Pacific Regional Capacity Building Programme for Energy Management and Energy Audits

Day 3 : Wednesday 1st March 2023

27 February – 03 March 2023
Nadi, Fiji

Key Takeaways from Day 2

EC vs EE

EC= immediate savings

Monthly consumption, Cost Savings

Energy Audit methodology and tools

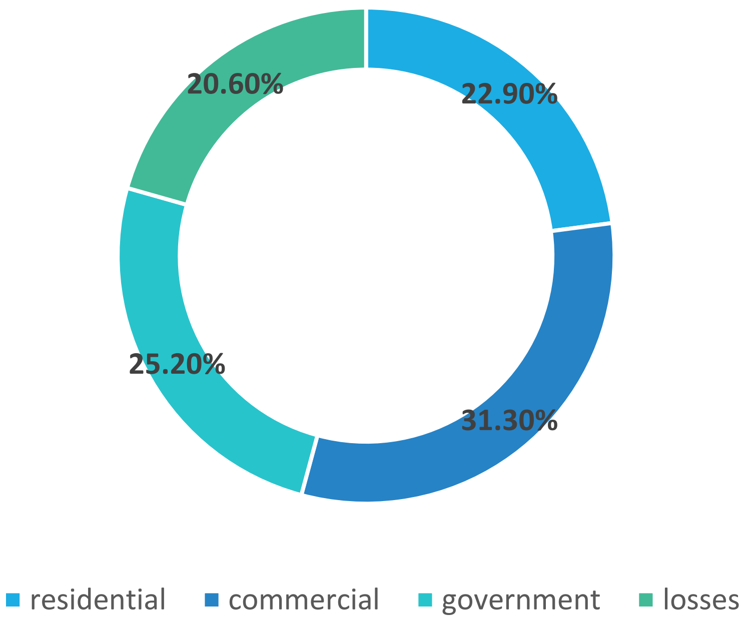
MEPSL + Residential Programs

Introduction to Energy Systems

LIGHTING, AIR CONDITIONING, REFRIGERATORS, HOT WATER, WATER PUMPS, TRANSFORMERS, TRANSPORT

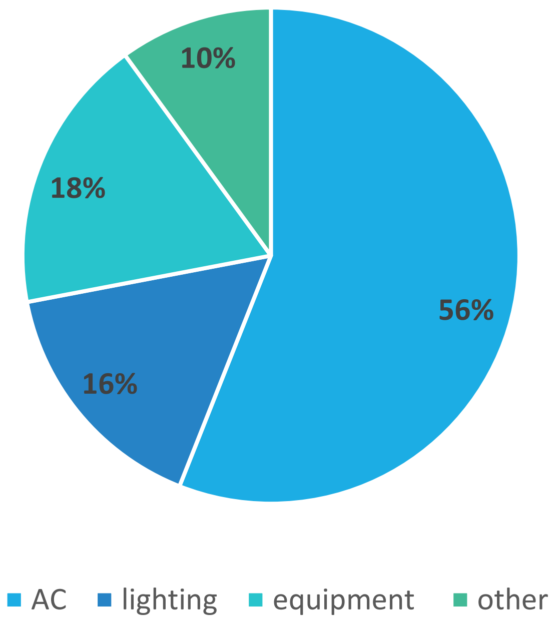
Energy Loads

Palau energy consumption by sector (2010)



Source: NREL (2015)

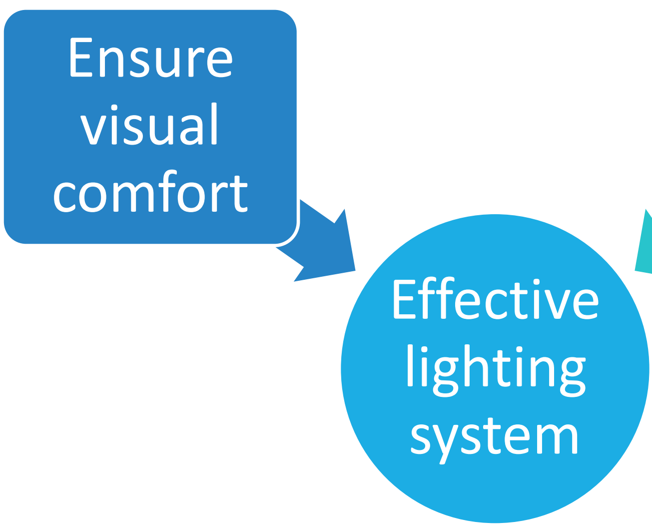
Typical Building Energy Consumption in Tropical Countries

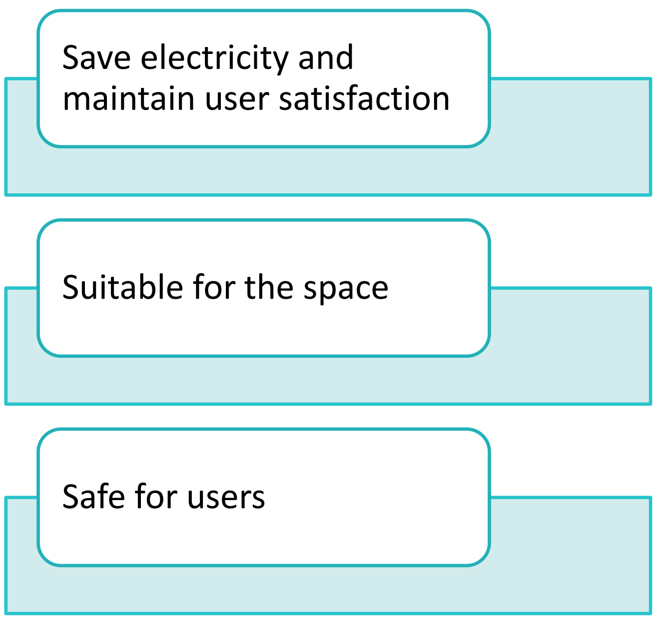


Source: Katili, A. & Boukhanouf, R. & Wilson, Robin. (2015)

Lighting

- Lighting accounts for significant energy consumption in industrial, commercial and residential buildings.
- An efficient lighting system must include visual comfort and minimizing energy consumption for the system.





1. Collect Information

- # of fixtures
- How many lamps and/or ballasts are in each fixture
- Types of lamps or ballasts uses'
- Fixture condition
- Wattage of each model of fixture used
- What is the space used for
- How many hours per day is the space used for
- At what height are tasks performed
- How much natural daylight is there

2. Gather tools

- Camera
- Tape measure, Digital laser measure
- Light meter
- Audit checklist

3. Measure

- Lux levels at various time of the day and document it along with the number of lamps ON.
- Electrical parameters like **Volt, PF, kW, kWh**.
- Compare the measured lux levels with the standard values as reference and identify locations of deviations.
- Collect and analyse the failure rates of lamps, ballasts and the actual life expectancy

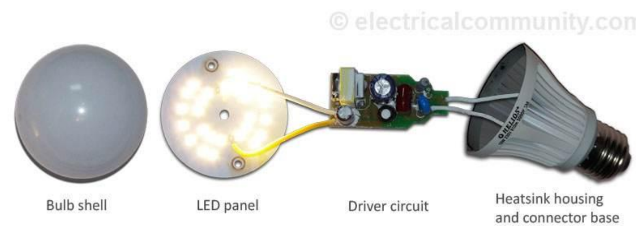
4.Identify improvement opportunities

Light Sources

- **Incandescent** – by filament heating

- **Reflector lamps** – filament heating along with internal reflectors

- **LED Lamps** – produce light using light-emitting diodes



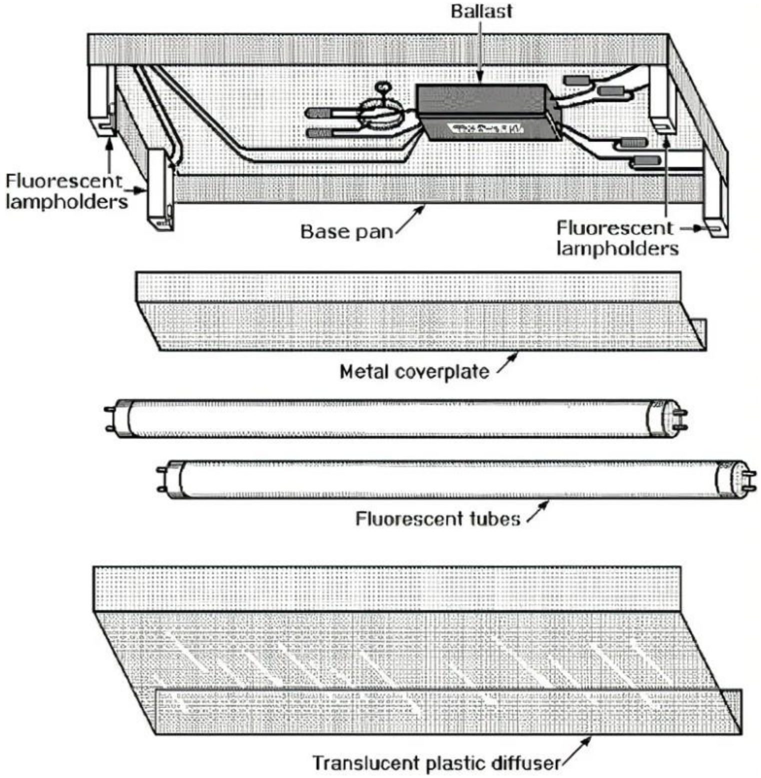
- **Gas Discharge Lamps** – excitation of gas in tube or elliptical outer bulb
  - Metal halide
  - High pressure sodium
  - Low pressure sodium
  - Mercury vapour
  - Fluorescent tube lights
  - Induction Lamps

Luminaire/ light fixture

- A light fixture or luminaire is the device or apparatus which carries the light source and contains the means of connecting the light source to the electricity supply.

Components

- Ballasts
- Lampholders
- Reflective material
- Lamps
- Lenses, diffusers or louvers housing



Lighting terms

Lumen - Brightness of light

- Total amount of light emanating from a light source

Illuminance/ Lux

- is a unit used to measure the intensity of light hitting a surface, typically a wall or floor in a lighting design. **1 LUX = 1 Lumen / m^2**

The Luminous Efficacy

- is a measure of how efficiently a light source produces visible light. **Expressed in Lumens per watt** .

Lumens

The lumen is a unit of measurement for the brightness of light. If a light bulb is blindingly bright, it produces a lot of lumens.

Lumens vs Watts

Lumens measure the total amount of light emitted by the bulb while watts measure the amount of power consumed by the bulb.

Lumens to Watts Conversion

BRIGHTNESS IN LUMENS	220+	400+	700+	900+	1300+
STANDARD	25W	40W	60W	75W	100W
HALOGEN	18W	28W	42W	53W	70W
CFL	6W	9W	12W	15W	20W
LED	4W	6W	10W	13W	18W

Selecting the right lux

- There are different recommended intensity levels depending on the room and the purpose of the space. E.g. A room which is used for storage, for example, needs relatively low light levels.

- **1 Lux = 1 Lumen / m^2**

Eg. A 400 lumen bulb in a room 10 m2 = 40 lux

A 400 lumen bulb in a room 20 m2 = 20 lux

- The bigger the room, the more you will need to create the right light levels

Selecting the right lux

LUX	Recommended application
50 lux	Family living room
100 lux	lifts, corridors and stairs. Areas that are transitory for occupants and don't require any detailed work. Warehouse areas and bulk stores will also require this minimal light level.
150 lux	Restrooms require this level of light
200 lux	Entrance areas and lobbies require this level of light, a restaurant dining area; reading
300 lux	Assembly Areas, like village halls require at least 300 lux
500 lux	Retail spaces should have this as a minimum light level, as should general office spaces. This level should be suitable for prolonged work on computers, machinery and reading.
>500 lux	Where fine detailed work is being carried out e.g. Operation theatres in hospitals 1000 lux

Lighting Design

Selection of appropriate type and quantity of lamps and light fixtures depends on:

- Fixture efficiency and lamp lumen output
- Reflectance of surrounding surfaces
- Effects of light losses
- Availability of natural light
- Room use
- Room size

Example: Calculation on Lumens and Lux

Calculate how many LED lights are needed in a bedroom with area 12 ft x 12 ft.

Given that:

- **1 Lux = 1 Lumen / m2**
- **Recommended lux level for bedroom= 150 lux**
- **Suggested lumen for bedroom: 800 lumen using 12 Watt LED Bulb**

Step 1 – Calculate the area of the bedroom

Step 2 – Using your answer in step 1) Calculate the lumens needed for the area

Step 3 – Calculate the number of LED lights needed.

- Divide the result in Step 2) by the lumens rating of your desired LED light bulb.

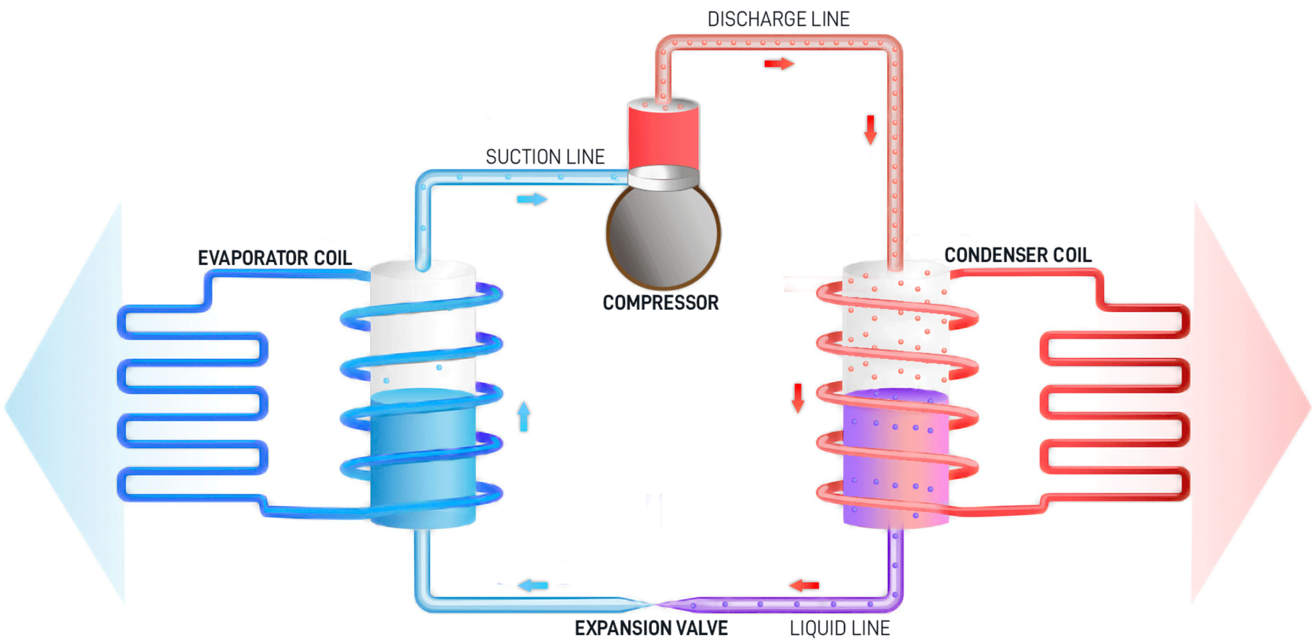
Example:
Calculate how many LED lights are needed in a bedroom with area 12 ft x 12 ft.

- **1 Lux = 1 Lumen / m2**
- **Recommended lux level for bedroom= 150 lux**
- **Suggested lumen for bedroom: 800 lumen using 12 Watt LED Bulb**

Calculate the area of the bedroom which is 12 feet x 12 feet	• Area in sq. feet = 144 • 1 sq.ft = 0.09290304 sq.m (or = 0.093 approx.) • Area in sq meters = 144 x 0.093 = 13.39
Using your answer in step 1) Calculate the lumens needed for the area	• 1 lux = 1 lumen/m2 • lumen = lux X area (m2) • lumen = 150 x 13.39= 2004 (approximately 2000)
Calculate the number of LED lights needed. Divide the result in Step 2) by the lumens rating of your desired LED light bulbs	• 2000/800 = 2.5= 3 LED bulbs (12 W)

Air Conditioning

- Heating, Ventilation and Air Conditioning (HVAC) systems control the ambient environment (temperature, humidity, air flow and air filtering). Air conditioning is an integral component of HVAC.
- Air conditioning works hand-in-hand with ventilation to cool the circulating air.



Types of air conditioning units – Inverter vs Non Inverter

The key difference lies in the compressor's ability to regulate the speed of its motor to adjust to the room's temperature.

Inverter AC	Non- Inverter AC
Variable speed compressor	Fixed speed compressor
Power consumption is reduced.	Less expensive
Improved cooling performance	Good for small rooms: A non-inverter AC will be ideal if you only need cooling in one or two rooms because it does not cool large areas effectively as an inverter AC does.

Types of air conditioning units – Stand Alone

1.Stand-Alone AC units (1 device). Examples: *Portable air conditioners, window air conditioners, floor mounted air conditioners, thru-the-wall air conditioners.*

Portable AC

Window AC

Floor mounted AC

Types of air conditioning units- Split-System

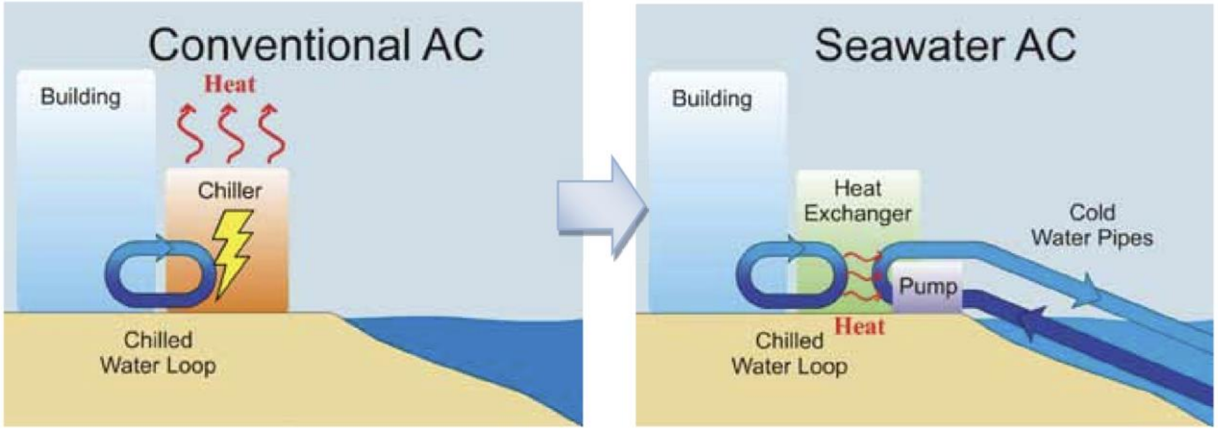
Split-System AC units (2 devices). Examples: *Central air conditioners, mini-split air conditioners, wall-mounted air conditioners, ceiling air conditioners.*

Central AC

Mini split AC

Ceiling AC

Types of air conditioners- Sea Water Air Conditioning (SWAC)



Suitability for SWAC

- Close access to deep cold water?
- A site close to shore, and a tight grouping of buildings?
- Large size or cooling loads, greater than 1000
- refrigeration tons or 3500 KW?
- High cooling usage throughout the year?
- High electrical rates

- Airports
- Data Centers
- District Energy / District Cooling Projects
- Government / Military facilities
- Hotels & Resorts
- Industrial / Manufacturing Facilities
- Large Office or Commercial Buildings
- Power Plants
- Shopping Malls / Department Stores

SWAC - Hotel application , Bora Bora

https://www.youtube.com/watch?v=6LmmlUxYTCc

SWAC- Airport Application, Curacao

https://www.youtube.com/watch?v=732Q3Rom4VQ

Understanding cooling loads and capacity

- Proper sizing is important for efficient air conditioning.
- Air conditioning capacity can be measured in Ton (tonnage), BTU per hour, and Watts

1 ton of air conditioning	=12,000 BTU per hour	= 3500 Watts of cooling (approx.)
2 tons of air conditioning	= 24,000 BTU per hour	= 5150 Watts cooling (approx.)

Air conditioner - User type	**Cooling Capacity in BTU**	**Cooling Capacity in kw**
Residential / domestic	6000 - 20000	1.76 - 5.8
Commercial / office	12000 - 50000	3.5 - 14.65
Industrial	30000 -	8.79 +

Energy audit – air conditioning

1. Collect information on factors affecting cooling loads:

- ❑ Room area (square feet is the commonly used measure)
- ❑ Climate – maximum temperature and humidity
- ❑ Number of individuals typically occupying the room during AC usage
- ❑ Ceiling height
- ❑ Presence of kitchen
- ❑ Heat generated by other electrical appliances
- ❑ Total area of windows in the room
- ❑ Floor number and building height
- ❑ Are your premises located on the top floor?
- ❑ Construction material used for walls, doors, and windows
- ❑ Points of air leaks in the room

2. Gather Tools

3.Measure and analyse

- ❑ Electrical parameters like **Volt, PF, kW, kWh**.
- ❑ Energy label

4.Identify improvement opportunities

Factors affecting cooling load

Factors affecting cooling load	
Room size	The most common rule of thumb is to use "1 ton for every 500 square feet of floor area.
Occupants - The energy output of the resting adult human body is equal to the power of a 100 W electrical light bulb	For every additional occupant in the room, add 600 BTU per hour as additional cooling capacity.
Ceiling Height	If the height of the ceiling is significantly higher than the 10-12 feet, add additional capacity in proportion.
Heat generated by other electrical appliances	A laptop would typically dissipate between 10 watts and 50 watts power. Add applicable BTU per hour to the capacity as per the applicable conditions.

Sizing Air Conditioners

Factors affecting cooling load	
Heat generated by other electrical appliances and lights	A laptop would typically dissipate between 10 watts and 50 watts power. Add applicable BTU per hour to the capacity as per the applicable conditions.
building location, indoor design conditions, orientation, and building construction	Solar gains through windows; Heat transmitted thru floors, ceilings, walls Infiltration of outside air

Undersizing and Oversizing Air Conditioners

Undersizing	Oversizing
• An undersized air conditioner would struggle to maintain the room at the set temperature. • Results in a higher compressor ON time, which would place undue stress causing it to wear out faster. • With an ambient temperature higher than usual, there is a possibility that the AC may not be able to achieve temperatures, especially in the lower range.	• While it may cool the room faster, it would require higher capacity electrical components like circuit breakers and wiring. • Oversized air conditioners usually short-cycle, meaning they power up and down throughout the day many more times than units that cycle properly. • Shorter cycles may not be long enough to remove humidity. • the increased frequency of cycling by an oversized air conditioner puts the unit at high risk of premature deterioration • higher initial cost and a higher cost of operation
• Result in higher electricity consumption leading to increased energy bills.	

Coffee Break

Pacific Energy and Gender Network

SPC

Refrigeration

Refrigeration makes up to 10% of household energy bills and up to 50% of industrial bills.

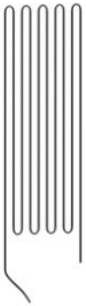
- Ensures food quality and safety
- Provides comfort in homes and commercial buildings (A/C)
- Prolongs health products and services
- Provides low temperature for fuels e.g. liquefied gas

How Refrigeration Works

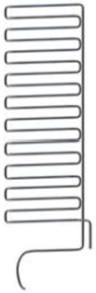
A refrigerator works to transfer heat from inside to outside, which is why it feels warm if you put your hand on the back side of fridge near the metal pipes.

Main Components

Compressor



Condenser



Evaporator

Capillary Tube

Thermostat

Refrigeration

Types of Refrigeration

When choosing refrigeration system, consider:

- Important regulations for the installation and choice of refrigeration equipment.
- Type of refrigerant in the refrigeration equipment.
- Type of refrigeration system.
- Compressor type.
- Location of installation.
- Room size.
- Equipment configuration.

Fridges

Freezers

Medical refrigeration

Display refrigeration

Ice machines

Blast chillers

Refrigeration

Energy-efficient refrigeration.

- **Measure the space for the fridge.** Leave at least a 1-inch clearance around the unit for adequate airflow.
- Consider the needs, and **get the right size**.
- Consider **opting out of the icemaker and dispenser** for home fridge. They increase a refrigerator's energy use by 14-20 percent and usually increase the purchase cost of the fridge as well.
- **Look for a fridge with an "energy saver" switch**. This switch lets you turn down or off the heating coils that prevent condensation. This enables you to better control the anti-sweat heaters in the fridge, which can lower your refrigerator energy costs by 5-10 percent.
- Ensure the fridge voltage suits the building **mains voltage**, to reduce load on transformers.
- Consider an **energy-certified refrigerator.** Compare the actual energy use number on EnergyGuide labels so you can find the most efficient refrigerator.

How to use refrigeration efficiently:

- Minimise the cooling load - Don't waste energy cooling something that does not need to be cooled. For example, put doors on retail display cabinets, don't add hot food to fridge, ensure the space being cooled is properly insulated, or create shading on the sunny side of a building.
- Take account of variable operating conditions
- Select the most efficient refrigeration cycle and components
- Design effective control systems for example, use of a variable speed compressor improves the accuracy of temperature control and makes a significant efficiency improvement.

Refrigerants

Type	Name	Chemical Name	Formula	A. Life	GWP	ODP
CFC	R-12	Dichlorodifluoromethane	CCl_2F_2	100	10200	1
HCFC	R-22	Chlorodifluoromethane	$CHClF_2$	12	1760	.05
HFC	R-32	Difluoromethane	CH_2F_2	4.9	677	0
HFC	R-134a	1,1,2,2-Tetrafluoroethane	$C_2H_2F_4$	9.6	1120	0
HFC	R-407a	R-32/125/134a (20±2/40±2/40±2)		18	2107	0
HFC	R-407C	R-32/125/134a (23±2/25±2/52±2)		15	1704	0
HFC	R-410a	R-32/125 (50+.5,−1.5/50+1.5,−.5)		17	2088	0
HC	R-290	Propane	C_3H_8	12	3	0
HC	R-600a	Isobutane	C_4H_{10}	12	3	0
	R-717	Ammonia	NH_3	0	0	0
	R-718	Water / Steam	H_2O	0	0	0

Hot Water

The water heater is one of the most important systems installed in a building. It provides hot water on demand to all taps and plumbing fixtures.

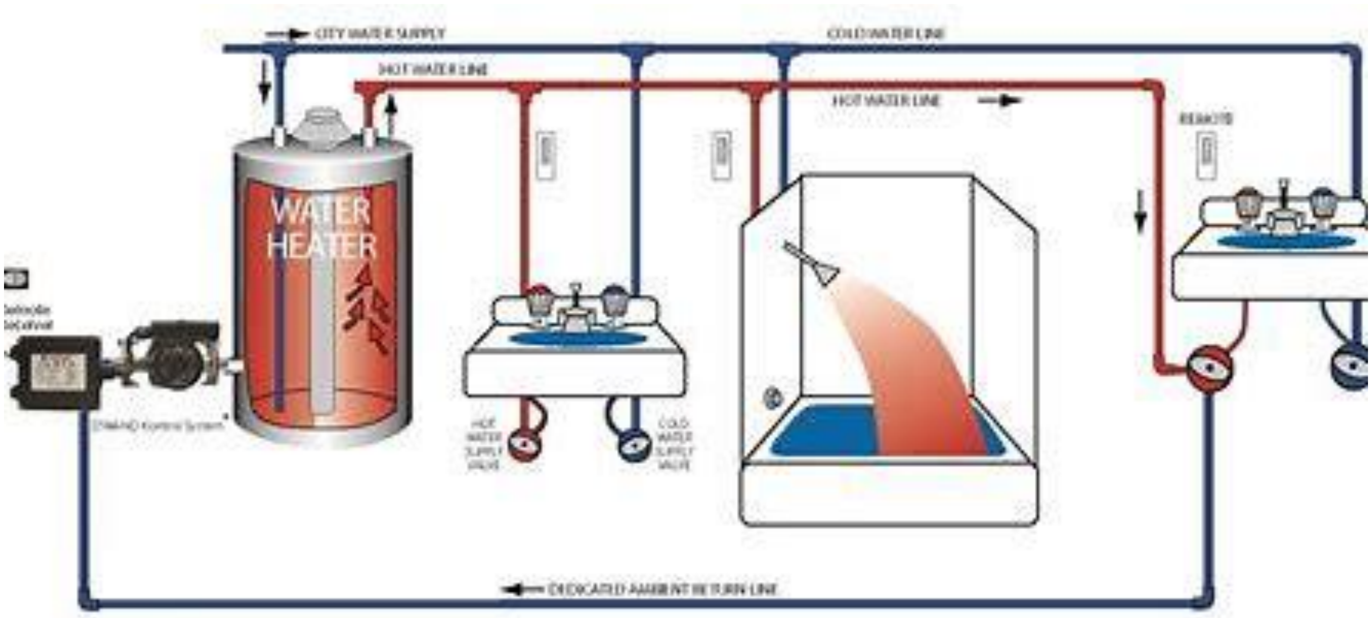
If maintained properly, a good hot water system will last 8 to 12 years on average, which means that when it comes to installing a new one, you should take the time to select a water heater that is right for your building.

Main Design Considerations:

- Fuel type for heating water – electric, solar or fossil fuel?
- Will hot water be generated locally or centrally?
- Will hot water be stored or generated on demand?
- How much hot water is needed?
- Budget

Hot Water System

Domestic hot water (DHW) is supplied to taps and some appliances. DHW is water that has been heated for cooking, food preparation, personal washing or cleaning purposes. Hot water system can also provide central heating in colder climates.



Hot water can be stored in a tank ready for use, or heated on demand.

Hot Water Boilers

Conventional Water heater

- Large insulated tank with 200-300L of water
- Powered by electricity, natural gas or liquid propane
- Cold water heated by unit to pre-set temperature
- Hot water kept in tank until use
- As water is used or cools, system heats water again

Pros

- Cost-effective
- A ready supply of hot water
- Low maintenance
- Long-lasting system

Cons

- Large bulky units
- You pay for hot water 24/7
- Water availability is dependent on tank size

Tankless (on-demand) water heaters

- No tank
- Cold water runs through heated coils
- Hot water instantly
- Natural gas and electric models
- May require larger gas line or higher capacity electrical system

Pros

- Endless instant hot water
- Small units that take up little room
- Low maintenance
- You only pay for the hot water you use

Cons

- Expensive to install
- Can be expensive to operate

Hot Water Boilers

Point-of-use heater

- Electric
- With/without tank
- Installed near the plumbing fixture that they will supply DHW
- Installed to supply DHW where fewer than 20 gallons of water are needed each day

Pros
- Inexpensive
- Easy way to provide hot water to one fixture

Cons
- Inefficient if used regularly

Solar Powered hot water heaters

- Use energy from the sun to heat hot water
- Have large insulated tank to store hot water
- Usually have gas or electric back-up to heat water if solar insufficient

Pros
- Environmentally friendly
- Less expensive in the long run
- Energy efficient

Cons
- Expensive to purchase and install
- Best suited to areas with year-round sun

Hot Water Boilers

Heat Pump

- Use heat that is in the air or ground to heat your water
- Heat is captured from the ground or air and pumped through the system to heat the water
- Hot water heated and stored in large insulated tank
- Use up to 60% less power than conventional heater

Pros

- Energy efficient
- Environmentally friendly

Cons

- Expensive to purchase
- Requires a warm climate
- Requires a large amount of space

Direct-Use Geothermal

- ❖ Large-scale facility to use geothermal water
- ❖ A well is drilled into a geothermal reservoir to provide a steady stream of hot water
- ❖ Primary forms of direct use include heating swimming pools and baths for therapeutic use, space heating and cooling, agriculture and industrial use.

Pros

- Energy efficient
- Multiple applications
- Industry promotes tourism

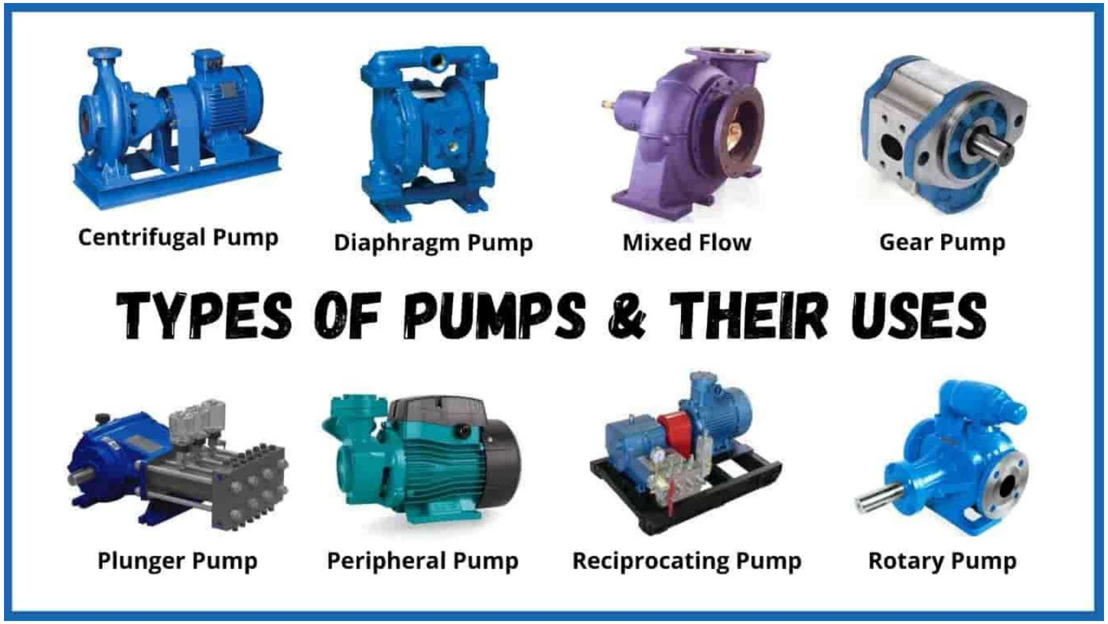
Cons

- Expensive to install
- Requires a warm climate and reservoir
- Requires a large amount of space

Water Pressure Pumps

What is a water pressure booster pump?

- A device that increases the water pressure flowing from the main supply into your home, which can be helpful if you have low water pressure on one or more taps.
- Provides a constant flow of hot water to multiple outlets simultaneously without loss of pressure or flow rate



Common and efficient types of water pressure pump system:

Constant Pressure (CP) Booster Systems

- Most used domestic water pressure booster system
- High water demand causes a pressure drop
- Controller will turn on the pump to replenish the tank until it reaches the required pressure setting.
- It will then shut off until demand drops again.

Variable Speed (VSD) Booster Systems

- More common choice for commercial and industrial applications
- Deliver water at constant pressure, which lowers energy consumption.
- Consists of a variable frequency drive (VFD), motor, pressure transducer, and controller to monitor the pressure in the system and adjust the speed of the pump motor to maintain constant pressure.
- VSD booster system reduces energy costs by up to 60%.
- These systems have reduced start-up currents than standard constant pressure pumps. Which means they are less likely to cause damage to your power supply.
- They also reduce wear and tear on the pump motor, increasing its lifespan.

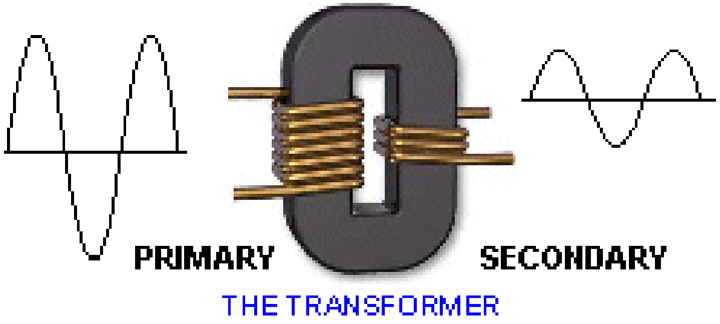
How to size and cost a water pressure pump:

- Measure the incoming water pressure with a water meter, ask your local plumber to install one.
- Decide how much more water pressure you want and what you plan on using it for.
  - E.g. your current shower has poor flow and the water temperature fluctuates when someone turns their tap on or flushes the toilet - medium-sized pump
  - E.g. several people in the house require constant hot showers and/or multiple bathrooms connected to the tank system - larger pump
- Consider investing in a more efficient pump over its lifetime.

Transformers

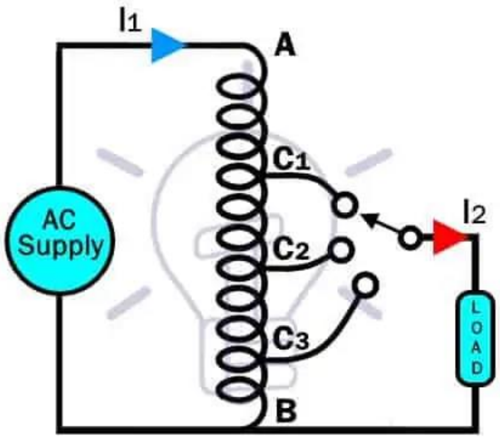
Transformers convert electrical energy to either a higher or lower voltage.

- In their most basic form, they consist of two coils of wire wrapped round an iron core.
- There is no electrical connection between the primary and secondary coils.
- The alternating current (AC) in the primary coil produces an alternating magnetic field in the core.
- This in turn induces an alternating current in the secondary coil.
- Transformers come in all sizes from domestic to utility scale

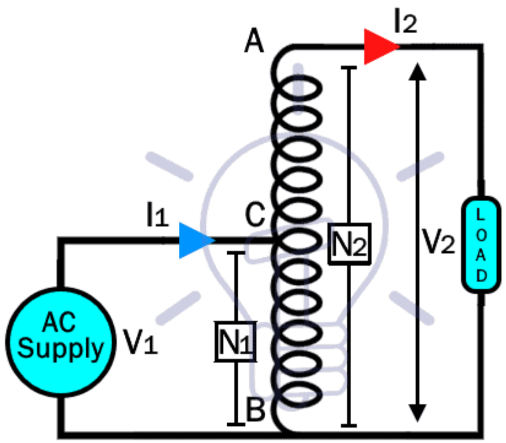


Domestic Autotransformers

- Many homes use appliances from overseas, that require different voltage compared to their original design.
- This requires homeowners to install step-up (low voltage to high voltage) or step-down transformers (high voltage to low).
- Because of the low leakage flux between primary & secondary, the impedance of the autotransformer is low. Thus, it may result in large fault currents in the secondary.
- The electrician who designs and installs your electrical system does so in a measured way. They should distribute it across your home to ensure the safe balancing of all loads.



Step-down



Step-up

Selecting and Sizing Transformers to Achieve Energy Efficiency

Conditions internal and external to a transformer can impact power supply and energy efficiency:

- Gradually loosening connections from temperature fluctuations, vibrations, or age.
- Deterioration of insulating materials can lead to arcing and overheating.
- 'Shorts' caused by mother nature – weather, insects, or animals – bridging two or more points together that should not touch.
- Power surges (high electrical currents) from too much demand, upstream grid issues, or lightning strikes.

How to Improve the Efficiency of Transformer?

There are different methods to improve the efficiency of transformers:

- **Insulation -** The insulation among core sheets must be ideal to prevent eddy currents.
- **Primary and Secondary Coil's Resistance -**The material of primary and secondary coils must be stable so that their electrical resistance is extremely little.
- **Flux Coupling -** Both the coils of the transformer must be wound in such a manner that flux coupling among the coils is utmost as power transfer from one coil to another will takes place during flux linkages.

E-mobility in Pacific Island Countries and Territories

PCREEE

Lunch

Case study: Government Infrastructure

PAPUA NEW GUINEA, TONGA

Coffee Break

Case study: Fisheries

KIRIBATI

Case study: Hotel

SOFITEL

Interactive Session

Thank You

SIDS Lighthouses Initiative

islands@irena.org

https://islands.irena.org

SIDS Lighthouses Initiative

IRENA Headquarters,
Masdar City, P.O. Box 236,
Abu Dhabi
United Arab Emirates

Additional resources

Regional Status Report on Efficient Lighting in Pacific Island Countries and Territories (2015)

Pacific Efficient Lighting Strategy (2016)

Energy Conservation Measures in Lighting

- **Turn off lights when not needed:** Lights should be turned off whenever an area is unoccupied, for example when people take a break form work or go to a meeting.
- **Take advantage of natural light:** Turn off some or all of the lights near windows during daylight hours. Where possible, consider replacing some of the iron sheet roofing of your sheds with transparent sheets to provide natural light.
- **Clean fixtures, lamps, and lenses** every 6 to 24 months
- **Try task (spot) lighting:** By focusing extra light where you need it, you may reduce the need for overhead lighting while decreasing glare and eyestrain
- **Experiment:** to see if removing lamps makes sense in your facility
- **Find out the preferences:** people working on computers – they may prefer less light for increased contrast on their monitors
- **Remove other unnecessary lamps where lighting levels exceed needs**

Energy Efficiency Measures in Lighting

- **Install more efficient lighting sources**



	LED	CFL	Incandescent
Average Life Span	25,000+ hours	8,000 hours	1,200 hours
Watts Used	8-12 watts	13-15 watts	60 watts
Kilo-watts Used*	44 KWh/yr	55 KWh/yr	219 KWh/yr
CO_2 Emissions*	45 pounds/yr	56 pounds/yr	225 pounds/yr

* Per bulb, based on 10 hours a day, 365 days a year

- **Lighting controls can help save energy**– by automatically turning lights off when they're not needed, by reducing light levels when full brightness isn't necessary. Common types of lighting controls include:
  - Dimmers
  - Motion sensors, occupancy sensors, and photosensors
  - Timer

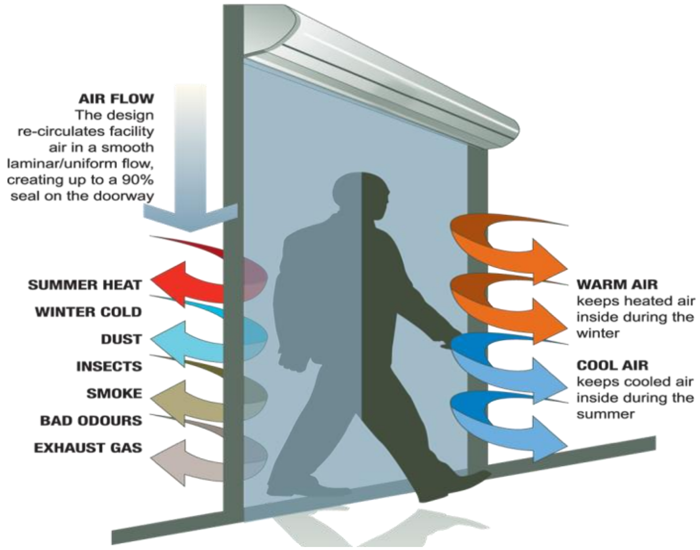
Energy Conservation Measures in Air Conditioning

- Turn off when not in use
- Make sure that doors and windows are closed
- Keep the Curtains or Blinds Drawn
- Use a ceiling fan (if already installed)
- Don't place appliances next to your thermostat
- Regularly cleaning your AC system and replacing its filters once a month can help lower its energy consumption by about 5 to 15 percent

Energy Efficiency Measures in Air Conditioning

- Install window tint or shade windows
- Insulate wall, roof, floor
- Replace old AC unit with more energy efficient option

- Use variable air volume (VAV's)/air curtains



- Use a smart thermostat

Calculations

Exercise 1 a)

A facility has the following equipment which are being used for certain hours during the day.

The list of equipment are provided below:

Name	Wattage, W	Quantity	Op. load, W	Op. hours/day	Energy consumption, kWh/day
		A	B	C	D = (AxBxC) /1000
Fluorescent tube lights	36	10	36	15	
Split air condition units	2600	3	1320	15	
Water pump	750	1	700	5	
Street lights	150	5	150	12	
Total					

Q1) Calculate the total daily energy consumption of the facility?

Exercise 1 a) - Answers

A facility has the following equipment which are being used for certain hours during the day.

The list of equipment are provided below:

Name	Wattage, W	Quantity	Op. load, W	Op. hours/day	Energy consumption, kWh/day
		A	B	C	D = (AxBxC) /1000
Fluorescent tube lights	36	10	36	15	5.4
Split air condition units	2600	3	1320	15	59.4
Water pump	750	1	700	5	3.5
Street lights	150	5	150	12	9.0
Total					77.3

Q1) Calculate the total daily energy consumption of the facility?

Total daily energy consumption of the facility = 77.3 kWh/day

Exercise 1 b) Identify energy saving measures

The following are the energy saving measures identified

Name	Wattage, W	Proposed measure
Fluorescent tube lights	36	Replacement with LED
Fluorescent tube lights		Minimizing Operating hours
Split air condition units	2600	Replacement with Inverter based Split AC
Split air condition units		Minimizing Operating hours
Water pump	750	Minimizing Operating hours by using level controller
Street lights	150	Replacement with LED

Energy saving calculations - Reducing operating hours

	Old Scenario					New Scenario - 1 (Reducing op.hours)				
Name	Wattage, W	Quantity	Op. load, W	Op. hours/day	Energy, kWh/day	Wattage, W	Quantity	Op. load, W	Op. hours/day	Energy, kWh/day
		A	B	C	D=(AxBxC) /1000		E	F	G	H=(ExFxG) /1000
Fluorescent tube lights	36	10	36	15	**5.4**	20	10	36	12	4.32
Split air condition units	2600	3	1320	15	**59.4**	2600	3	1320	12	47.52
Water pump	750	1	700	5	**3.5**	750	1	700	4	2.8
Street lights	150	5	150	12	**9.0**	70	5	150	12	9.0
Total					**77.3**					**63.64**

Q2) Calculate the total daily energy consumption of the facility?

Energy saving calculations - Equipment replacement

	Old Scenario					New Scenario - 2 (Equipment replacement)				
Name	Wattage, W	Quantity	Op. load, W	Op. hours/day	Energy, kWh/day	Wattage, W	Quantity	Op. load, W	Op. hours/day	Energy, kWh/day
		A	B	C	D=(AxBxC) /1000		E	F	G	H=(ExFxG) /1000
Fluorescent tube lights	36	10	36	15	5.4	20	10	20	15	3.0
Split air condition units	2600	3	1320	15	59.4	2600	3	690	15	31.05
Water pump	750	1	700	5	3.5	750	1	700	5	3.5
Street lights	150	5	150	12	9.0	70	5	70	12	4.2
Total					77.3					**41.75**

Q2) Calculate the total daily energy consumption of the facility?

Energy saving calculations

Q3) Calculate total energy saved by New Scenario - 1?

Total Energy savings = Σ (Energy consumption in old scenario – Energy consumption from new scenario)

Total Energy savings by New Scenario - 1 = 77.3 – 63.34

Total Energy savings by New Scenario - 1 = 13.96 kWh/day

Q4) Calculate total energy saved by New scenario - 2?

Total Energy savings by New scenario - 2 = 77.3 – 41.75

Total Energy savings by New scenario - 2 = 35.55 kWh/day