

IMPROVING

ENERGY



PERFORMANCE

IN BELIZE

A CONTINUOUS LEARNING CULTURE

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CLEAN ENERGY

SOLUTIONS CENTER

ASSISTING COUNTRIES WITH CLEAN ENERGY POLICY

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PREFACE

Energy professionals face tough challenges, in some cases we must ask customers to trust our judgement and make large investments in energy projects under the premise that the energy savings will significantly make up for the project costs. In addition to the financial burden, the energy services must meet the customer expectation and not disrupt the customer's operations. This handbook was developed to help energy assessors and managers in Belize complete successful projects by providing them with the tools, strategies, and frameworks.

The sustained growth of Belize's young energy workforce is an essential component of the country's strategy to mitigate the impact of climate change and achieve the goals set by: Horizon 2010-2030; the National Energy Policy Framework; the Sustainable Energy Action Plan; the National Climate Resilience Investment Plan; the Growth and Sustainable Development Strategy; the National Climate Change Policy, Strategy and Action Plan; and the Intended National Determined Contribution.

The handbook allows organizations to set and practically monitor progress toward sustainable goals. Chapters were organized in sequential steps and describe the entire process of design and implementation of energy projects from start to finish. The first chapter, energy fundamentals, includes basic industry concepts and useful concepts. The second chapter goes on to describe project preparation, necessary resources, and data gathering strategies. The third chapter goes through the site visit and how to gather all the relevant site, equipment, and occupancy information. The fourth chapter discusses the solution: energy and water conservation strategies; financial, energy savings, renewable energy, and environmental calculations; and prioritization of options.

The processes highlighted in this handbook are the basis for standardized training and the initial step toward professional certification of energy professionals.



Figure 1 Overall Process

I. ENERGY FUNDAMENTALS

The goal of every successful energy project is to improve the energy performance of the organization, to ensure that no rock is left unturned. A comprehensive approach should include a continuous improvement process not limited to the equipment, operations and maintenance of the facility, but also the implementation of an energy management system to address organizational systems, behaviours, procurement, and management.

The first step is to perform an energy assessment to gain a firm understanding on the current energy and water situation and use that information as a basis to develop the rest of the strategy. The results from the assessment will allow the organization to select and move forward with the installation of Energy Conservation Measures (ECMs) which can reduce operational costs. In environments where energy and water expenditures are among the top three operational expenses, it's recommended that customers consider the implementation of an energy management system and invest the resources necessary to ensure a successful outcome. The following chapters will explain the full process in the long run.

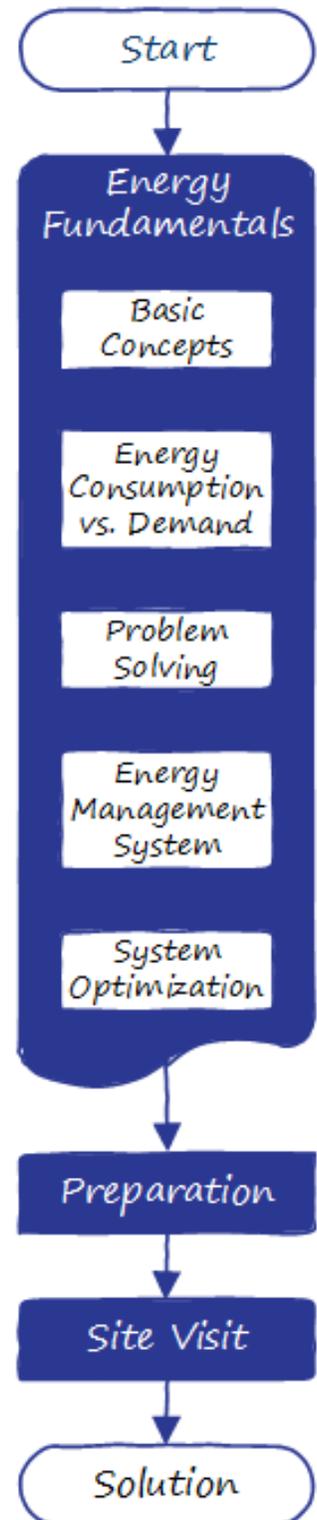


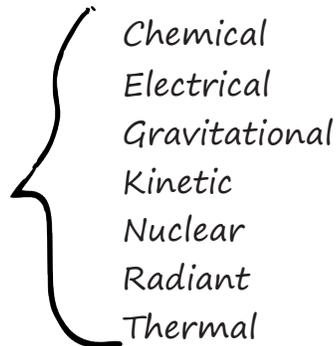
Figure 2 Energy Fundamentals

A. Basic Concepts

This section will define basic concepts, terms, and acronyms most frequently used.

Energy: Capacity to perform work or produce an external activity.

Energy Forms



1. Types of Energy

1. **Potential:** Energy stored by an object based upon its position.
2. **Kinetic:** Energy an object has because it's in motion.

2. Energy Sources

1. **Primary:** Energy that can be used directly, as they appear in the natural environment: fossil fuels, biomass, nuclear fuels, sun, wind, tides, water reservoirs, and geothermal energy.

2. **Secondary:** Electric energy is produced by electric plants which transform primary energy into electric energy.

Renewable: Energy resource that is naturally regenerated over a short time and derived directly or indirectly from the sun, or from other natural movements and mechanisms of the environment. Forms of Renewable Energy include:

i.- **Solar Energy:** Energy produced by converting solar irradiation to thermal or electrical energy.

ii.- **Wind Energy:** Electrical energy generated by using the force of the wind to spin electrical generators.

iii.- **Geothermal Energy:** Electrical or thermal energy produced from using underground hot water to propel turbine generators or generate thermal energy.

iv.- **Hydrogen Energy:** Electrical energy generated from hydrogen chemical reactions.

v.- **Tidal and Wave Energy:** Electrical energy produced by converting oceanic kinetic energy to propel electrical generators.

vi.- **Hydroelectric Energy:** Electric energy generated by propelling electrical generators using potential energy from water reservoirs or water causeways.

vii.- **Biomass Energy:** Electrical energy produced from using chemical reactions of organic materials to propel electrical generators.

viii.- **Biofuel:** Liquid fuel obtained from the conversion of biomass can be converted directly into liquid fuels and used to propel engines and generators.

i) **Nonrenewable:** Energy resources derived from fossil fuels, waste products from fossil sources, or waste products from inorganic sources.

x.- **Nuclear Energy:** Electrical energy generated from converting thermal energy to steam to spin electrical generators.

xi.- **Fossil Fuels:** Electrical energy produced from using chemical reactions of organic materials to propel electrical generators.

It isn't easy to determine which of these different sources of energy is best to use. All of them have their good and bad points.

End Use: Energy directly consumed by the user. It includes primary and secondary energy sources, i.e. electricity, gasoline, LNG, and LPG. Different sector organizations report end use energy while others report primary energy.

Energy Assessment (other terms often used are survey, evaluation, investigation, and most commonly, audit): The term assessment was chosen over the more common audit to disassociate all the negative connotations related to the later term. The assessments are classified per the level of effort necessary to complete the analysis, three levels have become industry standards recognized by international bodies and governments.

1. Level 1: Walk-Through Assessment

Level 1 energy assessment is a basic analysis of a historical utility bills combined with a site visit to identify energy and water conservation measures (ECMs) and estimate energy and water the savings and financial investments necessary to perform the installation. Level 1 results are sometimes used in preparation of Level 2 or Level 3 assessments.

This handbook will focus on Level 1 assessments.

2. Level 2: Investment Grade Assessment

Level 2 differs from Level 1 in the detailed calculations of energy use and investments necessary. Energy uses are broken down, measured, and demand is analyzed. The assessment will identify and calculate savings and investments necessary for ECMs. The ECMs should meet the organization's goals and consider operations and maintenance (O&M). The accuracy of the calculations should be sufficient for financing purposes.

3. Level 3: Energy Modeled Analysis

Level 3 adds to the requirements of Level 2 a computer energy model of the facility engineered to match the facility's energy behaviour and evaluate ECMs using life-cycle cost analysis (LCCA).

Level 3 focuses on potential capital-intensive projects identified during a Level 2 analysis.

Energy Baseline: benchmark against which energy performance is compared. Usually normalized to adjust for external variabilities such as weather, behaviour, building typology, etc.

Energy Conservation: Energy consumption reduction by affecting behaviours, using more efficient equipment, and elimination of waste, and rational use to achieve the same, or better, quality of service.

Energy Consumption: quantity of energy applied.

Energy Efficiency: proportion of input energy and performance output for energy, goods, or services.

Energy Management System (EnMS): set of policies, practices, procedures, and organizational administration aligned to achieve energy targets and objectives.

Energy Objective: specified outcome or achievement set to meet the organization's energy policy related to improved energy performance

Energy Performance: quantitative energy or water measurements against energy baseline.

Energy Performance Indicator (EnPI): measurement units used to represent energy performance.

Energy Policy: statement of organization's commitment to achieving energy performance improvement.

Energy Objective: high level organizational energy mission.

Energy Target: specific, measurable, attainable, relevant, and time bound (SMART) energy performance goals and energy objective.

Energy Use: type of activity for which energy is employed.

Heat Transfer: The Second Law of Thermodynamics states that "Heat can never pass from a colder to a warmer body without some other change, connected therewith, occurring at the same time." There are three common methods of heat transfer:

- 1. Conduction:** Objects at different temperatures are in contact with each other. Heat travels from the warmer to the cooler object until they are both at the same temperature. Conduction is the movement of heat through a substance by the collision of molecules. Some substances conduct heat more easily than others. Solids are better conductors than liquids and liquids are better conductor than gases. Metals are very good conductors of heat, while air is very poor conductor of heat.

- 2. Convection:** Warmer areas of a liquid or gas rise to cooler areas in the liquid or gas and the cooler liquid or gas occupies the vacant space. This cycle results in a continuous circulation pattern and heat is transferred to cooler areas until thermal equilibrium is reached.

- 3. Radiation:** Thermal radiation (often called infrared radiation) is a type of electromagnetic radiation (or light). Radiation is a form of energy transport consisting of electromagnetic waves traveling at the speed of light. No mass is exchanged and no medium is required. When the absorption of energy balances the emission of energy, the temperature of an object stays constant. If the absorption of energy is greater than the emission of energy, the temperature of an object rises. If the absorption of energy is less than the emission of energy, the temperature of an object falls.

Power Factor: is a measure efficiency for an electrical system calculated as the ratio of Real Power (kW) to Total Power (kVA). It is a measure of the systems electrical

efficiency in an alternating current circuit and is represented as a % or a decimal. The total electrical power, or apparent, (Kilo Volt Amperes or kVA) has two components:

1. **Reactive Power (Kilowatts or kW):** which produces work.
2. **Reactive Power (Kilo Volt Amperes Reactive or kVAR):** which generates the magnetic fields required in inductive electrical equipment (AC motors, transformers, inductive furnaces, ovens, etc.) Reactive Power is required by inductive electrical equipment which doesn't produce work. The Total Power (kVA) provided by the generating source must always be greater than the Productive Power (kW).

B. Energy Consumption vs. Demand

Energy demand is related to the capacity of the generation system necessary to provide power. Energy consumption refers the energy use of the system. There is a common water analogy where the demand is analogous to water pressure and energy consumption is the amount of water flowing through a pipe.

Electric utility customers are usually billed for their hourly energy consumption and their maximum energy demand depending on the rates set by the utility.

C. Problem-Solving

Problem solving is an essential skill that will help identify improvement opportunities in many aspects related to the energy use within the organization: energy and water conservation strategies, operations and maintenance options, energy management improvements, and project financing mechanisms. Failure to adequately identifying problems and their causes as well as implementing unsuccessful operations and maintenance strategies can be very costly.

The strategy recommended can be used to address complex, multilayer, problems by first adequately identifying the problem and then ensuring that the proposed solution will deliver the outcome desired. Firstly, the origin of the problem will be identified using a technique known as Root Cause Analysis (RCA). RCA consists of several steps listed in "Figure 7" on page 16.

D. Energy Management System

The Caribbean region is particularly sensitive to the variable and high energy costs, that is compounded by the reliance on foreign fuels to generate electricity. The implementation of energy management systems improves organizational energy performance by establishing energy objectives, policies, and targets for the organization; and monitors performance, and implements proactive measures and re-adjusts accordingly to stay on track.

The advantage of implementing a EnMS over a onetime energy upgrade are many. A systematic, EnMS approach takes into consideration all of the organizational aspects related to energy. The corporate and employee culture will evolve: incorporating

1. Define a detailed problem statement.

2. Investigate and gather information about the problem. Gather all the information related to the occurrence of the problem: duration, impacts, parties involved. For complex problems involve EnMS team to analyze, document, and reporting.

3. Identify potential causes by understanding the multiple cause and effects for each cause.

4. Identify the Root Cause(s). Identify the processes involved with the problem. Drill down on potential causes until root causes are identified for the various systems.

Figure 3 Root Cause Analysis (RCA)

5. Recommend and implement solutions. The implementation of complex solutions may require creative approaches and taking advantage of the opportunities for maximum success or leverage points to improve the likelihood of impact. The leverage points are listed from the least to the most impactful:

12	Constants, parameters, numbers (such as subsidies, taxes, standards)	
11	The sizes of buffers and other stabilizing stocks, relative to their flows	Adequately sizing equipment, inventories, storage, personnel.
10	The structure of material stocks and flows (such as transport networks, population age structures)	Making changes to physical structure is costly and time consuming unless it's done at inception. Proper energy system design is always preferable to retrofits.
9	The lengths of delays, relative to the rate of system change	Adjust the communication signal to get timely response, i.e. thermostats, faucets, dimmers.
8	The strength of negative feedback loops, relative to the impacts they are trying to correct against	Implement proactive maintenance, install monitoring systems, allow for control systems to do their intended job, i.e. open windows while the air conditioning is working.
7	The gain around driving positive feedback loops	Identify the resource(s) being unequally distributed and balance the distribution. Disconnect the two reinforcing structures so they are not dependent on the allocation of shared resource(s).
6	The structure of information flows (who does and does not have access to information)	Provide relevant and timely information about the process or system, i.e. install an energy meter display, visible water meter, etc.
5	The rules of the system (such as incentives, punishments, constraints)	Review social and absolute rules to validate applicability, exceptions, etc., i.e. utility and environmental regulation, duties, fees, etc.
4	The power to add, change, evolve, or self-organize system structure	Insist in diversity, promote experimentation, invest in R&D.
3	The goals of the system	Change the goals or leadership (indirectly affecting goals) of the system.

Figure 4 Leverage Points

2	The mindset or paradigm out of which the system — its goals, structure, rules, delays, parameters — arises	Highlight the failures of the old paradigm, and work to promote the new paradigm and find the support of people with the same views.
1	The power to transcend paradigms	Embrace adaptability, flexibility, and open mindedness.

6. Evaluate success of changes by confirming that actions taken were effective.

Figure 5 Leverage Points cont.

continuous improvement in energy efficiency, provide reliable documentation of metrics that monitor actual performance, help management make effective decisions, enhance

Table 1 Energy Management System Elements

- | | |
|---|---|
| <ul style="list-style-type: none"> • Document control • Records • Management review • Continuous improvement constructs • Internal audit/root cause analysis/corrective action • Management of change • Leverage management system elements in place • Alignment of goals within the organization | <ul style="list-style-type: none"> • Energy Performance Indicators (EnPIs) and goals • Training and communication systems • Management system terms • Energy procurement • Operational controls • Operations and maintenance • Organizational structures |
|---|---|

E. System Optimization

The complex interactions within energy and water systems may sometimes require optimization techniques to take into consideration all the parameters and find a solution in a realistic timeframe. Multiple building energy modeling software tools are available to perform energy related optimizations for energy generation as well as at the energy conservation measure combinations. The software allows for the comparison of different scenarios and helps with identifying the best energy conservation measures. Some packages also allow for predictive control of operations.

Building management software can be also be used to track information which can be

used to improve energy analytics and performance, operations and reduce management costs.

- *Components efficiency vs. system efficiency*
- *System sizing*
- *Reliability Centered Maintenance*
- *System performance decaySystem Optimization*

II. PREPARATION



Advanced preparation always pays off. The success of an energy project depends in large part on the preparation efforts done beforehand. In many cases, access to the multiple resources required for success is complicated, slowing down the process and hindering the progress.

A. Objectives

1. Definition of the purpose, scope, assessment, and deliverables

The organizations must establish the physical confines, equipment, processes, and resources to be considered for the project and ideally integrated into an energy management system.

2. Identification of data, information, and resources needed

Energy and water consumption and demand, building occupancy, descriptions and information about the physical plant, equipment, and staff.

3. Determination of current facility requirements

The organization should define current and future facility improvement plans, expansion projects, and building use, or occupancy changes.

4. Scope focus selection

The scope help the organization prioritize its efforts on investments that will produce the most savings from energy projects.

Applicable programs: Financial grants, rebates, tax incentives, etc.

Building Energy Codes: Requirements set by the CARICOM Regional Energy Efficiency Building Code (REEBC) which include building envelope, mechanical and electrical equipment especificacions.

Indoor Air Quality: Quality of the air affected by temperature, relative humidity, concentrations of biological or chemical pollutants.

Labelling and rating systems: Participation in international or local building energy labelling and rating systems which allow for the

Figure 6 Project Preparation

comparison with buildings with the similar typology.

Thermal Comfort: Indoor environmental conditions affected by air temperature, mean radiant temperature, air speed and humidity.

B. Management

The organization's management participation on the process from its inception is critical for the long term success of the project. The multiple management interventions are included below.

1. Roles and responsibilities of stakeholders' definition

Top management should be totally committed to the process and provide the resources necessary: delegating tasks, setting goals, establish proper communication channels within the organization, and assign a project champion. It's important for somebody to have ownership and responsibility over the tasks at hand. The role of the appointed energy managers should be shared with all the stakeholders so he or she is empowered to ask for support from within the organization.

2. Assessment schedule and energy project management

Identify time necessary to complete assessment and develop strategy to ensure that assessment covers all energy aspects of the facility to ensure good opportunities are not wasted.

3. Goals and objectives validation

Validate objectives and goals against the organization's policy and are specific, measurable, achievable, relevant, and time bound. Obtain a leadership written goal statement.

4. Scope and boundary of Energy Management System definition

Define physical system boundaries of energy flows within the system, in some cases it may be a single building, a floor, section, etc.

5. Energy policy assessment

Evaluate the organization's policy to ensure it benefits are clearly defined in regards to operational cost efficiency, sustainability, process efficiency, regulatory compliance and how they impact its energy targets.

6. Legal and other requirements identification

Identify applicable regulation applicable to the facility: building energy, electrical, mechanical, plumbing, solar, and more specific standards related to lighting, indoor air quality, thermal comfort, etc.

C. Information

The documentation of facility information, historical energy consumption, billing data, and measurements is necessary for the monitoring and validation of goals and used for building labelling efforts.

1. Information gathering forms and sources

a) Energy Assessment Levels: 1, 2, or 3

Select level of assessment planned based upon the outcome desired and resources available: Level 1 for basic assessments, Level 2 for comprehensive and investment grade assessments, and Level 3 for cases where detailed energy models are required as in new facilities.

b) Energy usage/intensity database guidelines

The buildings Energy Utilization Index (EUI) expressed in kBtu/ft² [MJ/m²] per year must be compared against similar building types. CARICOM has performed regional studies on building for different types of buildings. Unfortunately, the data is not statistically valid due to the limited sample size. There are other databases available for comparison provided by the European Union Building Database, the United States Environmental Protection Agency's Portfolio Manager, and the United States Department of Energy Building Energy Data Exchange Specification (BEDES) just to name a few.

c) Other energy and environmental sources of data

The CARICOM, the International Energy Agency, OAS, and OLADE are great sources of information.

2. Analytical tools

a) Simulation/modeling/energy

Energy analysis can be supported by computer tools available for simple calculations, or whole building simulations. Simulation tools can be very complex, selecting the most appropriate tool will depend on the application. Some building energy regulations require simulations to be performed to prove compliance.

In preparation for building energy simulations it's important to understand the inner workings of the tools by:

- Understanding the principles of the tool.
- Understanding the function and principles of the process being modeled.
- Simplifying model without sacrificing essential features.
- Verifying model accuracy by implementing quality control process.

Models may take a long time to develop which may make them cost prohibitive in some instances. Newer tools strive to be more user friendly and facilitate the generation of

more complex geometries and integrated equipment interactions. A list of available tools and other valuable resources can be found at the website of the International Building Performance Simulation Association (IBPSA) at <http://www.buildingenergysoftwaretools.com/>.

b) Spreadsheets

The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) has developed a set of energy data gathering and calculations spreadsheets available for download at their website www.ashrae.org/PCBEA.

c) Predictive Energy Conservation Measures selection software

Some of the building portfolio energy analysis tools have the capability of recommending energy conservation measures based upon the solutions generated using regression models from large building energy datasets. Building information and consumption information is entered into the software and it proposes ECMs to implement.

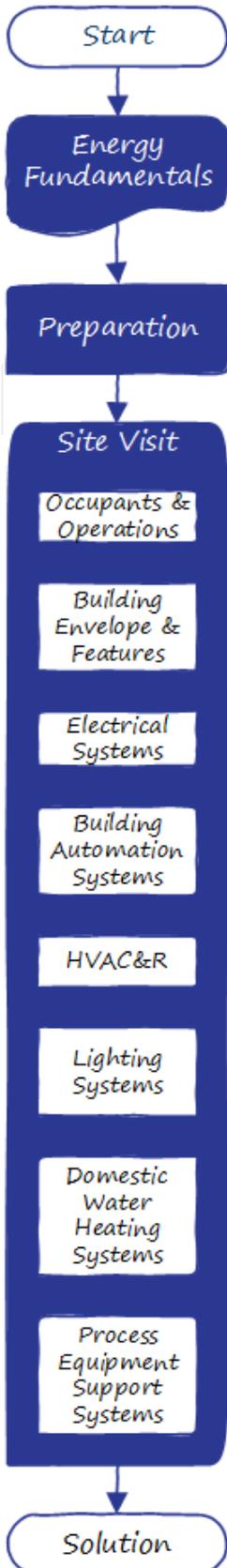
3. Equipment

There are two sets of recommended tools, the essential tools are for the Level I assessments and the advanced tools are for the LEVEL II and Level III assessments.

Table 2 Equipment

Essential tools:	Advanced tools:
Camera, preferably rugged and waterproof	Infrared thermometer
Clipboard or electronic tablet with audit forms	Data loggers: <ul style="list-style-type: none"> • kWh/kW loggers • Light level loggers • Temperature/Relative Humidity loggers • On/off motor loggers • Occupancy loggers • Centralized data logging systems
Phone or two-way radio to communicate with the team	
Flashlight	
Digital thermometer and relative humidity meter	
Personal Protective Equipment (safety helmets, gloves, eye protection, high-visibility clothing, safety footwear, and hearing protection)	Combustion gas analyzer
	Ultrasonic flowmeters
	Hand held manometers
	Pipe caliper
Light meter	Infrared camera
	Commercial 3 fan blower door system

III. SITE VISIT



The visit should be scheduled well in advance, security clearances obtained, and proper access granted with knowledgeable escorts to the spaces to be assessed. Employees should be notified, be made aware of the purpose of the assessment, and instructed to cooperate with the assessment team. Permissions to take pictures should also be requested in advance. The energy assessment can be performed by an individual or a team. It's important there is a qualified team leader to ensure successful communication. The team composition and size will depend on the complexity of the project.

A. Occupants and Operations Assessment

1. Interview occupants, facilities personnel, and maintenance staff regarding building operations, pending projects, and problems

Value the observations of every employee, the purpose of the interviews is to build a clear image of all the available building upgrade opportunities; and how the building and equipment are operated. Additional inquiries should address comfort issues, indoor air quality problems, or other problems. It's important for the assessment team to convey the message that the intent of the assessment is to improve operational efficiency and not question the performance of the staff.

2. Use, operational schedule, and purpose verification

Many of the savings calculations depend on the accuracy of occupancy and use. Check and record time clock settings, set points, and temperatures.

3. Missing and conflicting information resolution

The preliminary analysis might have highlighted discrepancies that should be addressed on site.

4. Recommended occupancy and operations energy conservation measures:

- Identify potential energy and water conservation opportunities.
- Identification of systems, processes, policies and procedures needed to implement and maintain an EnMS
- Analysis of existing systems, processes policies and procedures
- Energy management system gap assessment

Figure 7 Site Visit

B. Building Envelope and Features

1. Building envelope evaluation

Use forms, photographs, sketch the building and layout, digital or infrared to record information about building features. Mark up floorplans or fire exit plans if building plans are not available.

a) **Orientation:** Orientation largely affects the heat gain into the building. Record

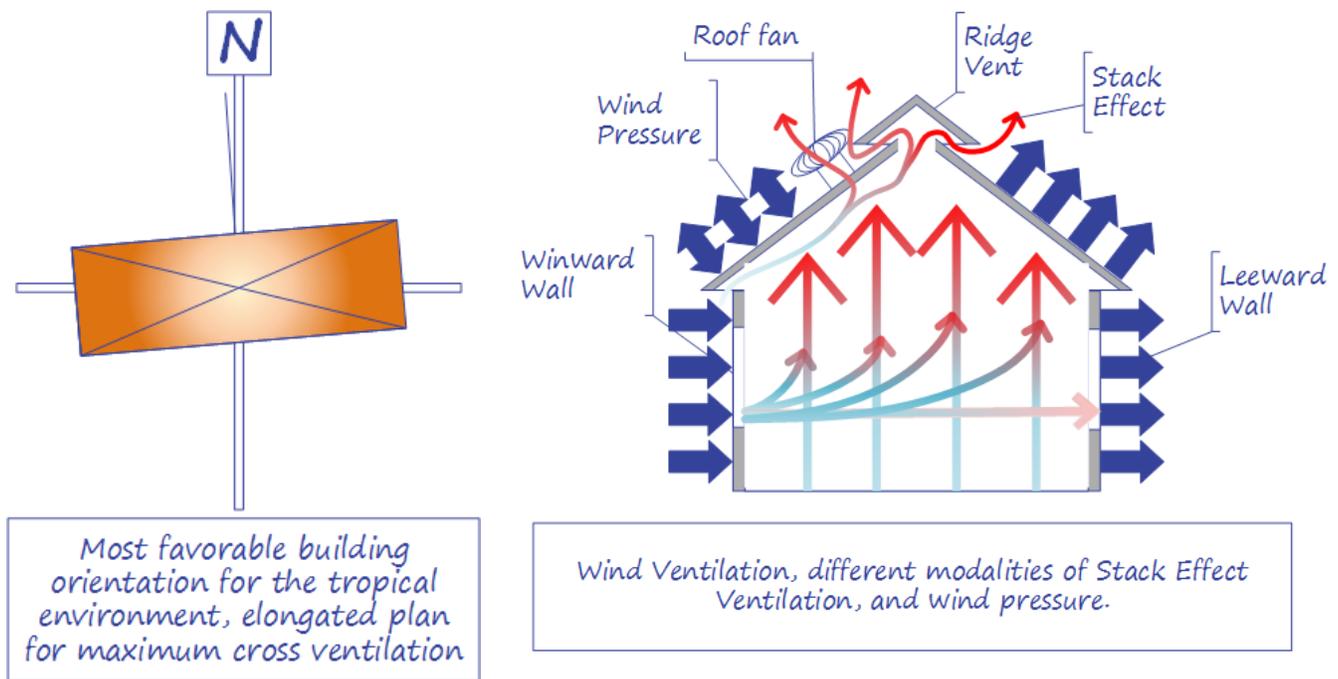


Figure 8 Building Orientation and Natural Ventilation

main building orientation, exposure of windows, doors, and shading.

b) **Glazing and doors:** Record frame type, surface area, glazing type, solar heat gain coefficient, percentage of wall area, air leakage, and if there are cracked or missing window panes.

c) **Vapor barriers:** Check for presence of vapor barrier and identify potential water condensation or mildew from poor wall moisture management.

d) **Insulation:** Check for presence of insulation by inspecting ceiling/attic and use infrared cameras to identify potential trouble spots. The main area to consider is the roof as it has the largest solar exposure.

e) **Solar reflectivity:** Record roof color, inquire about roofing or coating material specifications, roof reflectivity, age, check for deterioration of the coating, warranty, and expected life remaining.

f) **Air-tightness:** Check for dusty spots, over under pressurized spaces, and consider performing airtightness tests using a blower door system. Airtightness is very important at healthcare facilities as the fresh air intake and exhaust must be managed precisely to prevent health problems. The results of airtightness tests can be used to check with building energy code compliance.

Metal Roof Assembly Section

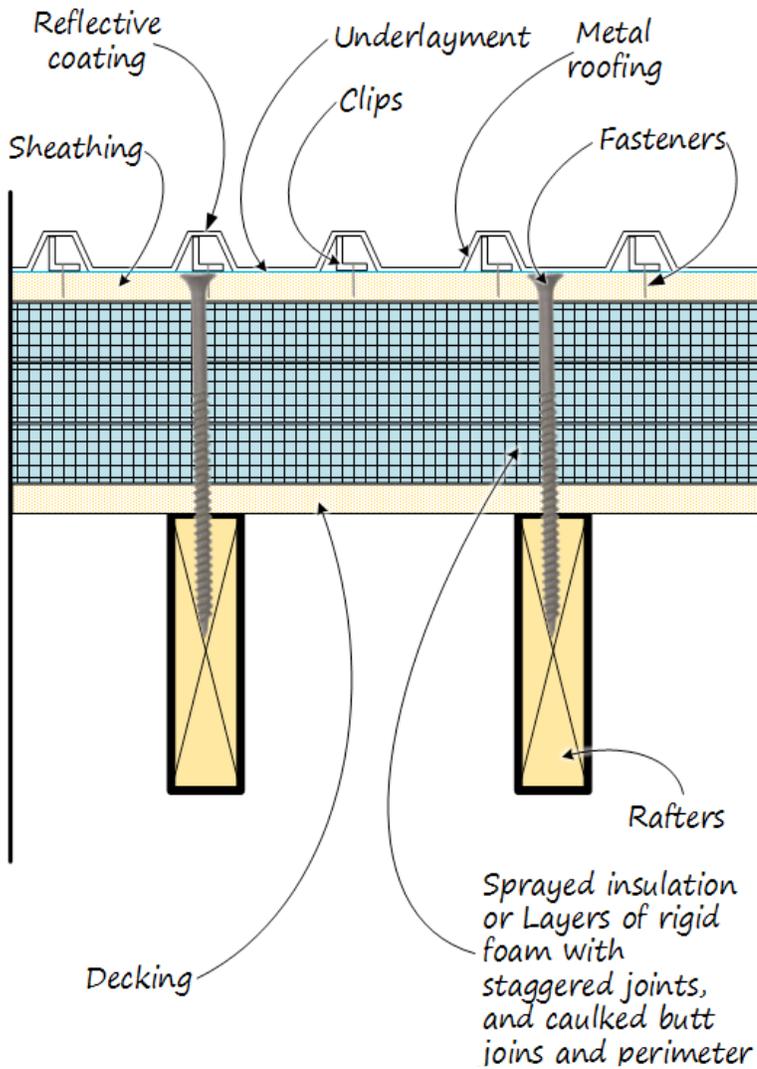


Figure 9 Metal Roof Assembly Section

2. Recommended building envelope energy conservation measures:

- Orientation:
 - Add external shading devices for window or walls
- Glazing and doors:
 - Add ceramic coated reflective window film
 - Seal windows to prevent unwanted infiltration
- Add solar screens or shades
- Replace windows
- Vapor barriers:
 - Add permeable vapor barrier on the inside face of the wall
- Insulation:
 - Coat the roof with reflective coating
 - Install phase change insulation to increase the thermal mass of the envelope
 - Add semi permeable spray or rigid insulation to the inside of the building

C. Electrical Systems

1. Electrical system evaluation

Use forms and photographs, digital or infrared to record information about electrical devices. Electrical measurements should always be performed by qualified personnel.

a) **Voltage levels:** Measure incoming voltage levels to ensure the output of the transformer is adequate.

b) **Surge protection:** Check electric circuits for surge protectors.

c) **Emergency back-up systems:** Record number, measure plug load consumption, and type of equipment back-up systems.

d) **Load analysis:** Install kWh data loggers to measure electric motors and pumps loads and calculate energy use.

e) **Evaluation of miscellaneous plug loads:** Identify and measure the consumption of miscellaneous plug loads from office equipment and other inductive loads.

2. Recommended electrical system energy conservation measures:

- Electrical transformer voltage calibration
- Phase load balancing

D. HVAC&R and Control Systems

Use forms and photographs to record information about BAS. The BAS allows facilities to have centralized control of the equipment and in some cases, track the energy consumption and maintenance events.

1. Evaluation of automated control systems

- Electrical
- Lighting
- Process
- HVAC&R

2. Evaluation of operational performance and response

a) **Direct Digital Control:** Computer receives signals from the connected remote sensors and then sends commands to the equipment after being processed by the computer.

b) **CO₂-based control:** These systems monitor the CO₂ levels in the return air and modulate the outside air damper to provide only the amount of outside air required to maintain desired levels. Teamed with volatile organic compounds (VOC) detectors, they can accurately manage the amount of fresh air to enter the system.

c) **Demand control:** Some non-essential loads, electrical motors, compressors, fans, and domestic water heaters. These loads should not affect productivity or customer comfort.

d) **Monitoring:** Signals like temperature, relative humidity, illuminance, CO₂, occupancy, energy consumption, and demand are monitored to be used for later controlling variables.

e) **Scheduling:** Similar in operation to timers, equipment schedules are controlled by the control system.

3. Evaluation of annual hours of use, condition, and energy ratings or efficiencies of energy consuming equipment. Use forms and photographs, digital or infrared to record information about HVAC&R equipment. Record systems nameplate information. Inspect system for compliance with the latest version of the building energy code/mechanical code.



Figure 10 CO₂ Sensor

4. Evaluation of system performance and response

1. Air distribution systems

Ventilation: Measure fresh outdoor air volume using an airflow hood or calculate if from the difference between supply air and return air and then compare with fan nameplate data. Compare flow with ASHRAE 62.1 levels. Measure airflow at a supply register and the nearest return register. Repeat for all supplies and all registers and compare with the design airflow.

Temperature: Measure and record the temperature at the farthest return grille and then measure the air entering the equipment. Verify temperature drop is less than 5%. The causes can be leakage or insulation problems. Repeat for the supply side.

Air leakage: For areas that are easily accessible, a thermal imaging camera may help identify hot spots on the intake and cold spots on the air conditioning distribution which could be potentially leaking. Leakage testing is not recommended for low pressure systems due to the high expense. The Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) HVAC Air Duct Leakage Test Manual is the industry reference duct leakage. For field calculations, SMACNA has mobile phone applications that allow for simple air leakage calculations. The following questionnaire can help identify duct leak presence, an affirmative answer for two of the questions indicates a high probability of duct air leakage which should be considered for sealing.

Filtration: Check the air filters Minimum Efficiency Reporting Values (MERV) to validate that their minimum particle removal efficiency meets or exceeds the requirements set by standards ASHRAE 62.1 for commercial buildings and 62.2 for residential buildings. The filters for commercial buildings should have a minimum MERV 8 and MERV 6 for residential buildings.

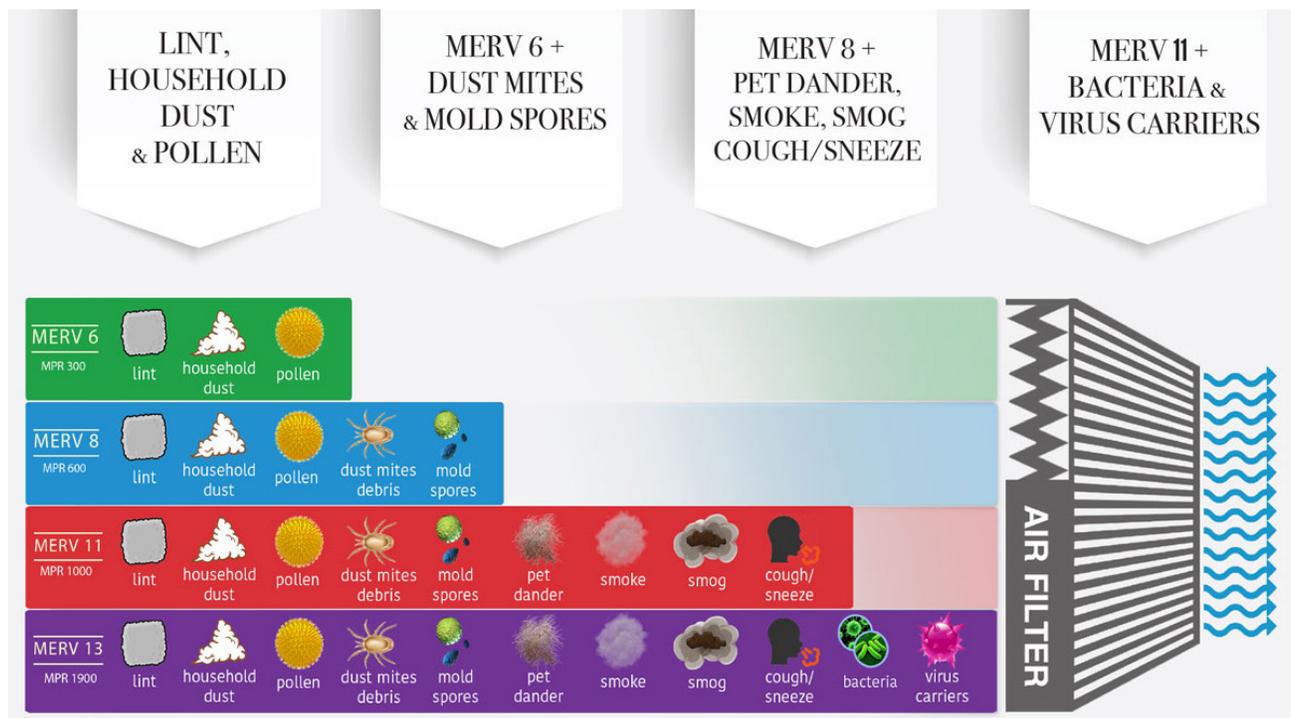


Figure 11 Air Filters Delivered (2017). Types of HVAC air filters

1. Evaluate ductwork construction:
 - Do they use slip-and-drive connections on metal ducts?
 - Do they use sheet rock, masonry for air distribution or ventilation shafts?
 - Are there faulty or missing gaskets (can you feel air leaking)?
 - Are there visible holes or gaps at corners, seams, connections or hangers?
 - Is there pressurized external insulation – aka “the air mattress effect”?
2. Look at the rooms at the end of the hall (ie, far away from fan):
 - Is there poor air flow in these rooms?
 - Are these rooms too cold in the winter or too hot in the summer?
3. Look for uneven air distribution/pressurization issues within the building:
 - Do some areas have excess air flow, while other areas are insufficient?
 - Does airflow delivered vary upon time of year (summer vs. winter)?
 - Are there issues with doors being difficult to open or close?
 - Does the bathroom exhaust grille fail the “two-ply toilet-paper test”?
4. Ask about occupant complaints:
 - Are there heating or cooling complaints?
 - Are there complaints about moisture, mould, odour, or air quality?
5. If practical, ask about the fans (the #1 sign of excess energy consumption):
 - Are they unable to setback the air handler at night or weekends?
 - Do fans commonly operate at excessive speeds – ie wide-open?
 - Have motors, pulleys, or sheaves been replaced to provide more airflow?

Insulation: Visually inspect ducts and refrigerant lines for insulation, look for bare ducting, condensation, noise, mould, and moisture. Check insulation levels against recommended insulation levels on Building Energy Codes like the International Energy Conservation Code (2015) or the ASHRAE 90.1 Standard (2016).

Pressure drop: For large packaged commercial air conditioning units measure the pressure at the equipment intake and equipment output. The negative or suction pressure entering the equipment combined with the positive or discharge pressure produce the equipment total external static pressure. This pressure is compared to the equipment's rated maximum total external static pressure to verify



Figure 12 Compromised refrigerant piping insulation with signs of mould

the system is operating within manufacturer rated pressures. When testing custom or field installed air conditioning systems verify that all the equipment pressures losses/gains are accounted for.

Stack losses:

1. Measure: gas temperature (FGT), combustion air temperature (CAT), O₂ in flue gas, % by volume actual unit output. Determine the CO₂ in flue gas, % by volume, dry gas basis, from the relationship to measured O₂, as described for each fuel. Express the actual unit output as a percentage of the maximum capacity rating.

2. Calculate dry flue gas (DG) using the following formula:

$$DG = \frac{11CO_2 + 8O_2 + 7(N_2 + CO) \times C \text{ burned} + 0.375 S}{3(CO_2 + CO)}$$

3. Calculate excess air assuming CO as zero for a complete combustion. Verify there is at minimum 15 percent excess air, equivalent to 3 percent oxygen.

$$EA, \% \text{ by volume} = \frac{100 \times O_2 \text{ dry}}{0.2682 N_2 - O_2 \text{ dry}}$$

4. Calculate the sensible heat energy in the flue gases from dry flue gas loss (LDG), % of fuel input

$$LDG, \% \text{ of fuel input} = [DG \times C_p \times (FGT - CAT)] \times 100$$

5. Calculate latent heat loss (LH), % of fuel input

$$LH = \frac{9H_2 \times [(enthalpy \text{ of vapor at } 1 \text{ psia \& FGT}) - (enthalpy \text{ of liquid at CAT})]}{100}$$

6. Calculate stack losses (LS), % of fuel input

$$LS, \% \text{ of fuel input} = LDG + LH$$

Measure intake air to ensure there is at minimum 15 percent excess air, equivalent to 3 percent oxygen.

2. Hydronic/Steam Systems

- Insulation

Check for overheating caused by failing pipe insulation or gaskets. Use infrared camera to locate hot spots.

- Traps

Check for lack of condensate discharge or extremely large quantities of steam leaking out of a trap. Also check externally for pinhole, connection joint, and gasket leaks. Use infrared camera to identify temperature differences upstream and

downstream from trap.

- Heat trace

- Perform the following:

1. Test insulation resistance using a megohmmeter before connecting cable to junction box.
2. Measure circuit voltage using multimeter with the circuit de-energized and after energizing.
3. Measure current (Amperage) at ambient temperature and record pipe temperature. Repeat measurement after 15 minutes.
4. Measure resistance (Ohm) using multimeter.
5. Operational test of temperature controllers
6. Visual inspection of all accessible heat tracing components
7. Evaluation of any existing fault conditions
8. Visual inspection of insulation and protective jacketing
9. Visual inspection of all accessible heat tracing components
10. Confirmation of cable integrity (dielectric test)
11. Cable fault location test
12. Steam leaks
13. Check piping visually for leaks.

- Valves and Taps

Check zones for poor temperature control and leaks.

3. Primary and secondary equipment

- Chiller

Perform heat balance test to verify accuracy of refrigerating capacity. The heat balance is the equilibrium between the heat rejected in the condenser or cooling tower and the sum of the heat from the evaporator and the heat from the compressor.

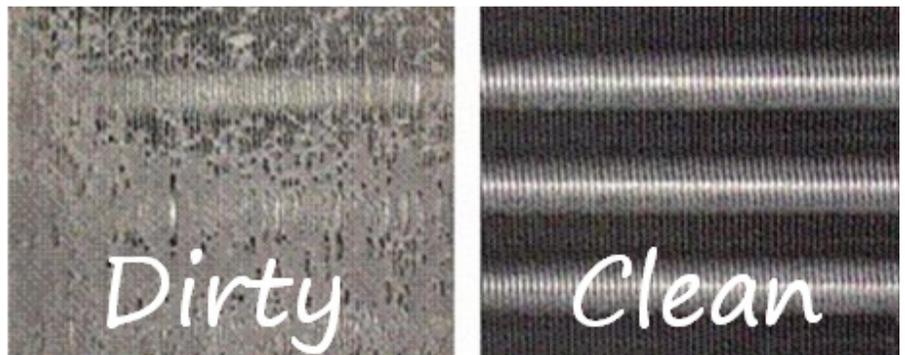


Figure 13 Example of dirty vs. clean coils.

The amount of heat rejected in the condenser and evaporator is calculated with the water heat transfer from the flow (gpm) and water temperature measurements differences.

- Cooling tower

Verify that the heat removed from the water is equal to the heat transferred to the air by taking temperature measures and performing heat transfer calculations. The outdoor air removes the heat from the cooling tower water. The heat rejected can be calculated from the difference between airflow and air temperature.

- Dry coolers

Check heat exchanger surfaces for obstructions, blockages, or debris.

- Energy recovery systems

- Air to air heat exchanger: a box that allows for the passage of incoming and exhaust air without contact and allows for the exchange of heat.

- Heat wheels: large cylinders which use cold and dry exhaust air to pre-cool and dehumidify fresh air. The wheel is spun by a motor.

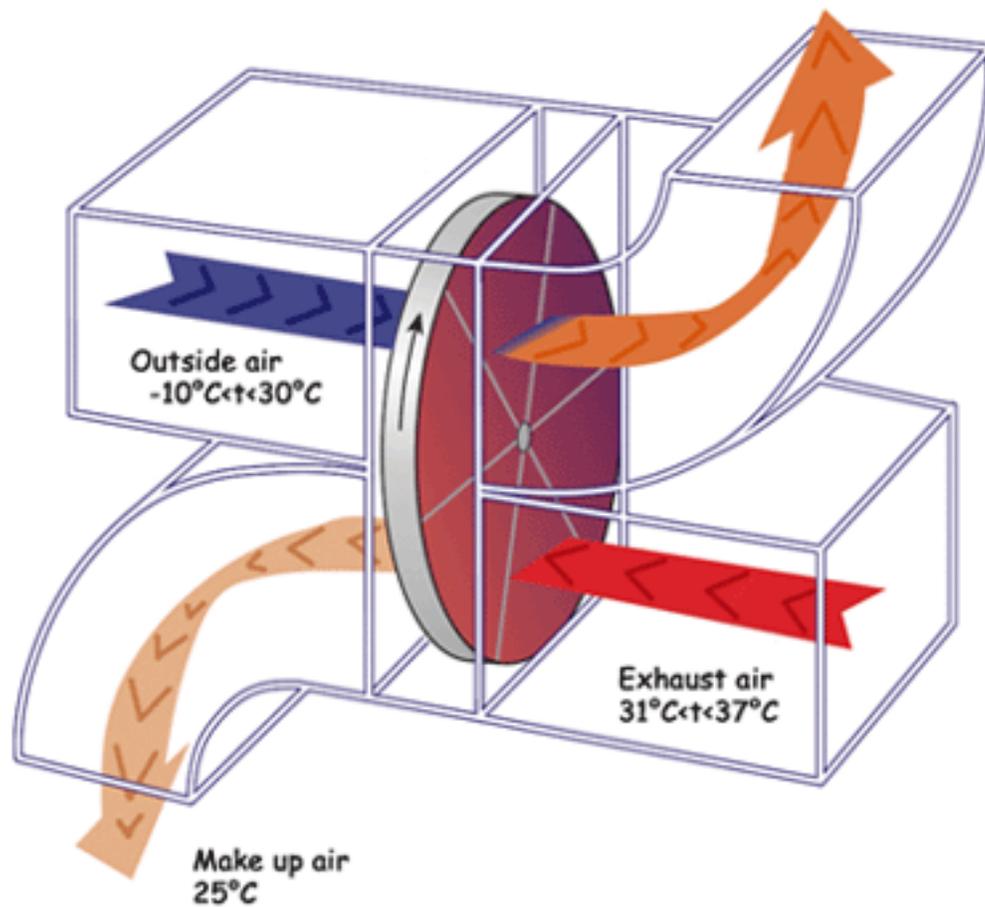


Figure 14 Heat Wheel using enthalpy process

- Variable-frequency drives (VFDs)

Check VFDs to ensure the downstream valves are fully open.

4. District energy systems

- Evaluate greenhouse gas emission reductions.

- Analyse peak demand curve and energy usage.
- Review flexibility of fossil fuel type switching.
- Review implementation status of sustainable energy technologies.
- Calculate use of waste heat.
- Identify fuel source options which can serve as emergency back-up power generation.
- Economic benefits and energy security: DE systems can be owned and managed by local entities, meaning the value of jobs and the control over energy delivery remain in the local community.

5. System interactions

- Review HVAC cooling loads after lighting and envelope upgrades.
- Review upgrade opportunities and take into considerations future facility upgrade plans.

1. Inside Environmental Quality

- Validate ventilation, thermal comfort, and humidity within a building to ASHRAE 62.1 and ASHRAE 55, and ASHRAE 90.1 or IECC 2015 and applicable standards and code requirements.
- Measure CO₂, CO, breathable particles, VOCs and biological contaminants.

2. Recommended HVAC&R energy conservation measures:

- Variable refrigerant flow designs
- Condensate return
- Dedicated Outdoor Air Systems
- System design pressures
- Use HVAC heat for water heating
- Humidification and dehumidification
- Calibrate sensors and controls
- Update firmware
- Check sensors and outputs for accuracy
- Install occupancy sensors
- Install daylighting controls

E. Lighting Systems

1. Evaluation of annual hours of use, condition, power, and equipment

Use forms, sketches, blueprints, layouts, and photographs to record information about lighting systems.

- Interior luminaires: Record number, type (fluorescent, incandescent, or LED), lighting colour temperature and colour rendering index, wattage, and physical layout of fixtures and lamps for each space.

- Exterior luminaires: Record number, type (metal halide, high pressure sodium, fluorescent, halogen, incandescent, or LED), lighting colour temperature and colour rendering index, wattage, and physical layout of fixtures and lamps for each space.

2. Evaluation of daylight availability and suitability

Record illumination levels at daylight spaces where artificial lighting is used during day to qualify spaces for daylighting controls.

3. Illuminance level measurement

Record light levels for the different spaces and compare with Illuminating Engineering Society of North America (IES) recommended illuminance levels for tasks performed.

4. Evaluation of lighting control types and methods

Record types of controls: manual switches, dimmers, occupancy sensors (infra-red or ultrasonic), and timers.

Table 3 Lamp Base Types

LAMP BASE TYPES

H.I.D.				
	BY22d SC Bayonet	FC2	G12 Medium Bi-Pin	R7S Recessed Single Contact
				
	POMB Position Oriented Mogul Base	EX39 Exclusionary Mogul Base	E39	Medium E26/27

C.F.L.							
	G23	GX23	GX23-2	G24q-1	G24q-2	G24q-3	G24d-2
							
	GX24q-3	GX24q-4	GX24q-5	2G11	2GX7	Medium E26/27	E12

Table 4 Lamp Base Types Continued

LAMP BASE TYPES

Linear
Flourescent



Table 5 Lamp Types

LAMP TYPES

H.I.D



Linear
Fluorescent



LAMP TYPES

C.F.L.



5. Energy conservation measures opportunities

- Replace lamps
- Reduce number of fixtures/lamps
- Replace fixtures
- Install skylights
- Install occupancy sensors
- Install or reprogram timers

F. Domestic Water Heating Systems

1. Evaluation of use, condition, ratings, and efficiencies of systems

Use forms and photographs to record information about domestic water heating systems.

- Equipment
- Distribution
- End uses

2. Energy conservation measures opportunities

- Improve piping insulation
- Review point of use distances
- Review end uses and adjust tank sizes
- Install point of use water heaters
- Install controls to meet demand at the time of use

G. Process Equipment Support Systems

1. Evaluation of annual hours of use, condition, power or efficiency

Use forms and photographs, digital or infrared to record information about process equipment.

- Compressed air
 - Review compressor sizing
 - Check distribution system for losses
 - Review needs and distances from compressor
 - Review inlet air location, the lower the incoming air the more efficient the compression cycle
- Process heating and cooling
- Check distribution system for losses and missing insulation
 - Review needs and distances end use
 - Check heat exchangers
 - Check refrigerant levels
- Refrigeration
 - Review refrigeration sizing
 - Check gaskets and seals

- Inspect evaporator coils for debris and obstructions
- Install data logger on large refrigeration systems
- Check for air curtains, vestibules, plastic curtains, open cabinet curtains, and loading dock seals
- Check refrigerant levels
- Inspect condensate line for obstructions, blockages, mould or plant growth, and continuity.

2. Recommended energy conservation measures:

- Repair leaking compressor valves
- Use synthetic lubricants in air compressors
- Reduce compressed air pressure
- Reduce compressed air leaks
- Increase header line in compressed distribution system
- Use outside air for compressor Intake
- Install high-efficiency motors
- Install variable speed drives and controls
- Install high-efficiency belts & drives
- Review overall needs and develop an integrated and comprehensive

engineering review that takes into consideration interactive effects, current needs, as well as future plans.

3. Retrocommissioning (RCx) opportunities evaluation

The idea behind RCx is to ensure equipment is operating at its intended optimal performance. The process is also intended to address design, installation, and maintenance issues. RCx reduces operations and maintenance costs (O&M). RCx can be integrated with retrofit efforts for equipment which is at the end of life or when there are significant efficiencies to be had by upgrading. The RCx process consists of four phases: Planning, Investigation, Implementation, and Hand-Off. The process details are included in the "Table 7 Retrocommissioning Process".

Retrocommissioning Process

Phases

- 1. Planning**
- Select the project
 - Set project objectives and obtain support
 - Select a commissioning lead
 - Document the current operating requirements
 - Perform an initial site walk-through
 - Develop the Retrocommissioning Plan
 - Assemble the retrocommissioning team
 - Hold a project kick-off meeting

- 2. Investigation**
- Review facility documentation
 - Perform diagnostic monitoring
 - Perform functional tests
 - Perform simple repairs
 - Develop Master List of Findings
 - Prioritize and select operational improvements

- 3. Implementation**
- Develop Implementation Plan
 - Implement selected operational improvements
 - Verify results

- 4. Hand-Off**
- Develop Final Reports
 - Compile a Systems Manual
 - Develop Retrocommissioning Plan
 - Provide training
 - Hold close-out meeting
 - Implement persistence strategies

IV. SOLUTION

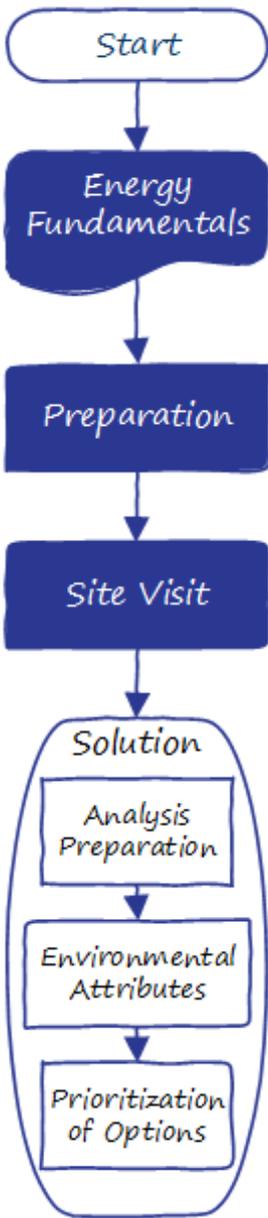


Figure 15 Solution

A. Analysis Preparation

Following the site visit to the facility, the data collected should be examined, cataloged and reviewed for completeness and accuracy. If any data is missing, it should be retrieved as soon as possible from facility

personnel or revisiting the site if necessary. ECMs identified during the site visit should be reviewed, followed by a thorough analysis of the equipment and operational changes identified. The analysis involves calculating all the costs and benefits for the identified ECMs and evaluate them using the Lifecycle Cost methodology described in (LCC).

1. Energy Conservation Measure (ECM) Development

a) Demand-side Measures Applicable to: Conservation, Renewable Energy, and Reduced Utilization

I. RESIDENTIAL

Space Conditioning

- Electric furnace improvements (intermittent ignition, automatic vent dampers, and heating element change-outs)
- Air conditioner (central and room) upgrades/replacements

- Improved equipment controls
- Solar assisted space conditioning (ventilation, air-conditioning, and desiccant cooling)
- Passive solar designs
- Air conditioner and heat pump clean and tune-up
- Heat pipes
- Whole house fans
- High efficiency fans and motors
- Hydronic pump insulation
- Register relocation
- Register size and blade configuration
- Return air location Duct sizing
- Duct insulation
- Duct sealing
- Duct cleaning
- Shade tree planting

- Heat pump (ground source, solar assisted, and conventional) upgrades/replacements
- Cycling of air conditioners and heat pumps
- Natural Ventilation
- Heat recovery ventilation
- Clock thermostats
- Setback thermostats
- Geothermal steam direct use

Water Heating

- Electric water heater upgrades/replacements
- Electric water heater tank wraps/blankets
- Low-flow showerheads and fittings
- Solar heating and pre-heat units
- Geothermal heating and pre-heat units
- Heat traps
- Water heater heat pumps
- Recirculation pumps
- Setback thermostats
- Water heater cycling control
- Solar heating for swimming pools
- Pipe wrap insulation

Lighting

- Lamp replacement
- Dimmers
- Motion detectors and occupancy sensors
- Photovoltaic lighting
- Fixture replacement
- Outdoor lighting controls
- Skylight installation

Building Envelope

- Attic, basement, ceiling, and wall insulation
- Passive solar building systems
- Exterior roof insulation
- Exterior wall insulation
- Knee wall insulation in attic
- Floor insulation
- Perimeter insulation
- Storm windows/doors
- Caulking/weatherstripping
- Sliding door replacements
- Installation of French doors
- Hollow core door replacement
- Radiant barriers
- Window vent conversions
- Window replacement
- Window shade screens
- Window reduction
- Attic ventilation
- Whole house fan
- Passive solar design

Other Appliances

- Refrigerator replacements
- Freezer replacements
- Oven/range replacements
- Dishwasher replacements
- Clothes washer replacements
- Clothes dryer replacements
- Customer located power generation based on photovoltaic, solar thermal, biomass, wind or geothermal resources
- Swimming pool pump replacements
- Gasket replacements
- Maintenance/coil cleaning

II. COMMERCIAL

Heating/Ventilation/Air Conditioning (HVAC)

- Heat pump replacement
- Fan motor efficiency
- Resizing of chillers
- Heat pipe retrofits in air conditioning units
- Dehumidifiers

- Steam trap insulation
- Variable speed drive on fan motor
- Solar assisted HVAC including ventilation, chillers, heat pumps, and desiccants
- HVAC piping insulation
- HVAC ductwork insulation
- Boiler insulation
- Automatic night setback
- Automatic economizer cooling
- Outside air control
- Hot and cold deck automatic reset
- Reheat system primary air optimization
- Process heat recovery
- Deadband thermostat
- Timeclocks on circulating pumps
- Chiller system
- Increase condensing unit efficiency
- Separate make-up air for exhaust hoods
- Variable air volume system
- Direct tower cooling (chiller strainer cycle)
- Multiple chiller control
- Evaporative roof surface cooling
- Cooling tower flow control
- Ceiling fans
- Evaporative cooling
- Direct expansion cooling system
- Heat recovery ventilation (water and air-source)
- Set-back controls for cooling
- Make-up air control
- Manual fan switches
- Energy saving exhaust hood
- Night flushing
- Terminal regulated air volume control scheme
- Variable speed motors for HVAC system
- Waterside economizers
- Airside economizer
- Gray water systems
- Well water for cooling

Building Envelope

- Wall insulation
- Floor/slab insulation
- Roof insulation
- Window and door upgrades, replacements, and films (to reduce solar heat gains)
- Passive solar design
- Earth berming
- Shading devices and tree planting
- High reflectivity roof coating
- Evaporative cooling
- Infiltration reduction
- Weatherstripping
- Caulking
- Reflective windows
- Replace glazing with insulated walls
- Thermal break window frames
- Tinted glazing
- Vapor barrier
- Vestibule entry

Lighting

- Delamping
- Reflectors
- Occupancy sensors
- Daylighting with controls
- Photovoltaic lighting
- LED exterior lighting
- Manual selective switching
- LED exit signs
- Daylighting construction
- Cathode cutout ballasts
- Outdoor light timeclock and photocell

Refrigeration

- Refrigerator replacement
- Freezer replacement
- Optimize heat gains to refrigerated space
- Optimize defrost control
- Refrigeration pressure optimization control
- High efficiency compressors
- Anti-condensate heater control
- Floating head pressure
- Hot gas defrost
- Parallel unequal compressors
- Variable speed compressors
- Water cooler controls
- Waste heat utilization
- Air doors on refrigeration equipment

Water Heating

- Electric water heating upgrades/replacements
- Electric water heater wraps/blankets
- Pipe insulation
- Solar heating and/or pre-heat units
- Geothermal heating and/or pre-heat units
- Circulating pump control
- Point-of-use water heater
- Heat recovery domestic water heater (DWH) system
- Chemical dishwashing system
- End-use reduction using low-flow fittings
- Other end-uses and miscellaneous
- Energy management control systems for building operations
- Onsite power generation based on photovoltaic, solar thermal, biomass, wind, and geothermal resources
- Energy efficient office equipment
- Customer-owned transformer upgrades and proper sizing

b) Industrial

Motors

- Retire inefficient motors and replace with energy efficient motors, including the use of electronic adjustable speed or variable frequency drives
- Rebuild motors to operate more efficiently through greater contamination protection and improved magnetic materials
- Install self-starters
- Replace improperly sized motors

Lighting

- Installation of reflectors
- Daylighting with controls
- Occupancy sensors
- Delamping
- Photovoltaic lighting
- Replace fixtures/lamps with LED fixtures/lamps

Heating/Ventilation/Air Conditioning (HVAC)

- Heat pump replacement/upgrade
- Furnace upgrade/replacement
- Fan motor efficiency
- Resizing of chillers
- Heat pipe retrofits on air conditioners
- Variable speed drive on fan motor
- Solar assisted HVAC including ventilation, chillers, heat pumps and

Industrial Processes

- Upgrades in heat transfer equipment
- Insulation and burner upgrades for industrial furnaces/ovens/boilers to reduce electricity loads on motors and fans
- Insulation and redesign of piping
- Upgrades/retrofits in condenser/evaporation equipment
- Process air and water filtration for improved efficiency
- Upgrades of catalytic combustors
- Solar process heat
- Customer located power based on photovoltaic, solar thermal, biomass, wind, and geothermal resources
- Power factor controllers
- Utilization of waste gas fuels
- Steam line and steam trap repairs/upgrades
- Compressed air system improvements/repairs
- Industrial process heat pump
- Optimization of equipment lubrication or maintenance
- Resizing of process equipment for optimal energy efficiency
- Use of unique thermodynamic power cycles

Building Envelope

- Insulation of ceiling, walls, and ducts
- Window and door replacement/upgrade, including thermal energy barriers
- Caulking/weatherstripping
- Water Heating
- Electric water heater upgrades/replacements
- Electric water heater wraps/blankets
- Pipe insulation
- Low-flow showerheads and fittings
- Solar heating and pre-heat units
- Geothermal heating and pre-heat units
- Other End-uses and miscellaneous
- Refrigeration system retrofit/replacement
- Energy management control systems and end use metering
- Customer-owned transformer retrofits/replacements and proper sizing

c) Agricultural

Space Conditioning

- Building envelope measures
- Efficient HVAC equipment
- Heat pipe retrofit on air conditioners
- System and control measures
- Solar assisted HVAC including ventilation, chillers, heat pumps, and desiccants
- Air-source and geothermal heat pumps replacement/upgrades

Water heating

- Upgrades/replacements
- Water heater wraps/blankets
- Pipe insulation
- Low-flow showerheads and fittings
- Solar heating and/or pre-heat units
- Geothermal heating and/or pre-heat units

Lighting

- Delamping
- Reflectors
- Occupancy sensors
- Daylighting with controls
- Photovoltaic lighting
- Outdoor lighting controls

Pumping/Irrigation

- Pump upgrades/retrofits
- Computerized pump control systems
- Irrigation load management strategies
- Irrigation pumping plants
- Computer irrigation control
- Surge irrigation
- Computerized scheduling of irrigation
- Drip irrigation systems

Motors

- Retire inefficient motors and replace with energy efficient motors, including the use of electronic adjustable speed and variable frequency drives
- Rebuild motors to operate more efficiently through greater contamination protection and improved magnetic materials
- Install self-starters
- Replace improperly sized motors

Other end uses

- Ventilation fans
- Cooling and refrigeration system upgrades
- Grain drying using unheated air
- Grain drying using low temperature electric
- Customer-owned transformer retrofits/replacements and proper sizing
- Programmable controllers for electrical farm equipment
- Controlled livestock ventilation
- Water heating for production agriculture
- Milk cooler heat exchangers
- Direct expansion/ice bank milk cooling
- Low energy precision application systems
- Heat pump crop drying

d) Government Services Sector

Streetlighting

- Replace incandescent and mercury vapor lamps with Night Sky compliant LEDs

Other

- Energy efficiency improvements in motors, pumps, and controls for water supply and waste water treatment
- District heating and cooling measures derived for cogeneration that result in electricity savings

e) Supply-side Measures

Generation efficiency

- Heat rate improvement programs
- Availability improvement programs
- Turbine improvements
- Boiler improvements
- Control improvements, including artificial intelligence and expert systems
- Distributed control local (real-time) versus central (delayed)
- Equipment monitoring
- Performance monitoring
- Preventive maintenance
- Additional or improved heat recovery
- Sliding/variable pressure operations
- Adjustable speed drives
- Improved personnel training to improve man/machine interface

Transmission and distribution efficiency

- High efficiency transformer switchouts using amorphous core and silicon steel technologies
- Low-loss windings
- Innovative cable insulation
- Reactive power dispatch optimization
- Power factor control
- Primary feeder reconfiguration
- Primary distribution voltage upgrades
- High efficiency substation transformers
- Controllable series capacitors
- Real-time distribution data acquisition analysis and control systems
- Conservation voltage regulation

f) Renewable Energy Generation Measures Applicable for the Conservation and Renewable Energy Reserve Program

- Combustible energy-producing materials from biological sources which include: wood, plant residues, biological wastes, landfill gas, energy crops, and eligible components of municipal solid waste.

Solar resources

- Solar thermal systems and the non-fossil fuel portion of solar thermal hybrid systems
- Grid and non-grid connected photovoltaic systems, including systems added for voltage or capacity augmentation of a distribution grid.

Wind resources

- Grid-connected and non-grid-connected wind farms
- Individual wind-driven electrical generating turbines

2. Analysis strategies

Several methods can be used to compare historical data analysis, benchmark building energy performance against similar buildings, and make adjustments for weather data variations. This section describes a few of the currently used methods.

a) Modified bin analysis

The thermal loads consist of weather dependent loads (solar and rain), time dependent loads (scheduled loads), and temperature dependent loads (conduction and infiltration). The energy consumption calculation uses two or more computational periods. For each period, the weather and time dependent loads are averaged and added to the conduction loads such that the load is characterized as a function of outside air temperature for the calculated period. The modified bin method utilizes bin weather data, number of hours in a specified time period when the dry bulb temperature is within a bin. The model assumes that:

- A. The exterior loads have a linear relationship with outdoor temperature.
- B. For a 24-hour time period, interior loads can be averaged over the “system on” or “system off” time periods.

Steps:

1. Estimate average and intermediate temperature loads for averaged internal and external loads.
2. Perform load calculations for the main two relevant temperature bins representative of the building location: Peak Cooling, T_{pc} ; and Intermediate Cooling, T_{ic} .

- Limitations on the Modified Bin Method

The building mass may distort the occurrence of the HVAC load, offsetting the load in time. Thermal cycling is not represented due to the averaging.

b) Spreadsheet

In some cases, its more practical to develop spreadsheets to perform economic analysis of ECMs. The calculations can be adjusted to compensate for weather variations

c) Energy modeling

For integrated and complex calculations, energy modeling software allows for the optimization of building systems and controls to reduce energy and water consumption. In addition, the energy modeling software usually provides GHG emissions outputs.

3. Assessment and related data analysis

a) Sample measurements

i. Motors

A pump motor for an irrigation system has a motor nameplate power 10 hp that runs

two hours a day or 730 hours per year. The owner wants to replace it with a high efficiency 5 hp motor which costs around \$100 more to purchase than the standard efficiency motor. The standard motor is 82% efficient and the high efficiency model is 92% efficient.

$$\text{Cost Savings} = (5\text{hp}) \times (730 \text{ hr/yr}) \times (.746 \text{ kW/hp}) \times [1/.82 - 1/.92] \times (.30 \text{ \$/kWh}) = 108.28 \text{ \$/yr}$$

ii. Lighting

Use the formulas in “Table 4 Lighting energy calculations” to calculate lighting energy use, costs, and estimate potential savings.

LIGHTING ENERGY USE [KWH] = NUMBER OF LIGHTS X HOURS PER DAY [HR] X
WORK DAYS PER YEAR X POWER [KW]

POWER COST [\\$] = LIGHTING ENERGY USE [KWH/YEAR] X ELECTRICITY RATE [\$/
KWH]

ENERGY SAVINGS [\\$] = POWER COST [\\$] - (PROPOSED LIGHTING ENERGY USE
[KWH/YEAR] X ELECTRICITY RATE [\$/KWH]) - (LAMP + INSTALLATION COSTS [\\$])

Figure 16 Lighting Calculations

b) Occupancy and operation

Building occupancy can be validated by installing occupancy sensors in a representative sample of the zones within the facility. It's preferable to take advantage of data loggers which can also record temperature, relative humidity, and/or light levels.

c) Schedule discrepancies

In some cases, the information provided during the interviews might differ from the occupancy measurements recorded by the occupancy data loggers. If that situation presents itself, the building staff should be questioned about the discrepancy and reasons behind it. Lighting calculations are very sensitive to occupancy.

d) Energy model results monthly/hourly data

Energy models must be validated against historical data and should match within 5%, otherwise the model should be reviewed for accuracy. There might have been some building operational changes after the latest utility bills.

e) O&M savings

When evaluating current maintenance practices, recommendations should be developed based upon type and age of the equipment, criticality and function of equipment, funding and staffing levels. Maintenance approaches should be part of a comprehensive maintenance program which should include:

- Assign the management of the program to a maintenance planning software or

maintenance tracking worksheet

- *Focus on maintenance items that would result in the lowest Lifecycle Cost.*
- *Implement an effective management system, for large facilities maintenance should be supported by a Computerized Maintenance Management System (CMMS). Selecting a CMMS consists of the following steps:*
 1. *Get senior management buy-in.*
 2. *Determine your current business process flow (BPF).*
 3. *Create a CMMS project team.*
 4. *Determine project objectives.*
 5. *Develop a list of specifications.*
 6. *Identify hardware alternatives*
 7. *Prepare a shortlist of vendors and select ranking based on the following categories:*
 - *Features*
 - *Ease of use*
 - *Vendor profile*
 - *Product support*
- *Take advantage of maintenance as a source of savings*
- *Practices that disrupt operations*
- *Develop SMART goals for the program as part of the EnMS*

Estimating maintenance costs can be difficult and demands extensive knowledge of the facility and its systems and equipment.

Types of maintenance approaches with key features and estimated cost

i. Reactive Maintenance, Breakdown, Emergency, or Run-to-Failure Maintenance

- *Features:*
 - *Catastrophic equipment failures*
 - *Safety hazards may occur*
 - *Emergency repair or replacement of damaged equipment*
- *Cost: \$18/hp/yr*
- *Description*
 - *Maintenance technique that allows for equipment to breakdown, providing for the repair or replacement of damaged equipment only when obvious problems occur. The advantages of this approach are that it works well if equipment shutdowns do not affect production and if labor and material costs do not matter.*

ii. Preventive Maintenance or Time-Based Maintenance

- Features:
 - Schedule maintenance activities at predetermined time or use intervals
 - Repair or replace damaged equipment before obvious problems occur
- Cost: \$13/hp/yr
- Description:
 - Technique for scheduling of maintenance activities at predetermined time or usage intervals, where damaged equipment is repaired or replaced before obvious problems occur. The advantages of this approach are that it works well for equipment that does not run continuously, and with personnel who have enough knowledge, skills, and time to perform the preventive maintenance work. The downside of this practice is that it may be wasteful since some equipment may be replaced before the end of its useful life.

iii. Predictive Maintenance or Condition-Based Maintenance

- Features:
 - Schedule maintenance activities when mechanical or operational conditions warrant
 - Repair or replace damaged equipment before obvious problems occur
- Cost: \$9/hp/yr
- Description:
 - Technique that consists of scheduling maintenance activities only when mechanical or operational conditions warrant—by monitoring equipment parameters for signs of wear that occur over time. Said parameters reach unacceptable levels triggering maintenance and the equipment is shut down to repair or replace damaged components to prevent a costlier failure from occurring. Advantages of this approach are that it works very well if personnel have adequate knowledge, skills, and time to perform the predictive maintenance work, and that it allows equipment repairs to be scheduled in an orderly fashion. It also provides some lead-time to purchase materials for the necessary repairs, reducing the need for a high parts inventory. Since maintenance work is only performed when it is needed, there is likely to be an increase in production capacity.

¹ Wesel. "Maintenance in Moderation Is the Most Efficient Method | www.tradelineinc.com." Tradeline, January 8, 2008. <https://www.tradelineinc.com/reports/2008-1/maintenance-moderation-most-efficient-method>.

Table 8 Maintenance Classes

Maintenance Classes (Modified Wesel ²)				
Maintenance Class	Effect of Failure	Desired Result	Analysis Used to Determine Most Effective Maintenance Technique	Implementation of Maintenance Practices
A: Mission Critical	Significant financial, safety and/or operational impact	Risk mitigation and maximize equipment and system availability	Reliability centered maintenance and risk assessment	Preventive and predictive approaches
B: Optimize Life-Cycle Costs	Minor impact on core business activities	Minimize equipment LCC over time	Reliability centered maintenance and risk assessment	Preventive, predictive, and reactive approaches
C: Minimize Short-Term Costs	No impact on core business activities	Minimize short-term costs	Risk assessment	Risk mitigation measures, visual inspection, and preventive maintenance
D: Industry Standard Maintenance	No impact on core business activities	Minimize short-term costs	Risk assessment	RS Means or original equipment manufacturer job plans, preventive maintenance
E: Out-of-Service	No impact on core business activities	Ability to operate Risk assessment Minimum maintenance	Risk assessment	Minimum Maintenance

iv. Reliability Centered Maintenance (RCM), Pro-Active, or Prevention Maintenance

- Utilizes predictive/preventive maintenance techniques with root cause failure analysis to detect and pinpoint the precise problems, combined with advanced installation and repair techniques, including potential equipment redesign or modification to avoid or eliminate problems from occurring.
- Cost: \$6/hp/yr
- This technique utilizes all the previously discussed predictive/preventive maintenance techniques, in concert with root cause failure analysis. This not only detects and pinpoints precise problems that occur, but ensures that advanced installation and repair techniques are performed, including potential equipment redesign or modification, thus helping to avoid problems or keep them from occurring. One advantage to this approach is that it works extremely well if

personnel have the knowledge, skills, and time to perform all the required activities. As with the predictive-based program, equipment repairs can be scheduled in an orderly fashion, but additional improvement efforts also can be undertaken to reduce or eliminate potential problems from repeatedly occurring. Furthermore, it allows lead-time to purchase materials for necessary repairs, thus reducing the need for a high parts inventory. Since maintenance work is performed only when it is needed, and extra efforts are put forth to thoroughly investigate the cause of the failure and determine ways to improve machinery reliability, there can be a substantial increase in production capacity.

4. Energy sources costs comparison

The Levelized Cost of Energy (LCOE) It represents the net present generation cost per kWh for the life of the equipment and an assumed financial life. In order to calculate the LCOE, capital costs, fuel costs, fixed and variable operations and maintenance (O&M) costs, financing costs, and an assumed utilization rate for each building type.

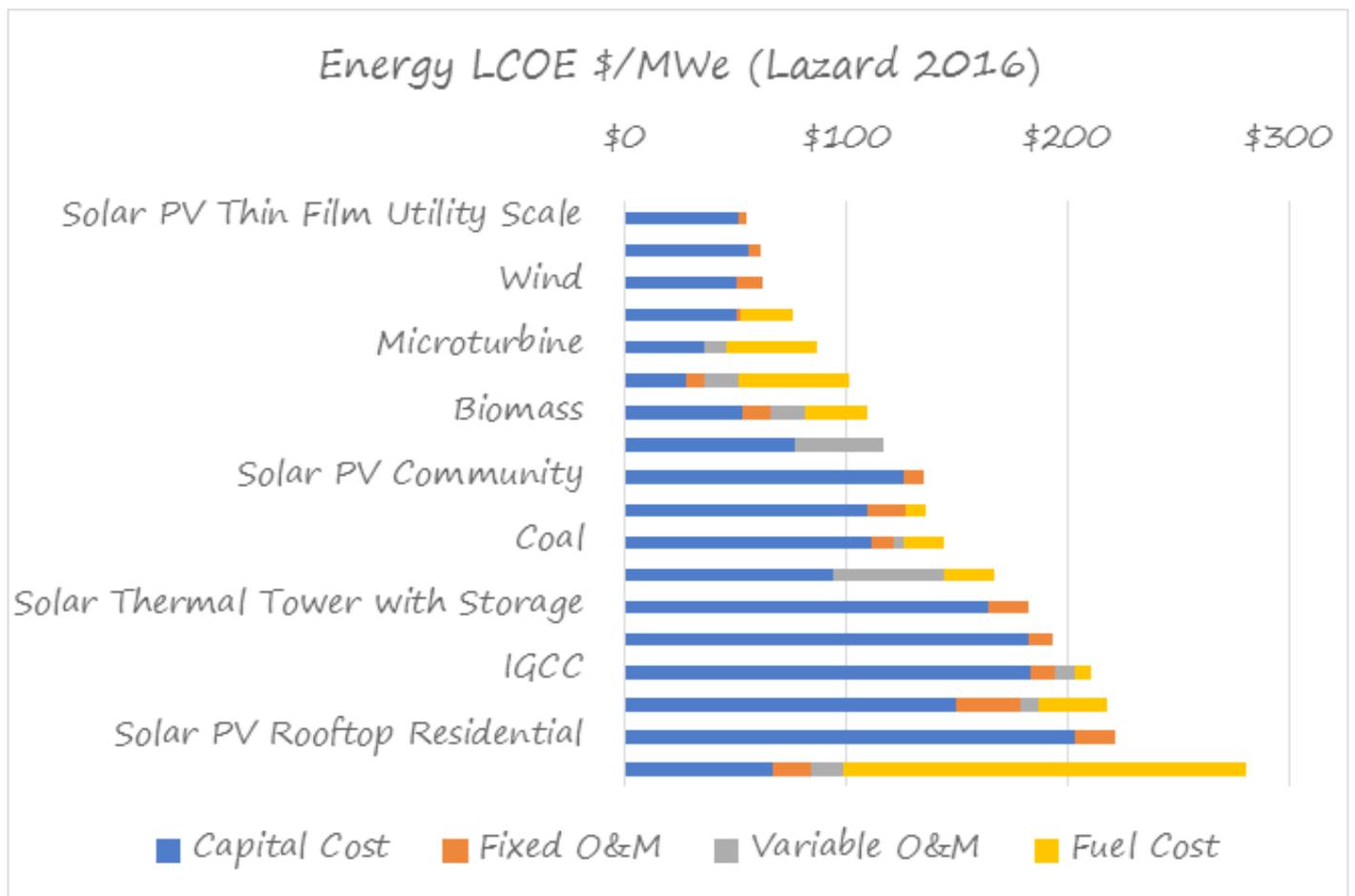


Figure 17 Energy Levelized Cost of Electricity (LCOE)

5. Reevaluation of the rate structure based on implementation of the ECMs

The implementation of ECMs is likely to affect the rate structure under which the facility is billed, configuring high demand equipment to operate at the optimal demand.

Table 9 Belize Electric Rate Schedule (2016)

COMMERCIAL 1		
<i>Commercial customers with average consumption less than 2,500 kWh</i>		
Block	kWh	Rate
1	0 to 50	\$0.30
2	51 to 200	\$0.36
3	201 +	\$0.40
Minimum Charge		\$5.00

COMMERCIAL 2		
<i>Commercial customers who are not classified as Commercial 1 or Industrial</i>		
Block	kWh	Rate
1	0 to 10,000	\$0.38
2	10,001 to 20,000	\$0.37
3	20,001 +	\$0.36
Service Charge		\$125.00

INDUSTRIAL 1		
		Rate
Demand (KVA)		\$33.00
Energy (per kWh)		\$0.28
Service Charge		\$125.00

INDUSTRIAL 2		
		Rate
Demand (kVA)		\$22.00
Energy (per kWh)		\$0.24
Service Charge		\$125.00

STREET LIGHTS		
kWh		Rate
1		\$0.42

6. Standardization of energy costs by system/equipment

a) Economics

1. Identification of potential incentives and funding for ECMs
2. ECM value calculation using engineering economics e.g.,

i. Simple Payback

This is one of the most commonly used forms of investment evaluation due to its ease of calculation. It represents the number of years required to recover the initial investment. Unfortunately, the method ignores the future value of money and returns past the breakeven point.

$$\text{Simple Payback} = (\text{First Cost}) / (\text{Annual Energy Savings})$$

ii. Cash Flow Diagram

Cash flow diagrams are useful to graphically depict the timing of the financial transactions as well as their nature as either expenses or income.

The horizontal line represents the timeline. The vertical arrows pointing up represent the income or expenses arrows pointing down.

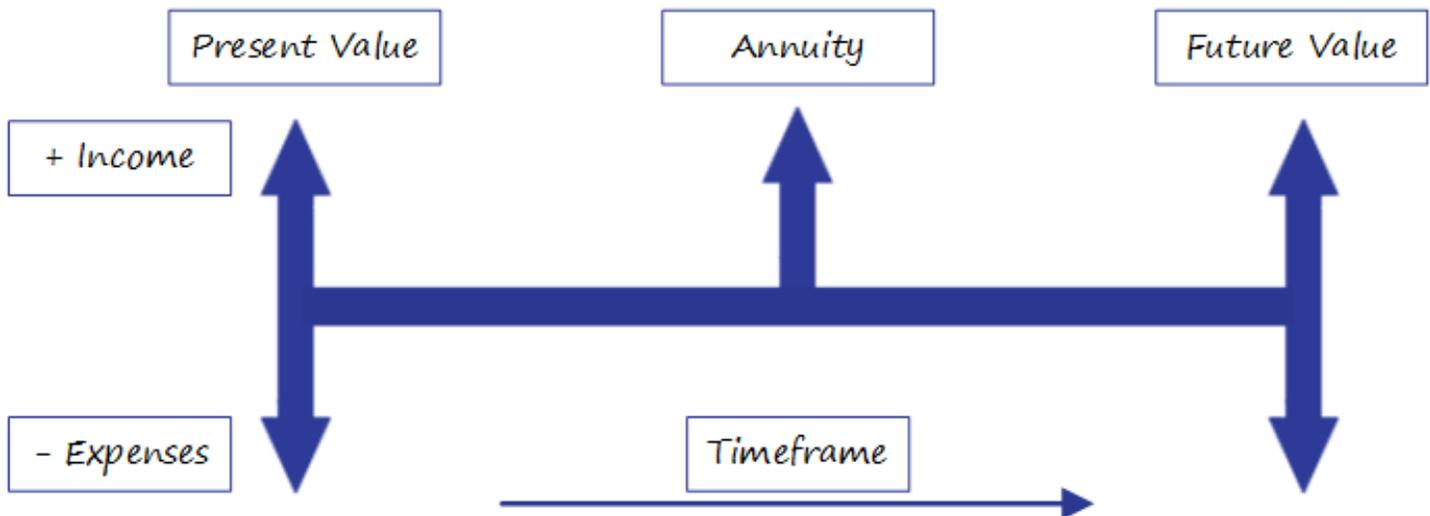


Figure 18 Time Value of Money (TVM)

iii. Time Value of Money (TVM)

TVM refers to the notion that money at hand is more valuable than the same amount in the future. It's assumed that money can earn interest and that consideration is part of the calculations. There are a few terms associated with TVM:

A: Annuity

FV: Future value of money. The future value of the investment

MARR: Minimum acceptable rate of return

PV: Present value of money. Current value or principal amount

I: Interest rate. Rate which is charged or paid for the use of money

N: Number of years

I: Initial investment

S: Salvage value. Estimated market value of an asset at the end of its useful life

R: Savings

D: Annual depreciation rate

B: Income bracket

ATS: Annual after tax savings

E: Annual expenses

CR (A|P): Capital recovery. Regaining of the invested capital over the life of an investment

TVM calculations can be performed using formulas, tables, or calculators with financial programming. The calculations use one of the following parameters as basis.

FV, simple interest: $FV = PV(1 + n \cdot i)$

FV, compound interest: $FV = PV(1 + i)^n$

PV, compound interest: $PV = FV(1 + i)^{-n}$

The factor $(1+i)^n$ is called future value factor, future worth factor, single payment, single sum, or compound amount factor. Its inverse is called the discount factor which can be used to compare expenses and savings at different periods by adding compound interest and bringing all the values to some common date in the future. Since the investment decision is to be made now, it's better to bring all costs and savings to their present time equivalents, called their present value. Discounting can be regarded as the reverse of addition of interest.

The nomenclature for the discount factors, $(X|Y, i\%, n)$ where "X" represents the desired value, "Y" is the known value, "i" is the interest rate, and "n" denotes a number of periods usually in years. The factor reads, "To find X given Y at i% for years." The discounting factors can be used to convert "Y" to "X" at constant interest rates compounded for the period "n". Discounted interest tables of values for $(X|Y, i, n)$ for selected values of "i" and "n" are provided in the (Appendix). The tables are organized by interest rates, the $(X|Y)$ factor determines column, and (n) the number of years determines the row. The following table lists the factor names with their associated formulas.

Table 10 Time Value of Money Factors

Factor Name	Converts	Symbol	Formula
Single Payment Compound Amount	to F given P	$(F/P, i\%, n)$	$(1 + i)^n$
Single Payment Present Worth	to P given F	$(P/F, i\%, n)$	$(1 + i)^{-n}$
Uniform Series Sinking Fund	to A given F	$(A/F, i\%, n)$	$\frac{i}{[(1 + i)^n - 1]}$
Uniform Series Capital Recovery	to A given P	$(A/P, i\%, n)$	$\frac{i(1 + i)^n}{[(1 + i)^n - 1]}$
Uniform Series Compound Amount	to F given A	$(F/A, i\%, n)$	$\frac{[(1 + i)^n - 1]}{i}$
Uniform Series Present Worth	to P given A	$(P/A, i\%, n)$	$\frac{[(1 + i)^n - 1]}{i(1 + i)^n}$
Uniform Gradient Present Worth	to P given G	$(P/G, i\%, n)$	$\frac{[(1 + i)^n - 1]}{i^2(1 + i)^n} - \frac{n}{i(1 + i)^n}$
Uniform Gradient Future Worth	to F given G	$(F/G, i\%, n)$	$\frac{[(1 + i)^n - 1]}{i^2} - \frac{n}{i}$
Uniform Gradient Uniform Series	to A given G	$(A/G, i\%, n)$	$\frac{1}{i} - \frac{n}{[(1 + i)^n - 1]}$

iv. Annual Worth (AW)

Used to compare alternatives by comparing the annual equivalent of all cash flows. The larger the AW the better.

$$AW = R - E - P(A|P, i, n) - S(A|F, i, n)$$

v. Present Worth (PW) or (P|A)

It uses the current equivalent of all the cash flows.

$$PW = A(P|A, i, n) + G(P|G, i, n)$$

vi. Tax Considerations

Some operational expenses such as energy, insurance, maintenance, property taxes can reduce income subject to taxes.

$$ATS = (1 - I)E + I \times D$$

vii. Lifecycle Cost (LCC)

This is the most comprehensive method of analysis and takes into consideration all the operational costs and savings for the life of the equipment. Usually the costs considered are: design and engineering, initial equipment and installation, commissioning, maintenance, operational, environmental impact, installation time, fuel, inflation, insurance, interest on the investment, salvage value, disposal and other lifetime expenses for the equipment. LCC calculations rely on equipment life in addition to interest rates and the desired financing period.

Once the evaluation parameters have been chosen, multiple alternatives can be evaluated by comparing their LCC values. The alternative should be prioritized based upon their LCC value, with the ones with the lowest value being the most favorable.

B. Environmental attributes

Environmental attributes refers to the characteristics of a power generation plant's impact on the environment such as avoided emissions or other impacts to air, water, or soil that may occur through the plant's displacement of a nonrenewable energy source.

1. Calculation of positive environmental impacts

a) Greenhouse gases (GHGs) impact calculations

Although some greenhouse gases are naturally occurring, the principal greenhouse gases that enter the atmosphere because of human activities are: carbon dioxide, methane, nitrous oxide and fluorinated gases. Calculating GHGs' emissions helps identify opportunities for cost and energy savings; and ensure the organization is operating within regulatory requirements. Organizations should manage their emission levels as environmental regulation ramps up.

The Greenhouse Gas Protocol (GHG Protocol) is the most widely used international accounting tool for government and business leaders to understand, quantify, and manage greenhouse gas emissions. GHG Protocol's toolset enables companies to develop comprehensive and reliable inventories of their GHG emissions. The GHG Protocol defines direct and indirect emissions as follows:

Direct GHG emissions: Emissions from sources that are owned or controlled by the reporting entity.

Indirect GHG emissions: Emissions that are a consequence of the activities of the reporting entity, but occur at sources owned or controlled by another entity.

The GHG Protocol further categorizes these direct and indirect emissions into three broad scopes:

Scope 1: All direct GHG emissions.

Scope 2: Indirect GHG emissions from consumption of purchased electricity, heat or steam.

Scope 3: Other indirect emissions, such as the extraction and production of purchased

materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities (e.g. T&D losses) not covered in Scope 2, outsourced activities, waste disposal, etc.

i. Greenhouse gases emissions offset calculation

Carbon offsets reduce emissions of greenhouse gases to compensate for emissions made elsewhere. The carbon offsets alternatives include: tree planting, renewable energy, energy conservation, and carbon dioxide and methane capture.

ii. Environmental goal evaluation using the Energy Technology Sustainability Index

Sustainability is characterized not only by the environmental aspects but also the economic and social aspects. For energy systems, technical and institutional dimensions are also important. Energy technology sustainability index (ETSI) characterizes the relative performance of the technology in terms of:

- Reliable and efficient energy supply
- Cost effective
- Low environmental impact
- High social benefits
- Locally manageable

The five dimensions can be quantified and qualified using the indicators listed on the table below.

Table 11 Energy Technology Sustainability Index

Dimension Codes	Indicators (Units)	Descriptions
TEI01	Energy availability (Mwh/KW/yr)	Amount of electricity provided from the technical system
TEI02	Efficiency of energy conversion (%)	Technology ability to convert the primary energy source to electricity
TEI03	System reliability	Measure of constancy of services
ECI01	Capital investment (USD/kW)	Initial investment for implementation of technical system (purchase and installation)
ECI02	Operation and Maintenance (O & M) cost (USD/kWh)	Required costs for regular operation and maintenance of the system
ECI03	Fuel Cost (USD/kWh)	Required costs for fuel procurement
ENI01	GHG emissions in gCO ₂ eq/kWh	Life cycle GHG emission in using the technologies

Table 11 Energy Technology Sustainability Index

Dimension Codes	Indicators (Units)	Descriptions
ENIO2	Land uses (m ² per kW)	Amount of land use and degradation due to energy production and consumption considering life cycle
SOIO1	Employment generation (Job per MW installed power)	Number of direct employment opportunities created
SOIO2	Compatibility of the technology with different end uses	Technical capability for using electricity for various income generating activities/appliances.
INIO1	Operational & Management capability required	Capacity/ skill required at the local level for the operation and management of the technologies.

C. Prioritization of Options

1. Comparison of predicted energy savings to project goals

- Compare estimated savings with projects goals using predefined Energy Performance Indicators (EnPIs).

2. Forecast the cost-benefit of ECMs after implementation

- Create a table with the yearly cash flows for the life of each ECM.

3. Prioritization on the defined goals

- Specific, measurable, achievable, acceptable, results-oriented, and time-bound EnMS goals
- Requirements of incentive and grant programs
- Environmental programs
- Pollutant emissions
- Regional Energy Efficiency Building Code compliance

4. Consideration of technical issues that impact prioritization

- Scheduling issues and occupant disruption
- Interactions among upgrade options
- Order of implementation

- Planned infrastructure upgrades
- Health, safety, and durability

5. Energy Management System, the Continuous Improvement Cycle

ISO management system standards use the Plan-Do-Check-Act (PDCA) cycle as a basis to manage and sustain continuous improvement within the organization. The Energy Management System cycle is a variation of the PDCA cycle, specific to energy performance, helping organizations improving energy performances.

Reactive vs. Effective Energy Management

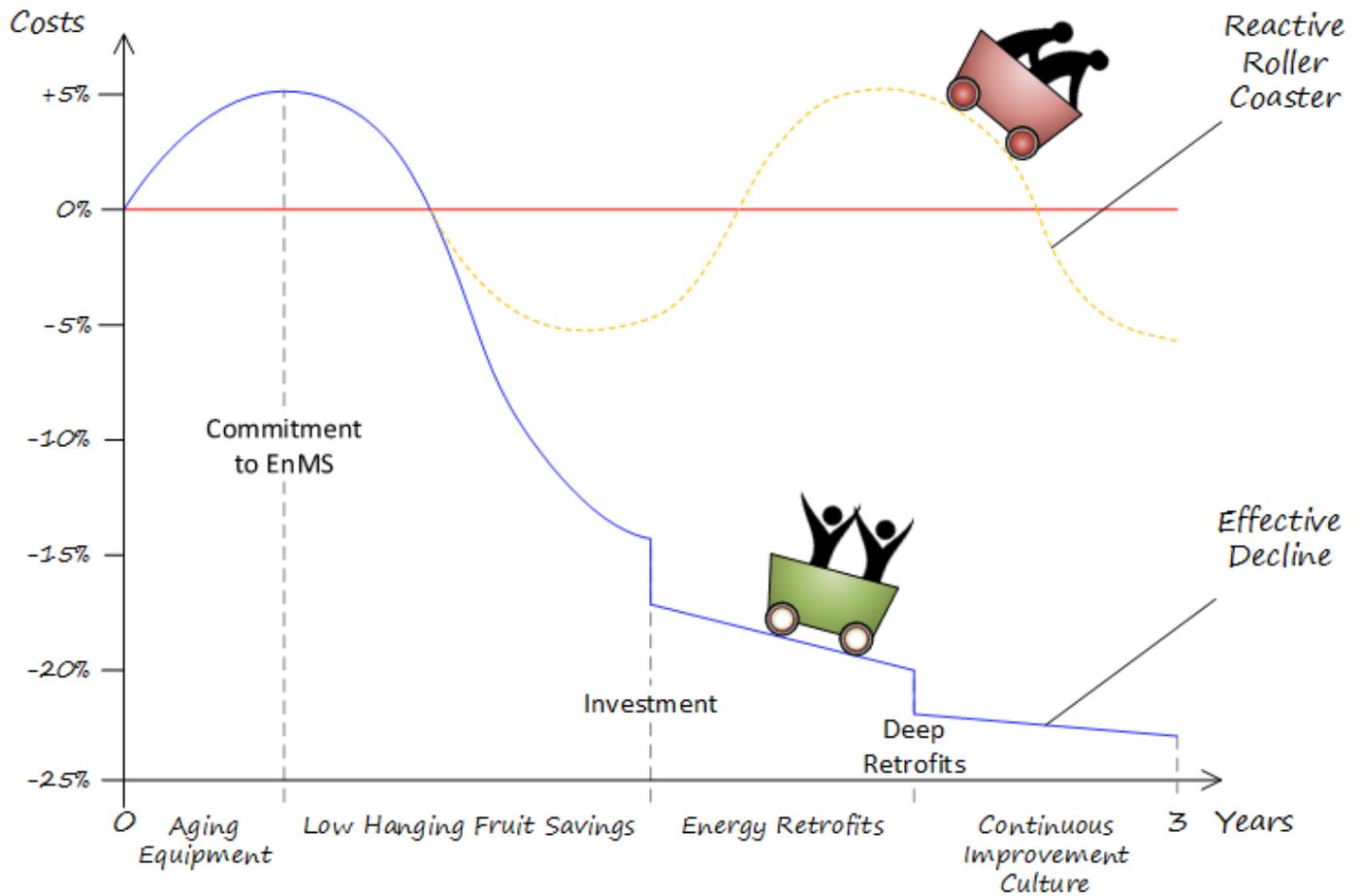


Figure 19 Reactive vs. Effective Energy Management

The EnMS Cycle involves:

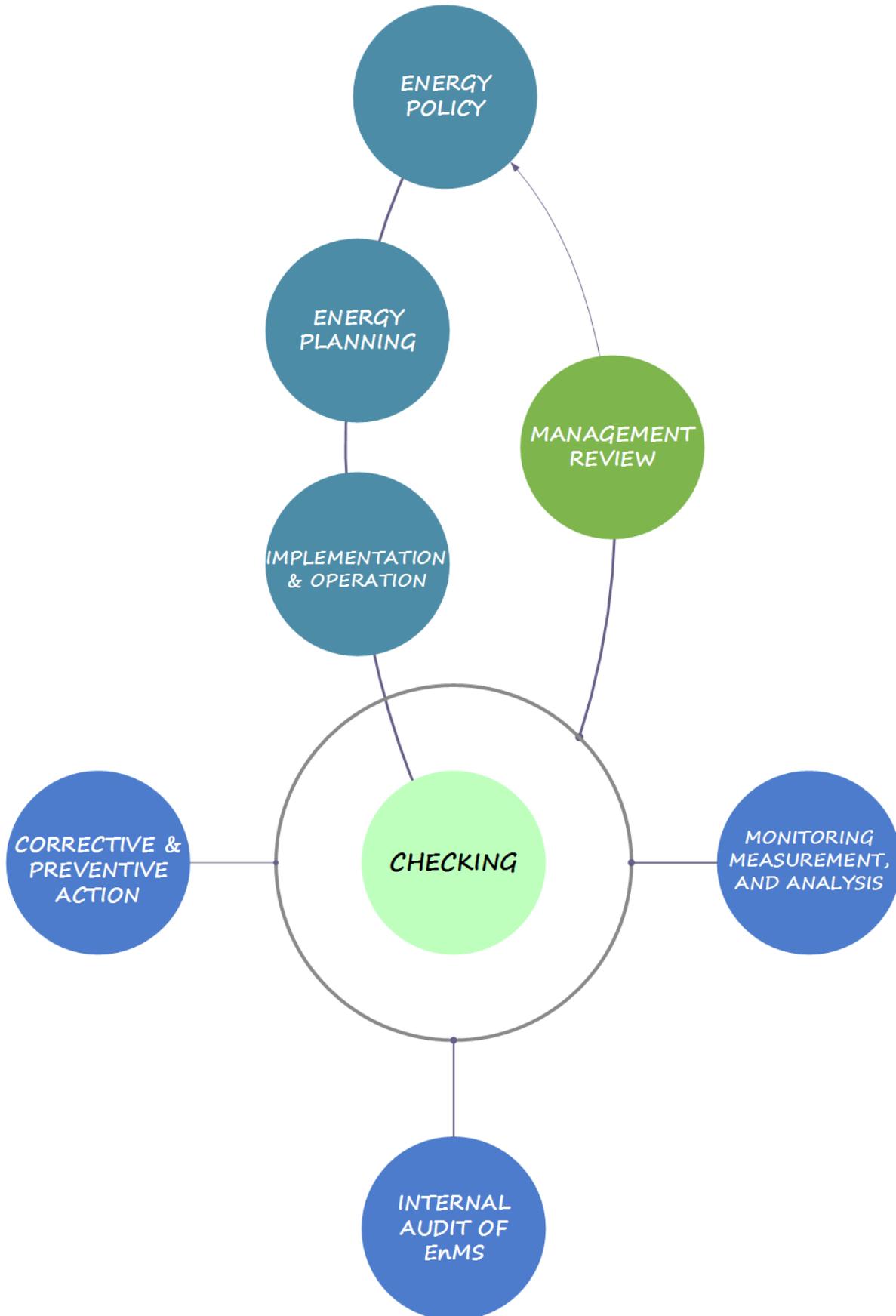


Figure 20 EnMS Cycle

a) Plan – engage with policy, define SMART objectives and targets

i. Management responsibility

Identify top management delegate willing to champion the process and support the continuous improvement of energy performance. Assign energy manager to communicate with the wider organization and oversee the completion of the project and supporting the continuous improvement process.

ii. Energy policy

Next, declare a statement of commitment in a published energy policy document that is communicated throughout the organization. The policy should describe:

1. The role of top management in monitoring energy improvement performance
2. The commitment to continual improvement in energy performance;
3. The compliance with applicable legal requirements
4. The created a framework for setting and reviewing energy objectives and targets.

iii. Energy planning

The energy manager must develop an energy management plan with progress indicators and advanced in stages which use a comprehensive approach to the organization's energy and water system demands to promote improvements in energy performance.

iv. Legal and other requirements

An energy management plan should be supported by legal and technical experts versed in:

1. Indoor air quality and thermal comfort
2. Personnel transportation including commuting
3. Applicable legal regulation and standards All potentially relevant sources of legal, such as:
 - Occupational safety regulations
 - Environment requirements
 - Additional regulation dealing with employee health and environmental
4. Industrial customers:
 - Cradle to Cradle manufacturing
 - Products and raw material transportation for industrial customers

v. Energy review

A qualified energy auditor must develop a data and documents repository to track energy performance and address record deficiencies, fill record gaps, and forecast EnMS performance. The information can be used to prioritize energy performance improvements.

vi. Energy baseline

Use the information from the energy review to define the historical and situational narrative and establish an accurate and reliable energy reference against which future performance will be benchmarked and investments analyzed.

vii. Energy performance indicators

Specify Energy Performance Indicators (EnPIS) for monitoring and measuring energy performance. Set and review EnPIS so they can help improve energy performance in cost effective manner. EnPIS must be often compared to the energy baseline.

viii. Energy objectives, targets and action plans

Establish, implement, review, and maintain documented specific, measurable, achievable, realistic, and time bound energy objectives, targets, and budgets for the relevant: functions, levels, processes, or facilities within the organization.

b) Do – change the culture

Use the organization's leverage points to implement the energy plan.

i. Competence, training and awareness

Assess staff competence to identify energy skills gaps, and then provide suitable training. Energy operating personnel should be reviewed frequently and systematically to confirm alignment with policy and goals.

ii. Communication

Integrate energy-related process and procedure requirements into the organization's communications and messaging.

iii. Documentation and control

Record information that describes the core elements of the EnMS, including initial drafts, schedules, data, reports, meeting minutes. Documents can be maintained electronically. The size and organization operations will dictate the documentation necessary. Management should define the criteria for the review and update of energy-related documents.

iv. Operational control

Determine, plan, communicate internally, effectively operate, and provide proper maintenance for operations with significant energy use.

- Significant energy consumption, cost, or energy-related impacts
- Reliance on fossil fuels
- Change the rate of energy use in comparison to previous periods Are essential to produce goods and services
- Have high potential for energy performance improvements.

v. Design

For future facilities, or changes to facilities, equipment, systems, and processes with significant impact on energy performance the design should consider energy sources, technology options, operational and maintenance costs, impact on the energy baseline, impacts on the EnMS.

vi. Procurement of energy services, products, equipment and energy

Develop procurement, bidding, and purchasing criteria aligned with the organization's energy objectives and targets. Inform vendors and customers the criteria will be part of the process used to select products and suppliers. Check and Act – measurement review and improvement

The energy management system is an evolving organism which needs to be reviewed frequently and consistently. Staff will commit to energy policies and goals which are perceived as valuable and relevant to the business.

vii. Monitoring and measurement

Monitor the success of the plan and actions:

1. Familiarize with the Energy Objectives and Targets
2. Understand the Energy Review
3. Revisit the Energy Baseline
4. Determine how to implement the desired EnPIS
5. Write a performance metrics plan that considers the purpose, approach, implementation costs, and operational improvements for each performance metric
6. Perform a lifecycle cost assessment for the energy system
7. Secure management support, review, and approval for the implementation of the energy system
8. Implement the metrics per the approved plan
9. Enforce procedures stay on course

viii. Evaluation of compliance

Include applicable milestones in the objectives, targets, and action plans to ensure compliance with legal and other requirements. Revisit often as regulation is ever changing.

ix. Internal audit

Conduct internal audit to evaluate performance of the EnMS to determine applicability, validity, relevance, enforcement, compliance, effectiveness, costs, and understand leverage points for the next revision of the EnMS.

It's essential that auditors selected are objective and impartial.

x. Non-conformities, correction, corrective and preventative action

Establish, implement, and maintain procedures for dealing with actual and potential nonconformities making corrections, taking corrective action and/or preventive action.

Procedures should include criteria that allows the organization to:

1. Review nonconformities and potential nonconformities and determine their causes.
2. Evaluate the need for action to ensure that nonconformities do not occur or reoccur.
3. Determine and implement the appropriate action needed.

xi. Control of records

Define storage medium, access protocols, and types of EnMS records to be maintained to demonstrate the energy performance results achieved as well as conformity to the requirements of its EnMS.

xii. Management review

Engage top management to consistently and systematically review the energy management system at planned intervals to evaluate the performance of the EnMS. The management review should allocate the time and resources to consider all aspects related to the EnMS.

APPENDIX A: EQUIPMENT FACT SHEETS FOR VARIOUS ENERGY EFFICIENT EQUIPMENT

LABELING STANDARDS

Currently, the Belizean market is populated with many different appliance and equipment labels. This section will help understand the information provided by the labels.

Almost all appliance energy labels provide some type of information on the product's energy use, or serve as a mechanism for consumers to compare the energy use of a particular product with the full range of similar models available on the market. This information allows for consumers to make more informed decisions regarding the purchasing or operation of products.

Labels provide information in a standardized format for comparing the energy use or energy efficiency of a given product to similar models available in the market, thereby making product energy use transparent.

TYPES OF LABELS

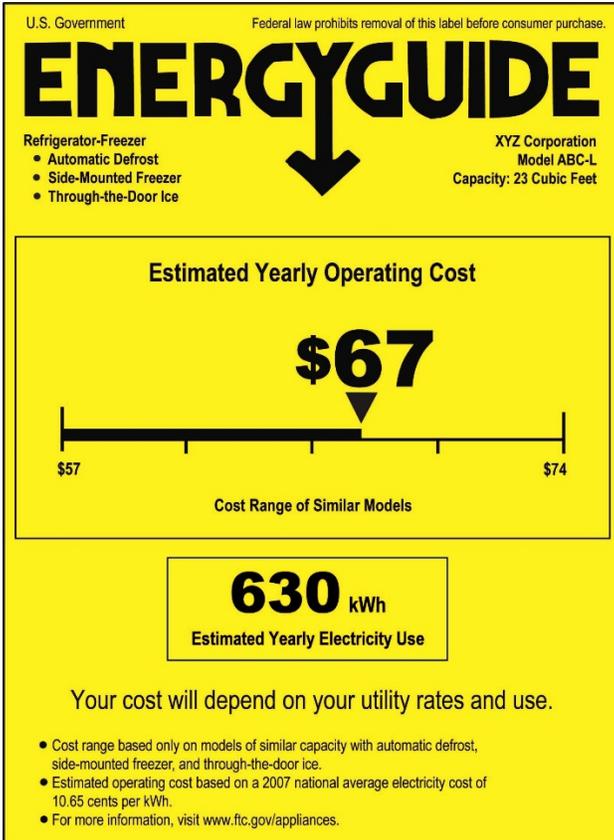
There are three basic types of labels based on the information conveyed by the label:

- Conformity labels indicate compliance with a given criteria or standard, e.g. Energy Star
- Comparative labels enable consumers to rank and/or compare multiple options



Labeling Standards

- Information labels display relevant data about the product in question.



The labels found in the Belize marketplace were a combination of the different types of labels.:

The United States FTC Energy Guide label has generated confusion as some customers believe that appliances which have this label attached are more efficient than the rest which is not always correct. The FTC's Energy Guide label is also mistakenly perceived to not be different from the U.S. EPA's Energy Star label which does not display detailed consumption information.

The Mexican voluntary appliance energy labeling standards for lighting, cooling,

refrigeration, and commercial motors, were created by the Comisión Nacional para el Uso Eficiente de la Energía (CONUEE) based on the FTC Label.

The other labels present in the marketplace are comparative labels: the Venezuelan Comisión Venezolana de Normas Industriales (COVENIN) have



formats that are very similar to the FTC label and the EU labels.

Labeling Standards

REFRIGERADOR
CAPACIDAD: 543,36 LITROS (19,2 PIE³)
DESCONGELACIÓN: AUTOMÁTICA

SANKEY
MODELO: RF-2152SS

GUIA DE CONSUMO

COMPARAR ESTE VALOR SOLO CON MODELOS

616

kWh/año

0 ESTE MODELO 2000 2700

RANGO REFERENCIAL DE CONSUMO kWh/año

PARA SU SELECCION COMPARE ESTE VALOR CON MODELOS DE CARACTERISTICAS SIMILARES.

EL PAGO DE ELECTRICIDAD DEPENDERA DE LA TARIFA ELECTRICA LOCAL Y EL USO QUE SE LE DE AL ARTEFACTO. CONSULTE CON SU EMPRESA DE SERVICIO ELECTRICO.

IMPORTANTE:
ESTE VALOR ESTA BASADO EN LOS METODOS DE ENSAYO ESPECIFICADOS EN LA NORMA VENEZOLANA COVENIN 3193.

LA REMOCION DE ESTA ETIQUETA ANTES QUE EL CONSUMIDOR ADQUIERA EL ARTEFACTO ES UNA VIOLACION A LA NORMA COVENIN 3235

Energía

Fabricante
Marca

Sistema de descongelación
Modelo / tensión (V) / frecuencia (Hz)

Más eficiente

A
B
C
D
E
F
G

Menos eficiente

CONSUMO MENSUAL (KWh/mes)
Clase de clima (conforme la norma NC-691)

Volumen útil del compartimiento refrigerado (l)
Volumen útil del compartimiento del congelador (l)
Temperatura en el congelador

31,91
Tropical (T)

295
87
-18°C

Norma NC-691
IMPORTANTE: EL CONSUMO REAL VARIA DEPENDIENDO DE LAS CONDICIONES DE USO DEL EQUIPO Y SU LOCALIZACIÓN. IMPORTANTE: ESTA ETIQUETA NO DEBE RETIRARSE HASTA QUE EL PRODUCTO HAYA SIDO ADQUIRIDO POR EL CONSUMIDOR.

Energía

REFRIGERADOR-CONGELADOR

Tipo de Descongelación : AUTOMÁTICO
Marca : SAMSUNG
Modelo : RT38FEAJDSL
Fabricante : Samsung Electronics Digital Appliances Mexico S.A. DE C.V.

Más eficiente

A
B
C
D
E
F

Menos eficiente

CONSUMO DE ENERGIA MENSUAL (kWh) **25,5**

POTENCIA NOMINAL (kW) **0,11**

CAPACIDAD (l) **380**

Volumen útil del compartimiento de refrigeración (l) 293
Volumen útil del compartimiento de congelación (l) 87
Temperatura del compartimiento de congelación (°C) * *** -18

Norma Covenin 178
Este Aparato cumple con los requisitos de seguridad eléctrica al usuario

IMPORTANTE
"El consumo de energía eléctrica dependerá de los hábitos de uso y localización del equipo"
"Esta etiqueta no debe retirarse hasta que el equipo haya sido adquirido por el usuario"
"El refrigerante HFC134a (R-134a) es un gas de alta incidencia en el calentamiento global. Evite liberarlo a la atmosfera"

The format of the Cuban labels is similar to the EU labels.

1. Commercial Exhaust Fans

SAVE MONEY AND KEEP THE COLD AIR INSIDE

KEEP THE AIR IN YOUR KITCHEN COOD AND CLEAN!

Although ventilation is vital for maintaining air quality and mitigating smoke in the kitchen, it also uses a large amount of energy. A 50% reduction in fan speed can reduce fan energy consumption by as much as 80%, equipment that minimizes fan speed when possible can yield large energy savings.

HOOD CONFIGURATION

There are three basic types of hoods based upon their vertical placement and fan orientation: island canopies, wall mounted canopies, and proximity. A well-engineered proximity hood can lower the exhaust needs by around 30% making it the most energy efficient configuration is the proximity hood, followed by wall mounted canopies, and then islands canopies.

The installation of side panels and overhangs can reduce energy consumption by allowing for lower exhaust

rates, preventing the loss of cold air, and more efficiently channel the heat to the outside

Lifetime Savings

Using all the exhaust ventilation recommendations can help you save up to \$50,000 during the life of the equipment.



of the building.

APPLIANCE PLACEMENT

The location of the equipment under the kitchen ventilation system can save you energy. Placing the equipment against the rear wall or covering the space behind the appliance reduces cross drafts and escape of fumes and heat. Moving open burner ranges to

the middle of the hood area to ensure the hood captures all the fumes. If you have more than one fan try grouping appliances with the same ventilation requirements together.

DEMAND CONTROL VENTILATION

Typical kitchen exhaust systems only have ON/OFF switches for kitchen and makeup fans. Demand Control Ventilation (DCV) systems react to smoke and heat from cooking surfaces and adjust hood exhaust airflow rates accordingly. DCV can also modulate makeup air systems airflow rates. Energy savings of up to 90% from fan energy consumption and up to 50% reduction in air conditioned use by implementing DCV at the kitchen.

Exhaust fans can be controlled using signals from optical or temperature sensors. The system can be monitored remotely to verify the savings.

DCV systems should be installed on at least 75% of the exhaust air. Include failsafe controls that result in full flow upon cooking sensor failure. Allow occupants the ability to temporarily

1. Commercial Exhaust Fans

override the system to full flow.

Install energy recovery devices with a sensible heat recovery effectiveness of not less than 40% on at least 50% of the total exhaust airflow. Precool a minimum of 75% of makeup air volume.

EXHAUST FAN EQUIPMENT SELECTION

Replacing your deteriorated exhaust fan with UL listed fans can save 30% on the energy use.

INTEGRATED DESIGN WITH HVAC

In cases where the kitchen is air conditioning, an integrated HVAC strategy that takes into consideration the combined fresh air demands for the dining room and the kitchen could reduce your energy consumption by adjusting the fresh air supply more accurately and prevent ventilation and HVAC energy waste.

REFERENCES

- Food Service Technology Center. (2013, 12 26). *CKV Design Guides*. Retrieved from <http://www.fishnick.com/ventilation/designguides>
- U.S. Environmental Protection Agency and the U.S. Department of Energy. (n.d.). *ENERGY STAR*

2. Commercial Ice Makers

MAKE ICE, DON'T WASTE ENERGY AND WATER

KEEP YOUR ICE COLD!

Annual energy operating costs from inefficient ice makers can amount to \$6,500, and \$1,000 in water costs (at current USVI rates).

Ice machines use energy to produce ice and to keep it frozen. These machines also contribute to water use dependent upon the type of ice produced.

ENERGY SAVING TIPS

- Keep lids closed to prevent cold air from escaping to the outside.
- Clean the coils regularly to keep the machine working at peak efficiency.
- Use a water filtration system to remove minerals and contaminants in the water which build up inside the water lines; this prevents additional strain on the compressor and improves machine efficiency.
- Install timers on ice machines to turn them off when not in service. Scheduling will depend on storage bin capacity,

insulation level, and ambient air temperature.

- Retrofit older machines with larger ENERGY STAR qualified ice machines to reduce energy consumption.

Lifetime Savings

Using a top rated ENERGY STAR continuous commercial ice maker can save more than \$5,000 during the life of the equipment vs. an old inefficient unit.



WATER SAVING TIPS

Reduce your water consumption by more than 25% by replacing your old ice maker with a continuous ice maker. This type of machine consumes less water than

batch machines.

Continuous ice makers make flake ice and nugget ice, batch machines make cube ice.

1. Flake ice is the term used to describe smaller, irregular ice. It is subdivided into scale ice (the flatter version) and granular ice (like the type used in frozen drinks).
2. Nugget ice is compressed flake ice, ideal for beverage cooling, grocery store displays and food processing.
3. Cube ice is a larger, clearer, and harder variety that retains the cold for longer.

COMMERCIAL ICE MAKER CONFIGURATIONS

There are two types of cooling systems for ice makers, air-cooled and water-cooled.

1. Air-cooled machines work by having air circulated by fans to
2. remove the heat from the refrigeration lines.
3. Water-cooled machines use an additional water line to remove the heat from the

2. Commercial Ice Makers

condenser but the water use increases significantly.

Additionally, the condensing units can be in three different configurations:

1. An ice-making head (IMH) is designed to fit on top of storage bins.
2. Self-contained units (SCU) have an ice making mechanism and storage bin integrated into the same cabinet or housing. They are more economical

but they add additional heat to the environment where they operate.

3. Remote condensing units (RCU) are units where the condensing unit is separate from the storage bin. This configuration can reduce air conditioning loads when the storage bins are located in air conditioned spaces.

If you are interested in purchasing a new energy efficient ice maker, please

visit the [ENERGYSTAR website](#) for the most efficient models.

REFERENCES

Food Service Technology Center. (n.d.).

U.S. Environmental Protection Agency and the U.S. Department of Energy . (n.d.).
ENERGY STAR

3. Freezers

SAVING ENERGY WITH FREEZERS

DO YOU NEED IT?

Having a freezer can be convenient to store a larger amount of food and reduce the number of shopping trips, but with the current electricity rates they cost around \$150 to operate per year for a medium size freezer. In most cases the freezer section of the refrigerator has sufficient food storage capacity. When calculating how much space is needed per person, use 45 liters per person for freezers. Have in mind that full freezers are more efficient than half-full ones.

DOWNSIZING

Old refrigerator and freezer can be replaced with a slightly larger energy efficient [ENERGY STAR](#) labeled refrigerator/freezer combo. Removing a freezer can lower utility bills.

OLD FREEZER?

Freezers that are more than 10 years old should be replaced with the most efficient freezer available.

Chest freezers are much more efficient than uprights. Use the [ENERGY STAR](#) website to find the most efficient options available; sort them by criteria like the annual energy use. The lower the energy use, the lower the utility bills.

HOW TO USE A FREEZER MORE EFFICIENTLY

The first step is make sure that the thermostat is set to the proper temperature so that the inside remains

Lifetime Savings

Using the refrigerator instead of a freezer saves \$1,500 during the life of the refrigerator¹.



Freezer Storage Chart (-18 °C)

Note: Freezer storage is for quality only. Frozen foods remain safe indefinitely.

Item	Months
Bacon and Sausage	1 to 2
Casseroles	2 to 3
Egg whites or egg substitutes	12
Frozen Dinners and Entrees	3 to 4
Gravy, meat or poultry	2 to 3
Ham, Hotdogs and Lunchmeats	1 to 2
Meat, uncooked roasts	4 to 12
Meat, uncooked steaks or chops	4 to 12
Meat, uncooked ground	3 to 4
Meat, cooked	2 to 3
Poultry, uncooked whole	12
Poultry, uncooked parts	9
Poultry, uncooked giblets	3 to 4
Poultry, cooked	4
Soups and Stews	2 to 3
Wild game, uncooked	8 to 12

¹ Savings calculated using an electricity rate of \$0.51/kWh.

3. Freezers

between 0-3 degrees Celsius.

Keeping the freezer full not only saves energy but can also help keep food frozen longer during a power outage.

Inspect the seal around the freezer door to prevent the warm air to get into the freezer.

Allow for hot foods to cool to room temperature before storing them in the freezer.

Label all the food items in the freezer so that freezer door doesn't remain open for a long time. It's a good idea to mark the calendar with the recommended maximum storage times as recommended by the USDA food safety and inspection service.

4. Occupancy Sensors

DON'T LEAVE IT RUNNING

DON'T LET LIGHTS, AC, AND, FANS RUN WHEN NOT IN USE!

Occupancy sensors can turn off, dim, and control lights, appliances, electronic devices, or other equipment automatically when not in use. The sensors can also enable the same equipment as people enter the rooms where they are installed. This valuable technology is applicable both in commercial and residential buildings.

HOW DO OCCUPANCY SENSORS WORK?

There are two main types of occupancy sensors: the passive infrared sensor (PIR sensor), and the ultrasonic sensor. PIR sensors detect the heat from the human body and have long range detection, but require an unobstructed line of sight. They work best in areas with high levels of movement. The ultrasonic sensor utilizes a mechanism similar to what bats use, bouncing sound waves off people and objects while detecting the frequency change between emitted and

reflected sound waves. Their limited range makes them a suitable option for detecting minor motions like typing and reading; they don't require an unobstructed line of sight which makes them ideal for restrooms and stalls.

Some sensors combine both technologies, or additional types of sensors, to overcome the limitations of individual sensors.

Lifetime Savings

Each occupancy sensors can save more than \$400 at the current electricity rates.



DAYLIGHTING AND AIR CONDITIONING

Occupancy sensors can be combined with daylight sensors in areas where the

natural lighting is sufficient to

meet the space lighting requirements. Some sensors incorporate dimming controls to adjust lighting levels or turn off some of the light fixtures to maintain the required lighting levels.

Space ventilation and/or air conditioning temperatures can also be controlled and adjusted based upon space occupancy.

VENDING MACHINES

Most vending machines stand alone in corners or hallway for most of the day with the lights on and keeping the drinks very cold; using a significant amount of energy. The older and inefficient vending machines can benefit from the installation of occupancy sensors; which power down the machines when there is no pedestrian traffic for a pre-defined period of time. If you are in the market for a vending machine, make sure that it is ENERGY STAR rated which can reduce energy consumption.

4. Occupancy Sensors

POWER STRIPS AND PLUG LOADS

TV's, stereos, computers, game consoles, cable boxes and other electronic equipment are usually left on or in standby mode when not in use. Occupancy sensors have been coupled with power strips which can shut down the equipment when the space is not occupied.

SENSOR MAINTENANCE

Occupancy sensors are virtually maintenance free, unless the sensor itself has

been dirtied with environmental debris, damaged by vandalism or electric disturbances.

LIFE

Most occupancy sensors come with 5 year warranties from the manufacturers.

COST OF INSTALLATION

Occupancy sensors are relatively inexpensive to install, starting at just above \$50 for the simple sensors and up to \$200 for the more complex sensors and installations.

References

National Renewable

Energy Laboratory.
(2013, June 4).

NREL Adds Eyes,
Brains to
Occupancy
Detection. Golden,
CO, US.

U.S. Environmental

Protection Agency
and the U.S.

Department of
Energy . (n.d.).
ENERGY STAR.

5. Refrigerators

SAVING ENERGY WITH REFRIGERATORS

REFRIGERATOR EFFICIENCY IS IMPORTANT

Refrigerators are an excellent way to store food and keep it fresh in the short term. It is important make sure they as energy efficient as possible to keep energy costs down.



Many consumers also opt for having a freezer, which is a convenient way to store perishable food and reduce the number of shopping trips, but with the current electricity rates a medium sized freezer can cost as much as \$180 to operate per year.

In many cases the freezer section of the refrigerator has sufficient food storage capacity.

You should care how energy-efficient your refrigerator is. The more energy efficient a refrigerator is, the lower your utility bill will be each month.

USE YOUR REFRIGERATOR EFFICIENTLY

The energy consumption of very small refrigerators can be as high as larger refrigerators. The most energy-efficient models are typically 10-15 cubic feet in capacity.

Try to avoid using multiple refrigerators. That spare fridge out back is costing you a lot of money.

If your refrigerator door does not shut tightly, check the door seal to see if it needs to be cleaned or replaced. A door leak allows cool air to escape, forcing your refrigerator to use more energy to keep food cold.

Cleaning the condenser coils found in the back or bottom

of the refrigerator will maximize its efficiency. A brush or vacuum can be used. Be sure to unplug the refrigerator before you start cleaning.

Keep the refrigerator away from heating appliances (ovens and dishwashers), and the sun. Direct exposure to



heat forces the unit to work harder and use more energy.

Warm air pushes your energy bill up, so try to keep it out. Minimize door openings and close the door quickly.

Keep the refrigerator full. A full refrigerator retains cold better than an empty one. Empty refrigerators in rental units use a lot of energy. Water bottles are a good way to fill empty space. The mass of cold items will enable the refrigerator to recover more

5. Refrigerators

quickly after the door has been opened. But be careful not to block the fan inside the fridge that allows cold air to circulate.

Check temperature settings for the most efficient appliance operation.

Refrigerator temperature should be 36-40 degrees.

IS IT TIME TO REPLACE YOUR REFRIGERATOR?

If your refrigerator is more than 10 years old it should be replaced energy efficient model.

Refrigerators still look pretty much the same from the outside as they did 10 to 15 years ago. What you can't see, however, is that there have been some dramatic energy efficiency improvements inside today's refrigerators.

Purchasing an energy efficient refrigerator, or replacing an old one, you can save up to \$450 in energy costs over its lifetime.

WHEN BUYING A REFRIGERATOR, ADD THE TWO PRICE TAGS

When buying a refrigerator, there are really two price

tags. The purchase price is only the first payment. The energy bill does make a big difference. It is better to pay more for an energy efficient model. Energy efficient models may seem to be more expensive than less efficient units, but they are better value.

You must add in the second price tag - the cost to operate the refrigerator over its lifetime. You'll be paying the energy price tag on your monthly utility bill for a long time. Look at available energy labels to find how much energy the refrigerator will use annually.

U.S. Government Federal law prohibits removal of this label before consumer purchase.

ENERGYGUIDE

Refrigerator-Freezer

- Automatic Defrost
- Top-Mounted Freezer
- No Through-the-Door-Ice-Service

Electrolux
FFHT1521Q*
Capacity: 14.5 Cubic Feet

Compare ONLY to other labels with yellow numbers.
Labels with yellow numbers are based on the same test procedures.

Estimated Yearly Energy Cost

\$40

Cost range not available

336 kWh
Estimated Yearly Electricity Use

† Your cost will depend on your utility rates and use.
† Cost range based only on models of similar capacity with automatic defrost, top-mounted freezer, no through-the-door-ice-service
† Estimated energy cost based on a national average electricity cost of 12 cents per kWh.

PART NO. A02090702
ftc.gov/energy



5. Refrigerators

Compare the energy use (in kWh) and cost to operate to other models of similar size and configuration. The more energy the refrigerator uses, the more it will cost you to operate it.

When you are comparing two models, be sure to compare both first and second price tags before you buy to figure out the true cost of buying and operating the refrigerator. You may find that although one appliance may cost more to purchase, it could end up costing you less over the lifetime of the unit. In Belize, it's important to increase the energy costs

shown on the energy guide.

The energy guide is based on the US energy cost per kWh.

The EnergyGuide shown is for a sample GE refrigerator. Its typical operating costs is USD 40/year at 12¢/kWh. In Belize, 40¢/kWh the typical cost will be \$334.

Follow the link for helpful tips on what to look for when buying a refrigerator.

<http://www.energystar.gov/products/certified-products/detail/refrigerators>

References

U.S. DOE and U.S. EPA(n.d).
ENERGY STAR
www.energystar.gov

6. Tankless Water Heaters

SAVE ENERGY WITH A TANKLESS WATER HEATER

A GREAT APPLICATION FOR HOT WATER

Tankless water heaters, also known as instantaneous, or on demand water heaters come in third in the energy efficiency ratings behind solar water heaters and heat pump water heaters. They are best suited for those residents who already have their buildings configured for gas, using 60 gallons or less, and/or have limited space for a water heater placement.

Tankless heaters can use a gas burner or electricity to heat the water as it flows through the heater. We will focus on the gas tankless water heaters as their electric counterparts are not beneficial to the island grid.

SAVE WITH A TANKLESS WATER HEATER

Conventional electric water heaters can represent 25-30% of a resident's utility bill. Tankless can lower the water heating consumption by up to 30%.

First, purchase water heaters based upon how much they cost to operate



versus their initial cost. Use the [ENERGY STAR website](#) to find the most efficient options available; sort them by criteria like the energy factor (EF), which indicates a water heater's overall energy efficiency based on the amount of hot water produced over a typical day. The higher the energy factor the more efficient the water heater. ENERGY STAR qualified tankless water heaters are required to have a minimum Energy Factor of 0.82, a minimum flow of 95 liters per minute (LPM) over a 25°F rise, a minimum warranty of 10 years on the heat exchanger and 5 years on parts, and meet the ANSI Z21.10.3/CSA 4.3 safety standards.

Second, in addition to

installing an efficient water heater, it's important to ensure use showerheads, and faucets (in bathroom and kitchen) are water efficient. Replacing old water fixtures with Watersense labeled water fixtures or

installing aerators can help you save between 25%-60% of the hot water used.

The third key to lowering the electrical consumption of the water heater is to adjust the water heater temperature to 50° C.

ADDITIONAL CONSIDERATIONS BEFORE YOU BUY

To ensure the water heater will meet your needs, calculate at least 9.5 LPM for each showerhead, 9.5 LPM for the kitchen faucet, and 5.7 LPM per bathroom faucet. Some tankless water heaters require a minimum flow of water to operate, usually around 2 LPM.

6. Tankless Water Heaters

If your cistern water has the potential for scaling, the heater lines will have to be cleaned to remove lime from the hoses at regular intervals.

Tankless water heaters need special venting to ensure exhaust gases are expelled outside the building.

Lifetime Savings

Purchasing a Tankless Water Heater to replace the existing water heater could save as much as \$7,800 during the life of the water heater.

Propane fueled tankless water heaters still require electricity to start, meaning in the event of a power outage the water heater will not work.



7. Freezers

SAVING ENERGY WITH FREEZERS

DO YOU NEED IT?

Having a freezer can be convenient to store a larger amount of food and reduce the number of shopping trips, but with the current electricity rates they cost over \$200 to operate per year for a medium size freezer. In many cases the freezer section of the refrigerator has sufficient food storage capacity. When calculating how much space is needed per person, use 1.5 cubic feet per person for freezers. Have in mind that full freezers are more efficient than half-full ones.

DOWNSIZING

Old refrigerators and freezers are inefficient can be replaced with an energy efficient [ENERGY STAR](#) labeled refrigerator/freezer combo to save space and lower bills.

It is inefficient to keep the old freezer outside for fish. Dispose of it!

IF YOU NEED A FREEZER

Freezers that are more than 10 years old should be replaced with the most

efficient freezer available.

Chest freezers are much more efficient than uprights. Use the [ENERGY STAR website](#) to find the most efficient options available; sort them by criteria like the annual energy use. The lower the energy use, the lower the utility bills.

HOW TO USE A FREEZER MORE EFFICIENTLY

The first step is to make sure that the thermostat is set to the proper temperature so that the inside remains between 0-5 degrees F.

Keeping the freezer full not only saves energy but can also help keep food frozen longer during a power outage. Add water bottles if you have space in the freezer.

Keep the freezer in a cool location. Outdoor freezers use a lot more energy.

Allow air circulation behind the freezer. Leave a few inches between the wall or cabinets and the freezer.

Inspect the seal around the freezer door to prevent the warm air to get into the freezer. Make sure the seals

Using the refrigerator freezer section instead of a freezer save \$1,500 during the life of the refrigerator.

Removing the 20 year old 'fish' freezer can save as much as \$500 a year.



around the door are airtight. If not, replace them.

Keep the door closed.

Minimize the amount of time the freezer door is open

Label all the food items in the freezer so that freezer door doesn't remain open for a long time. It's a good idea to mark the calendar with the recommended maximum storage times as recommended by the USDA food safety and inspection service.

7. Freezers

FREEZER BUYING GUIDE

New refrigerators are more efficient than ever.

Improvements in insulation and compressors mean today's freezers consume much less energy than older models. Select a freezer that's earned the ENERGY STAR for maximum energy savings and the latest features.

FREEZER TYPE

The two main categories of standalone freezers are chest freezers and upright freezers. Chest freezers are better insulated than upright freezers are and are therefore generally more energy-efficient. Moreover, the top-loading design of chest freezers means that less cold air comes out when they are opened than what escapes when the doors of upright freezers are swung open.

FREEZER SIZE

The larger the freezer, the more energy it requires to operate. Do not purchase a larger freezer than you need.

DEFROST FUNCTION

Automatic defrost freezers can consume up to 40 percent more electricity than manual defrost freezers can.

YOU SHOULD ADD IN TWO PRICE TAGS

When you are buying a freezer, there are really two price tags. The purchase price is only the first payment. The energy bill does make a big difference. It is better to pay more for an energy efficient model. Energy efficient models may seem to be more expensive than less efficient units, but they are better value.

You must add in the second price tag - the cost to operate the refrigerator over its lifetime. You'll be paying the energy price tag on your monthly utility bill for a long time. Look to the yellow EnergyGuide label to find how much energy the freezer will use annually.

Compare the energy use (in kWh) and cost to operate to other models of similar size and configuration. The more energy the freezer uses, the

more it will cost you to operate it. Don't forget energy is more expensive in the USVI.

When you are comparing two models, be sure to compare both first and second price tags before you buy to figure out the true cost of buying and operating the freezer. You may find that although one appliance may cost more to purchase, it could end up costing you less over the lifetime of the unit.

In the USVI it is important to increase the energy costs shown on the energy guide. . The energy guide is based on a mainland energy cost per kWh. The EnergyGuide shown is for a sample GE freezer. Its typical operating costs is \$26/year at 12c/kWh. In the USVI at 38c/kWh the typical cost will be \$82.

BUYING ENERGYSTAR IS A GREAT INVESTMENT

The price premium for a high efficiency freezer can be recovered quickly, often in 2 to 6 years.

8. LED Lighting



LED Bulbs Made Easy

Just Look for the ENERGY STAR®



- ★ Independently certified to deliver efficiency and performance.
- ★ Same brightness (lumens), 70–90% less energy (watts)
- ★ Lasts 15 times longer = big \$ savings
- ★ Help protect the environment and prevent climate change

Only LED bulbs that have earned the ENERGY STAR label have been independently certified and undergone extensive testing to assure that they will save energy and perform as promised.

ENERGY STAR certified LED bulbs are available in a variety of shapes and sizes for any application—including recessed cans, track lighting, table lamps, and more. You can even find certified bulbs that are dimmable. **Use this chart as a guide to finding the right ENERGY STAR certified bulb for your light fixture and remember to always check the packaging for proper use.**

	BULB TYPES				
TABLE OR FLOOR LAMPS					
PENDANT FIXTURES					
CEILING FIXTURES					
CEILING FANS					
WALL SCONCES					
RECESSED CANS					
ACCENT LIGHTING					

BRIGHTNESS

For brightness, look for lumens, not watts. Lumens indicate light output. Watts indicate energy consumed. ENERGY STAR certified bulbs provide the same brightness (lumens) with less energy (watts). **Use this chart to determine how many lumens you need to match the brightness of your old standard bulbs.**

Standard Bulbs (Watts)	ENERGY STAR Bulb Brightness (Minimum Lumens)
40	450
60	800
75	1,100
100	1,600
150	2,600

COLOR/APPEARANCE

ENERGY STAR certified bulbs are available in a wide range of colors. Light color, or appearance, matches a temperature on the Kelvin scale (K). Lower K means warmer, yellowish light, while higher K means cooler, bluer light.

2200K	3000K	3500K	4100K	5000K	6500K
WARM			COOL		
Soft White, Warm White		Neutral White, Cool White		Daylight (think blue sky at noon)	
Ideal for most indoor applications.		Good for kitchens and work spaces.		Good for reading.	



ENERGY STAR is the simple choice for energy efficiency. For more than 20 years, EPA's ENERGY STAR program has been America's resource for saving energy and protecting the environment. Join the millions making a difference at energystar.gov/lighting.

9. Clothes Washers

SAVE ENERGY & WATER WITH CLOTHES WASHERS

COLD WATER IS YOUR FRIEND

Switching from the hot water to the cold water setting in the clothes washer can save up to 90% of the energy used by the washer. Hot water or sanitary cycles also shrink cotton and wool so unless the garment is stained with oil or grease it's recommended to use cold water paired with a cold-water detergent. For extra cleaning power use chlorine free bleach, or the washer's pre-soak cycle.

TOP LOADING VS. FRONT LOADING

Old clothes washers used a central agitator to scrub the clothes. Newer top loaders use water to move the clothes around and clean them, where front loaders use the clothes' own weight for scrubbing. Front loading washers are often more than 20% more energy efficient, can fit more clothes, and use 40% less water than their top loading counterparts of

the same size.

OLD CLOTHES WASHER?

Clothes washers that are more than 10 years old should be replaced with the

Lifetime Savings

Using the top-rated ENERGY STAR front loading washer can save more than \$1,000 when using hot water during the life of the washer.



most efficient washers available. New washers are not only more than 50%¹ more energy efficient but also cut water use by about 40%.

Washer size can be determined based upon how many loads or the weight of clothing can be washed per load, the average large capacity washer found in most households is about 2.7 cubic feet. Energy Star rated appliances are more efficient than conventional appliances, but don't stop there, use the [ENERGY STAR website](#) to find the most efficient options available. Sort them by criteria like the Modified Energy Factor (MEF) which considers energy used for washing, heating the water, and drying the clothes. The second most important factor to consider is the energy annual energy use, listed on [EnergyGuide](#) label, required by the Federal government.

It is important to increase the operating cost shown on the EnergyGuide label for the costs in Belize. The cost on the label use a US (e.g. USD 12 c/kWh).

Another alternative is buying a washer/dryer combo

¹ Including hot water use

9. Clothes Washers

machine, where the washing and drying take are both done inside the same drum. These machines are very energy efficient but not as convenient due to their longer clothes drying time.

HOW TO USE THE CLOTHES WASHER MORE EFFICIENTLY

When doing laundry, wash only full loads unless the washer has the option to select smaller washer loads

with less water use.

Use the recommended amount of detergent, the excess detergent or using non High Efficiency (HE) detergent on HE washers create too much foam wasting energy.

After using the washers, leave the doors open so the machine has time to dry as the front seal can trap unwanted moisture inside. Keep children and pets out of the washers.

10. Dishwashers

SAVING ENERGY AND WATER WITH DISHWASHERS

SAVE MONEY, SAVE WATER AND SAVE THE ENVIRONMENT

There are many things to look for when considering the replacement or upgrade of an old washing machine:

- Newer, more efficient dishwasher will save an average of 5,000 gallons of water over its lifetime when compared to handwashing and help contribute to the effort to combat climate change and air pollution by using less energy and water, new dishwashers help lessen their impact on the environment.¹
- Current energy efficient models use just over 200 kWh/year with lifetime energy costs amount to around \$1,000.

CHOOSE THE RIGHT DISHWASHER

- Standard-capacity models hold more than eight place settings and six serving pieces, while compact-

capacity models hold up to that amount. If you have to operate a compact model more frequently, over time



you may use more energy than you would with a standard model.

- Choose a dishwasher with several wash cycle options. Lightly soiled dishes can use a light or energy-saving wash cycle, which uses less water and operates for a shorter period of time.

SAVE MONEY AND TIME

- Washing dishes in a dishwasher can save you over 230 hours of personal time over the course of a year, almost 10 days. It can cut your utility bills by

about \$160 per year.

- Get better cleaning with water boosted to temperatures around 60 degrees Celsius, which allows for improved disinfection compared to hand washing.

DISH WASHING BEST PRACTICES

- Scrape don't rinse, rinsing dishes can use up to 20 gallons of water before the dishes are even loaded.
- If dirty dishes sit overnight, use the dishwasher's rinse feature. It uses a fraction of the water needed to hand rinse.
- Load the dishwashers to capacity as they use about the same amount of energy and water regardless of the number of dishes inside.
- Select the no-heat drying option. It gives good drying results with less energy.

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1. U.S. Department of Energy. "Dishwashers for Consumers."

¹Energystar.gov "Dishwasher"

11. Ceiling Fans

SAVE ENERGY WITH FANS

FANS COOL PEOPLE, NOT EMPTY ROOMS

Fans lower the temperature a person feels because of the wind chill effect. The body feels cooler as the breeze from a fan evaporates the perspiration from the skin. For this reason, ceiling fans reduce the need for air conditioning. Turning the fans off when no-one is in a room will save energy.

SAVE WITH AN EFFICIENT FAN

Fans 10 years old, and older, should be replaced with fans that have direct current (DC) motors.

When purchasing ceiling fans use the ENERGY STAR website to find the most efficient available; sort them by: airflow vs. energy consumption at different speeds.

ENERGY STAR qualified ceiling fans with lights are over 50% more efficient than non-qualified models.

AVOID floor and window fans

– they are not currently rated and are generally do not move air as efficiently as ceiling fans.

FAN LOCATION

Ceiling fans are certified based on the environment where the fan is to be installed. Indoor fans should not be used outdoors, even if the area is mostly covered.

DRY LOCATIONS¹: Often noted just as "UL Listed"; a dry location is an indoor area that is not normally subject to



AERATRON E503 FAN 1

include kitchens, living rooms, dining rooms, bedrooms, foyers and hallways.

DAMP LOCATIONS: Lighting fixtures and fans marked "Suitable for Damp Locations" or "Suitable for Wet Locations" should be used in damp locations, which are



Lifetime Savings

Purchasing the top of the line ceiling fan in lieu of the most economical fan could result in savings of more than \$2,000 for the life of the fan². For air conditioned homes, the thermostat can be raised by around 3 degrees Celsius without sacrificing thermal comfort.

periodically subject to the

of operation per day.

¹ <http://www.lumens.com/ul-ratings-for-lighting-and->

[fans.aspx](http://www.lumens.com/fans.aspx)

² Savings calculated using 8 hours

11. Ceiling Fans

condensation of moisture in or near the electrical components. Indoor damp locations include bathrooms, indoor pools and utility rooms.

OUTDOOR DAMP LOCATIONS:

Outdoor damp rated fixtures should be used in covered locations that are not directly exposed to water, even during storms. Outdoor damp locations include covered patios and porches that are fully protected from water, even during storms.

WET LOCATIONS: Lighting and fans marked "Suitable for Wet Locations" should be used in wet locations, where water or other liquids may drip, splash or flow on or against the electrical components. Outdoor wet locations include open-air decks and patios, uncovered porches, outdoor dining areas, etc.

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U.S. EPA. *ENERGY STAR*.
www.energystar.gov
Heating and Cooling—
Consumer Energy Center
California Energy Commission
Fans—Sustainable Building
Sourcebook Green Building
Program

12: Heat Pump Water Heaters

SAVE ENERGY WITH HEAT PUMP WATER HEATERS

HEAT WATER AND COOL THE ROOM AT THE SAME TIME!

Heat pump water heaters (HPWH) are only second to solar water heaters in efficiency. HPWH is recommended for residents who live in areas with limited solar exposure.

HPWH function like refrigerators in reverse, removing hot and humid air from the environment surrounding the HPWH and transferring it to the water. The warmer the weather the better this technology works.

SAVE WITH A HPWH

Conventional electric water heaters can represent 25-30% of a resident's utility bill. HPWH can lower power consumption related to water heating by up to 80%.

Consumers should purchase water heaters based upon how much they cost to operate versus their initial cost. Use the [ENERGY STAR website](#) to find the most efficient options available; sort them by criteria like the energy factor (EF), which indicates a water

heater's overall energy efficiency based on the amount of hot water produced over a typical day.

When considering your purchase, note that a higher energy factor indicates a more efficient water heater. ENERGY STAR qualified HPWHs are required to have an energy factor of 2 or more, a first hour rating of 190 liters per hour, have at least a 6-year warranty (most systems have 10 year warranties) and meet UL 174 and UL 1995 safety standards.

In addition to installing a very efficient water heater, it's important to make sure that

the showerheads, and all bathroom and kitchen faucets are water efficient. Replacing old water fixtures with Watersense labeled water fixtures can help reduce hot water usage by 25%-60%.



The third key to lowering the electrical consumption of the water heater is to adjust the water heater temperature to 50° C.

SIZING A HPWH

To select the proper size for a HPWH it's important to know how much water will be needed at any given time. The following example will help you calculate the First-Hour Rating (FHR); the amount of hot water in gallons a storage water heater can supply per

Use in liters per minute (LPM)	Average liters of hot water per usage	Times used in 1 hour	Liters used in 1 hour
3 Showers (9.5 LPM)		38 ×	3 = 114
1 Shave (0.2 LPM)		8 ×	1 = 8
1 Hand dishwashing or food prep (8 LPM)		16 ×	1 = 16
Total Peak Hour Demand			= 138

12: Heat Pump Water Heaters

hour (starting with a tank full of hot water).

Lifetime Savings

Purchasing a Heat Pump Water Heater to replace the existing water heater could save as much as \$4,000 during the life of the water heater¹. In air conditioned homes, there would be additional savings.



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U.S. DOE and U.S. EPA(n.d.).
ENERGY STAR.
www.energystar.gov

13. Variable Speed Water Pumps

VARIABLE SPEED POOL PUMPS SHRINK COSTS

KEEP THE POOL CLEAN AND KEEP YOUR CASH!

Gone are the days of the single speed pump which wasted energy by running faster than necessary while filtering water. Modern, multi-speed and variable speed pumps are here to stay since they use 90% less energy than the older models. These more efficient pumps are also quieter; require less maintenance, while putting less strain on the filters and other parts of the system.

Pool pumps in tropical environments use more energy due to the water recirculating all year long.

THE MOST EFFICIENT POOL PUMP AVAILABLE

The purpose of pool pumps is to circulate water so it passes through the filter or other water features. As some features require more pumping power than others, pumps are sized for the most demanding task. Variable speed pumps generally use permanent magnet motors, a configuration similar to the

one used in hybrid cars. This technology combined with digital controls allows optimal pump speed control for the different pump tasks. In most cases, pump speeds will be lower than single speed pumps.

Lifetime Savings

The most efficient ENERGY STAR pool pumps can save more than \$24,000 over the lifetime of the pump, at current electricity rates.



The pump affinity law defines the relationship between motor speed, flow rates, and energy consumption. This law states that when the motor speed is cut in half, the flow rate is also reduced to half, but the power consumption of the pump is reduced by almost 90%.

DC-powered variable speed pumps can be solar powered, eliminating electric

consumption; but these pumps require a significantly higher investment than AC powered variable speed pumps.

ADDITIONAL SAFETY FEATURES

Some of the programmable variable speed pumps may pump at higher rates than the original pump and that could present hazards such as suction entrapment in pools with single drains at the bottom of the pool.

PUMP MAINTENANCE

Although maintenance for variable speed pumps is similar to single speed pumps, care must be taken to ensure that pump strainer baskets are clear of leaves and debris at all times; this ensures proper ventilation, protecting the motors from heat, dirt, and moisture.

LIFE

Most pump manufacturers have a one year full warranty, plus ten years on parts.

COST OF INSTALLATION

Variable speed pool pumps cost around \$3,000 installed and

13. Variable Speed Water Pumps

at current electricity rates, the investment would be recovered in less than a year.

When considering the purchase of a new pool pump it's important to visit the [ENERGY STAR](#) website and compare the different models to choose the most efficient product available.

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14. Reflective Roof Coatings

KEEP YOUR BUILDING COOL WITH A COOL ROOF

WHITE IS THE NEW GREEN!

The sun shines on roofs throughout the day, heating them, making the interior of a building behave like an oven. A cool roof is different from a conventional roof due to the fact that it reflects heat back into the atmosphere, keeping the building below much cooler instead of storing the heat. Cool roof properties are based on how much heat the roof reflects and how much heat it radiates when compared to a black object.

IMPROVED COMFORT

As summers get warmer, it's important to mitigate building heat gain. Cool roofs serve this purpose and create a more comfortable environment inside by lowering the roof temperature by as much as 40 degrees Fahrenheit when compared to dark or aged galvanized roofs.

Additionally, reflective colors work on the walls preventing the sun from heating up exposed Southern and Western

walls.

MUCH LOWER AIR CONDITIONING BILLS

Air conditioners use energy to remove heat from inside the building, so the less heat trapped under the roof the better. Cool roofs can reduce energy consumption by around 10% by acting like white beach cooler lids which keep the contents cool inside. The emphasis on white is due to its' reflective properties over the rest of the colors, a listing of different cool roof products can be found at the Energy Star website:

<http://www.energystar.gov/productfinder/product/certified-roof-products/> or <http://coolroofs.org/products/results>

Another energy-saving benefit is that cooler building interiors allow for refrigerators and freezers to work more efficiently.

BETTER SOLAR PANEL PERFORMANCE

Solar panels work best at

Lifetime Savings

Using a top rated cool roof can save more than %10 in air conditioned buildings.



lower temperatures and cool roofs reduce the temperature of the air space below the panels, even in the hot summer days.

Cool roofs also extend the life of the roof which will remain under the panels for 25 years. Replacing a roof once the panels are installed can be a

14. Reflective Roof Coatings

costly venture since the panels would have to be removed prior to replacing the roof.

SAFE POTABLE RAIN WATER HARVESTING

Many people harvest rainwater for potable use. Many of the materials and coatings used for roofs are not suited for drinking water so it's important to look for products rated under the [NSF International P151 Protocol at their website](#). NSF

International is a not-for-profit organization who developed the P151 Protocol to ensure roof chemical levels don't exceed known drinking water maximum contaminants and/or health advisories.

References

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Cool Roof Rating Council

15. Commercial Gas Fryers

STOP WASTING OIL AND LOWER YOUR ENERGY BILL

MAKE THE CRISP COUNT!

Old commercial fryers can use up to 40% more oil and 30% more energy than more efficient appliances. The best way to identify the most efficient fryers is to use the information provided by the EPA through their ENERGYSTAR efficiency standards program.

Commercial fryer performance can be measured by the energy input rate, the maximum rate at which a fryer draws energy expressed in kBtu/h or kW. The more energy a fryer can deliver to the oil, the faster it can reach the desired temperature and recover between loads. The more efficient the fryer, the more energy the fryer can deliver to the oil.

Although there are many factors to consider when selecting a fryer, the following factors are most significant: initial investment, food preparation productivity, ease of operation, heat generation in the kitchen and the type of energy used. The fuel source is

not necessarily the most important consideration, but in the end, the best equipment is the one that minimizes total operational costs.

Lifetime Savings

Using a top rated ENERGY STAR commercial fryer can save more than \$5,500 during the life of the equipment when compared to old inefficient fryers.



SIMPLE ENERGY SAVING TIPS

- Turn the fryer off or

during slack periods, when not in use.

- Operate the fryer at the proper temperature, higher temperatures waste energy.
- Follow the manufacturers' recommendations for operations and maintenance procedures.

ELECTRIC COMMERCIAL FRYERS

Improved electrical heat transfer technologies, thermostats with improved accuracy, and improved fry pot insulation have contributed to lower energy and gas consumption.

Additional features like automatic hands-free filtration systems help to lengthen the life of the fryer. Also, related to filtration, is the oil-filtering lock-out feature which enables users to preset filtering frequencies for better oil management. Advanced controls allow users to preprogram idle temps to reduce energy use.

If you are interested in purchasing a new energy efficient fryer, check out the

15. Commercial Gas Fryers

most efficient models at the [ENERGYSTAR website](#).

GAS COMMERCIAL FRYERS

Advanced gas heat exchanger designs allow for uniform heat distribution.

Thermostats with improved accuracy have reduced the energy and oil consumption in the most efficient commercial gas fryers.

Oil levels are kept by means of a sensor-activated automatic top-off feature that replenishes oil from storage.

If you are interested in buying a new energy efficient gas powered commercial fryer,

please visit the [ENERGYSTAR website](#).

COMMERCIAL PRESSURE FRYERS

Pressure frying reduces cooking time, cooking temperature, and therefore energy use. One disadvantage to pressure fryers is that the food is out of sight, so it can't be checked while being cooked.

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