Renewable Energy

機電工程署 EMSD

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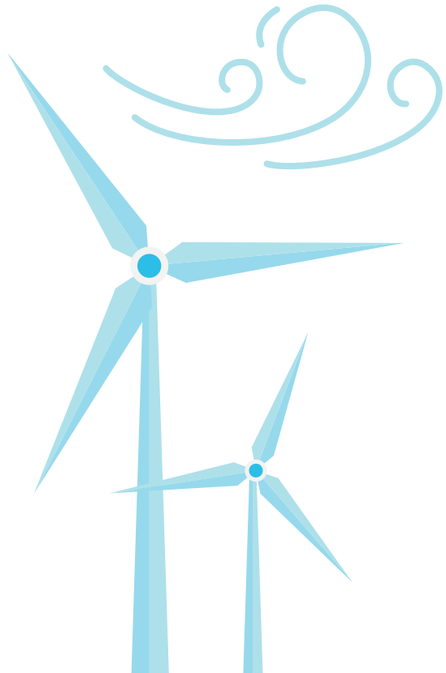


PREFACE

“At present, most of the consumed energy in the world comes from burning fossil fuels, which take millions of years to form and will be used up one day.”

With the gradual drop of fossil fuel reserves, the rise in oil price and the environmental impact on using fossil fuel, renewable energy is part of the solution to creating a greener and sustainable future. Renewable energy comes from the sun, wind, running water, waves, and geothermal and will never be exhausted. The increasing use of these renewable energy sources is important to address climate change and lessen dependency on fossil fuels, thereby enhance energy security and conserve our environment.

This education kit is designed for the Energy Technology and the Environment module under the “Liberal Studies Curriculum and Assessment Guide”, published by the Curriculum Development Council and the Hong Kong Examinations and Assessment Authority. Renewable Energy is a commendable, and indeed a necessary, topic to be introduced into the new curriculum. Aimed at Secondary Four to Six students, this kit has been designed for use in the classroom both by teachers and students. It will help them understand the key elements related to renewable energy, hand-in-hand with a number of case examples. The kit also introduces different forms of renewable energy, the advantages and disadvantages, as well as the ongoing development of various renewable energy technologies and projects.

Liberal study aims to liberate students’ minds and facilitate their independent and critical thinking. This education kit therefore encompasses news extracts and a wide variety of topics, such as climate change, waste energy recovery and the opportunities and challenges faced by Hong Kong by increasing the portion of renewable energy.

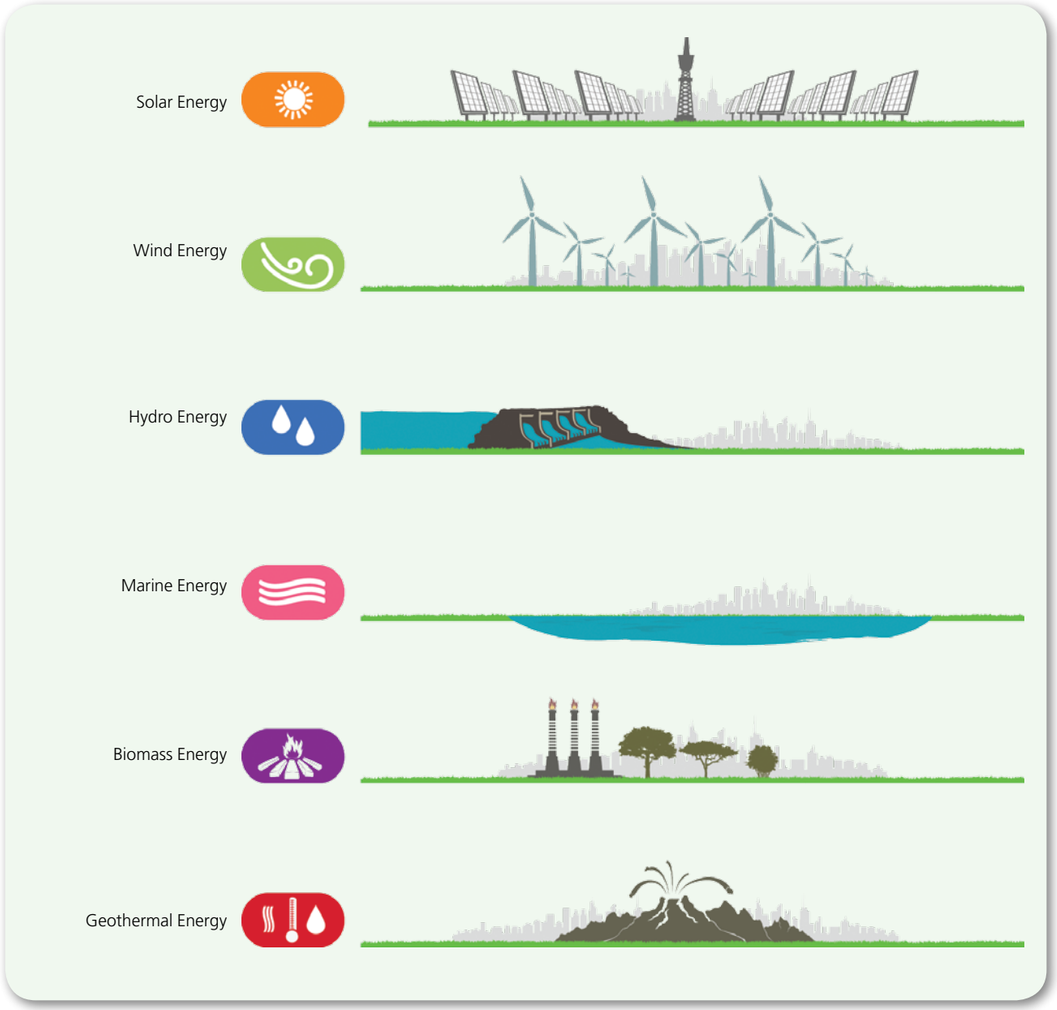
Providing a wide range of information, this education kit is produced with a number of objectives. They include helping students to acquire knowledge of the interdependence between energy and our daily life, develop critical thinking skills in interpreting and assessing the impact of different energy issues, and more importantly, to arrive at and voice out individual judgment after considering and balancing the different perspectives.

In a highly energy dependent metropolitan city like Hong Kong, we hope that this kit will help students better understand how important and valuable natural resources are, and facilitate them to become more aware of energy conservation issues and the benefits of renewable energy.

1 RENEWABLE ENERGY

What is Renewable Energy?

A lot of energy is expended in society. At present, most of the energy used in the world comes from burning fossil fuels such as coal, petroleum and natural gas. Fossil fuels are formed over millions of years in the history of the Earth. These reserves are limited and over time, will be exhausted. In contrast, renewable energy, such as solar, wind, hydro, marine, biomass and geothermal energy, can be produced and regenerated within the environment. These energy sources are both renewable and sustainable.



Different Forms of Renewable Energy

The Benefits of Renewable Energy

The extraction and use of these energy sources cause less impact to the environment when compared with fossil fuels. In general, they produce less pollution and greenhouse gases. Using renewable energy reduces urban air pollution, mitigates against global warming, diversifies energy sources thus enhancing energy security, and promotes local economic development and job opportunities. More importantly, the use of renewable energy helps to conserve fossil resources for future generations.

The Use of Renewable Energy in Hong Kong

In a study commissioned by the Hong Kong Government, solar power and wind power have been identified as potentially feasible for wide-scale application in Hong Kong. Besides, the Government has planned to make the best use of its waste-management facilities to turn waste into renewable energy. With regard to the various waste-to-energy facilities completed or being planned, including sludge treatment facility, integrated waste management facility, and a number of organic waste treatment facilities, the renewable energy generated is estimated to be able to meet about 1% of Hong Kong's total electricity demand by the early 2020s.

Do you know …

Incentivise Power Companies to Develop Renewable Energy

Under the New Scheme of Control Agreements, the two power companies in Hong Kong enjoy an incentive factor for various renewable energy developments.

In 2005, to promote the local use of renewable energy and drive greater energy efficiency, the government issued a circular on the "Adoption of Energy Efficient Features and Renewable Energy Technologies in Government Projects and Installations", which encourages the adoption of energy efficient features and renewable technologies in public works projects. The circular was updated and subsumed in a new circular on "Green Government Building" issued in April 2015.

To combat climate change, the renewable energy targets in the Green Government Buildings circular was further upgraded in May 2017.

Do you know ...

The Electrical and Mechanical Services Department (EMSD) issued the "Technical Guidelines on Grid Connection of Renewable Energy Power Systems (2016 Edition)". Renewable energy power systems up to 1MW can now be connected to the local electricity supply grid.

Both Hong Kong's power companies have launched loan funds, education funds and sponsorship schemes to promote the use of renewable energy, together with energy efficiency and conservation amongst their stakeholders.

Do you know ...

Use of Renewable Energy at Schools

To promote the use of renewable energy to the community, a number of schools in Hong Kong have adopted the use of renewable energy on school campus. The Government had planned the campus of Sing Yin Secondary School in 2008-09 as a demonstration building to showcase energy efficiency and renewable energy technologies with an educational purpose. Various environmental friendly features were installed on campus including lift regeneration system, occupancy sensors, auto-control for air-conditioning units and lighting, LED accent lighting and solar PV panels delivered energy savings of almost 30% annually. Sing Yin Secondary School was awarded the "Greenest School on Earth 2013" by the US Green Building Council.

Energy Saving Features at Sing Yin Secondary School
Source: Sing Yin Secondary School

2 SOLAR ENERGY

Solar energy is the energy carried in sunlight. It is the most abundant energy source on the planet. It is also the origin of fossil fuels and most other forms of renewable energy. Human beings have been using it for drying food and growing crops for thousands of years.

Floating Solar Power System at Shek Pik Reservoir
Source: Water Supplies Department

Today, people use solar energy to provide space heating in buildings, heat water and generate electricity using a variety of technologies. Solar water heating and solar photovoltaic technologies are suitable for application in Hong Kong, while various other technologies are also applied in different parts of the world.

How Does it Work?

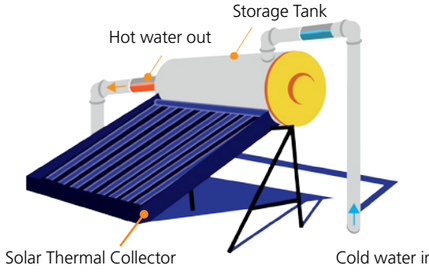
Solar Thermal Energy

Solar heating technologies are well developed and are widely used in many places around the world. The most common use of solar thermal technology is for domestic water heating. Others include solar space heating, cooling, cooking, and solar thermal electricity generation.

Solar Water Heating

Solar water heating systems make use of the heat in solar radiation to produce hot water. Solar thermal collectors transform the infra-red radiation from the sun into thermal energy in water. Their absorbent surfaces are usually dark and made of good thermal conductors such as copper or aluminium. These panels are usually installed on the roof of a building.

Heated water is stored in a well-insulated tank to reduce heat loss due to conduction or convection in cold or windy weather. The tank is often equipped with a standby electric or gas heater, which operates when the solar heating is unable to meet demand. This design has catered for the situation when solar energy is either unavailable or insufficient – at night, for example, on a cloudy day, or in the cooler months of the year.



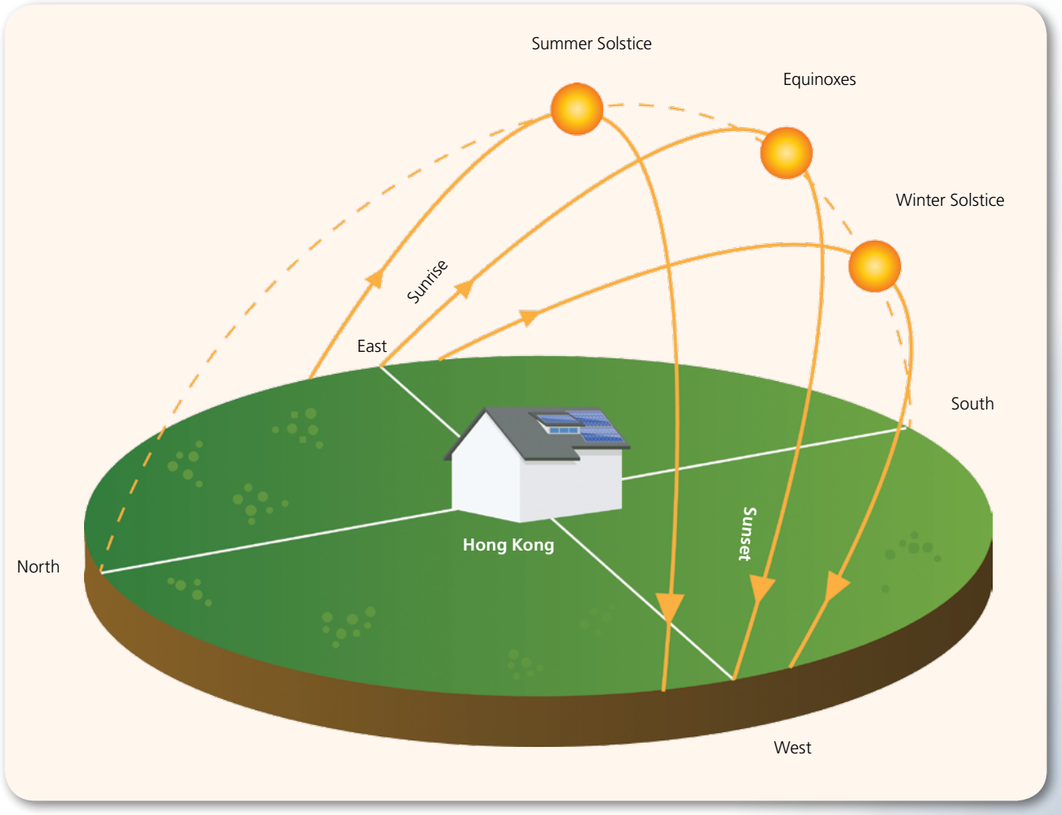
Solar Water Heating System

General Applications

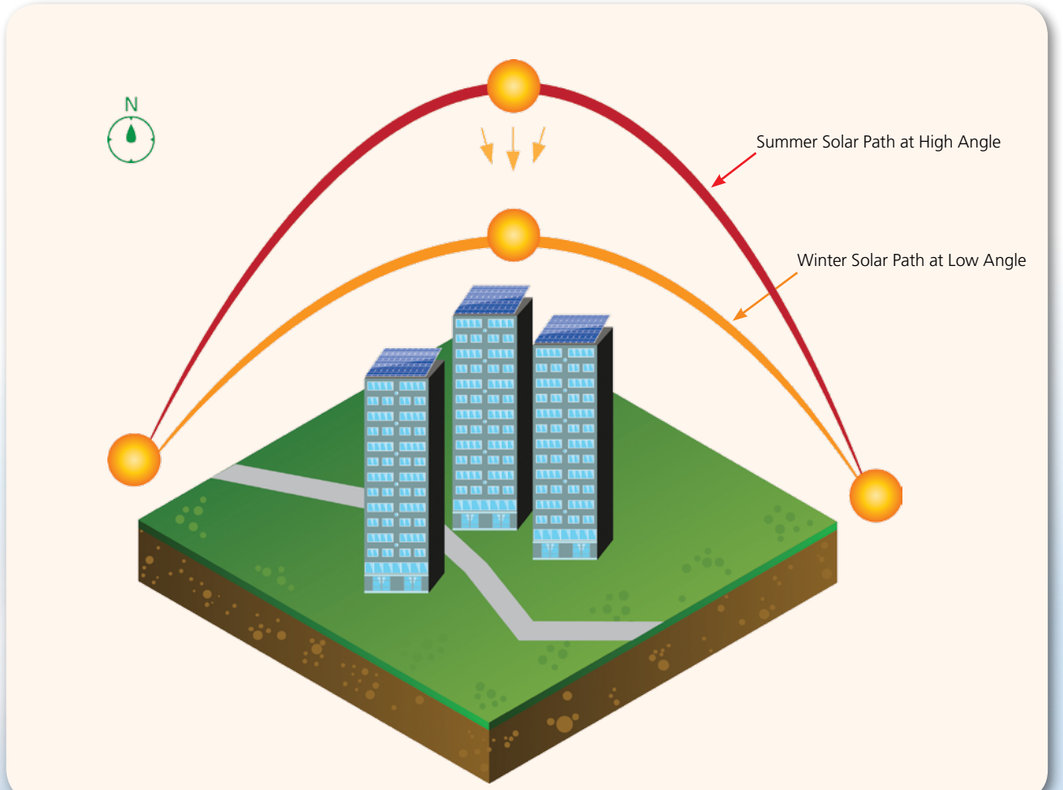
Solar water heating systems can be used for a wide range of applications, such as in hotels, hostels, households and hospitals, where there is regular demand for hot water. It is also suitable for sports centres and holiday resort villages. Water for swimming pools can, for instance, be pre-heated by a solar water heating system. Wider applications in low-rise office buildings with canteens and washrooms and showers can also be considered.

Worldwide Scenario

In the northern hemisphere, solar collectors are mounted on the south side of a roof so that they can capture more sunlight. In geographical latitudes of below 40 degrees, 60% to 70% of domestic hot water requirements with temperatures of up to 60°C can be provided by solar heating systems.



Solar Paths at Northern Hemisphere



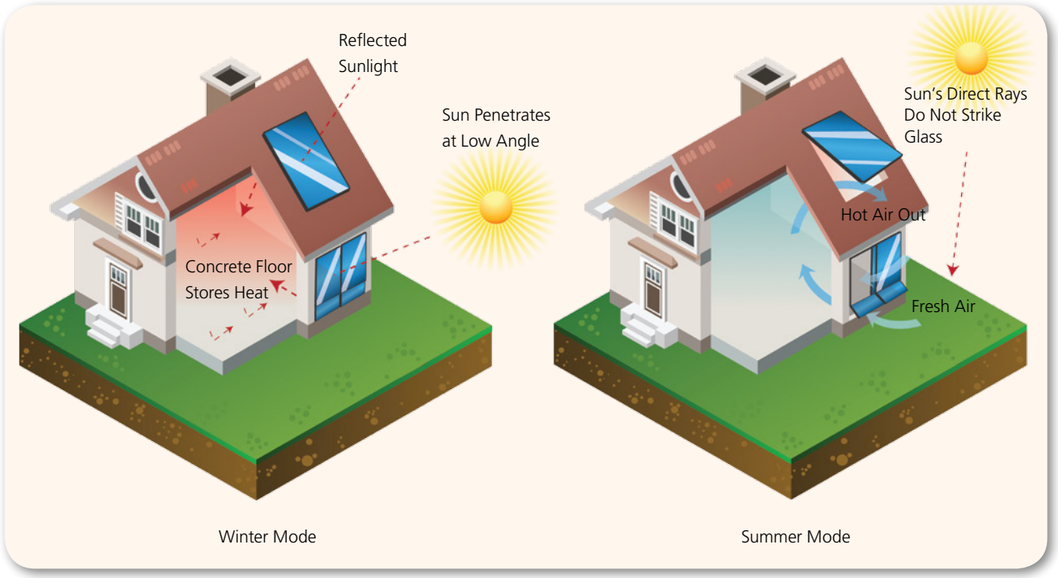
Solar Paths at Different Seasons

Hong Kong Scenario

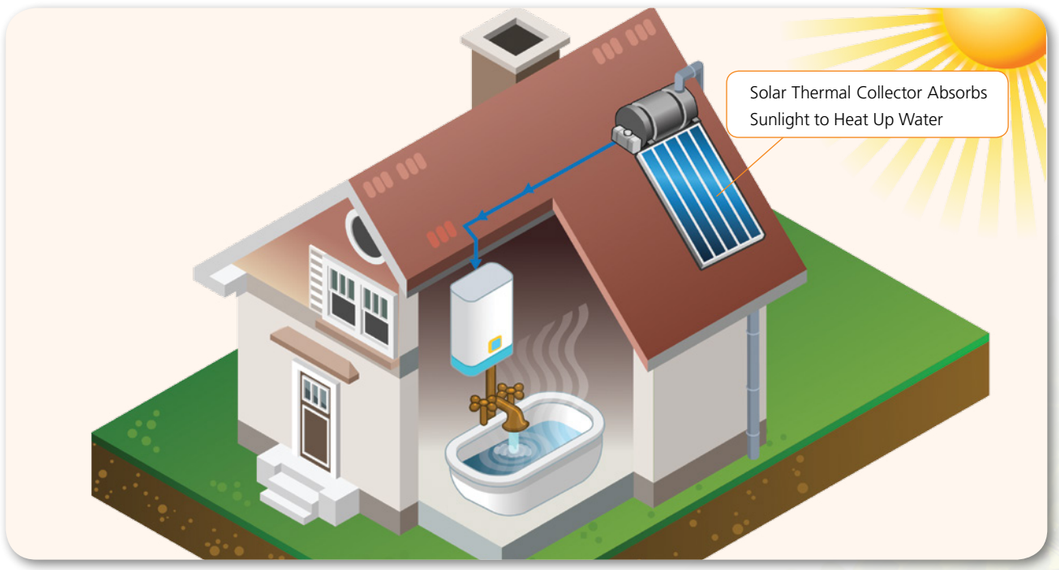
Hong Kong has been using solar energy for water heating applications for over 30 years. The first solar hot water heating installation was installed in 1980 for a bathhouse in Stanley. There are a number of solar water heating installations for low-rise buildings in some suburban areas while others are used at swimming pools.

Solar Space Heating

Many homes at higher latitudes use solar energy for heating spaces inside the building. Solar space heating systems can be classified as passive or active.



Passive Solar Heating System



Active Solar Heating System

>> Passive <<

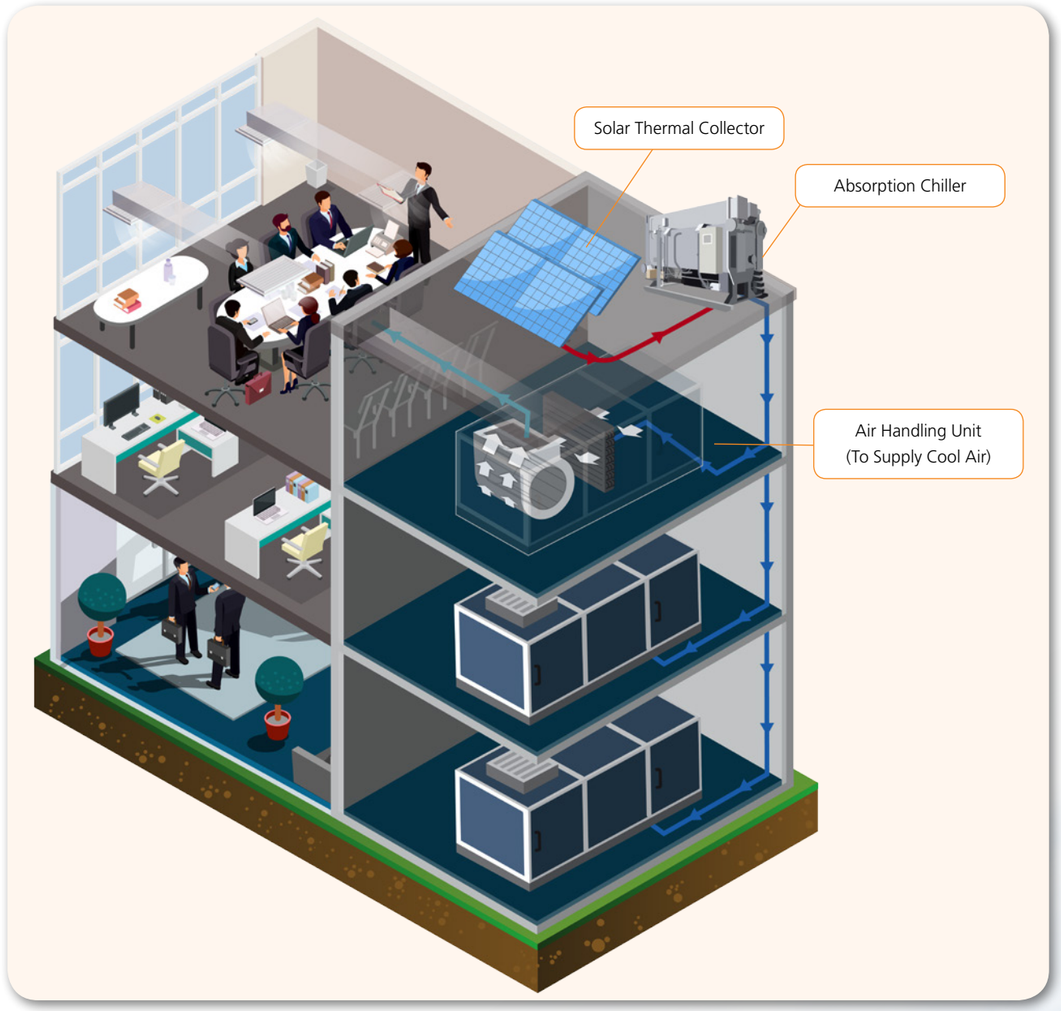
- A passive solar building is designed to make use of the heat from sunlight directly.
- No mechanical equipment is used to capture solar energy for heating.
- Building walls and floors absorb the energy from the sunlight, slowly releasing the heat and reducing the heat loss into the environment.

<< Active >>

- Active solar space heating systems consist of solar thermal collectors that are mounted on south-facing rooftops to take advantage of the winter sun.
- The thermal collectors absorb sunlight and produce heat.
- Air or water flows through the collectors and is warmed by the heat.
- Energy storage facilities may be available to store the heat, providing a steady supply of heat energy when there is no sunlight.

Solar Space Cooling

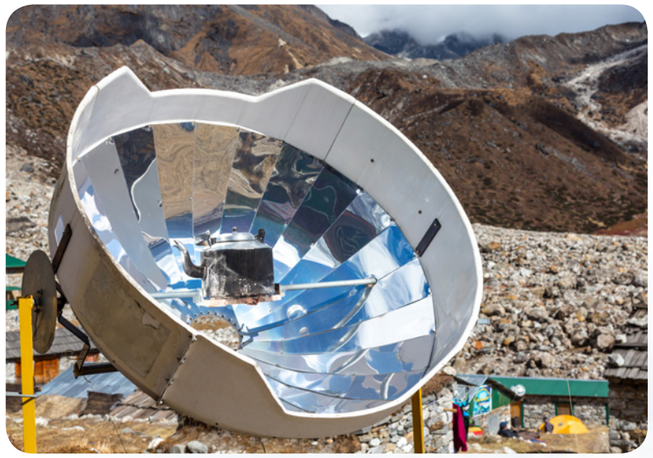
In addition to heating, heat energy captured from sunlight can also be used to provide space cooling. Solar cooling can be carried out by an absorption chiller alone, or in pairing with a solar water heating system. With an absorption chiller, heat is used to evaporate a refrigerant, with hot water from solar thermal collectors being used as the heat source. The condensation of the evaporated refrigerant provides the required cooling. Electricity is necessary to keep the refrigerant running, but the electricity consumed is relatively small compared to conventional electric chillers.



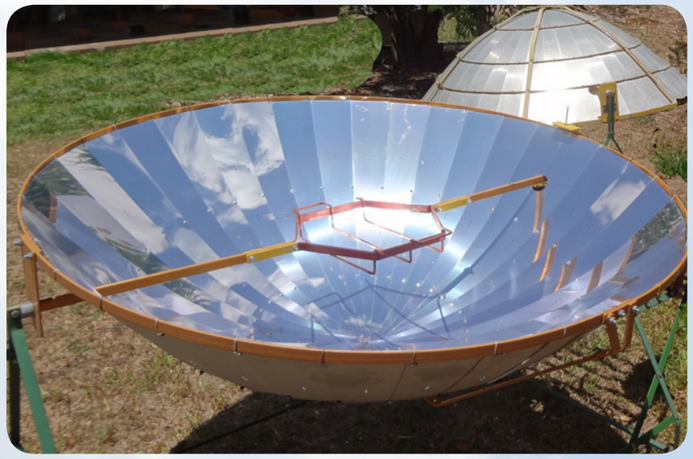
Solar Space Cooling System

Solar Cooking

Solar cookers use sunlight as their energy source. These devices consist of reflective metal, as their main component, to concentrate light and heat from the sun into a small area. A black pan is used to absorb the sunlight and convert it into heat. It is then necessary to trap the heat produced with a plastic bag or glass cover. Frequently used for outdoor cooking, the cookers reduce fuel consumption as well as the risk of fire. Their application also eases deforestation and desertification caused by the burning of wood. Common types of solar cookers include box cookers, panel cookers and parabolic solar cookers.



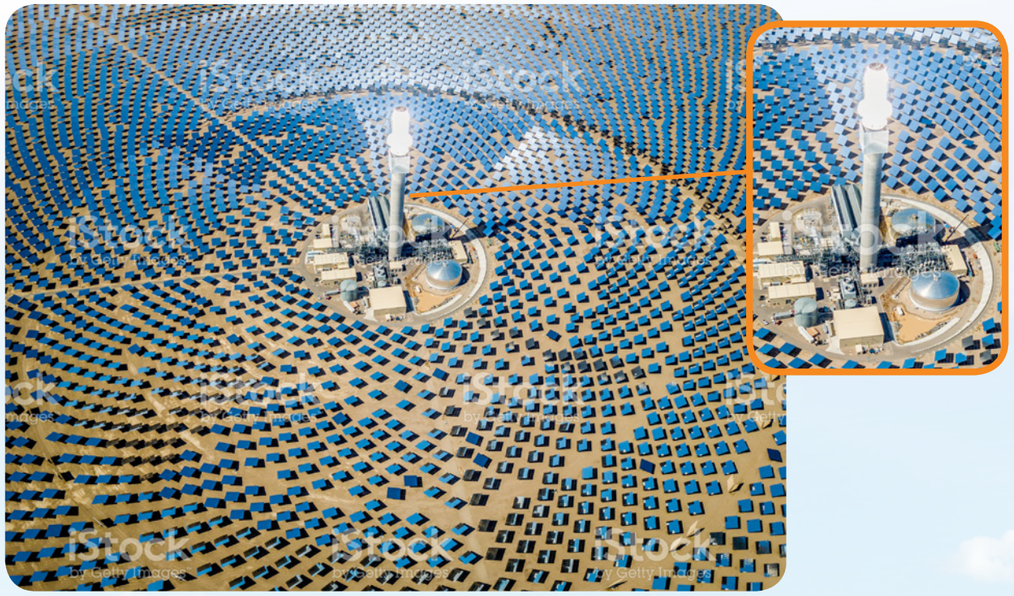
Solar Cooker at Nepal Himalaya



Solar Cooker at Caribbean

Solar Thermal Power

Essentially solar thermal power plants work along the same lines as fossil fuel plants, except that the steam is produced by the heat collected from sunlight instead of from the combustion of fossil fuels. Concentrating solar power (CSP) technologies use reflective devices to concentrate the sun's energy. They need direct beams from sunlight which is relatively low in Hong Kong. Therefore solar thermal electricity is unlikely to be applied locally. The three main types of CSP systems available are parabolic troughs (the most common type), solar dishes and solar power towers.



Solar Power Tower at Nevada

Parabolic Troughs at California

Solar Dishes at Australia

How Does it Work?

Solar Photovoltaic

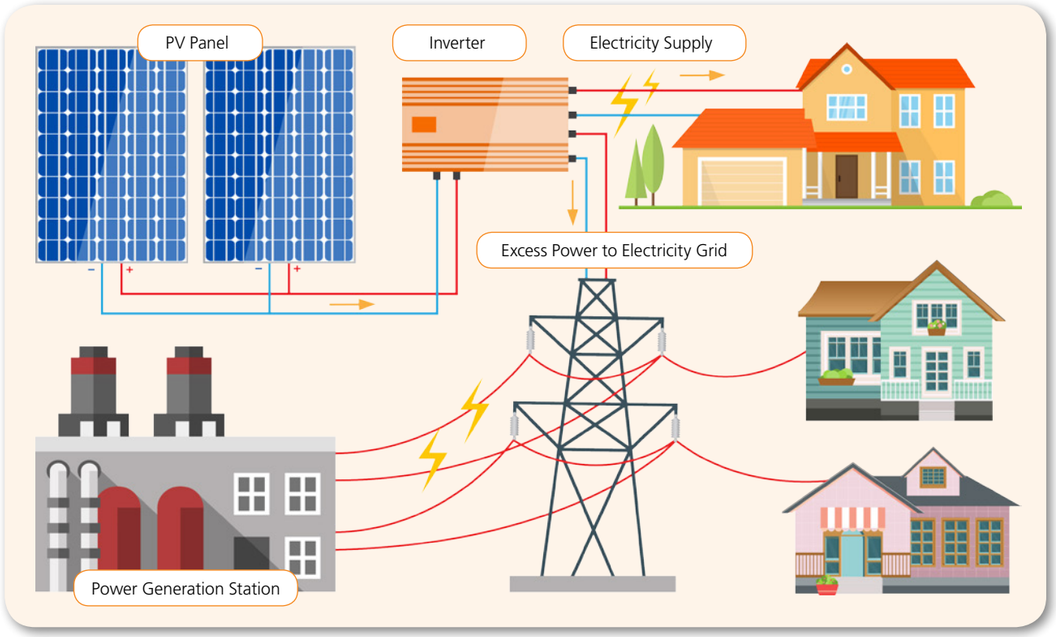
Photovoltaic (PV) panels are made up of solar cells, which can convert sunlight directly into electricity. The energy transformation is achieved through a photoelectric effect, exhibited in semiconductors such as silicon. When sunlight hits a solar cell, electrons in the material are excited and begin moving around. This starts an electric current which generates further electric current.

Solar Photovoltaic Pannel

Common Use of PV Panels

PV panels have no moving parts and are durable. The simplest and most common solar cell type provides power to watches and calculators. PV panels can be connected in series or parallel arrays with capacities ranging from several hundred watts to hundreds of kilowatts.

These PV panels can generate electricity to supplement the energy demand in a building. Any excess power that is unused, can be fed into the city's electricity grid.



Use of PV Panels

Electricity grid is an interconnected network for delivering electricity from power generation plant through high voltage transmission lines and low voltage distribution systems to individual consumers.

Building-integrated PV (BIPV) Systems

When the PV panels are integrated into a building's envelop, they are called Building-Integrated PV (BIPV) Systems. As part of the building's structure, the systems replace some of the building components on the roof, front wall or windows as part of its sun shading tools, in addition to producing electricity to meet a portion of the building's electricity demand.

Building-integrated PV (BIPV) System
Source: Electrical and Mechanical Services Department

Standalone PV Systems

Standalone PV Systems do not connect into the electricity grid. They need batteries to store the converted energy and supply power when sunshine is insufficient. They are usually found where connection to the grid is inconvenient or uneconomical, such as telecommunication equipment or telemetry stations located in remote locations. Solar-powered lighting poles have also been installed in different locations throughout Hong Kong.

Standalone PV System

The Pros and Cons of Solar Energy

Pros

- Free and inexhaustible
- Pollution free
- Able to supply energy in remote areas
- Quick and convenient installation
- Low operation cost

Quick and Convenient Installation

Cons

- Requires larger spaces
- High construction costs
- Dependent on weather and climate conditions
- Relatively unreliable
- High visual impact

Dependent on Weather and Climate Conditions

Practical Scenario

Grid-connected (or grid-tied) PV systems in Hong Kong are connected indirectly to the electrical system. The PV system operates in parallel with the electricity supply from the grid to meet demand at the site. Storage batteries are thus not required.

A number of BIPV systems, installed both by the government and private organizations have emerged recently, showcasing the benefits of these grid-connected systems.

Do you know ...

Hong Kong's Largest Solar Power System

In December 2016, the solar farm at Siu Ho Wan Sewage Treatment Works of the Drainage Services Department (DSD) came into operation. The largest of its kind in Hong Kong, the solar farm comprises over 4,200 polycrystalline photovoltaic panels with an installed generation capacity of 1,100 kilowatts. It can generate as much as 1.1 million kilowatt-hours of electricity annually.

The electricity generated by the solar farm at Siu Ho Wan Sewage Treatment Works is fed through an internal power distribution network to various facilities inside the plant, including screening facilities, a workshop, an administration building, an ultra-violet disinfection system and sludge treatment facilities, which account for about 25 per cent of the current annual electricity consumption of the plant.

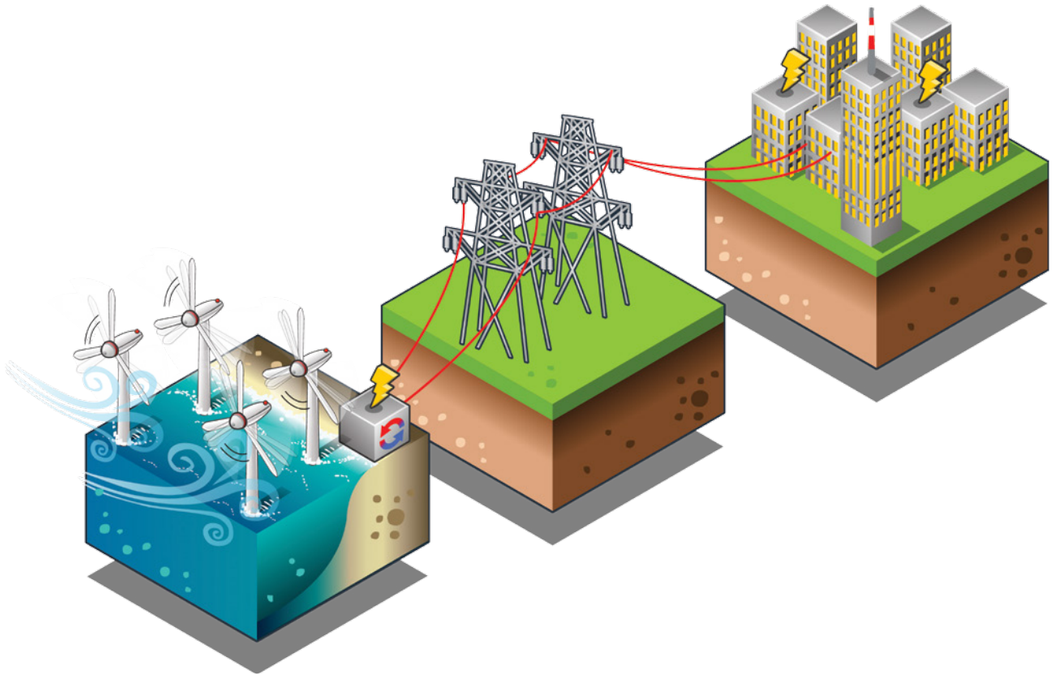
Solar farm at Siu Ho Wan Sewage Treatment Works
Source: Drainage Services Department

Location of Siu Ho Wan Sewage

3 WIND ENERGY

Wind contains kinetic energy. It is the movement of air as a result of variations in air pressure. It is a renewable energy source as it will continue to be produced as long as the sun shines on the Earth.

Wind turbines convert the kinetic energy of wind into rotational motion, which drives electric generators and produces electricity. This technology first emerged at the end of the 19th century, maturing into use for industrial applications in the 1980s. The typical size of wind turbines has grown steadily over the past two to three decades.



Wind Energy Generation

How Does it Work?

The wind turns the blades, spinning a shaft, which connects to a generator to generate electricity.

The average wind speed at a location depends on both the climate and the local landscape in the region. Turbines start rotating at wind speeds of around 3 to 4m/s. The generator will cut out at approximately 25m/s to protect themselves from possible damage.

The larger the turbine, the more electricity is generated. Large wind turbines rotate relatively slowly, both to reduce noise and the hazard they pose for birds.

Wind Farm at Spain

Wind Farm

When many of these turbines are built on the same location in arrays, it is usually called a “wind farm”. Wind farms are constructed at windy locations. Connected to the electricity grid, these wind farms deliver the power generated into the grid.

Do you know …

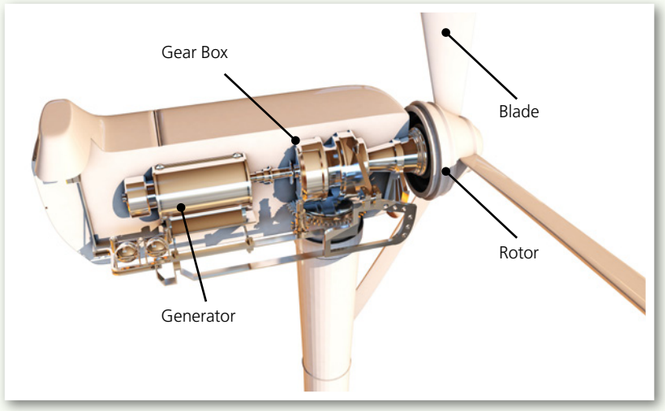
China is the global leader in terms of installed wind power capacity. Its wind power with a total exceeding 235 GW by 2017 year’s end.

Source: Renewables 2018 Global Status Report, REN21

Do you know …

The Internal Parts of a Wind Turbine

- A rotor, or blades, convert the wind's energy into rotational shaft energy
- A nacelle contains the drive train, usually consisting of a gearbox and a generator
- A tower supports the rotor and drive train, and
- Electronic equipment, such as controls, electrical cables, ground support equipment and interconnection equipment.

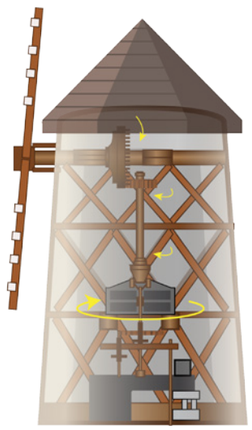


Internal Parts of Wind Turbine

Windmills

If the mechanical energy is used directly by machinery, such as a pump or grinding stones, the machine is usually called a windmill.

Windmills at Netherlands



Wind Turbine

If the mechanical energy is converted to electricity, the machine is called a wind generator or wind turbine. The electricity generated is mainly used in homes and for sale purposes.

Wind Turbine

Small Wind Turbine

Small wind turbines are often used in remote locations, sometimes in conjunction with PV panels, to provide off-grid power. Small wind turbines can produce several hundred watts, or go up to tens of kilowatt in power capacity. Small wind turbines are also found on sailing boats to charge batteries.

Small Wind Turbine

Offshore Wind Farm

Starting from the beginning of the 21st century, wind farm developers began to make use of the stronger winds over the sea by planting wind turbines on the seabed, often several kilometres from shore.

Offshore Wind Farm

The Pros and Cons of Wind Energy

Pros

- Free and inexhaustible
- Pollution free
- Supplies energy in remote areas
- Tourist attractions

Tourist Attractions

Cons

- Unreliable resource as wind is not predictable
- Limited locations for wind farms to be set up in coastal areas
- Noise pollution caused by the turbines operation
- Kills birds accidentally
- High construction costs for the building of turbines and setting up of wind farms in coastal areas

High Construction Costs

Practical Scenario

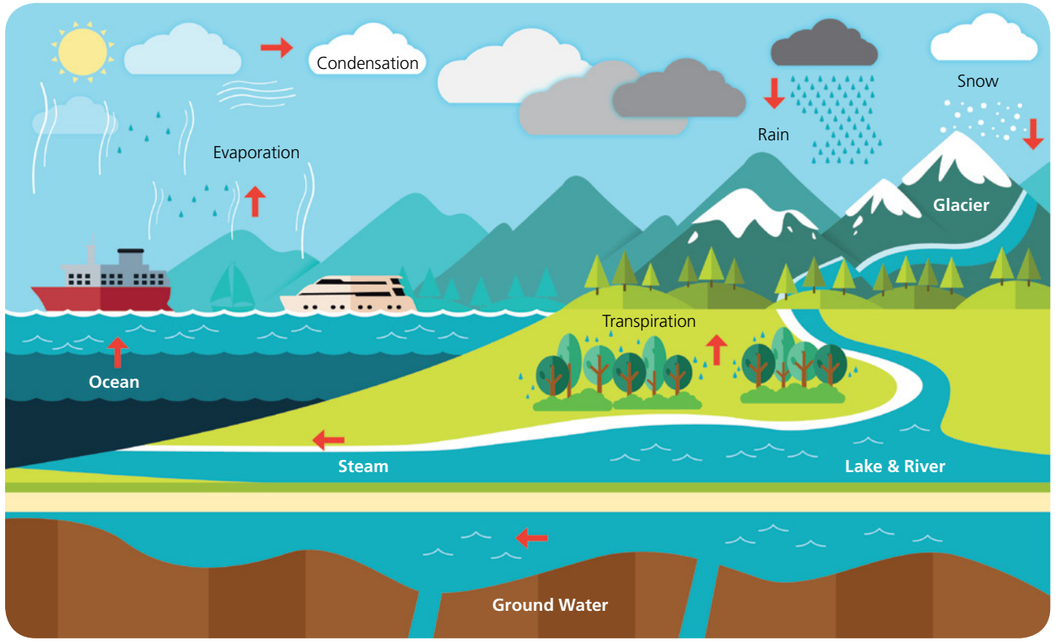
Rough estimates of the wind resource at a particular site in Hong Kong are available in the Wind Resource Maps site developed by The Electrical and Mechanical Services Department. Actual measurements and computer modelling are needed before designing the location and turbine type. Long-term predictions of the wind resource are used to predict the annual energy yield.

Wind Resource Maps Developed by The Electrical and Mechanical Services Department

The first commercial-scale wind turbine in Hong Kong was built by The Hongkong Electric Company Limited (HEC) as a demonstration project on Lamma Island. Inaugurated in February 2006, the exhibition centre next to the wind turbine provides information on the wind power station as well as the major types of renewable energy and their applications in Hong Kong and other parts of the world.

Wind Turbine on Lamma Island

4 HYDRO ENERGY



Hydrologic Cycle

Hydro energy is considered renewable as the sun powers the global hydrologic cycle. The heat of sun evaporates water in the oceans and rivers, drawing it into the air as water vapour. When the water vapour meets the cooler air in the atmosphere, it condenses and forms clouds. The moisture eventually falls to the earth as rain or snow, replenishing the water in the oceans and rivers. Gravity drives the water, moving it from high ground to low ground. The force of moving water can be extremely powerful.

Do you know …

The top countries for hydropower capacity and generation are China, Brazil, Canada, the United States, the Russian Federation, India and Norway, which together accounted for about 63% of the global installed capacity at the end of 2017.

Source: Renewables 2018 Global Status Report, REN21

How Does it Work?

Hydropower plants capture the kinetic energy of falling water to generate electricity. Flowing water rotates turbines and generators, where kinetic energy is converted to mechanical and then electrical energy. Based on the installed capacity, hydropower stations can be divided into micro hydro, mini hydro, small hydro and large hydro systems.

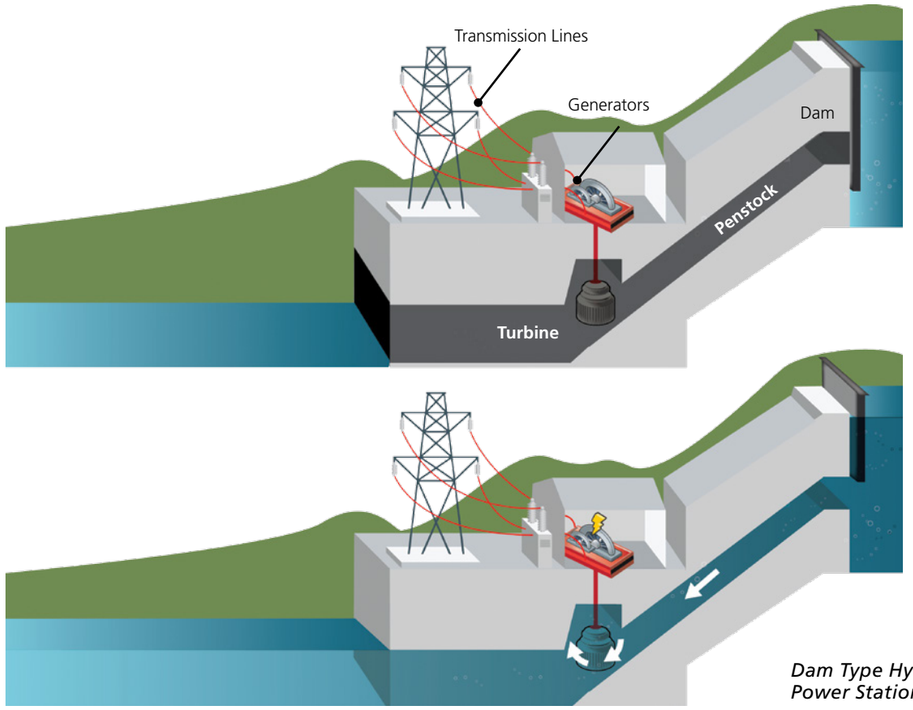
Hydropower Plant on Drina River Serbia

Do you know …

The International Energy Association defines hydroelectric station as:

- Large-hydro: 100 MW or more of capacity feeding into a large electricity grid;
- Medium-hydro: From 20 MW to 100 MW almost always feeding a grid;
- Small-hydro: From 1 MW to 20 MW usually feeding into a grid;
- Mini-hydro: From 100 kW to 1 MW that can be either stand-alone, mini-grid or grid-connected;
- Micro-hydro: From 5 kW to 100 kW that provide power for a small community or rural industry in remote areas away from the grid; and
- Pico-hydro: From a few hundred watts up to 5 kW (often used in remote areas away from the grid).

Hydroelectric Power



Dam Type Hydroelectric Power Station

Dam Type Hydroelectric Power Station

Most hydroelectric power stations are dam type stations. This involves the construction of a dam to store water in a reservoir to create the water head (height) difference. Driven by gravity, water flows through a channel (called a penstock) to reach a turbine at a lower level to make it spin. Although hydroelectric dams are usually built for large hydro stations with hundreds and even thousands of mega watts in capacity, they are also built for small hydro stations.

Hydroelectric dams store water, they then release the water for power generation when needed. This type of system is therefore more suited than other irregular renewable energy sources to provide power at peak loading times.

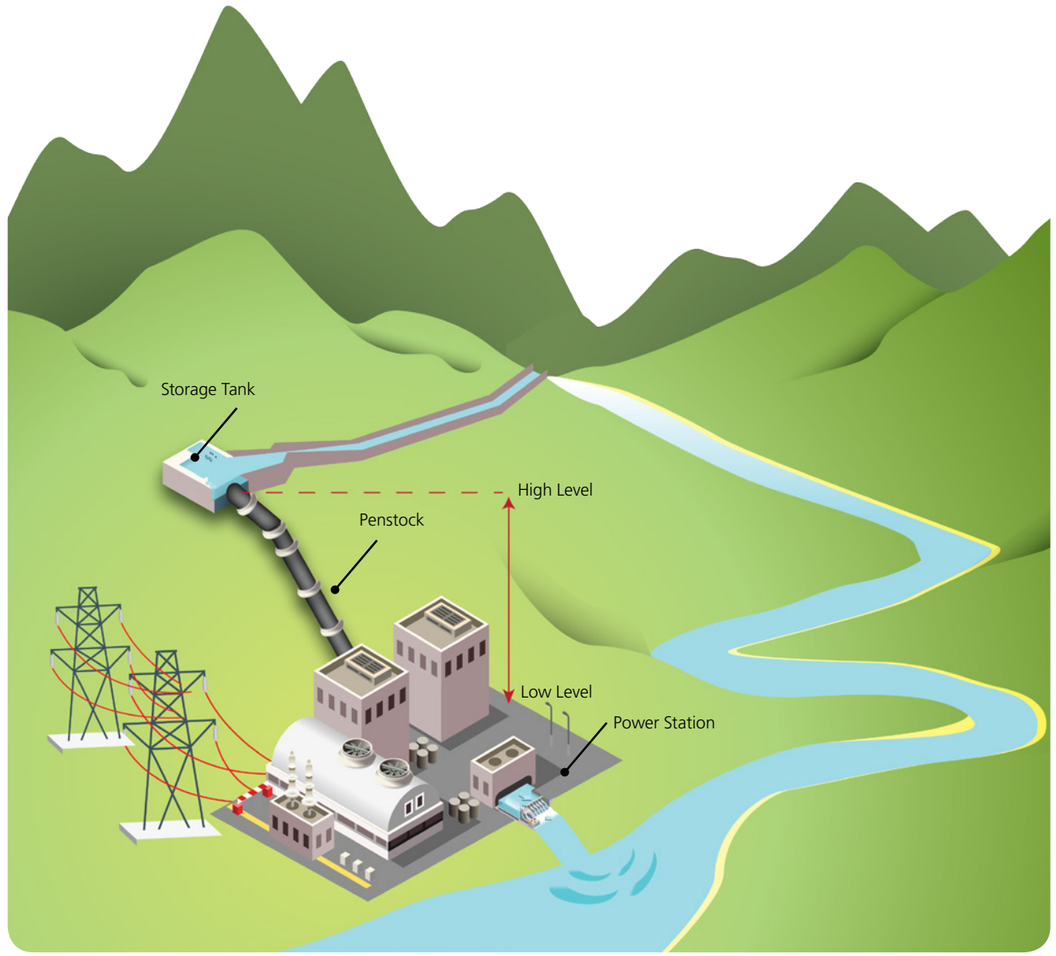
Do you know ...

The construction of hydroelectric dams can cause flooding of upstream areas and obstruct the journeys of migrating fish. Vegetation will also be destroyed — their decay in turn will emit methane, which is a greenhouse gas.

Run-of-river Type Hydroelectric Station

This type of hydroelectric station extracts energy from the water as it passes through. Gravity drives water collected by a diversionary weir down through a penstock to drive a turbine at a lower level. The water then runs back into the river channel. Run-of-the-river systems are usually mini or micro hydro systems. However in recent years, they have been used in larger projects in British Columbia in Canada and other areas.

Since they do not store a lot of water, the systems impose less impact on the surrounding environment than hydroelectric dams. However, the electricity generated is affected by the seasonal flow of the river.



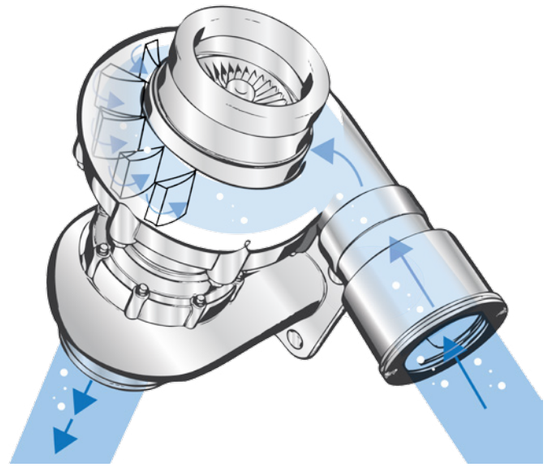
Run-of-river Type Hydroelectric Station

Turbine

Turbines with different runner shapes and sizes are used in hydroelectric systems.

Francis Turbine

The most common turbine type found in hydroelectric stations. They consist of a radial-flow turbine with water flowing inward in a radial direction over the curved runner blades towards the centre of the turbine. Francis turbines are suitable for hydroelectric systems with water heads of between 2 metres and 200 metres, with an efficiency rate of over 90%.



Francis Turbine

Pico Hydro Turbine

Used in small hydroelectric power generation projects with capacities below 5 kW. Pico hydro systems can be used in streams, rivers, irrigation canals and waterfalls, with only a very low water head. Pico hydro turbines are portable, thus they are suitable for remote communities in developing countries. Apart from generating electricity, some pico hydro turbines, such as water mills, can also be used to provide mechanical power for various applications such as grinding flour and irrigation.

The Pros and Cons of Hydro Energy

Pros

- Stable supply of energy
- Low operating cost
- Multi-purpose:water management, flood prevention, navigation, etc

Cons

- Location restrictions
- Enormous construction costs
- Floods land and destroys villages and historical buildings
- Damages the ecology of the river

Practical Scenario

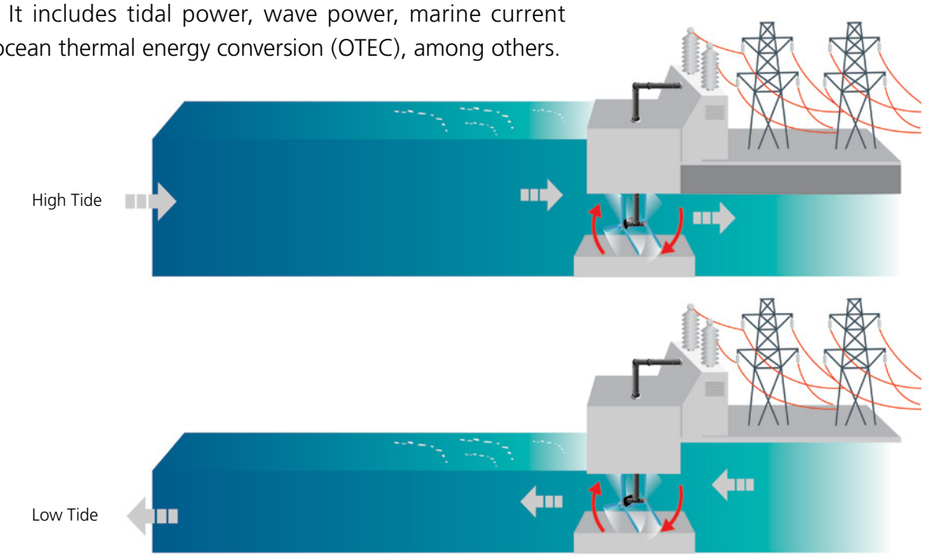
Hong Kong does not have rivers with sufficient flow and head for large-scale hydroelectric generation. On the other hand, there are certain locations in the territory where it may be possible to install small hydro-related installations.

Tuen Mun Water Treatment Works
Source: Water Supplies Department

Year	Organisation	Installation Venue	Installation Type	Application	Capacity
2013 to 2017	Water Supplies Department	Tuen Mun Water Treatment Works	Water Turbine Generator	Generate electricity to supplement part of the Treatment Works' electricity consumption	500 kW

5 MARINE ENERGY

Marine energy refers to the different forms of energy available from the oceans. It includes tidal power, wave power, marine current power and ocean thermal energy conversion (OTEC), among others.



Tidal Power Generation

Tidal Power

Tides are generated in the Earth's oceans due to the gravitational attractions of the Moon and the Sun. Their relative positions trigger the periodic rise and fall of the sea levels. The height of tides also depends heavily on local factors, such as the geography of the sea floor and coastlines.

How Does it Work?

Tidal power can be captured by building dams that admit and release water through a turbine. It can also be generated by positioning water turbines in a tidal current, just like wind turbines at a windy location. The turbines, propelled by the tides, then drive the electrical generators.

The construction of tidal power stations has long suffered from relatively high costs and limitations in finding locations with sufficiently tidal heights or flow velocities. Recent technological developments and improvements, both in design and turbine technology now mean that tidal power may have much higher potential than previously assessed.

Do you know ...

Asia's first tidal power station, a 40 kW tidal power facility, was installed at Daishan County in eastern Zhejiang Province at the end of 2005.

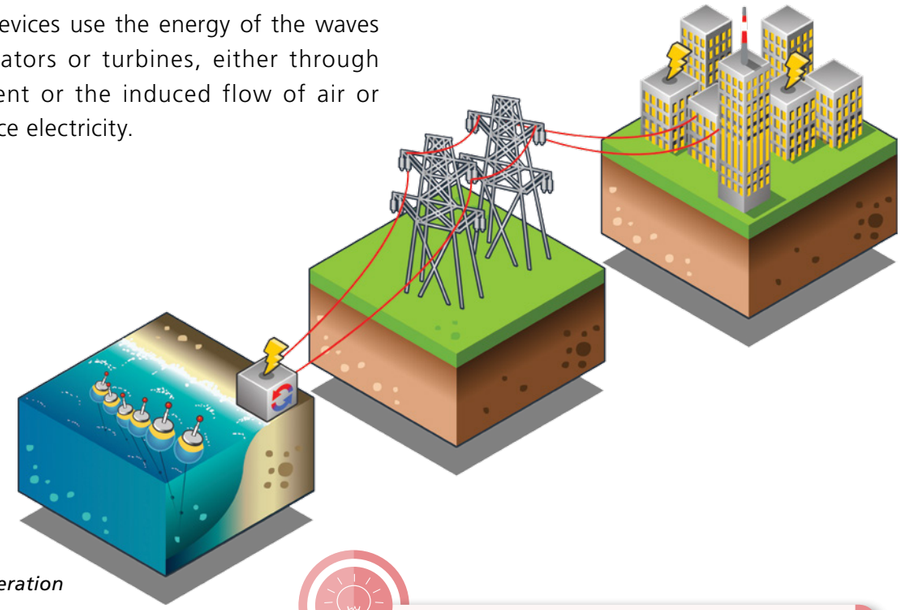
Wave Power

Waves are created by wind blowing over the sea surface. Waves contain both kinetic and potential energies. Kinetic energy lies in the movement of the water, and potential energy is stored in the water displaced from the mean sea level. Due to the prevailing trade winds in both the northern and southern hemispheres, the highest concentrations of wave energy occur between 40 degree and 60 degree latitudes.

Wave

How Does it Work?

Wave energy devices use the energy of the waves to drive generators or turbines, either through direct movement or the induced flow of air or water to produce electricity.



Wave Power Generation

Do you know ...

The world's first commercial-scale wave farm was built 5 km off Portugal's northern coast in 2008. The facility will be generating a total rated capacity of 2.25 MW.

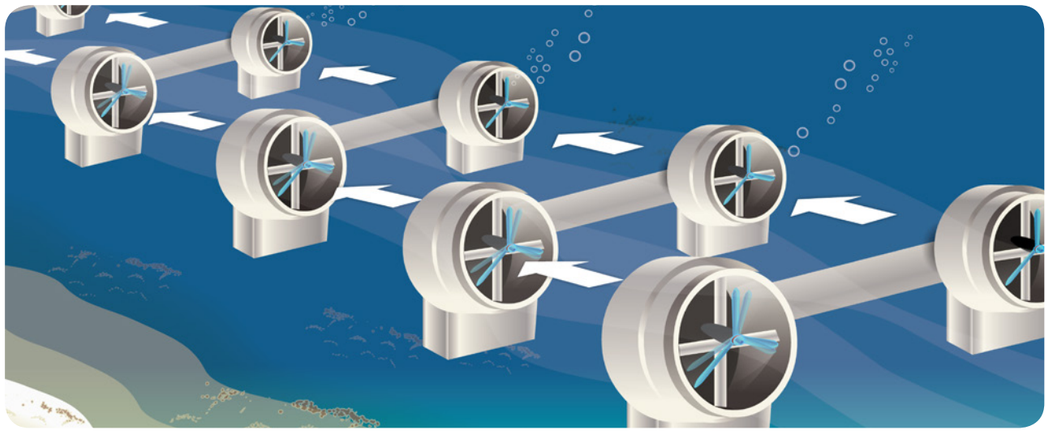
Marine Current Power

Marine current is caused by changes in the tides and the thermal and salinity differences in sea water. Electricity can also be generated from marine currents using submerged turbines with rotor blades and generators.

Tidal Turbine

How Does it Work?

Water turbines work on the same principle as wind turbines by using the kinetic energy of the moving fluid and transforming it into useful rotational and electrical energy. The velocities of these currents are lower than those of the wind. However, owing to the much higher density of water, water turbines are much smaller than their wind-driven counterparts for the same installed capacity.



Marine Current Generation

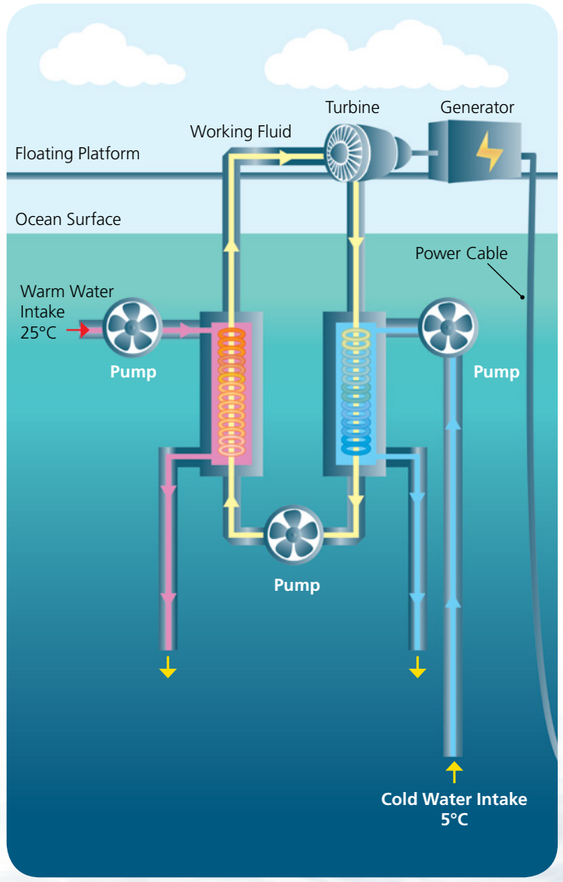
Ocean Thermal Energy Conversion (OTEC)

The sun heats the surface water of the oceans. In tropical regions, the surface water can be 40 or more degrees warmer than the deep sea floor. Ocean Thermal Energy Conversion (OTEC) makes use of this temperature difference, between the warm surface water of the oceans and the cold water at depths of approximately 1,000 metres to generate electricity.

How Does it Work?

Through OTEC technologies, warm surface water is turned into steam, or it is used to heat another fluid (e.g. Ammonia), turning it into vapour to spin a turbine and produce electricity. At the same time, the cold, deep seawater is brought to the surface to cool the steam or vapour, converting it back into liquid to restart the cycle.

OTEC plants can be constructed on land or installed on a floating platform or on a ship at sea. OTEC needs a temperature difference of at least 20°C to operate efficiently. This limits the use of OTEC to tropical regions where the surface waters are warm enough. The efficiency of OTEC systems are usually low, as the cyclical pumping of water and the transportation of electricity to land are both energy-intensive. Application is also limited to regions where there are significant temperature differences between the sea surface and deep water temperatures.



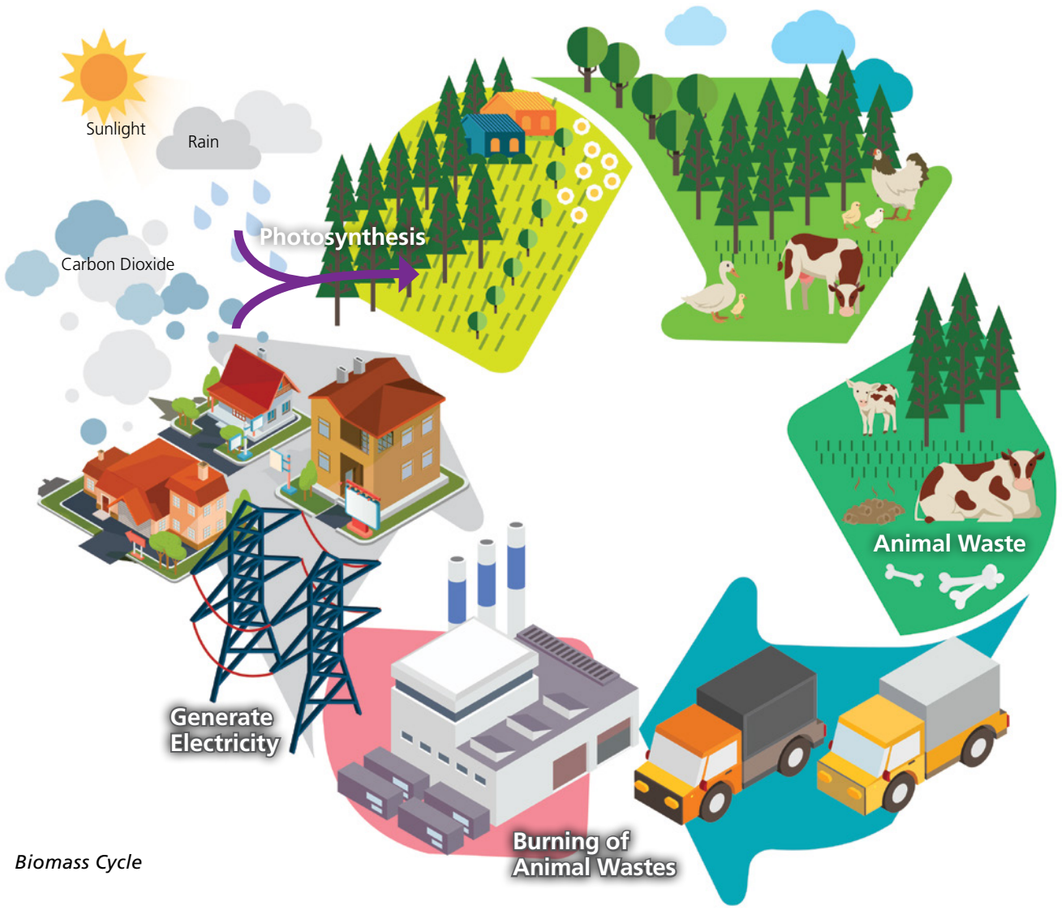
OTEC Working Cycle

6 BIOMASS ENERGY

Biomass is any organic matter such as wood, crops, seaweed, food waste, animal waste that can be used as an energy source. Biomass is a renewable energy source because its supplies are not limited. We can always grow trees and crops, and animal waste will always be available. This organic matter can be made available or produced in a relatively short period of time as compared to fossil fuels.

How Does it Work?

The chemical energy that is stored in plants or the animal waste is called bio-energy. All organic matter contains stored energy from the sun. During the photosynthesis process, plants absorb sunlight to convert water and carbon dioxide into oxygen and sugars. These sugars are carbohydrates to support their growth. They also act as foodstock for other animals. Burning this biomass releases the stored energy in the form of heat, which is then used to drive a generator to produce electricity.



Biomass Cycle

Using Biomass Energy

Usually, wood is burned to produce heat. Burning, however, is not the only way to release biomass energy. There are three other alternatives – bacterial decay, fermentation and conversion.

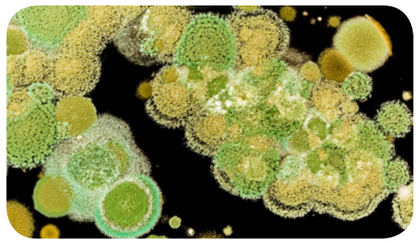
Burning

Burning biomass releases energy in the form of heat to produce steam, which is then used to drive a generator to produce electricity.

Burning

Bacterial Decay

Bacteria feed on dead plants and animals, producing methane. Methane, the main ingredient in natural gas, is produced whenever organic material decays. Many landfills are recovering and using the methane gas produced by the decay of garbage for their own plant usage.



Bacterial Decay

Fermentation

There are several processes that can produce alcohol (ethanol) from plants, especially corn. The most common process involves using yeast to ferment the starch in the plant to produce ethanol.

Fermentation

Conversion

Today, biomass can be converted into gas and liquid fuels by heating or adding chemicals to the biomass. The gas and liquid fuels can then be burned to produce heat or electricity, or it can be used as a fuel for automobiles.

Conversion

With more technological advancements, newer conversion processes, such as gasification and anaerobic digestion, have been developed.

Do you know ...

The surplus landfill gas from the North East New Territories Landfill (NENT) is treated and delivered as an alternative source of fuel for Towngas production.

Landfill Gas Utilization Plant at Shuen Wan Landfill
Source: The Hong Kong and China Gas Company Limited

The Pros and Cons of Biomass Energy

Pros

- Less pollution and carbon emissions
- Biodegradable, nontoxic
- Alternative waste treatment

Cons

- Producing biomass energy is more costly than producing fossil fuels

Practical Scenario

Municipal Solid Waste

Turning waste into energy is the process of converting the energy content in waste to heat or electricity. Municipal solid waste (MSW), made up of residential and commercial waste, is the largest source of waste in developed countries. MSW, in particular the organic fraction, can be a valuable source of energy. Apart from generating power, turning waste into energy provides alternatives for MSW disposal other than in landfills. According to the Policy Framework of Hong Kong Blueprint for Sustainable Use of Resources 2013 to 2022 issued by Environment Bureau, a sizable integrated waste management facility with enhanced capacity will be needed to turn waste to energy and to deal with MSW that has not been taken out of the waste stream.

Landfill in Tuen Mun
Source: Information Services Department

Do you know ...

In Hong Kong, approximately 9,000 tonnes of MSW is being thrown away at landfills every day. The Government has planned to make the best use of its waste-management facilities to turn waste into renewable energy. With regard to the various waste-to-energy facilities completed or being planned, including sludge treatment facility, integrated waste management facility, and a number of organic waste treatment facilities, the renewable energy generated is estimated to be able to meet about 1% of Hong Kong's total electricity demand by the early 2020s.

Food Waste

Food waste accounts for much of Hong Kong's waste problem. In 2008, the government commissioned a pilot composting plant at Kowloon Bay Waste Recycling Centre to gain experience and information on the collection and treatment of organic waste. Biological treatment technology will be adopted for the recycling of food waste into useful resources such as compost and biogas.

Do you know ...

What Can We Do to Minimise Food Waste?

In December 2012, the Government set up the Food Wise Hong Kong Steering Committee to drive leadership in food waste avoidance and reduction. The Environment Bureau launched the "Food Wise Eateries" Scheme in November 2015 to encourage food eatery outlets in the hotel and food & beverage sectors to reduce food waste at source together with customer through offering portioned meals and adopting food waste reduction measures.

Food Wise Hong Kong
Source: Environmental Protection Department

To tackle the increasing food waste problem, the Government has also proposed the development of a modern Organic Waste Treatment Facility (OWTF) in Siu Ho Wan, North Lantau, to handle and recycle about 200 tonnes of food waste every day.

At present, there are some privately run food waste recycling centres in Hong Kong. They usually process and turn food waste into pig feed, fish feed, fertilizers, etc.

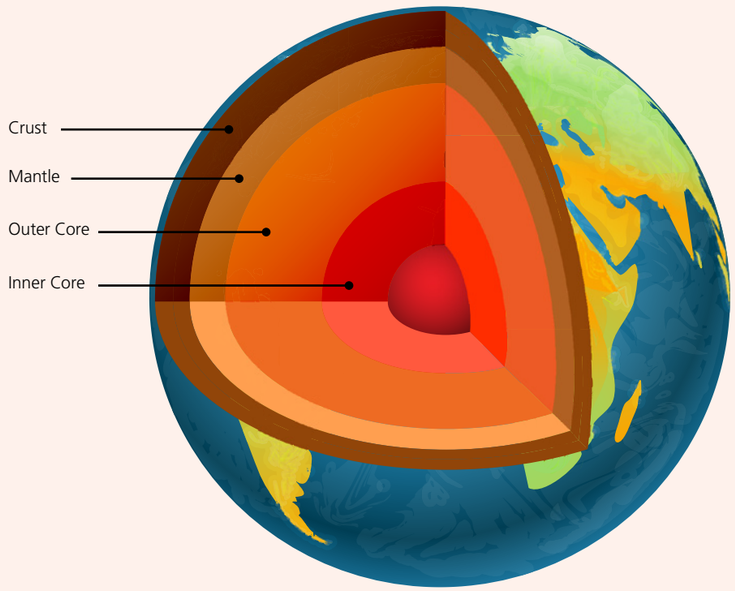
7 GEOTHERMAL ENERGY

The Earth can be divided into four layers from the surface to its interior – the crust, the mantle, the outer core and inner core.

Geothermal energy refers to the heat from within the Earth. The energy mainly originated from the formation of the planet, while a small proportion comes from radioactive decay and tidal dissipation. The heat energy is released during earthquakes, volcanoes and geyser eruptions.

Heat is transferred from great depths under the ground to the Earth's surface by geysers or hot springs. Heat can also be extracted from hot dry rocks or magma. Large amounts of geothermal heat are also released by volcanic activity along tectonic plate boundaries.

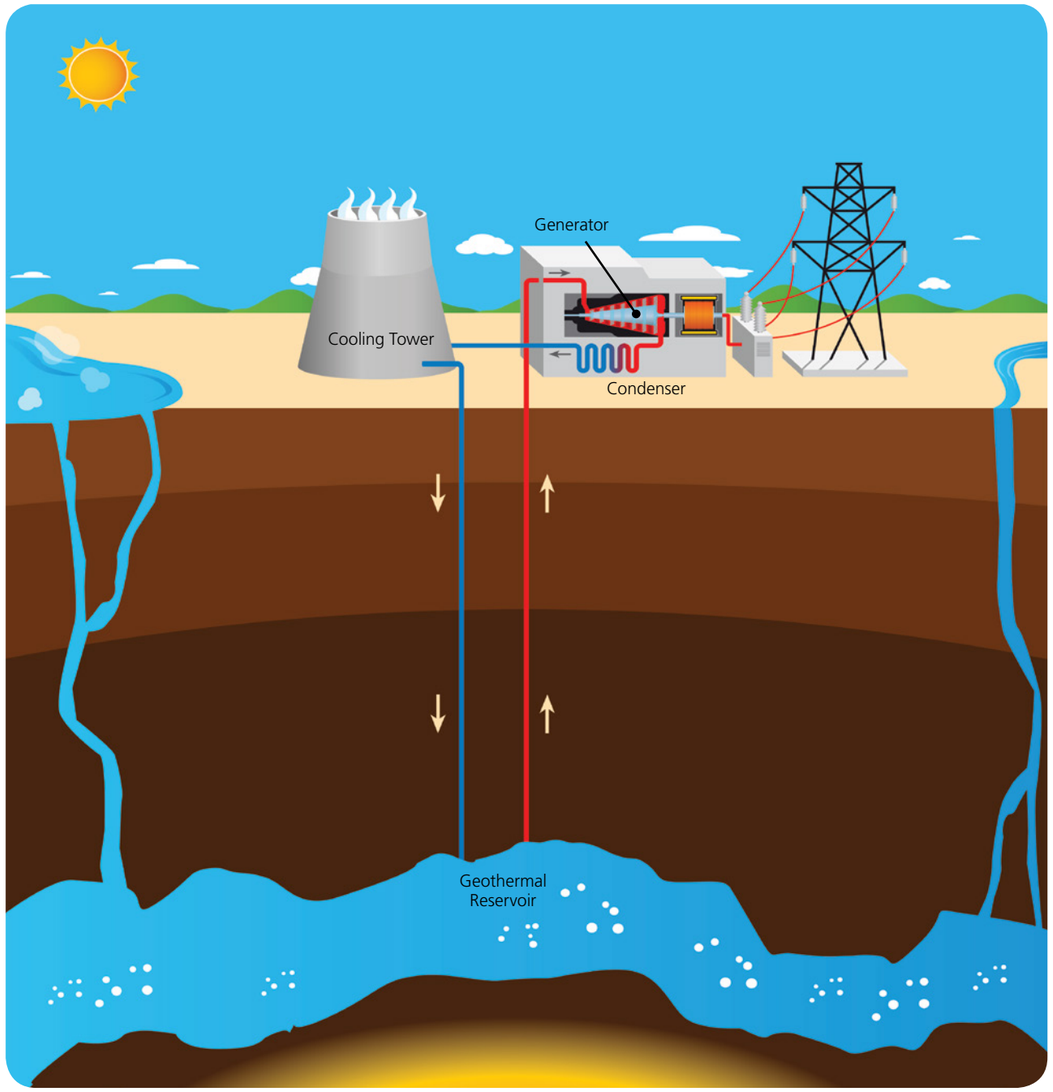
Volcano



Layers of the Earth

How Does it Work?

Geothermal power plants are generally built where geothermal reservoirs are located within 3 to 4 km of the surface. They draw superheated water to the surface from high temperature (150 to 400°C) underground hot water wells. The superheated water is converted into steam and is diverted through a turbine engine to drive a generator.



Geothermal Power Generation

Applications of Geothermal Energy

There have been direct uses of geothermal district heating systems, where hot water near the Earth's surface can be piped directly into buildings. Direct geothermal heating is far more efficient than geothermal electricity generation. Direct geothermal heating systems are less demanding on temperature requirements, so operation is viable over a large geographical range.

Do you know ...

Binary plants make use of naturally sourced hot steam generated by activity from within the Earth's core. All geothermal plants convert thermal energy to mechanical energy, and through turbine, to electrical energy.

An alternative to extracting geothermal energy is the use of geothermal heat pumps. These pumps transfer heat from the ground (or water) into buildings in winter to control inside temperatures, reversing the process in the summer to cool it. Although most household heating or cooling is still based on traditional furnaces and air conditioners, geothermal heat pumps have become more popular in recent years.

The Pros and Cons of Geothermal Energy

Pros

- Less emission
- Inexhaustible
- Low operation cost
- Stable supply

Cons

- Limited locations
- Risks of land subsidence
- Gas and metal pollution from underground water
- Huge set up and operation cost of pipes and coils

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