Energy Management and Energy Audits
in
Small Island Developing States

Webinar V : **Save Energy, Save Money**

Target audience: *Homeowners and Youth*

Date: 22- 23 June 2022
Time: 12.30 to 14.00 pm GST

Content

- **Background**
  - *Objective, Methodology, Target audience*
- **Day-1: Energy Management Training for Homeowners and Youths**
  - *Fundamentals of Energy, Efficiency and Conservation*
  - *Understanding your Household Electricity Bill*
  - *Energy Conservation Measures in Homes & Schools*
  - *Q&A*

Introduction

Background

Government of Grenada recognized that **reducing the energy consumption, managing and increasing the efficiency of energy usage** - is the quickest and cheapest way to have the highest returns on investment for energy transition.

Objective

To strengthen various energy end users' capacity, to undertake energy audits and identify energy cost saving measures which can be implemented practically.

Methodology

Conduct a series of webinars and a face-to-face training program

- ☞ Developing training materials
- ☞ Webinars – for various type of end users
  - **First Webinar :** Homeowners and Youth
  - **Second Webinar :** Hotels and Financial Institutions
  - **Third Webinar :** Training institutions government ministries and statutory organisations
  - **Fourth Webinar :** Commercial and Industrial Sectors
  - **Face to Face** session and on site practical training secession
  - **Fifth Webinar :** Homeowners and Youth

Fundamentals of Energy Efficiency and Conservation

Introduction - Energy

- What is Energy…???

Energy helps us to do **Work**.






Definition of Energy

- ***Energy*** – It is the ability/capacity to do work
- ***Work*** – It is the transfer of energy. A force of moving a body over a distance is called work.
- ***Power*** – It is rate at which energy is converted to work

Power = Energy / time (Joules per second or Watts, W)

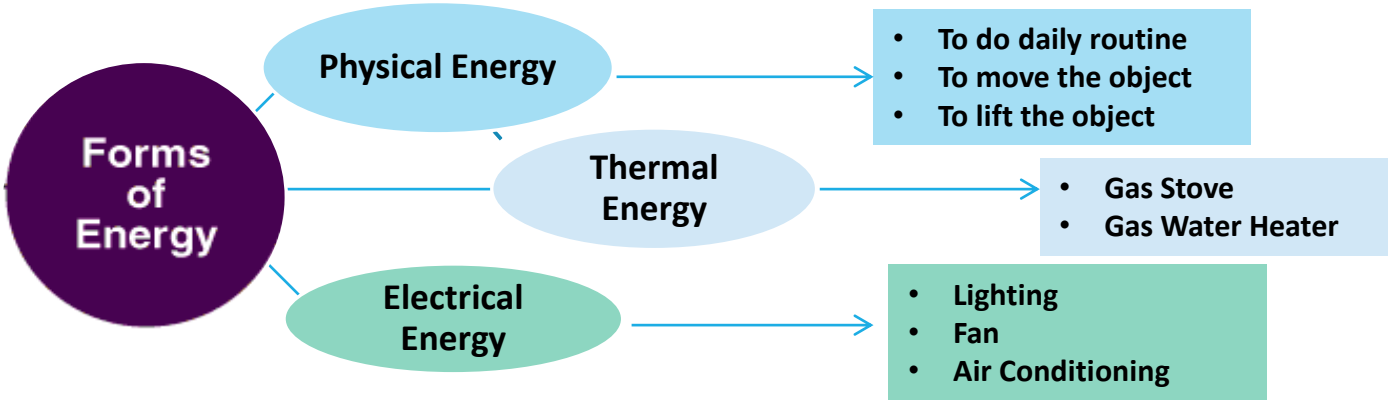
Energy = power x time (kWh)

- ***Kilowatt (kW)*** - A unit of measure of the amount of power needed to operate equipment, equivalent to one thousand (1,000) watts
- ***Kilowatt-Hour (kWh)*** - A measure of electrical energy equivalent to power consumption of 1000 watts for 1 hour. It is the most commonly used unit of measure indicating the amount of electricity consumed over time (*what you get charged*)

1 Joule = Newton x meter

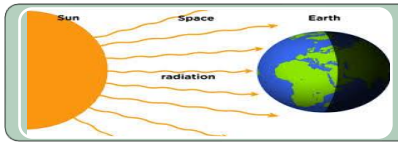
1 Watt = volt x ampere

Different forms of energy



Chemical Energy: is the energy released or absorbed by cleavage/formation of bonds in various compounds.

Some of the examples include fossil fuels such as Gasoline, Mogas, Biomass, Batteries etc.



Electromagnetic Energy: is the radiant energy that travels in the form of waves.

Some of the examples include Visible light, X-rays, gamma rays and radio waves

Mechanical Energy: is energy stored in the form of tension or compression.

Some of the examples include compressed springs and stretched rubber bands

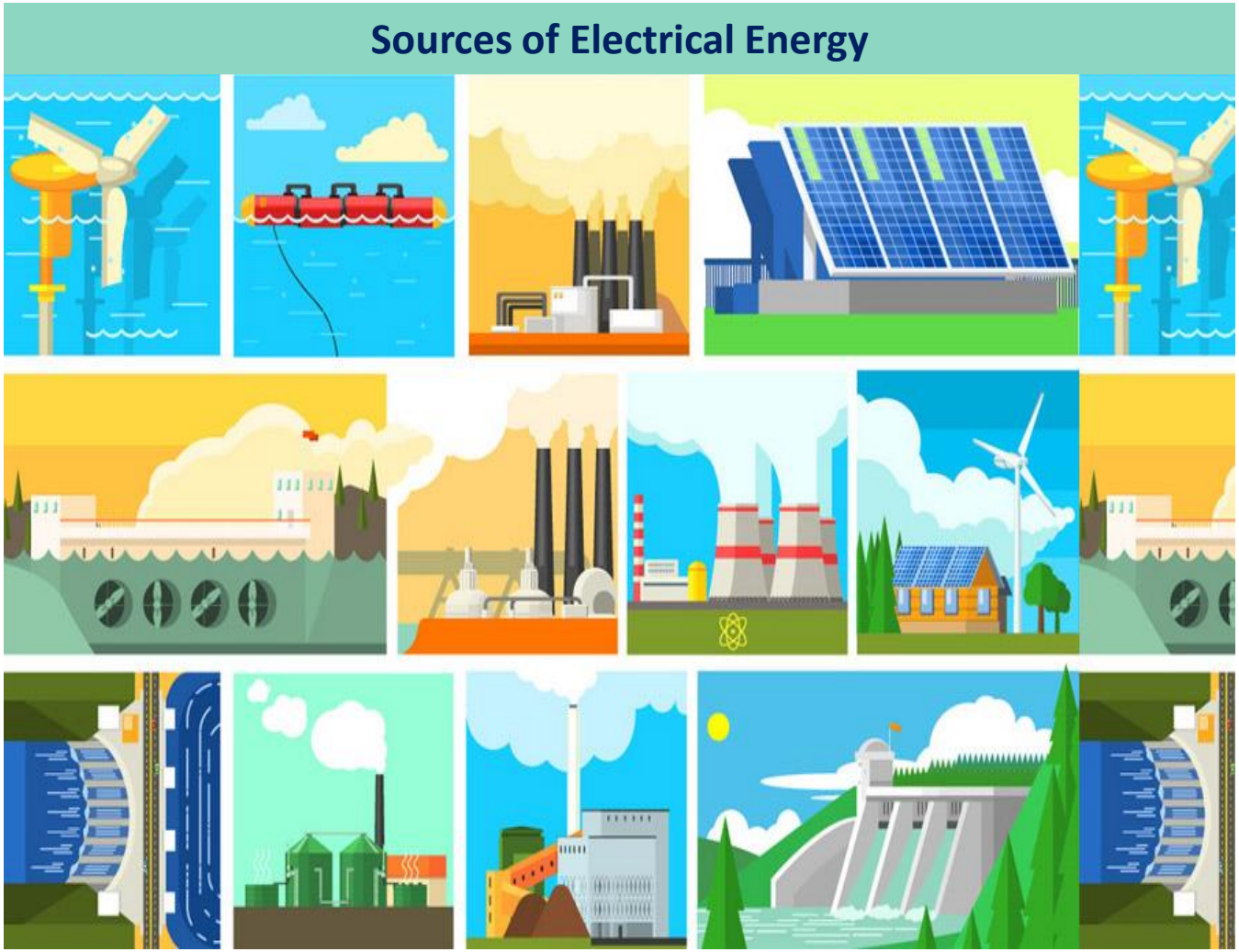
Electrical energy: is delivered by tiny charged particles called electrons moving through a metal wire or some medium.

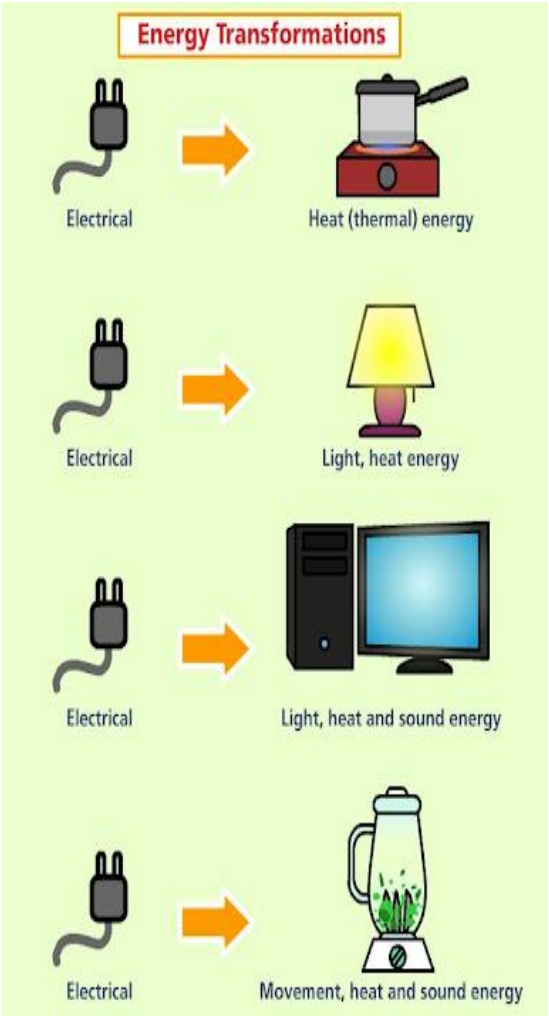
Some of the examples are lightening strikes, power plants

Thermal Energy: is the form of energy generated using temperature difference as the driving force .

Some of the examples include geothermal energy, Steam and solar thermal energy

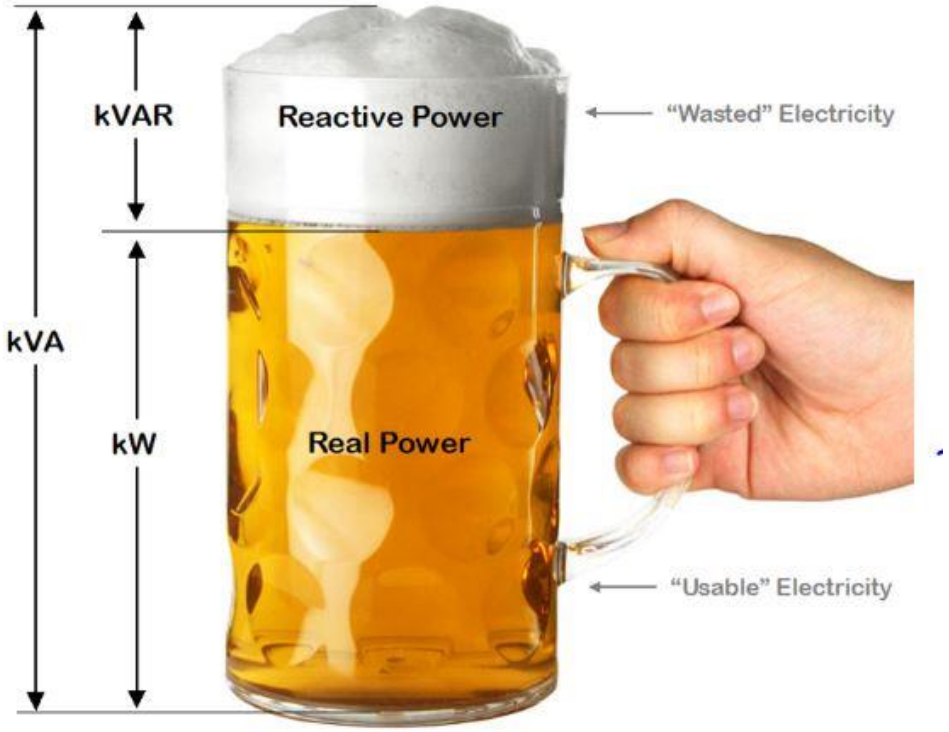
Electrical Energy (Sources & Energy Transformations)





Component of Electric Energy

- Electric Energy
  - Active Power or True Power (kW)
  - Reactive Power (kVAR)
  - Apparent Power (KVA)



Electrical Energy : Metering

How To Decide Which Appliance Will Consume More Energy

- Depends on **“INPUT POWER” or “Active Power”** of the appliance.
- Generally written on **“Product Information Tag”** and measured in **Watt (W) or Kilo Watt (kW)**

1000 W = 1KW OR 1W = 1/1000 KW

INPUT POWER (kW)	X	TIME (Hr)	=	ELECTRIC ENERGY (kWh)

1 Unit of Electric Energy Consumed = 1 kWh
It is the amount of active power or true power consumed in one hour

Energy Efficiency v/s Energy Conservation

Energy efficiency is **"using less energy to provide the same service"** either through technology upgradation or through proper utilization of the appliances.

Energy conservation is any **"behavior that results in the use of less energy"** to do same work**.**

- ☞Turning off a light is energy conservation, not energy efficiency
- ☞Replacing conventional incandescent with LED lamps, is energy efficiency
- ☞Setting air conditioner thermostat temperature at 24^{o}C, is energy conservation.
- ☞Replacing non-inverter air conditioner with inverter air conditioner, is energy efficiency.

Energy Conservation Vs Energy Efficiency

Energy Efficiency	Energy Conservation
Energy Efficiency is using technology that requires less energy to perform the same function (or) service -**Technology improvement / advancement**	**Energy conservation** is using less energy by changing our **behavior or habits** (in addition to using energy more efficiently)
Examples	**Examples**
Use of high-efficiency lighting bulbs (LED)	Use of Staircase
Use of high-efficiency ceiling fans (BLDC)	Use of bicycle
Use of inverter-based air conditioner	Use correct size burner based on a cooking vessel
Use of induction technology – cook stove	Citizens interested in saving energy make use of solar or renewable energy sources (like solar battery back-up for mobile charging /recharging battery/ torch light etc.)

Energy Efficiency v/s Energy Conservation

Both energy efficiency and energy conservation refer to saving energy through its wise and rational use.

Energy Efficiency looks to employment of different technologies to use less energy while providing the same output or function, for example using front load washing machine instead of top load.

Energy Conservation refers to behavioral practices, iron the staff cloths accumulating as batch instead piece by piece.

Importance of Energy

Energy is particularly important to a country's economic growth and development

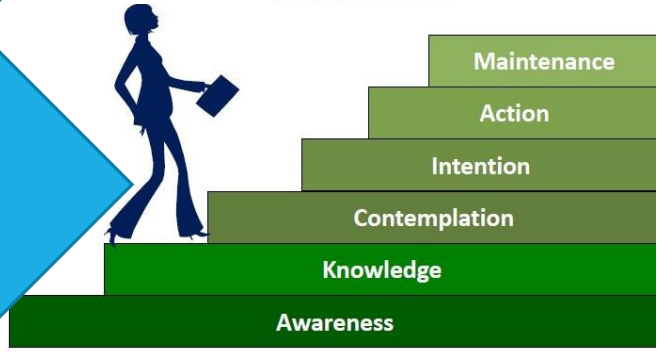
Incandescent Bulb

Energy efficiency is the goal to reduce the amount of energy required to provide products and services.

LED

Energy conservation is the saving of energy by any means including energy efficiency.

Energy Management is defined as the steps taken to minimize usage and wastage of energy.



Energy Use

Scenario: ***Commuting to 2rd Floor in a building in public place***

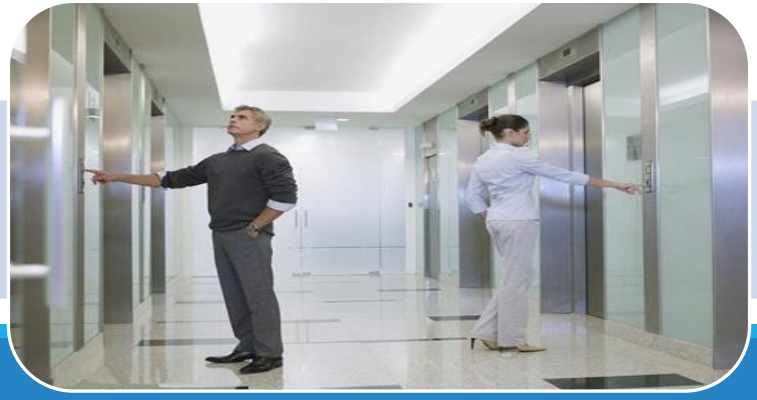
Energy Conservation

Taking the stairs

Efficient Use of Energy

More than 3 people using the lift at the same time

Energy Intensive Process



Single person using the lift

Energy Use

Scenario: ***Travelling to nearest supermarket***

Energy Conservation

Using a bicycle for shopping

Efficient Use of Energy

Hatchback car for moderate shopping

Energy Intensive Process

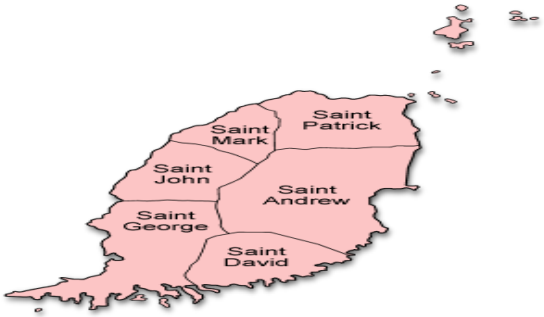
Pick-up SUV car with minimal shopping

Benefits of Energy Conservation

Homes/Buildings/Industry

- Reduced Energy Bills
- Increased comfort levels
- Increased productivity
- Reduced maintenance cost
- Increased profits.

National



- Reduced fuel imports
- Resources to improve infrastructure
- Optimise the additional power demand
- Supports in meeting NDC commitments.

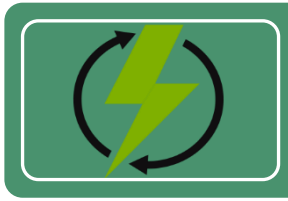
Global

- Reduced Greenhouse gas emissions
- Maintains a sustainable environment.

Energy Management

Efficient energy use, is using less energy to provide the same level of energy service

Wastage of Energy



Minimise energy consumption

Energy Intensity

To look over again and again

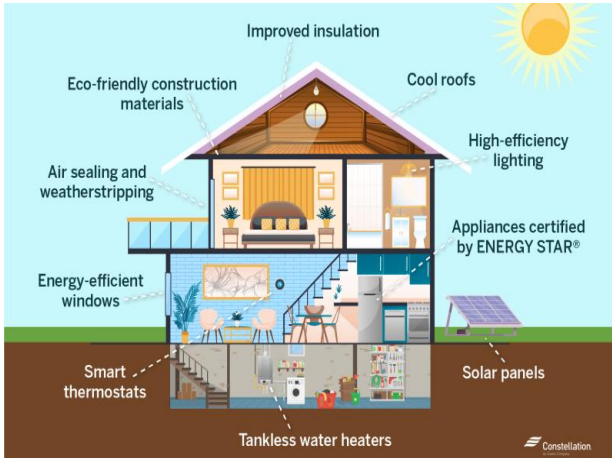
Energy efficiency and Renewable energy are said to be the twin pillars of sustainable energy policy.

Energy Audit

An energy audit is to determine where, when, why and how energy is used in a home / facility (school/ building/hotel), and to identify opportunities to improve efficiency

Preliminary review of energy use

- Collect and analyze utility data
- Base load of appliances to be noted
- Assess energy efficiency improvement potential



Home /Building assessment

- Visually inspect building and key systems
- Home data collection (Electrical Utility bill)
- Interview occupants
- Immediate energy savings opportunities

Data Analysis

- Evaluate equipment performance
- Analyze energy losses and improvement potential
- Develop list of energy saving opportunities

Energy audit report

- Summarize energy audit findings (cost – Benefit)
- Develop action plan for implementation

Energy Audit Step # 1 : Data Collection

- Appliance / Equipment in use, technology related, etc
- Specifications of all major energy consuming equipment / areas /section
- Energy consumption figures from bills / receipts and Costs
- Occupancy and operating schedules
- Specific energy consumption (per month or Sq. meter)
- Best energy efficiency norms and comparison (internal norm of facility or other similar home / hotels)

CUSTOMER NO.	ACCOUNT NO.	ACCOUNT TYPE
0000034233	0034318	Domestic

Estimate

ELECTRICITY CHARGES

METER READINGS		NO. OF DAYS	USAGE THIS PERIOD (kWh)	TYPE OF SERVICE	NON-FUEL	FUEL	DEMAND / FLOOR AREA	DUE DATE	CURRENT ELECTRICITY CHARGES
18-Mar-20	17-Apr-20								
2864	2955	30	91	Metered	$36.92	$38.52		05-Jun-20	$75.44

RATES / kWh (unit)	
FUEL	$0.42329
NON-FUEL	$0.40570
GOVERNMENT CHARGES ECS	
ENVIRONMENTAL LEVY	$0.00
VAT (non-fuel)15%	$0.00
VAT (other)15%	$0.00

ELECTRICAL USAGE HISTORY

PERIOD	DAYS	USAGE (kWh)	kWh/DAY
17-Apr-20	30	91	3
18-Mar-20	30	84	3
17-Feb-20	31	57	2
17-Jan-20	29	122	4
19-Dec-19	27	92	3
22-Nov-19	32	84	3
21-Oct-19	27	64	2
24-Sep-19	32	80	3

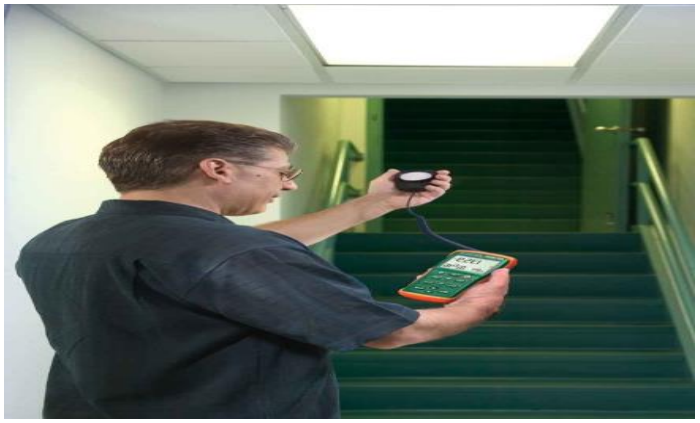
BILLING DETAILS

PREVIOUS BALANCE	$6.77
LESS PAYMENT	$60.00CR
ADJUSTMENTS	$5.46CR
BROUGHT FORWARD	$58.69CR
COVGOVT DISC	$15.01CR
ELECTRICITY CHARGES	$75.44
GOVERNMENT CHARGES	$0.00
TOTAL CURRENT CHARGES	$75.44
TOTAL AMOUNT DUE	**$1.74**

NOTES:
Govt. Discount = $15.01CR
Grenlec Discount = $5.46CR
Your bill shows a COVID-19 relief discount above from Government and Grenlec on your electricity charges (non-fuel & fuel ONLY) for the bill issued in Apr. 2020.

Energy Audit Step # 2 : Observations and measurements

- Observation of present operating practices and parameters set for appliance / equipment
- Measurement of operating parameters and Energy related parameters for all energy sources/utilities using portable instruments/building instrumentation
- Conducting tests and trials on equipment/Utilities to assess the performance wherever applicable
- Review of maintenance practices
- Interaction and discussions with occupants, operators, supervisors, in-charges etc.



Energy Audit Step # 3 : Data Analysis and Findings

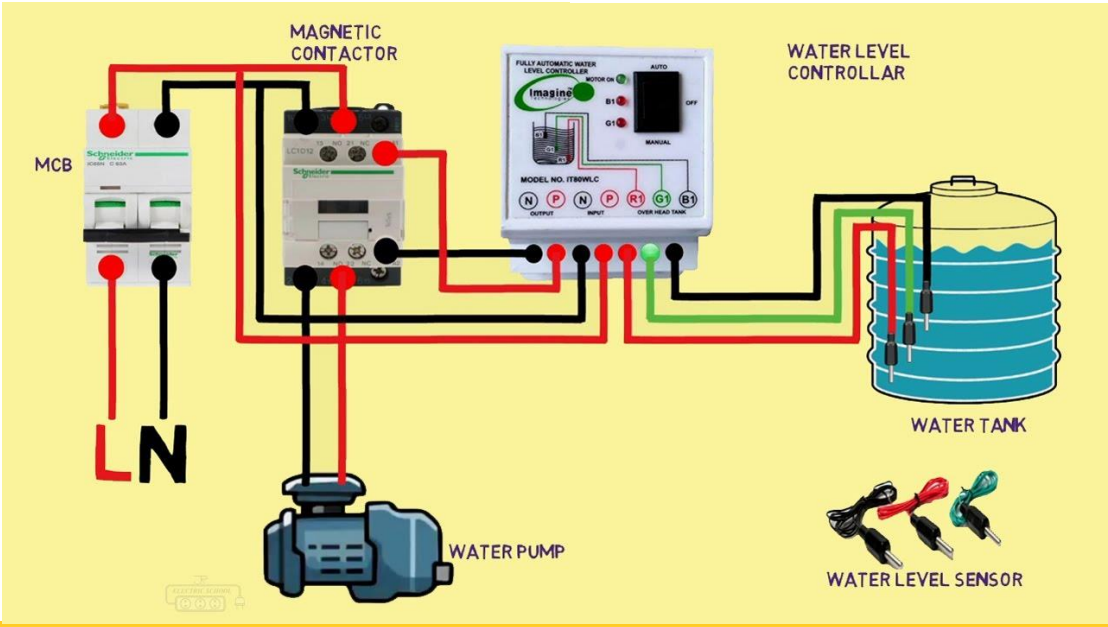
- Estimation of specific energy consumption of each equipment/ area / section and comparison with optimum/design or best achievable values
- Estimation of efficiency and performance
- Identifying the factors contributing to the deviation in specific energy (losses)
- Analysis remedial measures to reduce energy consumption
  - Change in operating parameters
  - Loss reduction
  - Loss recovery/retrofit applications
  - Replacement

Energy Audit Step # 4 : Implementing low-cost measures and conduct trials

- Changing the operating parameters and improved house keeping/ maintenance practices
- Reconducting tests - as in case of boilers, refrigeration and air conditioning
- Other measures such as star delta conversion in motors, reshuffling of equipment, etc.

Energy Audit Step # 5 : Techno-economic evaluation

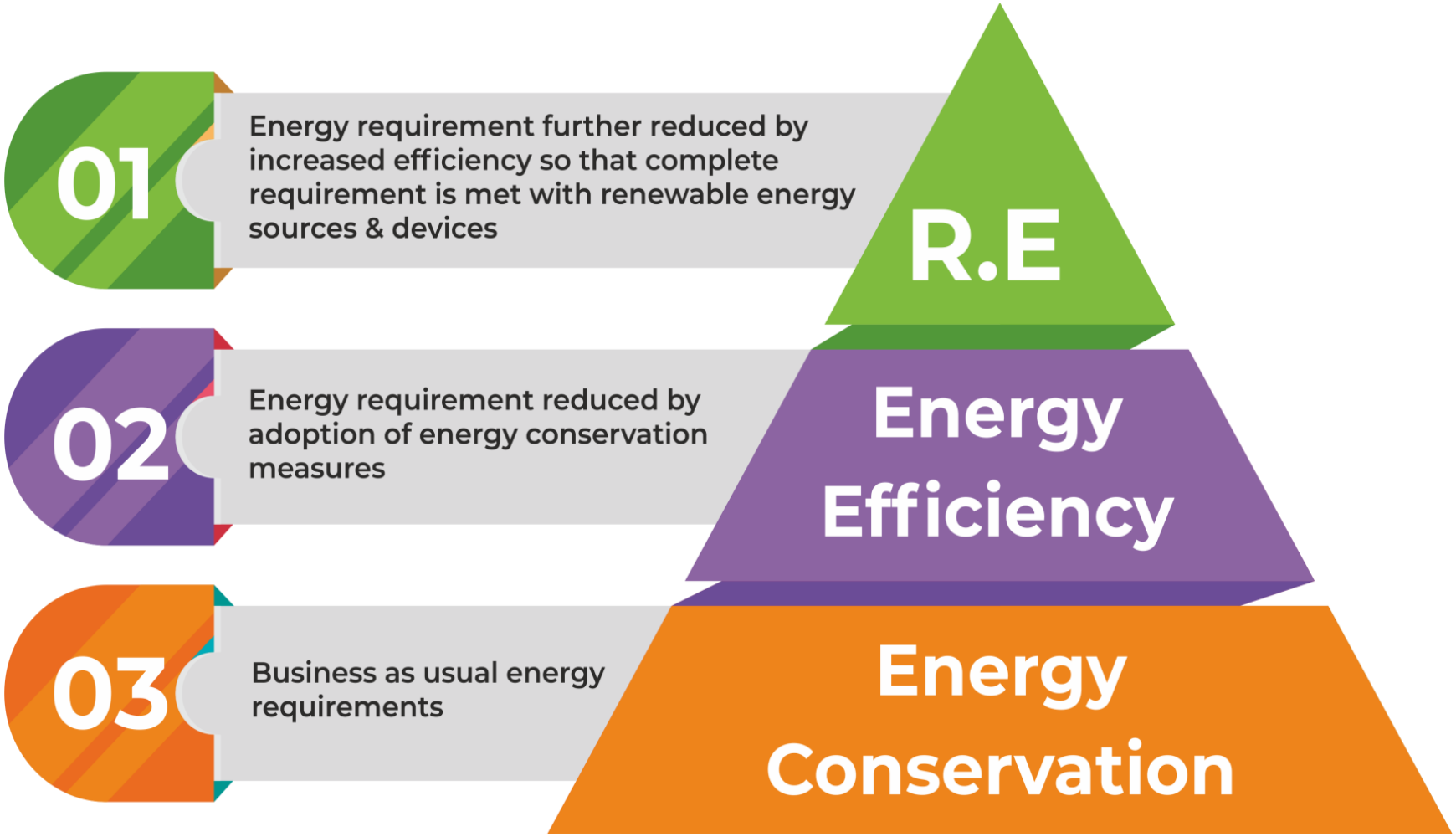
- Estimation of energy savings and other related savings
- Estimation of cost savings
- Estimation of investment required
- Evaluation of payback period/return on investment etc.



Energy Audit Step # 6 : Report preparation and Presentation

- All the measurements, observations, analysis, findings and recommendations of Step # 1 to # 5
- Identifying suppliers/contractors for recommended measures to implement
- Total energy saving potential and total investment required for all the immediate, short term, medium term and long-term measures i.e., based on pay back period
- Classification of measures based on investment (budget available / allocation)

Energy Pyramid - Approach



Session : 2
Understanding Different Components of Electricity Bill

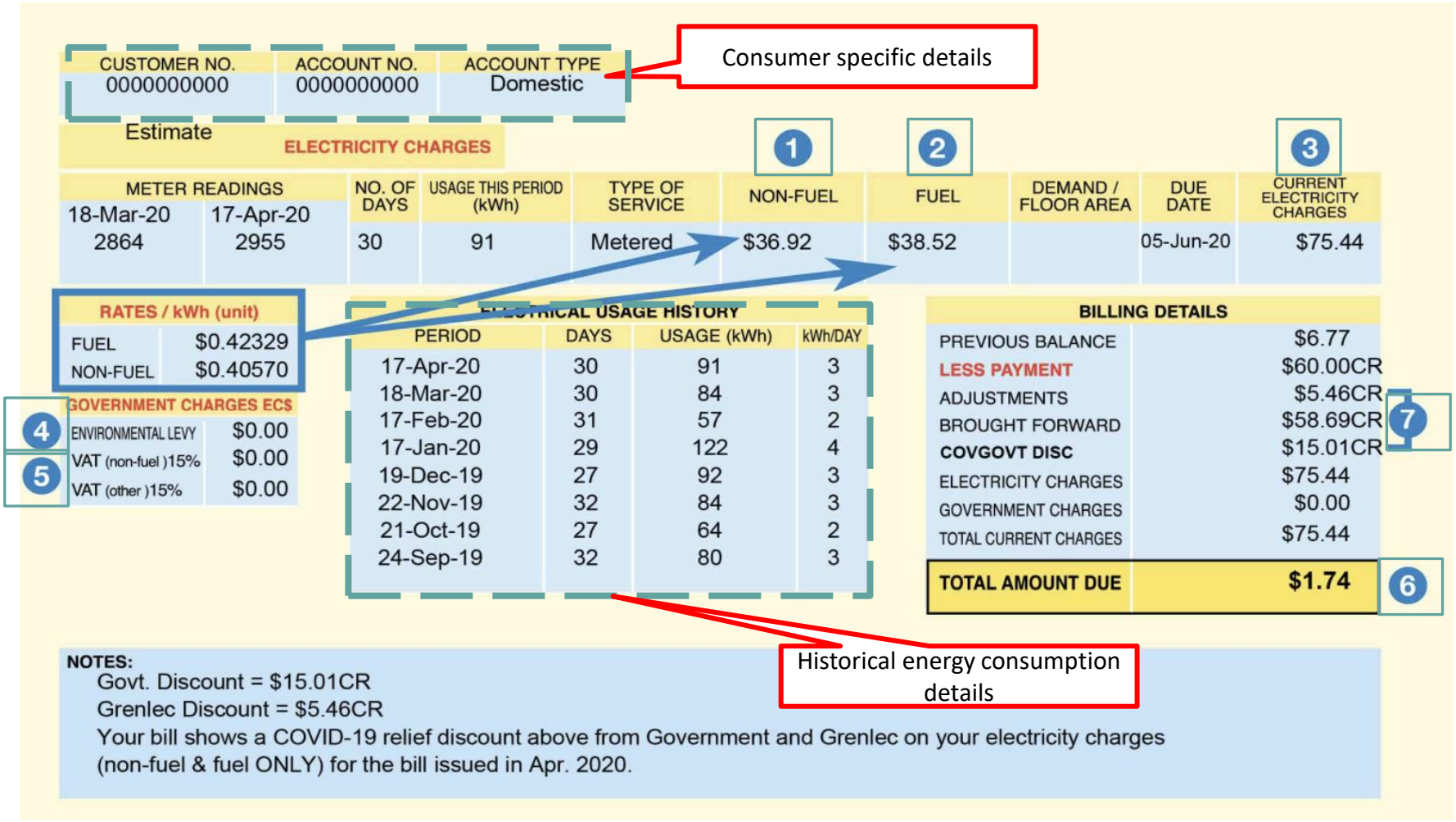
Electricity tariff structure of GRENLEC for 2021

Different Component of Electricity Bill

- **Fuel Charge**
  - Recover fuel cost
  - Fuel Rate x Unit Consumed
- **Non-Fuel Charge**
  - Recover O&M cost
  - Provide profit to electricity utility
  - Non-Fuel Rate x Unit Consumed
- **RE Charges (Future)**
  - RE Rate x Unit Consumed
- **VAT**
  - 15% of nonfuel charges for units >99

Source: https://grenlec.com/customers/ratesandfees/

Understanding your Household Electricity Bill



Source: https://grenlec.com/customers/tools-to-help-you/yourbill/

Factors Impacting Monthly Electricity Bill

- Increase in number of people
- Improper utilization of electrical appliances
- Increase in number of activities due to special occasions
- Faulty installation of equipment
- Billing issues
- Increase in number of appliances

Case Studies : Electricity bill Calculation

Description	Quantity	Wattage	Operating hours/month	Month Energy consumption, kWh
	A	B	C	$D = A * B * C/1000$
Television	01	50	120	6.0
Fridge	01	120	250	30.0
Washing machine	01	400	30	12.0
1.0 Ton Air conditioner	01	800	50	40.0
LED lights	03	15	240	10.8
Outdoor lighting (MH type)	02	40	300	24.0
Total monthly energy consumption				**122.8**

Case Studies : Electricity bill calculation

Fuel charges	= 0.4459 $
Non-Fuel charges	= 0.4057 $
VAT	= 15% of non-fuel charges for monthly consumption above 99 kWh

Total Electricity Bill = (Fuel charge + Non-Fuel Charge)x Number of units in kWh + VAT

Total Electricity bill with the existing equipment

*= {(122.8*0.4459)+(122.8*0.4057)} + (122.8*0.4057*0.15)* = **112 $**

Case Studies : Electricity bill saving option

Option: If Outdoor lamps are replace with integrated solar lamps with 20 W LED lamps and battery backup and photo sensor. Calculate what is the reduction in the electricity bill?

- Monthly energy consumption for outdoor lighting = 0 kWh

Total monthly electricity consumption with Solar outdoor lamps = 122.8 – 24 = 98.8 kWh

Total Electricity bill after replacing all outdoor lighting with Solar outdoor lamps

*= {(98.8*0.4459)+(98.8*0.4057)} + 0 + 0*

= **84.1 $**

Reduction electricity bill = 28% with an investment of 1000 $

Energy Conservation Measures in Homes & Schools

ECM – 1 Replace the conventional lamps with LED lamps

Present Scenario		New Scenario	
Number of Fluorescent Tube Lights **(A)**	4	Number of LED Tube Lights **(A)**	4
Rated Input Power	36 W	Rated Input Power	20 W
Operating Load **(B)**	36 W	Operating Load **(B)**	20 W
Operating Hours Per Day **(C)**	8	Operating Hours Per Day **(C)**	8
Energy Consumption Per Day **(D)** = (AxBxC)/1000	1.15 kWh	Energy Consumption Per Day **(D)** = (AxBxC)/1000	0.64 kWh
Operating Days in a Year **(E)**	365	Operating Days in a Year **(E)**	365
Annual Energy Consumption **(F_{Old})** = ExD	420 kWh	Annual Energy Consumption **(F_{New})** = ExD	234 kWh
Annual Energy Saving **(G)** = **F_{Old} - F_{New}**		186 kWh	
Annual Cost Saving **(H) =** 0.78xG		145 EC$	
Cost of one LED Lamp **(I)**		30 EC$	
Total Investment **(J)** = IxA		120 EC$	
Simple Payback Period **(K)** = J/H		0.8 Years	

ECM – 2 Install motion sensors for alternate lights in Corridors - School

Present Scenario		New Scenario	
Number of Fluorescent Tube Lights in Corridor **(A)**	10	Number of Fluorescent Tube Lights in Corridor **(A)**	10
Rated Input Power	36 W	Rated Input Power	36 W
Operating Power **(B)**	36 W	Operating Power **(B)**	36 W
Operating Hours Per Day **(C)**	15	Operating Hours Per Day **(C)**	10
Energy Consumption Per Day **(D)** = (AxBxC)/1000	5.4 kWh	Energy Consumption Per Day **(D)** = (AxBxC)/1000	3.6 kWh
Operating Days in a Year **(E)**	365	Operating Days in a Year **(E)**	365
Annual Energy Consumption **(F_{Old})** = ExD	1971 kWh	Annual Energy Consumption **(F_{New})** = ExD	1314 kWh
Annual Energy Saving **(G)** = **$F_{Old} - F_{New}$**		657 kWh	
Annual Cost Saving **(H) =** 0.78xG		512 EC$	
Cost of one motion sensor light **(I)**		80 EC$	
Total Investment **(J)** = IxA		800 EC$	
Simple Payback Period **(K)** = J/H		1.5 Years	

ECM – 3 Replace non-inverter AC with inverter AC

Present Scenario		**New Scenario**	
Number of Non-Inverter AC **(A)**	3	Number of Inverter AC **(A)**	3
Rated Input Power	1300 W	Rated Input Power	1300 W
Operating Load **(B)**	1220 W	Operating Load **(B)**	1050 W
Operating Hours Per Day **(C)**	15	Operating Hours Per Day **(C)**	10
Energy Consumption Per Day **(D)** = (AxBxC)/1000	54.9 kWh	Energy Consumption Per Day **(D)** = (AxBxC)/1000	31.5 kWh
Operating Days in a Year **(E)**	300	Operating Days in a Year **(E)**	300
Annual Energy Consumption **(F_{Old})** = ExD	16,470 kWh	Annual Energy Consumption **(F_{New})** = ExD	9450 kWh
Annual Energy Saving **(G)** = **F_{Old} - F_{New}**		7020 kWh	
Annual Cost Saving **(H) =** 0.78xG		5475 EC$	
Cost of one Inverter AC 1 TR Capacity **(I)**		3000 EC$	
Total Investment **(J)** = IxA		9000 EC$	
Simple Payback Period **(K)** = J/H		1.6 Years	

ECM – 4 Minimize operating hours of water pump by using level controller

Present Scenario		New Scenario	
Number of Water Pump **(A)**	1	Number of Water Pump **(A)**	3
Rated Input Power	750 W	Rated Input Power	750 W
Operating Load **(B)**	700 W	Operating Load **(B)**	700 W
Operating Hours Per Day **(C)**	5	Operating Hours Per Day **(C)**	4
Energy Consumption Per Day **(D)** = (AxBxC)/1000	3.5 kWh	Energy Consumption Per Day **(D)** = (AxBxC)/1000	2.8 kWh
Operating Days in a Year **(E)**	365	Operating Days in a Year **(E)**	365
Annual Energy Consumption **(F_{Old})** = ExD	1277.5 kWh	Annual Energy Consumption **(F_{New})** = ExD	1022 kWh
Annual Energy Saving **(G)** = **F_{Old} - F_{New}**		255.5 kWh	
Annual Cost Saving **(H) =** 0.78xG		199.2 EC$	
Cost of one level controller		100 EC$	
Total Investment **(I)**		100 EC$	
Simple Payback Period **(K)** = I/H		0.5 Years	

ECM – 5 Replace Ceiling fans with Electronically Commuted BLDC fans

Present Scenario		**New Scenario**	
Number of AHU **(A)**	5	Number of AHU **(A)**	5
Rated Input Power	75 Watt	Rated Input Power	30 Watt
Operating Load **(B)**	60 Watt	Operating Load **(B)**	28 Watt
Operating Hours Per Day **(C)**	12	Operating Hours Per Day **(C)**	12
Energy Consumption Per Day **(D)** = AxBxC	3.6 kWh	Energy Consumption Per Day **(D)** = AxBxC	1.68 kWh
Operating Days in a Year **(E)**	300	Operating Days in a Year **(E)**	300
Annual Energy Consumption **(F_{Old})** = ExD	1080 kWh	Annual Energy Consumption **(F_{New})** = ExD	504 kWh
Annual Energy Saving **(G)** = **F_{Old} - F_{New}**		576 kWh	
Annual Cost Saving **(H) =** 0.78xG		450 EC$	
Cost of one BLDC fan**(I)**		150 EC$	
Total Investment **(J)** = IxA		750 EC$	
Simple Payback Period **(K)** = J/H		1.7 Years	

ECM – 6 Replace HPMV Perimeter lamps with Solar LED lamps - School

Present Scenario		New Scenario	
Number of street lamps **(A)**	15	Number of street lamp **(A)**	15
Rated Input Power	150 W	Rated Input Power	70 W
Operating Load **(B)**	150 W	Operating Load **(B)**	70 W
Operating Hours Per Day **(C)**	10	Operating Hours Per Day **(C)**	10
Energy Consumption Per Day **(D)** = (AxBxC)/1000	22.5 kWh	Energy Consumption Per Day **(D)** = (AxBxC)/1000	10.5 kWh
Operating Days in a Year **(E)**	365	Operating Days in a Year **(E)**	365
Annual Energy Consumption **(F_{Old})** = ExD	8212.5 kWh	Annual Energy Consumption **(F_{New})** = ExD	3832.5 kWh
Annual Energy Saving **(G)** = **F_{Old} - F_{New}**		4380 kWh	
Annual Cost Saving **(H) =** 0.78xG		3416.4 EC$	
Cost of one solar LED street lamp **(I)**		200 EC$	
Total Investment **(J)** = IxA		3000 EC$	
Simple Payback Period **(K)** = J/H		0.9 Years	

Energy Conservation Measures Summary

Energy Conservation Measures	Simple Payback Period Years
Short Term Measures	
Replace the conventional lamps with LED lamps	0.8
Minimize operating hours of water pump by using level controller	0.5
Replace HPMV Perimeter lamps with Solar LED lamps - School	0.9
Medium Term Measures	
Install motion sensors for alternate lights in Corridors - School	1.5
Replace non-inverter AC with inverter AC	1.6
Replace Ceiling fans with Electronically Commuted BLDC fans	1.7

Interactive Session

Exercise for First day: (5 questions)

1) What is important to collect during home energy audit from monthly Electricity Bill

kWh

2) Environmental levy and VAT are applicable above **99** (kWh) of monthly electricity consumption.

3) Every home purchase solar based LED lamp for perimeter lighting. It means the household is promoting **Energy Conservation**

4) Refrigerators efficiency has improved over last 10 years, New Refrigerators consume less energy? **Yes**

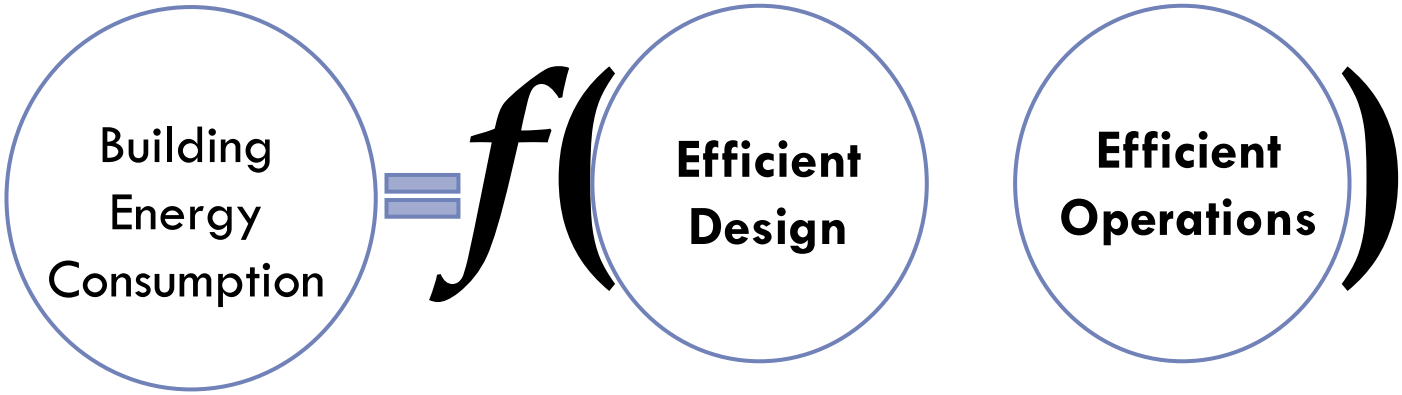
5) Home Energy Audit needs the discussions with family members? **Yes**

- **Day-2: Step by Step Approach to a Home Energy Assessment**
  - *How to identify the highest energy consuming appliances in a home*
  - *How to reduce energy consumption at home through energy conservation measures*
  - *How to shop for and identify energy efficiency devices, equipment and appliances*
  - *Basic calculations on energy savings and payback for simple energy conservation measures*
  - *Q&A*

DAY-2
Step by Step Approach to a Home Energy Assessment

Home Energy Audit

- Energy audit is a procedure to understand **WHERE** and **WHEN** electricity is used--or wasted at home. This will eventually help to reduce the use of electricity or use it more efficiently.
- Electricity in homes is mostly used for lighting, air conditioning, and electrical appliances like refrigerators and electronics like TVs and computers.



Energy efficiency is not just limited to the smart use of appliances, but extends to installation of windows, roofing and even landscaping.

Steps involved for conducting Home Energy Audit

Step-1 : Identify the energy intensive appliances

- Calculate Energy Consumption By Household Appliances

Step-2 : Identify energy saving opportunities

Step-3 : Calculate annual energy saving (kWh/Year)

Step-4 : Calculate annual cost saving (EC$/Year)

Step-5 : Calculate investment require (EC$)

Step-6 : Calculate payback period.

How To Do Home Energy Audit

Step-1 : Identify the energy intensive appliances

- Calculate Energy Consumption By Household Appliances

Energy Consumption Per Day (kWh/Day) = **Number of Appliances** x **Rated Input Power (kW)** x **Operating Hour Per Day (Hrs.)**

Energy Consumption Per Month (kWh/Month) = **Energy Consumption Per Day (kWh/Day)** x **Operating Days Per Month**

Energy Consumption Per Year (kWh/Year) = **Energy Consumption Per Day (kWh/Day)** x **Operating Days Per Year**

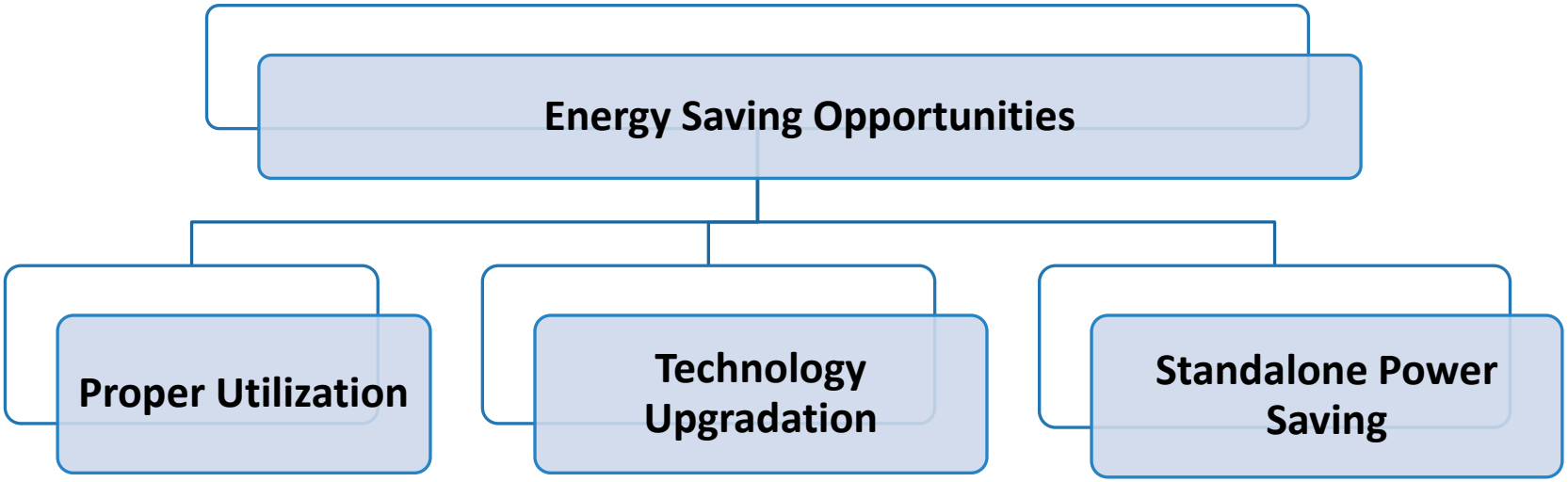
Rated Input Power

To know rated input power, refer **“PRODUCT INFORMATION TAG”** or **“PRODUCT BROCHURE”**.

$$Input\ Power\ (kW) = \frac{Input\ Power\ (Watt)}{1000}$$

How To Do Home Energy Audit

Step-2 : Identify energy saving opportunities



How To Do Home Energy Audit

Step-3 : Calculate annual energy saving (kWh/Year)

Annual Energy Saving (kWh/Year) = **Annual Energy Consumption in Present Condition** - **Annual Energy Consumption after implementing energy saving measure**

Step-4 : Calculate annual cost saving (EC$/Year)

Annual Cost Saving (EC$/Year) = **Annual Energy Saving (kWh/Year)** x **Per Unit Electricity Cost (0.78 EC$/kWh)**

Step-5 : Calculate **investment** require for procuring new energy efficient appliances (EC$)

Step-6 : Calculate payback period.

$$\textbf{Payback Period} = \frac{\textbf{Investment (EC\$)}}{\textbf{Annual Cost Saving (EC\$)}}$$

A payback calculation will help to decide which energy efficiency upgrades to prioritize

Energy Saving Measures in Lighting System

Step – 1 Energy Consumption by Lighting Fixtures

Appliances	Number	Rated Watts (W)	Operating Hours Per Day	Daily Energy Consumption (kWh/Day)	Operating Days In Year	Annual Energy Consumption (kWh/Year)
Florescent Tube Light	3	28	10	0.84	365	306.6
Incandescent Bulb	2	40	13	1.04	365	379.6
Total Annual Energy Consumption (kWh/Year)						686.2

$$\text{Energy Consumption Per Day (kWh/Day)} = \frac{\text{Number of Appliances} \times \text{Rated Input Power (W)} \times \text{Operating Hour Per Day (Hrs.)}}{1000}$$

$$\text{Energy Consumption Per Year (kWh/Year)} = \text{Energy Consumption Per Day (kWh/Day)} \times \text{Operating Days In Year}$$

Step -2 Identifying energy saving opportunities- Household Lighting

Energy Saving Measure – 1 Switch OFF Lights whenever not using.

Appliances	Number	Rated Watts (W)	Operating Hours Per Day	Unutilized Hours Per Day	Actual Utilized Hours Per Day
Florescent Tube Light	3	28	10	2	8
Incandescent Bulb	2	40	13	1	12

Step – 3 Annual Energy Saving

Appliances	Number	Rated Watts (W)	Actual Utilized Hours Per Day	Operating Day In Year	Annual Energy Consumption (kWh/Year)
Florescent Tube Light	3	28	8	365	245.2
Incandescent Bulb	2	40	12	365	350.4
Total Annual Energy Consumption *(after switching OFF light)*, kWh/Year					595.6
Total Annual Energy Consumption *(in normal days)*, kWh/Year					686.2
Annual Energy Saving, kWh/Year					90.6

Step – 4 Annual Cost Saving

Annual Energy Saving, kWh/Year	90.6
Annual Cost Saving (EC$) *(@0.78 EC$/kWh)*	70.6

Step – 5 Investment

Investment (EC$)	Nil

Step – 6 Payback

Payback	Immediate

Annual cost saving of 71 EC$ with ZERO investment

Energy Saving Measure – 2 : Technology Upgradation

Replace the conventional incandescent bulb and CFL bulb with LED lamp.

Incandescent Bulb	CFL Bulb	LED Bulb
40W	12W	7W
60W	18W	10W
75W	22W	13W

Replace the conventional FTL tube light with LED tube lights.

FTL Tube Light	LED Tube Light
55W	22W
38W	20W
28W	18W

Step – 1 Energy Consumption by Lighting Fixtures

Appliances	Number	Rated Watts (W)	Operating Hours Per Day	Daily Energy Consumption (kWh/Day)	Operating Days In Year	Annual Energy Consumption (kWh/Year)
Florescent Tube Light	3	28	10	0.84	365	306.6
Incandescent Bulb	2	40	13	1.04	365	379.6
Total Annual Energy Consumption (kWh/Year)						**686.2**

Step -2 Identifying energy saving opportunities – Replace conventional lamps with energy efficient LED lamps

Appliances	Number	Rated Watts (W)	Operating Hours Per Day	Daily Energy Consumption (kWh/Day)	Operating Days In Year	Annual Energy Consumption (kWh/Year)
LED Tube Light	3	18	10	0.54	365	197.1
LED Bulb	2	7	13	0.18	365	65.7
Total Annual Energy Consumption (kWh/Year)						**262.8**

Step – 3 Annual Energy Saving

Annual Energy Consumption *(in present condition),* kWh/Year	686.2
Annual Energy Consumption *(after replacing),* kWh/Year	262.8
Annual Energy Saving, kWh/Year	423.4

Step – 4 Annual Cost Saving

Annual Cost Saving (EC$)	330

Step – 5 Investment

Lamp	Quantity	Price of One Lamp (EC$)	Total Cost of Lamp (EC$)
LED Tube Light	3	52	156
LED Bulb	2	32	96
Total Investment			252

Step – 6 Payback

Payback	0.76 Years

Energy Saving Measures in Heating and Cooling Appliances

Energy Consumption By – Heating and Cooling Appliances

Window AC 1 Ton = 1150 W
Window AC 1.5 Ton = 1300 W

Split AC 0.8 Ton = 800 W
Split AC 2 Ton = 1930 W

Water heater = 3000 W

Fan = 75 W

Note: *Above mention running watts of appliances is only for reference, actual running watt may vary for different models.*

Energy Saving Measure – Ceiling Fan

Replace the conventional ceiling fan with energy efficient BLDC fan.

Fan Speed	BLDC Fan	Traditional Fan
1	6 W	16 W
2	10 W	27 W
3	14 W	45 W
4	19 W	55 W
5	28 W	75 W

- BLDC motor fans consume less power as compared to the traditional ceiling fans.
- These fans come with a **remote control uni**t thereby allowing you to switch ON and OFF the fans easily.
- BLDC motor fans come with a **Timer and Sleep mode** that will enable you to set a specific time limit (number of hours) while sleeping.

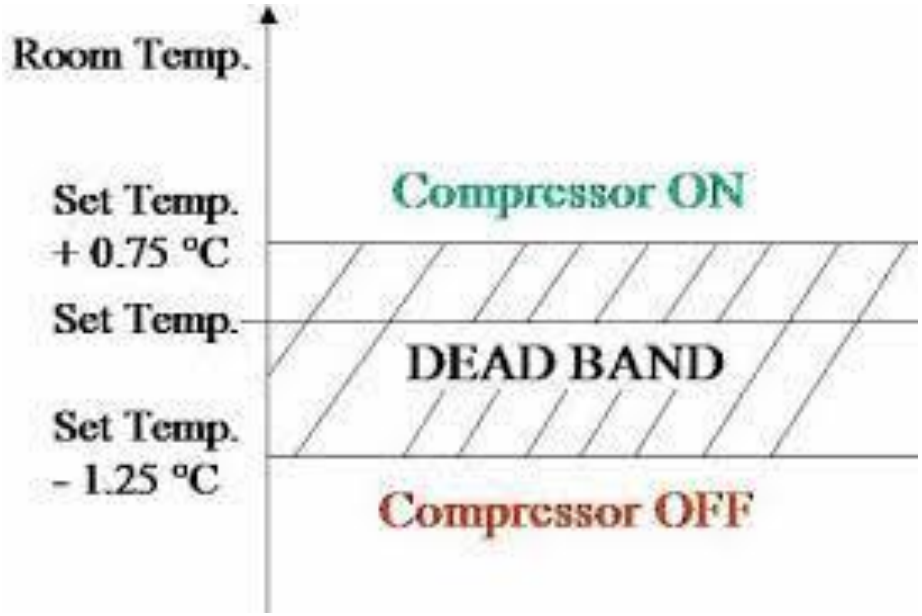
Energy Saving Measure – Ceiling Fan

How Much Money We Can Save……????

	Regular Fan	BLDC Motor Fan
Rated Input Power	75 Watts	28 Watts
Daily Consumption (@15 Hr/Day)	1.125 kWh	0.42 kWh
Yearly Consumption (300 Days)	337.5 kWh	126 kWh
Costs (EC$ 0.78 per unit)	EC$ 263.25	EC$ 98.28
Yearly Saving (EC$)	165	
Investment (EC$)	400	
Payback (Years)	2.42	

Working Principle of Non-Inverter Air Conditioner

Window AC 1.5 Ton = 1300 W



- Power consumption by air conditioner when compressor is **ON** : 1300 W
- Power consumption by air conditioner when compressor is **OFF** : Stand By Power

Considering the 'ambient temperature' and 'set temperature' the compressor inside the air conditioning unit switches ON/OFF.

Energy Saving Measure – Air Conditioner

1. **Set the temperature of AC around 24 - 27 ^{o}C.**

   By doing so **3-4% power can be saved.** *(Savings in lower temp (<24^{o}C) – 6% for every rise in 1^{o}C and in higher temp (>24^{o}C) – 4% for every rise in 1^{o}C)*

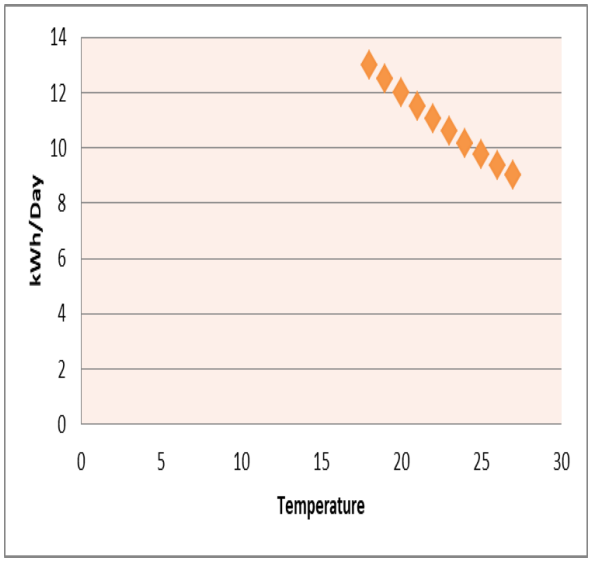
Example:

- Let us assume, 1.5 tons window AC and its rated input power is 1300 W/Hr.
- AC will operate for 10 hours in a day.
- Electricity cost: EC$ 0.78/kWh

Temperature	Total Energy Used (kWh/Day)	Cost of Using AC		% Energy or Cost Saved w.r.t 18^{o}C
		EC$ Per Day	EC$ Per Year	
27	9.0	7.02	2562	30.8
24	10.5	8.19	2989	19.2
18	13.0	10.14	3701	NA

Energy Saving Measure – Air Conditioner

- Increase your AC temp from **18°C to 24°C** can help you to save around **EC$ 730** in a year.
- Increase your AC temp from **18°C to 27°C** can help you to save around **EC$ 1168** in a year.
- **Investment : Nil**
- **Payback : Immediate**



Feeling **HOT** at 27°C

Set the temperature of AC at 27°C and use fan at optimum speed.

Avoid using ceiling fans because hot air will be redistributed. Rather, use floor fans to provide better airflow for added comfort and cooling

Energy Saving Measure – Air Conditioner

2. Always set the **TIMER** to automatically switch **OFF** AC after certain duration of time.

CASE – 1 (AC SWITCH ON TIME – 8:00 PM TO 6:00AM)			
Appliance	**Set Temperature**	**Total Energy Used (kWh/Day)**	**Cost of Using AC Per Day (EC$)**
AC	27^{o}C	9.0	2.88

CASE – 2 (AC SWITCH ON TIME – 8:00 PM TO 4:00AM)			
Appliance	**Set Temperature**	**Total Energy Used (kWh/Day)**	**Cost of Using AC Per Day (EC$)**
AC	27^{o}C	7.2	2.30

Cost Saving

- Per Day - EC$ 0.46
- Per Year – EC$ 168

- Investment - Nil
- **Payback – Immediate**

Energy Saving Measure – Air Conditioner

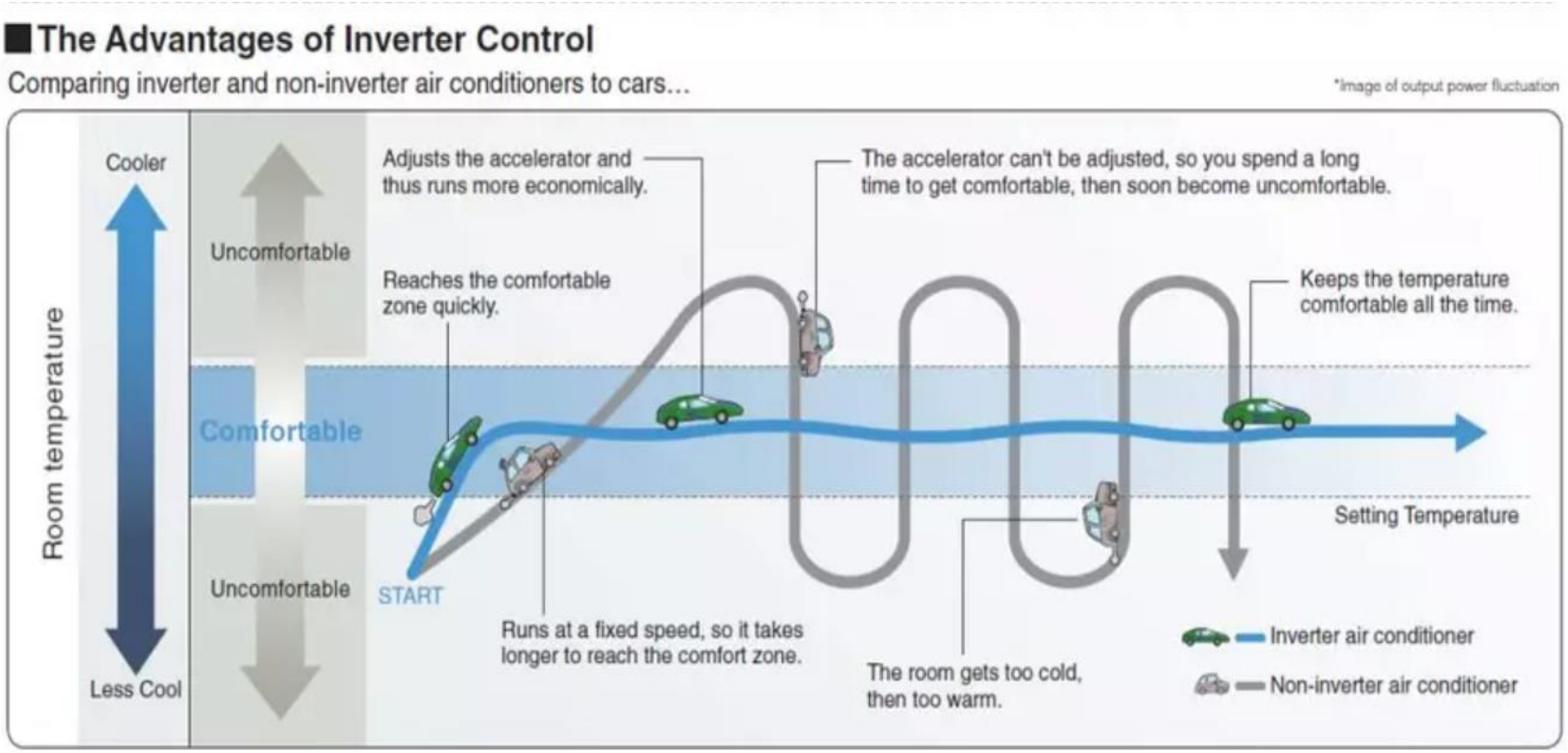
3. Keep AC outdoor unit (Condenser Unit) in shade and ventilated area.

Air conditioning outdoor unit on a roof without shading

Air conditioner outdoor unit with shading

Energy Saving Measure – Air Conditioner

3. Replace the old non-inverter AC with new energy efficient inverter AC.



Technology Upgradation – Air Conditioner

Appliances	Rated Watts (W)	Monthly Energy Consumption (kWh)
Non Inverter AC (1 TR)	1184	93
Inverter AC (1 TR)	840	65
Monthly Energy Saving (kWh)		28
Annual Energy Saving (kWh)		336
Annual Cost Saving (EC$)		268
Investment (EC$)		3000
Payback (Years)		11.1

Since the payback period is too high, it is recommended to purchase a new inverter air conditioner at the time of retrofitting.

Energy Saving Measure in Air Conditioner

4. Reduce the heat load of room.
   - By putting curtain on windows.
   - Close door and windows.
   - Arrest air leakage near door and windows.
   - Avoid ironing of clothes in AC room.

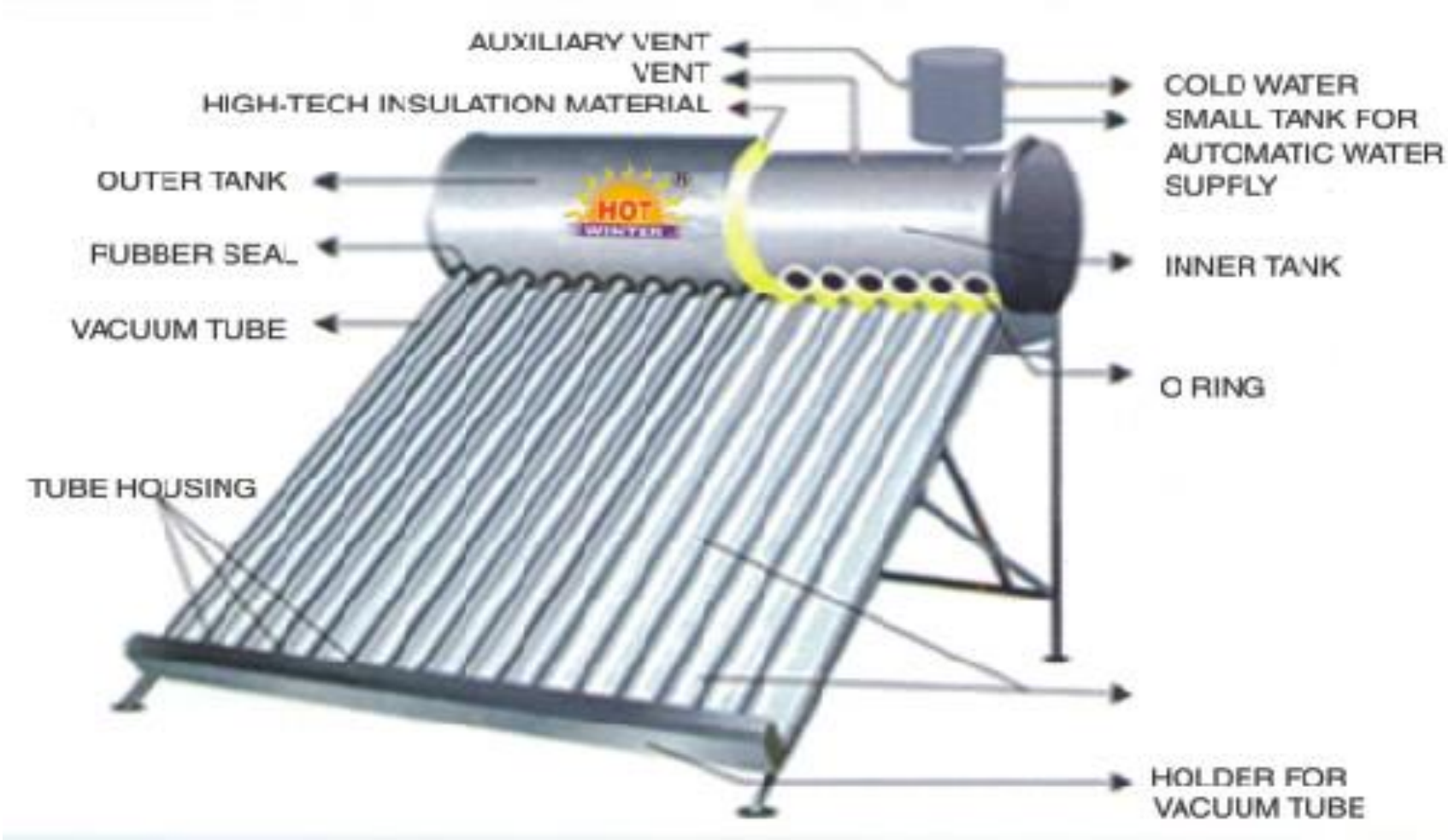
5. Always keep units serviced and clean. Monthly cleaning of air filters will improve the performance and life span of the air conditioner and will save energy.

Energy Saving Measure – Water Heater

Replace Electric Water Heater With Solar Water Heater OR Gas Water Heater

1. **Electric Water Heater**
   - Convert electric energy into heat energy.
   - Easy installation, Less expensive & require less maintenance.
   - Operating cost is high and don't give instant hot water
2. **Gas Water Heater**
   - Natural gas or LPG is burnt. This combustion produces heat energy.
   - Provide instant heat.
   - Cheaper to run as gas is cheap. Hence, suitable for large families.
   - Release carbon monoxide.
3. **Solar Water Heater**
   - The light radiations from the sun are converted into heat energy.
   - Operation cost is ZERO. As sun rays are FREE.
   - Hot water is available even during power cut.
   - Need additional rooftop space and also required annual maintenance.

Energy Saving Measure – Solar Water Heater



Energy Saving Measures in Kitchen

Energy Consumption By – Kitchen Appliances

Refrigerator = 120 Watts

Bread Toaster = 850 Watts

Rice Cooker = 200 Watts

Water Kettle = 1200 Watts

Induction Stove = 2000 Watts

Microwave = 1800 Watts

Note: *Above mention running watts of appliances is only for reference, actual running watt may vary for different models.*

Types of Cook stoves

1. **Gas:** This type of cook stove has a burner on top and uses gas (LPG or PNG) to to cook food.
2. **Electric:** This type of cook stove has a coil that heats up due to resistance when current passes through it. As its name, it uses electricity to generate heat and cook food.
3. **Induction:** Although this type of cook stove uses electricity but it uses magnetic property of steel to directly heat the cooking vessel. Unlike other cooking methods it does not use flames or red-hot element to cook. Thus, it is considered more energy efficient. Also, it only heats the vessel in contact thus reduces possibility of injury.

	Gas	Electric	Induction
Efficiency	40%	74%	84%

Source: US Department of Energy

Energy Saving Measures – Refrigerator

- Do not open door frequently.
- Don't leave the fridge door open for longer than necessary, as cold air will escape.
- Do not overload the refrigerator.
- Avoid putting hot or warm food straight into the fridge.
- Cover liquids and wrap foods stored in the refrigerator. Uncovered foods release moisture and make the compressor work harder..
- Leave enough space between your refrigerator and the walls so that air can easily circulate around the refrigerator.
- Don't keep your refrigerator or freezer too cold. *The thumb rule is that you set the temperature of the fridge between 2.5 and 4.5 degrees Centigrade. The freezer chamber should be set at an ideal range of -15 to -17.5 degrees Centigrade.*

Energy Saving Measures in Other Home Appliances

Energy Saving Measures

1. **Electric Iron**
    - Select iron boxes with automatic temperature cut-off.
    - Do not put more water on clothes while ironing.
    - Do not iron wet clothes

2. **Washing Machine**
    - Run washing machine only with full load.
    - Use optimal quantity of water and detergent
    - Use timer facility to save energy.
    - Prefer natural drying over electric dryers.

3. **Mixture grinder**
    - Dry grinding in food processors (mixers and grinders) takes longer time and as such consumes more energy than liquid grinding.

Standalone Power Saving

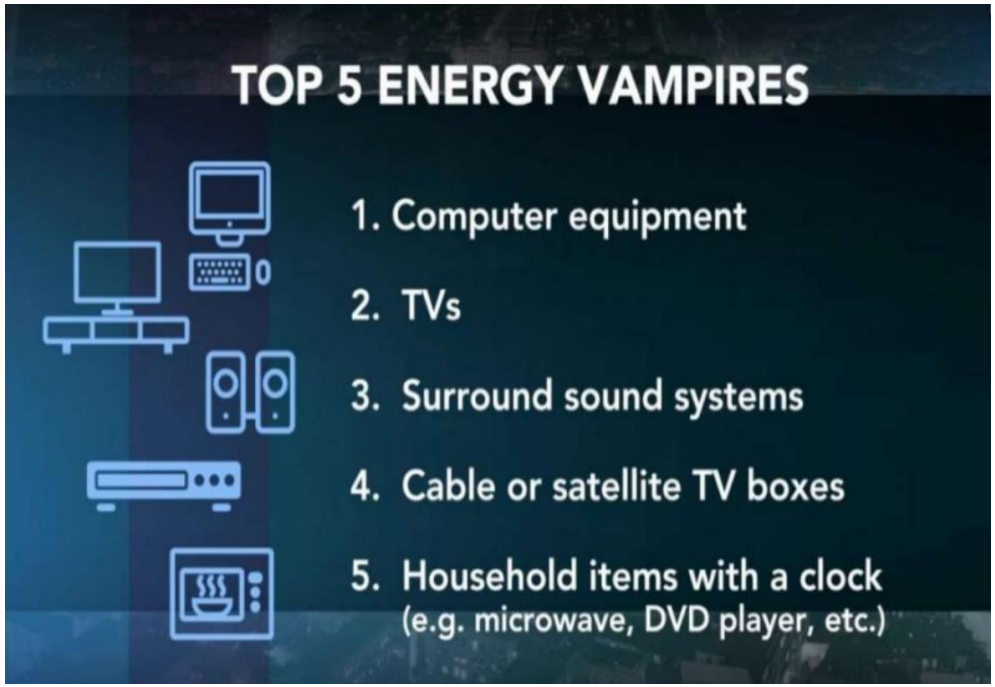
Stand-By Power

- Standby **power** is electrical **power** that a device consumes when not in use, but plugged into a source of **power** and ready to be used.

Example:

1. TV is OFF with remote but main power supply is ON.
2. TV is OFF but set-top box is ON.
3. Not using microwave but it is ON from main power supply.
4. Not using internet but modem is ON.

Stand-By Power



Appliance	Stand-by power (Watts)
DVD Player	10
Microwave	5
Desktop computer	9

Appliance	Stand-by power (Watts)
Cable Set-up box	10
Audio system	24
Television	7

Stand-By Power

- In a survey it was found that in 85% houses set-top box and TV was **not switch OFF** from main supply during night time.
- It was also found that in 30% houses computer was **not switched OFF** from main supply after use.

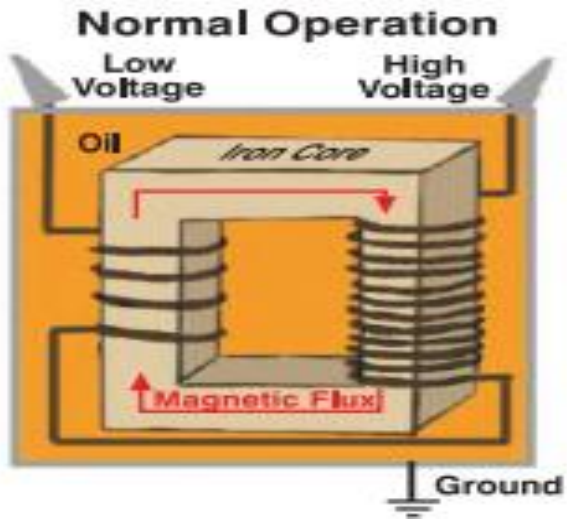
Appliances	Hours/Day	Days/Year	Watt	kWh/Year	Yearly Cost Saving (EC$)
Set-Top Box	16	365	10	58	45.2
TV	16	365	7	41	31.9
Computer	14	365	9	45	35.1

It is recommended to switch OFF the appliances from plug point.

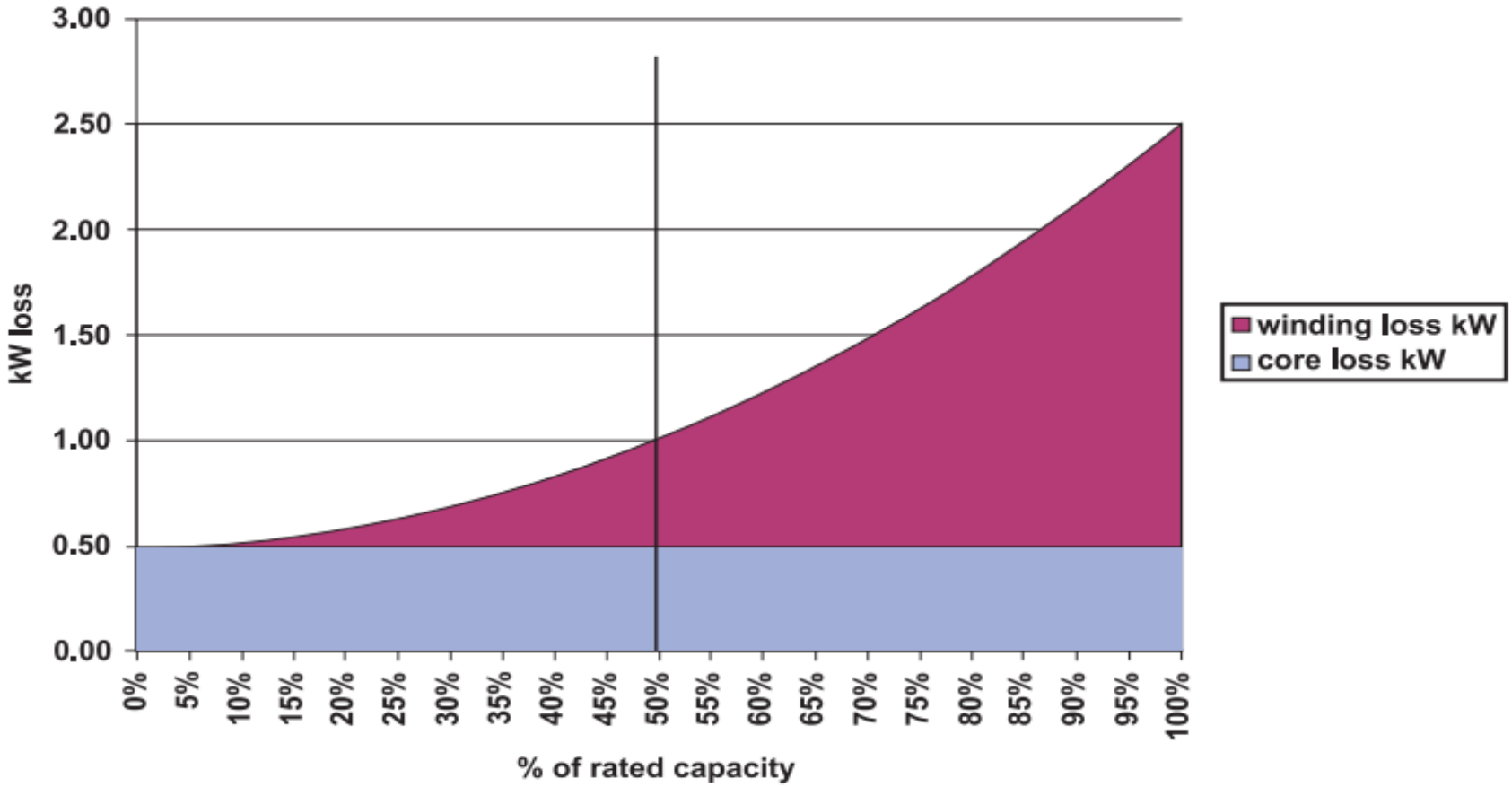
220/110 V Dry Type Transformer

Transformer Losses

1. **No-load loss (also called core loss)**
    - It is the power consumed to sustain the magnetic field in the transformer's steel core.
    - It occur whenever the transformer is energized.
    - It does not vary with load.
2. **Load loss (also called copper loss)**
    - It is the power lost in the primary and secondary windings of the transformer.
    - Associated with full-load current flow in the transformer windings.
    - It varies with the square of the load current.



Transformer Losses



Both **No-Load and Load losses** of transformer are provided by manufacturer in test certificate.

Transformer Losses

Minimum efficiency required for low voltage dry type transformer *(as per US Department of Energy)*

- Lower rating transformers have low efficiency.
- In home generally 1 KVA or smaller size transformer is used for 110V appliances.
- Hence, losses in smaller rating transformer is around 2.5~3%.
- After using the 110V appliances disconnect the transformer from main power supply to save standby loss.

Efficiency required (%)

kVA	TP-1	DOE (2016)
15	97.00	97.89
30	97.50	98.23
45	97.70	98.40
75	98.00	98.60
112.5	98.20	98.74
150	98.30	98.83
225	98.50	98.94
300	98.60	99.02
500	98.70	99.14
750	98.80	99.23
1000	98.90	99.28

Domestic Transformer Losses

To meet the appliance rated voltage and frequency (like 110 V and 60 Hz imported from US), smaller rating transformers are in use.

Smaller rating transformers and its losses

Transformer Rating	Efficiency, %	Core Loss, % (Watts)	Winding Loss, % (Watts)
1 KVA	94	3% (30	3%(30)
2 KVA	95	2% (40)	3%(60)
3 KVA	95.5	1.5% (45)	3%(90)
5 KVA	96.5	1.5%(75)	2%(100)

- Fixed loss in transformer takes place, if it charged (or appliance connected)
- Energy loss per day (2 KVA transformer) without appliance in use : 960 Wh (~ 1 kWh)
- If same transformer **ON position** for a month fixed energy losses : **29 kWh**

Recommendation : Always Un-Plug domestic transformers from Power Supply

Case Study – Transformer Losses in a Hotel

- Total loss (including load and no-load loss) in dry type transformers are:

Transformer Rating	Loss
75 KVA	1.5 kW
30 KVA	0.6 kW
5 KVA	0.1 kW

- Total fixed loss in dry type transformers is around 2.2 kW.
- Annual fixed loss in dry type transformers is 19,272 kWh
- Annual monetary loss is EC$ 18,115 (Considering electricity cost is 0.94 EC$/kWh)
- Since the national grid supply power at 220V and loss is high in 220/120 V transformers, it is recommended to avoid using 110V appliances.

Awareness need to be created about fixed loss in 220/110 V dry type transformers.

How to shop for and identify energy efficiency devices, equipment and appliances

Tips To Select Energy Efficient Appliances

1. **Pick the right size -** Running a large machine – even the most energy-efficient one – uses more electricity than a compact one, so don't buy something bigger than what you need.
2. **Check energy-saving settings** - Appliances like dishwashers and washing machines often have energy saving settings.
3. **Read the energy guide label** - When buying home appliances, look for the energy guide label. These stickers indicate the efficiency statistics for the appliance as well as the estimated operational costs and energy consumed. These stickers may also indicate the amount of money and energy you can save over the appliance's lifetime.
4. **Prioritize -** Energy efficient appliances may be more expensive as compared to others but this is a myopic view. When you are buying appliances, look at the long-term impact such as how much money you will save. Then, prioritize the appliances you need to invest in to maximize your savings. For example, you save more by replacing an old refrigerator than you could by replacing an old toaster.

Energy Labelling

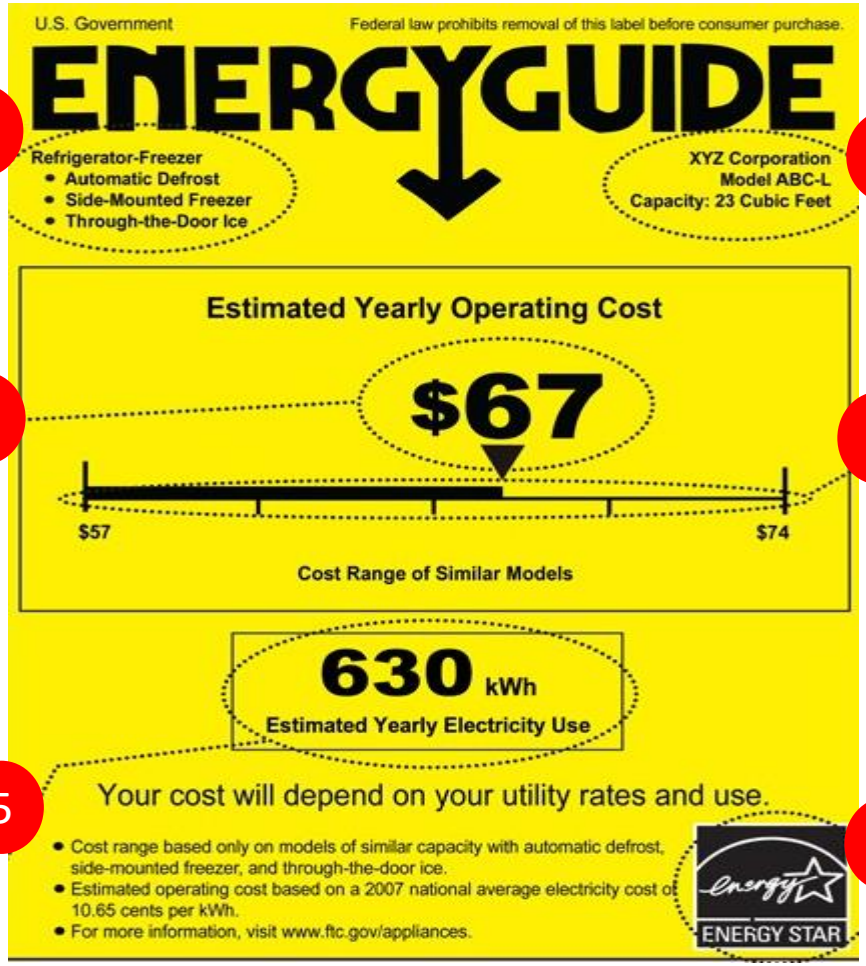
1. **Endorsement Label:** When you shop for a new appliance, look for the endorsement label. These labels are present on all qualified products that meet specific standards for energy efficiency. Look for the label on home appliances, electronics, water heaters, and other products that consume energy. These products usually exceed minimum performance standards by a substantial amount. The following are some endorsement labels of some countries.
    - **ENERGY STAR®** label is an international standard for endorsement of energy-efficient products. This program is also used in Japan, Switzerland and UK.
    - **Indian Star** labelling system

Energy Labelling

2. **Informative Label:** These labels provide information on energy consumption, energy efficiency rating and operating cost. It does not give any comparison to other models in the market. Usually, customers find it a little difficult to understand.

Different countries have different labels depending on what they would like to highlight.

Energy Guide Label



1. Maker, model number, & size of the appliance.
2. Estimated yearly operating cost.
3. The cost range will help to compare the energy use of different models with same features
4. The ENERGY STAR® logo shows that this model meets criteria for energy efficiency.
5. Estimated yearly electricity consumption.
6. Key features of the appliance.

Source: https://www.energy.gov/energysaver/shopping-appliances

Thank You