Energy Efficiency and Audit

Introduction

- Presents the guideline on Energy Efficiency – Residential and Small Commercial Applications. Also includes brief section on Energy Audits.
- This guideline provides the minimum knowledge on energy conservation and energy efficiency measures for residential and small commercial buildings.
- This guideline does not cover large thermal/mechanical equipment such as furnaces, boilers, compressed air systems, etc. for heavy commercial and industrial applications. However, sections on lighting, refrigerators, air-conditioners and small power equipment may be applicable.

What is Energy Efficiency?

- Energy efficiency (EE) means reducing the demand for electricity by changing energy usage behaviour as well as reducing the actual amount of electricity used per time period.
- Being energy efficient and improving energy productivity in our products, homes and small-scale commercial buildings can help to:
  - reduce energy bills
  - protect the environment
  - enhance commercial energy productivity
  - contribute to a competitive energy market
  - enable better management of energy demand.

Policies Relevant to Energy Conservation

- Residential and small commercial buildings should follow any policies that are typically applied in the country or region where the energy efficiency measures are carried out.
- The relevant policies may include:
  - In-country Energy management programs.
  - In-country minimum energy performance standards

and labelling policies

Standards Relevant to Products and Equipment

- In Australia and New Zealand, the relevant standards include:

- AS/NZS 3823.1.1:2012 Performance of electrical appliances - Air conditioners and heat pumps Non-ducted air conditioners and heat pumps - Testing and rating for performance
- AS/NZS 3823.1.2:2012 Performance of electrical appliances - Air conditioners and heat pumps Ducted air conditioners and air-to-air heat pumps—Testing and rating for performance
- AS/NZS 3823.1.3:2005 Performance of electrical appliances — Air conditioners and heat pumps Part 1.3: Water-source heat pumps—Water-to-air and brine-to air heat pumps—Testing and rating of performance
- AS/NZS 3823.1.4:2012 Performance of electrical appliances - Air conditioners and heat pumps Multiple split-system air conditioners and air-to-air heat pumps - Testing and rating for performance
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Standards Relevant to Products and Equipment

- AS/NZS 3823.2:2013 Performance of electrical appliances - Air conditioners and heat pumps Energy labelling and minimum energy performance standards (MEPS) requirements
- AS/NZS 4474.1 Performance of household electrical appliances - Refrigerating appliances Energy consumption and performance
- AS/NZS 4474.2 Household refrigerating appliances - Energy labelling and minimum energy performance standards requirements
- Greenhouse and Energy Minimum Standards Act 2012 (GEMS)
- In-country building codes where applicable

Standards Relevant to Products and Equipment

- In USA the relevant codes and standards include:

- ICC IECC (2012) The International Energy Conservation Code
- Amended Energy Policy and Conservation Act of 1975 (EPCA)
- US Department of Energy, Compliance Certification Management System (CCMS) - 10 CFR Parts 429, 430 and 431
- In-country building codes where applicable

Understanding Electricity Bills and Tariffs

- This is something that is applicable to systems that are connected to the utility and thus incorporates energy measurement.
- Knowing parameters such as number of units (kWh) used per month, billing days, last reading, current reading, daily energy consumption and other relevant information is very important.
- Moreover, the tariffs applicable for residential customers may be different from small commercial, maximum demand and other category of users. This may vary from utility to utility. This is the rate charged per unit consumption of electricity stated as $/kWh.

Worked Example 1

- A sample of an electricity bill for a residential customer is given below:

Tariff Description	Reading Type	Meter Number	Reading		Usage kWh	Billed Days
			Current	Previous		
Domestic	Normal reading	999: 1	073078	073069	18	30

- The tariff description clearly indicates that this is a domestic customer. The reading provided is a normal reading, in some instances, this maybe estimated. However, this may depend on the utility meter reading procedures.

Worked Example 1

- Previous reading was 73060 and current is 73078, therefore:
- Current usage = Present – Previous = 073078 – 073060 = 18 units or (18 kWh). This is the monthly energy consumption. Billed days is 30.
- Daily energy consumption is 18/30 = 0.6kWh/day.
- So, the consumer can take note of monthly and daily energy consumption which is then comparable from one billing period to another.

LIGHTING

Natural light

- Some considerations and techniques whilst using natural light include:
- *Windows and other types of natural lighting, especially skylights and glazing facing east and west, be avoided unless there is consistent shading from trees or parts of the building. At least, the skylights should be glazed with diffusing glass rather than clear glass to avoid glare to eyes.*

Incorrect Positioning: Facing East/West

Natural light

- In the tropics, indirect lighting through the roof is reasonable using “light tunnels” or similar approaches that prevent direct sunlight entry into the room but do increase the room lighting without the use of electricity.
- Painting internal walls with a light color to reflect light inside the room rather than absorb the light.

Natural light

- It should be noted that residential lighting is cheap these days, cheaper than operating fans or air conditioning units. Since the main cause of heating in a residence is direct solar heating, keeping sunlight out is an important energy efficiency factor in the overall energy efficiency measures.

Energy-efficient Lighting

- Artificial lighting is characterised by the lumens and the ‘colour temperature’ of the light emitted. Lumens represent the amount of visible light emitted, so an 800 lumens incandescent light and an 800 lumens LED (light-emitting diode) light will produce the same amount of visible light.

Energy-efficient Lighting

- The colour temperature represents the ‘feel’ of the light: a ‘warm’ yellow (or pink-white) light versus a ‘cold’ blue-white light; this is usually stated in Kelvin (K), the unit of absolute temperature (Figure 2).

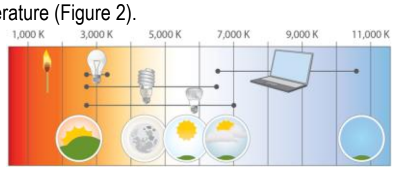


Figure 2 The Kelvin scale of light colour temperatures

Power Consumption – Common Lights

	Incandescent	Halogen	CFL	LED
Description	An older style of lighting, no longer sold (banned) in many countries. It is effectively a metal filament heated until it glows and produces light. Incandescent are least energy efficient.	This lamp is a combination of halogen gas around a tungsten filament. Halogen lamps are able to operate at much higher temperature and provide better light efficiency than incandescent lamps. They produce heat when operating.	An adaptation of traditional linear fluorescent lighting that can be retrofitted into traditional light fittings to replace incandescent and halogen lamps for energy efficiency gains	LEDs are combined in groups in lamps or light fittings to produce a bright and extremely energy efficient light source. There is accelerated use of LEDs in traffic lights, car headlights, street lights, general lighting, etc.
Luminous flux and Wattage				
450 lumens	40W	29W	11W	9W
800 lumens	60W	43W	13W	12W
1,100 lumens	75W	53W	20W	17W
1,600 lumens	100W	72W	23W	20W
Average Rated life (h)	750 - 2000	2000 - 4000	8000 – 20,000	35,000 to 50,000
Efficiency	Least Efficient			Most efficient

Comparison of Luminous Characteristics

Luminous Performance Characteristics of different Luminaires

Type of lamp	Lumens/Watt		Colour rendering index	Typical Applications	Typical life (hours)
	Range	Average			
Incandescent	8-18	14	Excellent (100)	Homes, restaurants, general lighting, emergency lighting, etc.	1000
Fluorescent lamps	46-60	50	Good (67-77)	Offices, shops, homes, offices, etc.	5000
Compact Fluorescent lamps	40-70	60	Very good (85)	Hotels, shops, homes, offices, etc.	8000-10,000
High pressure mercury (HPMV)	44-57	50	Fair (45)	General lighting in factories, garages, car parking, flood lighting, etc.	5000
Halogen lamps	18-24	20	Excellent (100)	Display, flood lighting, stadium exhibition grounds, construction areas, etc.	2000-4000
High pressure sodium	67-121	90	Fair (22)	General lighting in factories, ware houses, street lighting, etc.	6000-12,000
Low pressure sodium	101-175	150	Poor (10)	Roadways, street lighting, etc	6000-12,000
Metal halide lamps	75-125	100	Good (70)	Industrial bays, flood lighting, retail stores, etc.	8000
LED lamps	30-50	40	Good (70)	Reading lights, desk lamps, night lights, spotlights, security lights, signage lighting, etc	40,000 – 100,000

Luminaire design and positioning

- Major considerations for luminaire design and positioning include:
  - Whether the light is diffused or directional
  - Whether the light is localised or distributed over a large area
  - The proportion of light produced by the lamp that is absorbed by its fitting (luminaire efficacy)
  - The colour temperature of the lamp

Recommended illuminance for various tasks

Class of Task		Recommended maintained Illuminance (Lux)	Representative Activities
Movement and Orientation		40	Corridors, walkways, etc
Rough intermittent		80	Staff change rooms, loading bays, locker rooms, etc
Normal range of tasks	Simple	160	Waiting areas, staff canteen, entrance halls, etc
	Ordinary or moderately easy	240	Food preparation areas, kitchen, etc
	Moderately difficult	320 - 400	Routine office tasks (reading/writing), study rooms. Inspection of medium work
	Difficult	600	Drawing boards, fine painting, fine machine works
	Very difficult	800	Fine inspection, colour matching of dyes
Extremely difficult		1200	Graphic arts, extra fine works
Exceptionally difficult		1600	Jewellery and watch making. etc

General Measures in Lighting systems

- Reduce excessive illumination levels to standard levels using multiple switches, de-lamping, etc.
- Aggressively control lighting with clock timers, delay timers, photo-sensors, occupancy sensors, etc.
- Install efficient alternatives to incandescent and mercury vapor lighting. Look at - Efficacy (lumens/Watt) of various technologies.

General Energy Conservation measures in Lighting systems

- Select ballasts and lamps carefully with high power factor and long-term efficiency in mind.
- Upgrade obsolete fluorescent to LED lamps or high efficiency fluorescent types.
- Consider lowering the fixture to enable using less of them.
- Consider day lighting with the use of light tunnels where practical, avoid using east or west facing skylights unless they are shaded, since this will ensure less heat gain to the building.

Worked Example 2

- A house has 4 x 4ft fluorescent tube lights at 43W each (accounting for the losses in the ballast). The lights are on for 5 hours on average each day. An inspection was carried out with a lux meter, that showed the sitting room area having a lux of 400 whereas a lux of 160 would have been sufficient according to the recommended levels. The owner is now thinking of reducing the number of lights to 2 lights to get the recommended lux.

Worked Example 2

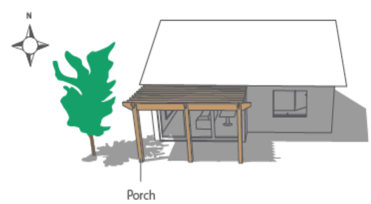
- At the same time, the owner is considering replacing the fluorescent tubes with LED tubes.
- With the 4 fluorescent tubes, the owner would have been yearly consuming = 4 x 43 x 5 x 365 = 314 kWh
- Assuming a tariff rate of $0.33/kWh, the yearly cost comes to 314 x 0.33 = $103.62
- Upon using 2 LED tubes, the owner would be yearly consuming = 2 x 18 x 5 x 365 = 65.7kWh
- Assuming a tariff rate of $0.33/kWh, the yearly cost comes to 65.7 x 0.33 = $21.68
- Suppose the owner buys the LED tubes for $10 each, a total of $20 to retrofit in the fluorescent fitting, the net savings will be $103.62 - $21.68 - $ 20 = $61.94 in the first year and $103.62 - $21.68 = $81.94 in subsequent years. The cost of the LED tubes would be recouped in approximately 3 - 4 months via energy savings.

HEATING AND COOLING

Direct Sunlight and Shading

- The cause of heat gain is direct sunlight that enters through a window, and is absorbed by the building's elements, e.g. floor and fittings.
- This heat gain is then converted to heat which is transferred to the space in the room. This can be true for all building surfaces, including walls and roofs.
- For most houses in the islands, the roof is the main source of heat with walls facing east and west a problem too. Also, large glazing areas facing east and west also contribute in heat gain.

A Tree and a Porch Shading the House



Windows

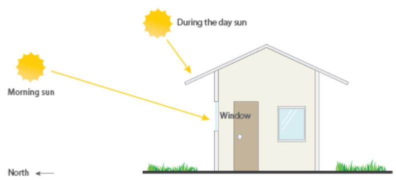
Examples of techniques to reduce heat transfer through window include:

- Long overhangs and windows facing only to the north and south are best since the overhangs will shade the windows and there will be little or even no direct solar entry during the day (Figure 4). East and west sides of the house should have verandas or no windows at all where practical.

Curtains and Blinds

- Curtains and blinds: Suitable material with insulating properties can create an insulating air gap between the window and the room. Curtains and blinds should have a white color or reflective surface.

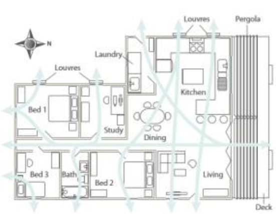
Use of Long Overhangs

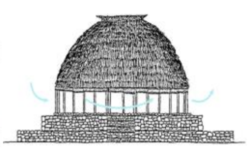


Air Movement and Ventilation

- Good ventilation design can capture prevailing cool breezes to keep a house cool in hot and humid conditions, or flush out hot air from the interior quickly and effectively on hot evenings.
- Cross-ventilation can be achieved by positioning doors and windows on opposite sides of the house to allow wind to flow through (Figure 5).

Cross -Ventilation





Insulation and Thermal Mass

- Insulation reduces the transfer of heat in or out of a house, helping to keep the indoor temperature stable. Without insulation, the indoor temperature of a house would be strongly influenced by outdoor conditions, increasing the cooling requirements.

Insulation and Thermal Mass

- An excellent way to almost eliminate roof heat entry is to place reflective foil insulation directly under the roofing material and foam or fibreglass insulation over the ceiling then ventilate that attic space – preferably with eave level openings to let in cooler air and a ridge vent to let the heated air out by convection.

Air Conditioning and Other Heating and Cooling Devices

There are two main ways of cooling a building efficiently:

- Ceiling fans: a low energy appliance that can be used year long. The blades rotate so that air is blown downwards increasing natural body cooling.
- Air conditioners: The current ranges of high efficiency inverter type air conditioners present an efficient way of cooling if used together with insulation and other types of cooling. In hot conditions, the temperature should be set around 23–25°C.

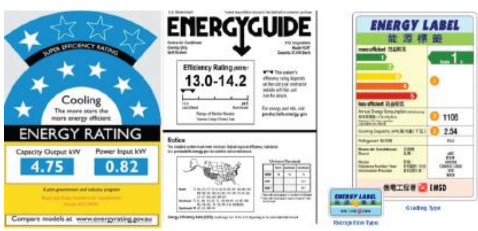
Air Conditioning and Other Heating and Cooling Devices

- Furthermore, it is also recommended to use high efficiency domestic single-phase air conditioners with a high government issued energy rating label to achieve lower electricity consumption.
- In some countries in the Pacific, Australian, Japanese, Chinese and USA government issued energy labels are required on all imported refrigerators, freezers, air conditioners and other energy using appliances.

Air Conditioning and Other Heating and Cooling Devices

- Just like on other appliances, air conditioners are given star ratings, Australia/New Zealand labels mostly use blue for their cooling function. The more stars a product has, the more efficient it is, however, energy consumption is the major determinant. Examples of different types of energy labels are shown in figure.

Energy Labels for AC



Energy Labels for AC

- The capacity output figures on an air conditioner label will let you know the amount of cooling the model can produce.
- These are the figures you should check when comparing star ratings with Australia/New Zealand/US/China energy labels.
- The US label provides rating in SEER, the higher the value, the more energy efficient it is. The Chinese labels come with grading with grade 1 as most efficient and grade 5 as least efficient.

Suitable Size

- Sizing for air conditioners is provided as a kilowatt (kW) capacity output figure (not to be confused with the power input, which is the amount of power required to produce the listed cooling /or heating output) and you can find this on the energy rating label, as well as on the manufacturer's product literature.
- In the US, this is usually stated in BTU.

Suitable Size

- There are many different elements within your home that will impact on the size of air conditioner you will require. These include (but are not limited to):
  - Whether you are looking to heat/cool a single room, a larger space or your entire home;
  - Size of room/home (including ceiling height);
  - External wall materials;
  - Insulation levels; and
  - How many windows you have, their glazing, shading and orientation.

General Measures

- Other general measures to ensure energy conservation pertaining to air-conditioners include:
- Ensure regular maintenance is performed, such as cleaning air filters.
- Close off rooms not in use. Shut doors and vents to unused areas and only heat or cool the rooms you're using.
- Improve window efficiency. Prevent heat gain with well-fitted curtains and blinds. Open curtains to let the sun in during the day and close them before it gets dark in cold conditions. Close curtains during the hottest part of the day.

General Measures

- Consider tinted film on windows to reflect heat. This reduces heat gain.
- Catch the breeze. Make the most of natural airflow in the cooler parts of the day by opening windows to bring in the breeze and let the hot air out.
- Use fans before air conditioning. Fans cost less to run (much less than air conditioners) and move heat away from a person's body so the person feels cooler. Combining the use of ceiling fans and Air-conditioners can be cost effective

Hot Water

- Hot water can be amongst the largest energy user for a household along with refrigerators and freezers.
- Although picking an energy-efficient method of heating water will help reduce energy usage, it is also important to consider reducing the amount of hot water used.
- For example, having "cold showers" to cool off or shorter showers or installing water-saving shower heads. There are various methods to heat water, with electricity or gas being the primary energy sources.

Advantages and Disadvantages

	Storage Water Heaters	Instantaneous	Solar Water Heaters
Advantages	- Cost to heat water is paid according to how much hot water is used.	- Low upfront cost. - Cost to heat water is paid according to how much hot water is used. - Unlimited hot water. - Physically small installation. - Minimal waste of water compared to storage water heater.	- Uses a free and clean energy source reducing the amount of electricity used. - If natural heat is not enough, it can be boosted with electricity.
Disadvantages	- Uses a lot of electricity; can be expensive. - Supply of hot water each day is limited by storage tank capacity. - Radiates heat into the space where it is located.	- Has a minimum flow to operate and takes time for heat exchanger to reach temperature.	- Requires suitable roof space and a more complicated installation. - Requires storage tank. - More expensive to install than conventional electric or gas water heaters.

General Measures – Hot Water

Some general hot water delivery energy saving measures include:

- Take showers directly from the tap without any heating or take short showers instead of baths.
- Lower the temperature on your water heater when possible.
- Fix leaks in pipes.
- Install low-flow shower heads.

General Measures – Hot Water

- Install a timer that turns off your electric water heater at night or times when you don't use it. You can also do it manually when using solar water heaters with back-up heating. Switch on back-up heating only when required due to rainy weather or excessive water use.
- Consider replacing with a more energy efficient water heater.

FREEZERS AND REFRIGERATORS

Freezers and Refrigerators

- Relevant energy departments in some Pacific Island countries are now making it mandatory for appliances to follow certain product standards or be compliant to regional standards in order to be imported for the country markets.
- They may also require them to come with energy rating labels. Always consider purchasing refrigerator with a lower kWh per year and with a higher energy star rating. Note, a 5-star unit that is actually too big for a family use and uses 600kWh/year is a worse choice than 3-star refrigerator of sufficient size that uses 500kWh/year.

Energy Labels for Refrigerators

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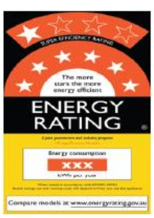

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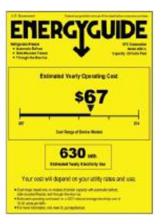
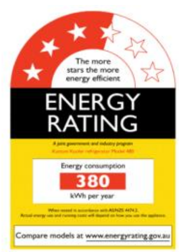
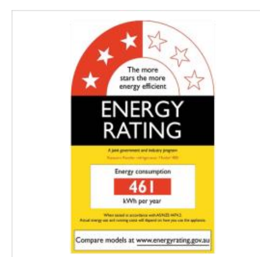


Worked Example 3





Worked Example 3

- Assuming both the refrigerators in figure meet the storage/usage requirements of a customer and he/she does not have any budget constraints. The customer finds 3.5 star rating attractive but wishes to know how much energy is drawn daily and how much it will cost them to run the refrigerator for the entire year in both cases.
- Case 1 – 3.5 star with 380kWh yearly consumption
- Daily energy consumption will be 380/365 = 1.04kWh/day
- Assuming a tariff rate of $0.33/kWh, the yearly cost will be 380 x 0.33 = $125.4/year. Therefore around $10.45/month.
- Case 2 – 3 star with 461kWh yearly consumption
- Daily energy consumption will be 461/365 = 1.26kWh/day
- Assuming a tariff rate of $0.33/kWh, the yearly cost will be 461 x 0.33 = $152.13/year. Therefore around $12.68/month

General Measures – Refrigerators/Freezers

Some general ways to conserve energy pertaining to refrigerators and freezers include:

- Avoid over – sizing, match the items that are to be refrigerated.
- Install units with a lower energy consumption and higher energy rating where economical.
- Avoid frequent opening of doors.
- Ensure the door seals are clean and tight, and it shuts completely.
- Place units in a cool, well-ventilated place out of the sun.

Other Common Electrical Appliances

- Washing machine and dryers: Use energy efficient washers, replace old washers and dryers with more efficient units and use clothes line drying where possible.
- Dishwasher: Wash only full loads. Use energy efficient appliances, replace old dishwashers with more efficient ones.
- Electric Kettles: Replace inefficient electric kettles. Plan hot water usage and use thermo flask to store water for daily usage. Heat water through gas stoves if electricity bills are to be reduced.

Other Common Electrical Appliances

- Television: Power consumption varies depending on the brightness levels chosen for the screen, with the higher brightness levels consuming more power. Position the TV so that there is minimal glare from windows or lighting, otherwise the brightness may need to be increased. Televisions also come with energy rating labels, always prefer the lower yearly energy consumption unit in the screen size

Other Common Electrical Appliances

- Computer: Switch computer off when not in use, including the monitor. Ensure power management is enabled for computers and monitors. Avoid using "screen savers" as the monitor will consume more than in sleep mode.
- Standby power: Turn off appliances at the wall to reduce unnecessary use of power in standby mode. The use of accessible switches, timers and automated controls in the home can also assist in reducing energy consumption.

Water Efficiency

- Water-efficient appliances and fixtures, combined with sensible water use, saves money and helps in becoming more energy efficient. The biggest water-users in the home are washing machines, showers, taps and toilets. Some of the water saving recommendations include:
- Upgrading to water-efficient appliances and fixtures. An example is shown in figure 9. The higher the star rating, the more water efficient the appliance.
- Upgrading to showerheads with lower flow rate in litres per minute. There will also be savings on energy bills because less water will need to be heated.
- Avoid leakages in pipes.

ENERGY AUDIT

Energy Usage Assessment - Residential/Small Commercial Buildings

- An energy usage assessment is essential for lowering high energy consumption for residential / commercial buildings.
- Many households/organisations would like to save energy, but to have the most impact and success, they need to do an energy usage assessment.
- Energy audits will help to understand more about the way energy is used for the small commercial installation, and help in identifying areas where energy waste can occur.

Preliminary Energy Audit

The methodology of preliminary energy audit may include the following:

- Establish energy consumption in the household/organisation (energy bills and invoices).
- Obtain related data on energy consumption (rating, operating hours, etc.).
- Estimate the scope for energy saving.

Preliminary Energy Audit

- Identify the most likely and the easiest areas for attention (e.g. unnecessary lighting, higher temperature settings, insulation, leakages, etc.).
- Identify immediate especially no or low-cost improvements/savings (replacement of lamps, switching off equipment when not in use).
- Set up a reference point for energy consumption.
- Identify areas for more detailed study/measurement (Investigating scheduling of process operations, data logging, energy meters, etc)

Detailed Energy Audit – Phase 1

Step No	Plan of Action	Purpose / Results
	Phase 1 – Pre-Audit Phase	
Step 1	- Plan and organise - Walk through Audit - Informal interview	-Establish an energy audit team or hire services. -Organise instruments and time frame. -Easily available data collection (energy bill). -Familiarisation with commercial operations. -First hand observation of current level of operation and practices.
Step 2	- Introductory Meeting with audit team and people concerned	-Build co-operation, organise assessment sheets, etc.

Phase 2

	Phase 2 – Audit Phase	
Step 3	Primary data gathering and detail household/small commercial operations	-Operation flow chart, single line diagram of installations, etc. -Annual energy bill and energy consumption pattern.
Step 4	Conduct assessment and monitoring	-Measurements (data logging). -Lighting survey, confirm and compare all equipment operating data with design data. Look at efficiencies, energy ratings, year of manufacture, etc. -Assessment of non-electrical aspects such as roof/wall color, positioning of trees and verandas, placement of fans and appliances, etc.
Step 5	Conduct detailed trials (This maybe more applicable to large residential or commercial installations)	Trials/tests - 24hour power monitoring (maximum demand, power factor, kWh). - Load variation trends.

Phase 2 – Cont'd

Step 6	Analysis of energy use	-Identification of areas needing changes.
Step 7	Development of energy conservation opportunities	-Conceive, develop and refine ideas. -Review ideas suggested. -Research and do brainstorming on new/efficient technology.
Step 8	Cost benefit Analysis	-Assess technical feasibility, economic viability, etc. -Select most promising options. -Prioritise by low, medium- and long-term measures.
Step 9	Report and Present (if required)	Document draft report

Phase 3

Phase 3 Post Audit Phase		
Step 10	Implementation and follow up	Monitoring and periodic review

Equipment for Energy Audit

Name	Function	Precaution
Multimeter	Measures voltage, current, frequency, etc.	Avoid short circuits. Watch out for maximum voltages. Do not use instrument when hands are wet.
Clamp meter	Mostly for measuring load in amps.	Check out rating of clamp meter before use on bigger equipment
Data logger	Measures and records voltage, current, kVA, kWh, Hz, etc for a time duration.	Follow safety procedures while hooking this up in the switchboard
Lux meter	Measures incident light and this value in Lux could be evaluated against the human daylight sensitivity curve.	No major precaution needed.

Equipment for Energy Audit

Smart Energy Meters	The primary purpose of smart meters is to provide information on how end users use their electricity on a real-time basis. It uses a wireless communication to help track the electricity consumption and thus save both electricity and money. Electricity consumption can be controlled and monitored through mobile or internet.	Requires correct wiring. Avoid short circuits.
Plug in energy meters	Inexpensive energy meters can provide much of the basic data required. Provides cumulative kWh for a recording period, instantaneous V, A, W, PF and frequency.	No major precaution needed.

Measuring current in a circuit using a clamp meter

Motor Efficiency

Some general measures to lower energy consumption in motors include:

- Properly sized to the load for optimum efficiency.
- Use energy-efficient motors where economical.
- Use soft starters or voltage reduced methods to start for large motors.
- Use synchronous motors to improve power factor.
- Check alignment.
- Provide proper ventilation.
- Check for under-voltage and over voltage conditions.

Power Factor

- The power factor of the motor is given as:
- Power factor = Cos ø = kW/kVA
- Induction motors, especially those operating below their rated capacity, are the main reason for low power factor in electric systems. Therefore, the motor should be matched and rated for the right application. Lightly loaded motors run at low power factor, and thus draw more energy.

Worked Example 4

- Suppose, the power requirement for a motor is 2kW. The current requirement at power factor of 0.85 will be:
- Using, P = VI cos ø
- I = P/(V cos ø) = 2000/(240 x 0.85) = 9.80A
- Next, the current requirement at power factor of 0.7 will be:
- I = P/(V cos ø) = 2000/(240 x 0.7) = 11.90A
- The load requirement of 2kW is the same, however at low power factor, a higher current is required which means increased energy consumption

Motor Maintenance

A checklist of good maintenance practices to help ensure proper operation would include:

- Inspecting motors regularly for wear in bearings and housings and for dirt/dust in motor.
- Checking load conditions to ensure that the motor is not over or under loaded.
- Lubricating properly. Manufacturers generally give recommendations for how and when to lubricate.
- Checking periodically for proper alignment of the motor and the driven equipment. Improper alignment can cause shafts and bearings to wear out quickly.

Energy Conservation opportunities in Small Pumping Systems

- Ensure adequate Net Positive Suction Head (NPSH) at site of installation.
- Installation of high efficiency pumps.
- Operate near best efficiency point.
- Use booster pumps for small loads requiring higher pressures.
- Repair seals and packing to minimize water loss by dripping.
- In the case of an over designed pump, provide variable speed drive or downsize/replace impeller or replace with correct sized pump.

Annex 1

Sample Home/ Small Commercial Energy Audit Checklist

Name of Owner: ____________________
Address: ____________________
Phone Contact: ____________________
Does the building have energy metering facility? ____________________
(If no, go to section B)
Date of start: ____________________
End Date: ____________________

A) Obtain last 6 months electricity bill

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Monthly Electricity Consumption (kWh)						
Billing days						
Daily Electricity consumption (kWh)						

Analyse the trend and reasons for rise or fall. Identify scope and areas for further analysis.
Comment: ....
....
....
....

Annex 1

B) Fill table appropriately. Walk-in survey. For small commercial, draw flow charts, etc to know equipment operation process, schedules, etc.

No	Area	What is wasting Energy?	How to save energy?
1	Lighting		
2	Water heater and piping		
3	Air-conditioner		
4	Refrigerator		
5	Electric kettle		
6	Electric Iron		
7	Television		
8	Other small power appliances		
9	Motor loads (for small commercial)		

C) This may require obtaining measurements or looking at ratings of individual appliance.s

	Loads	Number of equipment	Watts /Amps/Lux	Duration of Use	Estimated daily Energy consumption	List (high, medium to low)	Scope for saving
1	LED lights						
2	Refrigerator						
3	Air conditioner						
4	Electric Iron						

Annex 1

5	Electric kettle						
6	Water heater						
7	Television						

D) For small commercial, if data logging is required, record results in a table. Draw graphs. Identify current-intensive equipment, maximum demand, etc.

E) Final Calculations/Rough cost-benefit analysis/Recommendations.

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F) Comments upon implementation and monitoring for next few months or a set timeframe.

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