using high efficiency windows, optimizing the ventilation system, *etc.*, will all reduce the cooling load as well as the direct use of

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[1] Cheaper usually means more efficient use of resources, e.g. using natural gas directly as a fuel instead of converting it to electricity first.

[2] Electricity demand charges are a measure of the extra generating and transmission capacity that must be held ready to meet peak demand. While not saving energy, peak reduction measures save both consumer and utility money.

electricity for lighting, heating fans, *etc*. A much smaller chiller is also required, saving additional capital dollars, and making the overall package even more cost effective. (See Capital Cost Savings below)

Indirect savings, therefore, often allow much higher levels of efficiency to be cost effective. Comprehensive energy management which addresses all end-uses together over several years, and takes advantage of indirect savings, are much more effective that a one-measure-at-a-time approach[3].

Sometimes indirect effects can be both positive and negative. For example, use of efficient lighting will increase the heating load while reducing the cooling load. However, heating systems produce heat more efficiently than lighting, therefore the net impact of efficient lighting is almost always positive, especially if natural gas is used for space heating.

In larger buildings with several interacting systems, it is not an easy task to estimate the size of indirect savings. Many energy management companies use computer simulation models to estimate the performance of a complex system such as an HVAC, or the whole building. Some common models are:

DOE II - models whole building
Merriweather - models HVAC system

Capital Cost Savings

Buildings that incorporate advanced building designs can cost no more to build than conventional buildings. Using more efficient lighting, curtain wall systems, office equipment and taking advantage of natural light and free cooling, actually reduces the size of the lighting, cooling, heating and mechanical systems required. The extra cost of efficient systems is offset by the lower capital cost of the smaller systems and mechanical rooms.

Maintenance Savings

Buildings that have energy efficient systems often operate with reduced run times on mechanical and electrical systems. This can result in lower maintenance costs due to the extended life of the equipment. Changing to efficient compact fluorescent lighting that have ten times longer life, reduces the number of lamp changes and results in lower labour costs. Trying to estimate these saving is difficult and should be done in consultation with the building operators or the service company that has the maintenance contract for the building.

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[3] It is also why "Energy Services Companies" take a long term comprehensive view to maximize their revenue.

Example of Estimating Costs and Savings

To compare efficient with conventional technologies, it is important to use the same load or conditions for each, consider both energy and demand charges when estimating the saving, and take any energy and capital savings from interactive effects into account whenever possible. Operational or labour differences should also be considered.

Savings = energy savings + demand savings + operational or maintenance savings + savings through indirect effects

Costs = difference in capital cost - savings in capital through indirect effects

Sometimes there will be no differences in capital cost. For example, energy efficient "Energy Star[4]" office computers and peripherals cost no more than current models but use 60% less power. The cost of high efficiency windows is also approaching that of ordinary windows of the same quality.

Example: Let us compare a standard fluorescent fixture with a energy efficient fixture. The standard fixture has four 40-watt lamps and a magnetic ballast. It consumes 186 watts. The efficient fixture has two 32-watt T8 lamps, a reflector, and an electronic ballast. It consumes 59 watts. It is assumed that the illuminated space requires light for 4000 hours per year and that the light is on during the period of peak demand. The efficient system produces about 15% less light per fixture, but most office spaces are over lit and a reduction of light levels is acceptable.

Energy Saving = Run-time (hrs/yr) x Incremental Energy Savings (kW)
= 4000 x (186 - 62) /1000
= 496 kWh/yr

Demand Savings = Incremental Demand Reduction (kVA)
=(186 - 62) /1000
= 0.124 kVA/month

Indirect Savings = Reduction in Cooling Load
= $3.00/yr

Labour Savings = Reduction in Maintenance
= $1.00/yr (Due to reduced lamp changes)

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[4] A United States manufacturer/government partnership to develop high efficiency technologies

Total Savings = Energy Cost Savings + Demand Cost Savings + Labour Savings + Indirect Savings
= (Energy Savings x Energy Charge) + (Demand Savings x Demand Charge) + Labour Savings + Indirect Savings
= (496 kWh/yr x $0.0334/kWh) + (0.124 kVA/month x $13.01/kVA x 12 month/yr) + $1.00 + $3.00
= $16.57 + $19.36 + $4.00
= $39.93

Cost of Standard Fixture = Fixture & Ballast Cost + Lamps
= $40 + $30
= $70.00

Cost of Efficient Fixture = Fixture & Ballast Cost + Lamps
= $105 + $30
= $135

Incremental Cost = Cost of a Standard Fixture - Cost of Efficient Fixture
= $135 - $70
= $65

Now that the costs and savings have been identified, an evaluation needs to be done to determine if the technology is cost effective as defined by financial criteria.

3. FINANCIAL TOOLS FOR EVALUATING ENERGY EFFICIENCY OPTIONS

The financial manager of a private organization is responsible for approving projects that will improve the financial position of the company. In the case of a public organization, they look at projects that best allow the firm to deliver prescribed services within the constraints of the allotted budget. In either case investment in energy efficiency can help to lower operating costs to reach financial goals. A good financial manager will evaluate an energy project based upon four financial measurement tools - Simple payback, Return on Investment (ROI), Net Present Value (NPV) and Internal Rate of Return (IRR). Each tool adds value to the quality of the investment decision. A brief description of each is given below. More details are given in Appendix A.

Remember that in an energy conservation project, the cost of the project is incremental cost of energy efficient equipment over the conventional equipment, and the income to the project is the savings accrued.

Simple Payback.

Simple payback measures the time it takes for the energy savings to payback the initial cost of the project. We calculate the time period it takes to recover our initial investment by dividing the initial investment by the estimated energy saving.

Payback period = Estimated project cost / Estimated energy saving per period (years, months)

This measure is effective for establishing the time period required to recover your initial investment. It is simple to calculate but does not consider three very important factors.

1. Energy savings continue for the life of the equipment or project life - payback does nor take into account the life of the equipment.
2. A safe dollar is worth more than a risky one - payback does not allow comparison of the option with other investments
3. A dollar today is worth more than a dollar tomorrow - payback does not take the time value of money into account.

Return on Investment. (ROI)

Return on investment goes one step better by taking into consideration the effective life of the project. It measures the return of the project measured in percentage. A 30% ROI means that we recovered our initial investment and another thirty percent. It is calculated by dividing the energy savings over and above the initial investment by the initial investment and multiplying this by 100 to get it into percent. The result is a return on investment for the life of the project. To compute annual return divide this number by the length of the project.

ROI = (Total Energy Savings (For Life of Project) - Estimated Project Cost) / Estimated Project Cost) x 100

Like payback, ROI does not take time value of money into account and the benefits of compound interest and cannot be used to compare the project to other investments. Also, if cash flows occur towards the end of a project rather than in a steady stream, ROI can overstate the attractiveness of a project.

Net Present Value. (NPV)

The Net Present Value is the best method for evaluating projects. It measures the increase in value of the investment based on the organizations required rate of return. It takes into account the equipment life, risk of the investment and when the energy savings will be delivered. It is simple to calculate using the NPV formula or by using a spreadsheet net present value function.

If the sum of the present values of the expected annual energy savings are greater than the initial energy investment, the NPV of the project will be positive and should be undertaken. The risk of the project is taken into account by selecting an appropriate discount (hurdle) rate for the investment. Calculating NPV is very simple using a financial calculator or a spreadsheet. (Refer to Appendix A)

Net Present Value (NPV) = Initial Investment + Sum of the Present Values of the Estimated Energy Savings (Life of the Project)

The Internal Rate of Return (IRR)

Internal Rate of Return follows the same reasoning as Net Present Value. The main difference is that rather than picking a discount rate depending upon the risk of the project, this method relies on an iterative solution to determine what discount rate will cause the NPV of the project to equal zero (see Appendix A). IRR is calculated by trial and error by varying the discount rate in the NPV formula until the NPV is equal to 0. An easier method is to use a calculator or spreadsheet IRR function and the processor will do the iterative solution for you.

The resulting rate of return, IRR can be used to evaluate the profitability of energy projects and to make direct comparisons to alternative projects and investments. The time value of money, timing of cash flows and project length are taken into account in this analysis.

Evaluating An Energy Efficiency Project - An Example

To demonstrate why it is important to use NPV and IRR in making energy investment decisions let us consider a proposed lighting retrofit at Acme Tools (see Box). In this example we will use the four financial tools to evaluate a project, first over the life of the equipment, then over shorter periods to reflect possible time constraints. Evaluation over periods shorter than the equipment life may be important if external financing is required or a building will be occupied over a limited number of years.

When we look at the financial analysis using all of the tools we can begin to appreciate the importance of using NPV and IRR that take into consideration important aspects of decision making: risk, time value of money and project life. Using payback as the only means of selecting projects has severe limitations. Payback does allow the lifetime savings to be taken into account or comparison made with other investment opportunities. Payback also does not change when time constraints are put in place, and a bad investment decision would result if the time constraint was three years. You would earn 0% return on your initial investment of $60,000 and you would have been better off sticking your money in the bank. On the other hand, ROI can lead us to rejecting good projects because it can understate the attractiveness of a project. If we rejected a project with a five year time constraint based upon an annual ROI of 6.7 % we would be rejecting a project that has a positive net present value and offers a rate of return of 20%.

To summarize financial investment decisions, payback and ROI are adhoc rules and can often lead to bad investment decisions when used on there own. IRR gives us a useful tool to compare the expected returns to investing in other projects or leaving money in the bank. NPV takes into account all of the important variables related to project investments and leads to better investment decisions. It is easy to calculate and should be used for evaluating all of your proposed projects. There are other considerations that should be taken into account when deciding which projects to pursue. The following section presents other issues that the energy manager will have to consider when competing for financial resources.

Acme Tools: Proposed Lighting Project

Project Description: Due to a reduction in operating budget the maintenance department proposes to change all four lamp T12's to two lamp T8's with electronic ballasts and reflectors. The resulting energy savings will allow the maintenance department to reduce energy costs and keep existing staff working full time.

Project Details:	Installed project cost	$60,000.
	Estimated Energy Savings	$20,000.
	Required Rate of Return	Hurdle Rate = 16 %
	Equipment Life:	10 years

Financial Tools: **Simple Payback** = Estimated project cost / Estimated energy saving per period (years, months)

ROI = (Total Energy Savings (For Life of Project) - Initial Project Cost) / Initial Project Cost) x 100

Net Present Value (NPV)
NPV = (Initial Investment + Sum of the Present Value of the Estimated Energy Savings for the Life of the Project)

Internal Rate of Return (IRR)
Method: Set NPV = 0 and Solve for Discount Rate

Time Constraint (years)		Equip. Life	5	3
NPV (Discount Rate = 16%)		$31,607	$4,729	($13,002)
IRR		31%	20%	0%
ROI		23.3	6.7	0
Payback		3.0	3.0	3.0
	Time Period			
Initial Investment	Year 0	-60,000	-60,000	-60,000
Energy Savings	1	20,000	20,000	20,000
	2	20,000	20,000	20,000
	3	20,000	20,000	20,000
	4	20,000	20,000	
	5	20,000	20,000	
	6	20,000		
	7	20,000		
	8	20,000		
	9	20,000		
	10	20,000		

Deciding Among Several Different Energy Efficient Options

A detailed financial analysis helps us to determine which options will add the most value to the firm by determining the appropriate level of investment. We will show that law of diminishing returns does not apply if efficiency options are effectively packaged.

Table 1 summarizes several energy efficient lighting retrofit options. In order to make a decision on which option to select, a financial analysis provides the bases for determining the most cost effective solution. To simplify this analysis we will consider only the direct energy savings opportunities and will not quantify other cost benefits such as reduced maintenance or reduction cooling loads.

Simple payback tells us that all the available options will return our investment within a three year period. Payback time is less than the expected life of the equipment and we should further our analysis. The next step is to determine if savings are sufficient to cover the risk of investing in an energy project.

The four options offer a return on investment (ROI) of 27% to 46% over the ten year expected life of the retrofit. Because ROI does not take the time value of money into account or the timing of the cash flows it should only be used as a rough guide to determine the relative profitability of the four options. If we use ROI to make a financial decision on an energy project we run the risk of accepting a project that does not meet our company hurdle rate. This can occur when energy saving cash flows occur towards the end of the project. On the other hand, we could also reject a profitable project when the benefits of compounding principle are not taken into account and ROI understates the attractiveness of the project. In our case, cash flows are constant and the returns calculated actually understate the attractiveness of the project. Knowing this, we can conclude that with a minimum ROI of 27% all of these projects are profitable and further analysis should be undertaken to determine the best project.

The Internal Rate of Return (IRR) numbers give us a direct comparison of investing in energy efficient lighting as opposed to leaving our money in the bank and collecting compound interest. All of the proposed retrofits offer a return above the company hurdle rate and should be considered. IRR also allows us to make investment decisions based on alternative means of financing. For instance, if we needed to borrow money we can add the additional cost of borrowing to our company hurdle rate and make a direct comparison to the project IRR. Although it is a useful financial tool, IRR should not be used by itself as it does not take into account the relative size of the savings. A project with a lower IRR can be a better investment. For example, if we had to choose between two projects. Project A: $10 investment with an IRR=40% or Project B: $1 with an IRR= 60%. The $10 investment will add $4 to the value of the business while the smaller project will add only $0.60. Project A would be the best choice if the company hurdle rate is less than 40% and they have the $10 to invest.

In our case we will assume that we have financial resources to invest in the best option. Because these are mutually exclusive projects (can only do one of the proposed options) we should select the one that adds the most value to the company. Since Net Present Value is the only financial tool we have discussed that takes into consideration timing and size of cash flows, time value of money, initial investment and the company hurdle rate, we should use it to make this decision. Option 2 has the highest Net Present Value ($96) and is the best investment.

Table 1 - Comparison of Fluorescent Light Fixtures Performance and Costs

	Existing	**Option 1**	**Option 2**	**Option 3**	**Option 4**
Lamp Type	4 x F40 Fluorescent	4 x T8 Fluorescent	2 X T8 Fluorescent	2 X T8 Fluorescent	2 X T8 Fluorescent
Ballast(s)	2 x 2 lamp Electro-Magnetic	1 x 4 lamp Electronic	1 x 2 lamp Electronic	1 x 2 lamp Electronic	1 x 2 lamp Electronic (dimmable)
Reflector	White	White	Specular Reflector	Specular Reflector	Specular Reflector
Controls	Central Switching	Central Switching	Central Switching	Occupancy Sensors	Occupancy + Daylighting
Light Level (lumens/m2)	900	900	600	600	600
Lamp Efficacy (lumens/watt)	70	90	90	90	90
Power Input (watts/fixture)	186	112[5]	60[5]	60[5]	60[5]
Hours of Use (hours/year)	4000	4000	4000	2500[6]	1800
Annual Electricity (kWh/yr per fixture)	744	448	240	150	108
Annual Energy Costs at 3.34¢/kWh	$24.85	$14.96	$8.02	$5.01	$3.61
Annual Demand Costs $13.01/kVA[7]	$29.04	$17.49	$9.37	$9.37	$9.37
Total Annual Electricity Costs	$53.89	$32.45	$17.38	$14.38	$12.97
Total Annual Savings in Electricity Costs[8]	- -	$21.44	$35.50	$39.51	$40.91
Percentage Savings in Electricity Costs	- -	40%	68%	73%	76%
Fixture Cost[9]	$40	$80	$105	$125	$150
Simple Payback (years)	- -	1.9	1.8	2.2	2.7
Net Present Value (k=16%, t=10yrs)	- -	$55	$96	$89	$74
Internal Rate of Return (t=10 yr.)	- -	53%	55%	45%	35%

4. RELIABILITY AND AVAILABILITY OF ENERGY EFFICIENT PRODUCTS

In considering a new technology, it is important to consider its reliability. Energy efficient technologies, like all products, have gone through a developmental phase. They are, consequently, as reliable as conventional products. Quality control, and the increase in the number of standards for efficient products has made selection much safer and easier. In many cases, however, local suppliers contractors may not be familiar with the technology and also may not be able to obtain good prices from manufacturers. This often perpetuates misinformation about the reliability and high cost of a new technology long after it has been commercialized.

The lack of a local supplier of a technology also affects pre and after sales service. Use industry newsletters and other sources to obtain manufacturer and product information, get prices from larger wholesalers or distributors, and approach utilities and specialized agencies that promote energy efficiency to help with technical questions. All of these sources will work with local suppliers to help increase local availability of energy efficient products and services.

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[5] Electronic ballasts operate fluorescent lamps at a higher efficiency, *i.e.* the power consumed by the lamp is reduced by 10% from the rated wattage

[6] Depends upon potential to reduce actual hours of use.

[7] It assumed that all light fixtures are operating during each monthly peak demand.

[8] Interactive cooling affects are not included in these calculations.

[9] Fixture costs may vary from those quoted. Rates of return calculations will change is capital costs increase or decrease.

5. COMBINING OPTIONS

The most cost effective energy efficiency projects are those that combine several opportunities together and which take advantage of equipment retirement and replacement schedules. For example, undertaking a compressive lighting retrofit project will always be more cost effective than individual upgrades. Undertaking a HVAC system motor and drive upgrade as each system goes through it's annual maintenance will always be more cost effective than a special shutdown. Not only will there be savings in labour, but there will be the opportunity to package together opportunities into large enough projects to obtain volume discounts, lower management fees and third party leasing or energy performance contracts.

Staying away from "one-off" upgrades will also avoid "cream skimming" and lost opportunities. There are several ways of approaching energy management so that opportunities are not lost and highly cost effective measures can be used to help finance less cost effective ones.

Avoiding "Cream Skimming" and Lost Opportunities

It is very important to avoid taking initial advantage of the quick-fix, low-cost options alone, while at the same time loosing the opportunity to make much higher savings later. De-lamping existing light fixtures can be an effective way of generating savings at low cost. The savings can be used later to upgrade the fixture when it needs replacement. Replacing old ballasts with conventional electromagnetic ones, however, without considering a full lighting retrofit, means that the opportunity to save three times as much energy has been lost for up to 10 years. In most cases, a lighting retrofit with electronic ballasts, T8 lamps, and reflectors is cost effective and easily financed. Wait until the whole fixture needs upgrading and then do a comprehensive retrofit.

Taking advantage of stock turn-over

Take a long term comprehensive view, and use the replacement time for each piece of energy using equipment to your advantage. For example, if an old chiller has a few more years of life, but it would be cost effective to replace it now with a more efficient one, wait until you have considered efficient lighting options and other upgrades that reduce the cooling load. Consider the cost effectiveness of the whole package, including a smaller chiller, and implement the package over a three year period.

Cross subsidization

Use the low cost savings from de-lamping, operational efficiencies, maintenance improvements, etc. to cross subsidize more expensive measures. If measures and upgrades can be done sequentially without losing opportunities, this can be done by carrying forward savings and reinvesting them in more expensive options. Alternatively, package all of the options together in a multi-year plan and finance the whole package through internal investment, lease, loan, or energy performance contracting (see also Guide to Financing Options). The result is much higher savings at a lower overall cost.

6. ESTIMATING TOTAL ENERGY SAVINGS

The information from the energy equipment inventory/audit, energy bill analysis, and this guide can be used to estimate the savings and costs of each option and combine the opportunities into a single package for the least cost and ease of implementation. Once energy efficient options have been evaluated and selected, then the total savings from all measures can be added together and compared with current energy use. A report can be prepared in the form of a set of recommended upgrades, a schedule, and expected savings and costs. Options for financing the comprehensive multi-year plan should also be provided where possible. If a building simulation model is being, then it should be calibrated against current energy bills and then used to predict total savings using the proposed upgrades.

Appendix A

Financial Tools for Evaluating Energy Efficiency Options

1. Simple Payback

Simple payback measures the time it takes for the energy savings to payback the initial cost of the project. We calculate the time period it takes to recover our initial investment by dividing the initial investment by the estimated energy saving.

Payback period = Estimated project cost / Estimated energy saving per period (years, months)

Example: Estimated lighting retrofit project cost $60,000.00. Estimated energy cost savings are $20,000 per year.

Payback period = $60,000 / $20,000 per yr.

Payback period = 3 years.

Simple Payback Discussion: This measure is effective for establishing the time period required to recover your initial investment. It is simple to calculate but does not consider three very important factors.

1. Energy saving continue for the life of the equipment or project life.
2. A safe dollar is worth more than a risky one.
3. A dollar today is worth more than a dollar tomorrow.

Advantages

1. Simple to calculate.
2. Easy to understand and explain.
3. Provides a rough indicator of the associated risk based on project length..

Disadvantages

1. Too simplistic a measure on which to base decision.
2. Does not take the life of the investment into account.
3. Does not allow a comparison with other types of investments
4. Does not take the time value of money into account.
5. May lead to bad investment decisions.
6. Payback implies that capital has to be spent in order to achieve the savings. This is the reason why any payback greater that 1 to 2 years is often considered too long. It does not allow for the financing of energy savings equipment, paying for both the equipment and the financing out of the savings.

Recommendations: Calculate Net Present Value and Internal Rate of Return to take the above mentioned factors into consideration.

Return on Investment goes one step better by taking into consideration the effective life of the project.

2.0 Return on Investment (ROI)

Return on investment measures the return of the project measured in percentage. A 30% ROI means that we recovered our initial investment and another thirty percent. It is calculated by dividing the energy saving over and above the initial investment by the initial investment and multiplying this by 100 to get it into percent. The result is a return on investment for the life of the project. To compare annual return divide this number by the length of the project.

ROI = (Total Energy Savings (For Life of Project) - Estimated Project Cost) / Estimated Project Cost) x 100

Example: Estimated lighting retrofit project cost $60,000 Estimated Energy Cost Savings are $20,000 per year. Estimated life of lighting equipment 10 years.

Total Energy Savings = Energy savings / period * Number of periods
= $20,000/yr. x 10 yrs.
Total Energy Savings = $200,000

ROI = (Total Energy Savings - Estimated Project Cost) / Estimated Project Cost) * 100
= (($200,000 - $60,000) / $60,000) x 100
ROI = 233% over ten years or 23.3% per year

ROI Discussion: It is hard to make a decision using ROI in this case because there is not another project with which to compare the estimated ROI. Since ROI does not take time value of money into account and the benefits of compound interest, it cannot be compared to other investments. In this case a ROI of 23.3 % looks good but is putting money in the bank a better investment? If cash flows occur towards the end of a project rather than in a steady stream, ROI could overstate the attractiveness of a project.

Advantages

1. Easy to use for comparison purposes.
2. Takes life of equipment into account.

Disadvantages

1. Does not account for cash flow timing.
2. Does not take into account the time value of money.
3. May lead to bad investment decisions.

Recommendation: Do a NPV and an Internal Rate of Return calculation to determine if the proposed investment meets company investment criteria. i.e. Determine if the project Rate of Return is greater than the Rate of Return (Hurdle Rate) required by the company for this type of project.

3. Net Present Value (NPV)

The Net Present Value is one of the preferred methods for evaluating projects. This method gives us a "yes" or "no" for the investment decision. It takes into account the equipment life, risk of the investment and when the energy savings will be delivered. It is simple to calculate using the NPV formula or by using a spreadsheet net present value function.

If the sum of the present values of the estimated energy savings are greater than the initial energy investment, the NPV of the project will be positive and should be undertaken. The risk of the project is taken into account by selecting an appropriate discount rate for the investment.

Net Present Value (NPV) = Initial Investment + Sum of the Present Values of the Estimated Energy Savings (Life of the Project)

$$= -CF_0 + \sum (CF_t / (1+k)^t)$$

Where CF_0 = the cash flow at time zero (Initial investment)
CF_t = the cash flow at time period t (Energy savings)
k = the discount rate (Based on risk of project)
t = time period of cash flow from time zero (Number of years)

Example: Estimated lighting retrofit project cost $60,000. Estimated Energy Cost Savings are $20,000 per year. Estimated life of lighting equipment 10 years. Assuming this was a first energy project there is uncertainty about realizing the estimated savings and the required return of the project should include a risk premium to reward the company for undertaking this project. If this was a guaranteed investment, the discount rate could be as low as the bank rate (Approximately = TBill rate + 2%)

Calculate the discount rate based on risk of the proposed project:

k = rf + rm

Where rf = risk free rate
rm = risk premium (Estimated value based upon type of investment)

Canadian Risk Benchmarks

Risk free

90 Day Tbill Rate rf = 6 % (November 24, 1995)

Risk Premiums (Toronto Stock Exchange 1926-1988)

Gov't Bonds rm = 0.8%
Corporate Bonds rm = 2.1%
TSE 300 rm = 3.0% (diversified stocks)
Common Stock rm = 7.5%

Company Risk Premium

New energy projects rm = 10% (Uncertainty of technology and equipment life)

Calculate discount rate:

$k = rf + rm$
$= 6\% + 10\%$
$k = 16\%$

Calculate NPV:

$$NPV = -CF_0 + \sum (CF_t / (1+k)^t)$$
$$= -60{,}000 + 20{,}000/(1+.16)^1 + 2000/(1+.16)^2 + 2000/(1+.16)^3 + \ldots\ldots 2000(1+.16)^{10}$$
$$= \$31{,}607$$

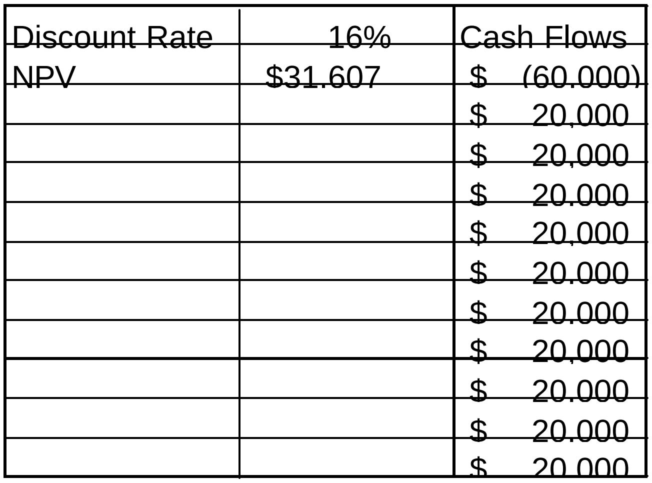
Alternative Excel Spreadsheet Method: Calculating NPV is very simple using a financial calculator or a spreadsheet.

Required variables:

Discount rate k = 0.16
Cash flows in cells D2 to D12

Excel Function:

= NPV(.16,D2:D12)



Discount Rate	16%	Cash Flows
NPV	$31,607	$ (60,000)
		$ 20,000
		$ 20,000
		$ 20,000
		$ 20,000
		$ 20,000
		$ 20,000
		$ 20,000
		$ 20,000
		$ 20,000
		$ 20,000

Advantages

1. Easy to determine which projects add the most value to the organization.
2. Allows for non-simple cash flow problems.
3. Takes into account the timing of energy savings.
4. Project risk is accounted for in the discount factor.
5. Equipment life is taken into consideration.
6. Leads to better investment decisions.

Disadvantages

1. Somewhat difficult to understand.

Decision: This project will provide an annual rate of return in excess of 16% and should be undertaken if financing is available. If a loan is required the discount rate would have to be adjusted to account for the additional cost of capital at the companies borrowing rate. Calculate IRR to compare this project to other financial investment alternatives.

4. The Internal Rate of Return (IRR)

Internal Rate of Return follows the same reasoning as Net Present Value. The main difference is that rather than picking a discount rate depending upon the risk of the project, this method relies on an iterative solution to determine what discount rate will cause the NPV of the project to equal zero.

$$NPV = - CF_0 + \sum (CF_t / (1+IRR)^t) = 0$$

IRR is calculated by trial and error by varying the discount rate k in the NPV formula until the NPV is equal to 0. An easier method is to use a calculator or spreadsheet IRR function and the processor will do the iterative solution for you.

Example: Estimated lighting retrofit project cost $60,000. Estimated Energy Cost Savings are $20,000 per year. Estimated life of lighting equipment 10 years. The risk of the project same as in the previous example.

Trial and Error:

This solution would involve increasing the discount rate from 16% in the above NPV calculation until the NPV = 0. If you select a rate that is too high, NPV will be a negative number.

$$- CF_0 + \sum (CF_t / (1+IRR)^t) = 0$$

Alternative Excel Spreadsheet Method: Calculate IRR by entering cash flows into a financial calculator or using the IRR function on a spreadsheet.

Required variables:

Cash flows in cells D2 to D12

Excel Function
= IRR(D2:D12)

IRR	31%		Cash Flows
			$ (60,000)
			$ 20,000
			$ 20,000
			$ 20,000
			$ 20,000
			$ 20,000
			$ 20,000
			$ 20,000
			$ 20,000
			$ 20,000
			$ 20,000

Excel Spreadsheet Solution:

IRR = 31%

The resulting rate of return, IRR is a very useful number that can be used to evaluate the profitability of energy projects and to make direct comparisons to alternative projects and investments. The time value of money, timing of cash flows and project length are taken into account in this analysis. IRR has a number of pitfalls that should also be considered when using this tool to evaluate energy projects.

Advantages

1. Easy to determine which projects add value to the organization.
2. Allows for non-simple cash flow problems.
3. Takes into account the timing of energy savings.
4. Equipment life is taken into consideration.
5. Widely employed in practice by financial managers.
7. Allows comparison of optional investments.

Disadvantages

1. Multiple internal rates of return are generated when non-simple cash flow series occurs.
2. Does not always determine best project, as it does not take into account the relative size of the investment and energy saving potential. In other words, if we selected a small project with the highest IRR we could pass up an opportunity to invest in a project that could decrease operating costs even more and improve the financial position of the company.
3. When comparing two options, the investment with highest IRR will not necessarily add the most value to the company.

4. Does not allow for varying the interest rate for energy saving cash flows

Decision: This proposed project will reward the company with an estimated a rate of return IRR = 31%. This is greater than the company's hurdle rate which was set at 16 % for this type of investment. If the IRR was less than the hurdle rate, this would mean that the project will not return the required rate of return based upon the risk of the project. The project therefore should be postponed until this level of return is acceptable or more information is available. Case studies of similar projects or proven efficiency gains can help to minimize risk and increase the probability of getting the project accepted. If internal financing is not available, an option would be to borrow money.

Note: A Net Present Value calculation should always be done to verify acceptance of the project due to the previously mentioned limitations of the IRR function.