Module 5 - **Trainers Guide**

Renewable Energy General Principles

ENGLISH – VANUATU

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Cover photo: Ground mounted Solar PV in remote Fiji Island. Source: Zack Maraf (top centre). Harnessing of various types of renewable Energy. Source: Photo by Elena Zhuravleva from Pexels (bottom left), Pico-Hydro turbine in operation. Source: Powerspouts, New Zealand (bottom right).

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GLOSSARY

Biomass - Organic matter used as fuel, plant materials and animal waste used especially as a source of fuel.

Climate Change - A change in global or regional climate patterns.

Coal - Coal is a combustible black or brownish- black sedimentary rock with a high amount of carbon and hydrocarbons. Coal is classified as a non-renewable energy source because it takes millions of years to form.

Energy - The ability to do work.

Energy security - Uninterrupted availability of energy sources at an affordable price.

Fossil fuel - A natural fuel such as coal or gas, formed in the geological past from the remains of living organisms.

Fuel cell - Is an electrochemical cell that converts the chemical energy of a fuel (hydrogen) and an oxidizing agent (oxygen) into electricity.

Global - Relating to the whole world, worldwide.

Global warming - A gradual increase in the overall temperature of the earth's atmosphere generally attributed to the greenhouse effect caused by increased levels of carbon dioxide, CFC'S, and other pollutants.

Heat - The quality of being hot, high temperature.

Impact - A marked effect or influence.

Natural Gas - Is a non-renewable hydrocarbon used as a source of energy for heating, cooking and electricity generation.

Non-renewable energy - Sources that will run out or will not be replenished for thousands or even millions of years.

Oil (crude oil) - Unrefined petroleum, a viscous liquid derived from petroleum, especially for use as a fuel or lubricant.

Petrol (unleaded gasoline) - A light fuel oil that is obtained by distilling petroleum and used in internal combustion engines.

Pollution - The presence in or introduction into the environment of a substance which has harmful or poisonous effects.

Renewable Energy - Energy from a source that is not depleted.

Thermal - Relating to heat. Thermal process is basically heating.

The "Renewable Energy General Principles" training module is an introduction to the fundamentals of renewable energy sources and their importance.

Upon completion of the course, the learners will achieve the following learning outcomes:

- Identify the different types of energy sources.
- Define renewable energy.
- Describe ways of using renewable energy.
- Explain the current global energy use and its impact on environment.
- Discuss the types of renewable energy technologies and their advantages and disadvantages.
- Describe the importance of renewable energy to the community.

HOW TO USE THIS GUIDE?

The trainer guide is provided with the class notes and includes activities which need to be done after each section of the course. The guide acts as a recommendation only. After seeing the situation on the ground in each community, the experienced trainers may use their judgment to modify their delivery and assessment techniques to achieve better results.

The Trainer Guide provides detailed notes written in the form that can be directly delivered to the learners. However, the very detailed notes are intended to broaden the knowledge of the learner as well. You are not required to read each paragraph from the Trainer Guide, but you are expected to know the materials sufficiently to train others. Firstly, you must know what key concepts the learners need to learn. These are normally called learning outcomes. The learning outcomes are all listed at the start of the Trainer Guide, and you must ensure that at minimum, every learner achieves those 7 learning outcomes. You are required to take at least a week to go over the TG and go through the activities in the Learner Workbook. During the actual training you can refer to the Trainer Guide and explain it to the learners in your own words. If you are unsure of something always refer to the TG notes. Also note to take heed of the time recommended for each session and activity.

In case where learner literacy levels are low, trainers are advised to adapt to the situations and modify activities as appropriate. It is advisable to keep a continuous record of competencies of learners. All competencies are achieved when learners fulfil all learning outcomes.

HOW TO CONDUCT ACTIVITIES

- Activities are best done in groups or pairs. It is recommended that in each group there is at least one who is more literate or a more active learner who can help to translate and explain the training contents to learners who are slower to understand.
- You may divide the learners into groups of at least 2 and preferably 3-4 learners and ask them to carry out a rigorous discussion within the group. Some activities can be given to the groups for overnight preparation. The trainer needs to be aware of the dynamics of relationships in the community when dividing learners into groups. Sometimes women and youth are not free to share their views when the men from the communities are present. The trainer should ideally ask learners for their guidance when organising them into groups for discussions.
- Ideally the learners may present the results of their activities to the class and have a class discussion based on their findings.
- It is not necessary that all groups present in the same activity.
- However, it is important that all groups are given opportunity to present or verbally discuss their answers.
- At all times, encourage learners to be interactive and participative in class.
- Learners must be encouraged to be vocal and to contribute actively in class discussions.
- To better improve learning, the learners must be encouraged to strongly inquire about the topics through questions.
- The activities allow trainers to observe if the learners have achieved the learning outcomes. If possible, do keep record of the learner's achievement of learning outcomes so that you can help them learn better. A sample record table is given in this guide.
- Adapt existing activities and/or alternative suitable activities in case the desired literacy levels of learners are not met or the desired resources are not available.

TEACHING TOOLS

The following tools/items may be required to enhance learner learning:

- Laptop/ computer and projector to play videos or present notes to the whole class. This will depend on availability. In case this is not available, you are recommended to take large prints of the key concepts and display to the learners while teaching.
- Provide each learner with pen or pencil, and paper to allow them to participate.
- Whiteboard and markers or black board and chalk can be made available to allow both facilitator and learner to state a point.
- The Learner Progress Record sample given below can be used to observe learners, note their feedback, and assess if they have achieved the specific learning outcome. This recording is useful for both the learner and trainer so you can focus on those who are falling behind. Note there are no marks to be awarded and the record is only to improve learning. This is entirely optional.

TABLE 1: Learner Progress Record – optional for trainers to use.

Leaner Progress Record (Optional)	Date:
Learner Name:	
Learning Outcome:	Achieved Outcome (Yes or No) and Comments
1. Identify different types of energy sources	
2. Define renewable energy	
3. Describe ways of using renewable energy	
4. Explain of global energy use and its impact on environment	
5. Discuss the types of renewable energy technologies and their advantages	
6. Describe the importance of renewable energy in the community	

LESSON PLAN AND TIMES

TABLE 2: Lesson Plan and recommended timing of each session

Chapter	Lesson Type	Recommended Time
1. Ice Breaker - Introductions	Theory and activity 1	30 minutes
2. Energy	Theory	50 minutes
	Activity 2	30 minutes
	Activity 3	30 minutes
	Activity 4	30 minutes
3. Renewable Energy Technologies	Theory	90 minutes
	Activity 5	30 minutes
	Activity 6	20 minutes
4. Renewable Energy & Community	Theory	30 minutes
	Activity 7	30 minutes

1

Ice Breaker Introductions

Trainers must understand that the learners who are attending the module have taken time from their usual daily activities which sustains their livelihood. Most will also be very nervous and unclear regarding what the module is all about. Hence the trainer must ensure that the learners are comfortable and not too nervous. It is important to make them feel at ease so that they can focus on the module and absorb as much knowledge as possible.

Tell them that this is an informative module and there will be no tests or marks in this. You must inform them that this module is being run so that they can take the information to help themselves to transition to renewable energy. Even if they do not use it, they can always use the knowledge to help others. In any way this module will better equip them to help grow their communities. Tell them to be at ease and focus on enjoying the day and asking as many questions as they want. Also tell them to not worry too much about complicated things as you will guide them through this.

ACTIVITY 1

Introduce yourself briefly to the learners. Ask if they are all comfortable at the venue. One by one ask them their names and tell them to give some details about themselves – such as what they would normally be doing at that time and what they hope to gain from the module at the end of the day. In addition, if time permits – ask them what they think about renewable energy. There is no correct answer, and the goal of this activity is simply to get them relaxed and engaged into the session.

You may crack few light jokes as laughter always lightens the mood and helps learners relax. Ask the learners about their prior experiences in renewable energy and how much they know about the topic. Also ask them what they wish to gain from this training session and record their answers on paper so that it helps the trainer in setting a direction to the course. This input will help the trainer direct the training to the learners needs.

2 Energy

2.1 What is Energy

Legends have always mentioned the sun as all powerful. The sun gives energy to plants, and they feed humans and animals. The sun has a special place in all cultures. Energy may be described as something which has many forms and keeps changing form to give us something useful. Some of the forms of energy are:

Heat energy – Recall when you started a fire to boil some water. When you come near a fire you feel hot due to this energy.

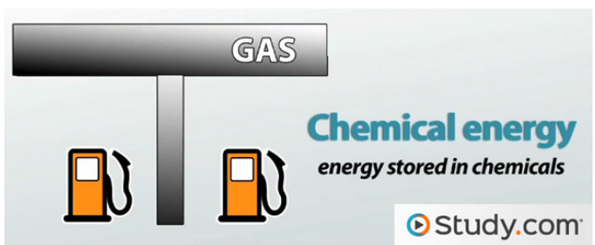
FIGURE 1: **Can you recall how water gets heated?**[1]

Mechanical energy – Mechanical energy is the sum of potential energy and kinetic energy.[2] This is when the energy of your outboard engine gives push to your boat.

FIGURE 2: **Mechanical Energy is driving the boat**[3]

Chemical energy – Inside batteries chemicals are used to store electrical energy so you can use that to turn on a radio. When fuels are burned, chemical energy is released and converted into heat or mechanical energy.

FIGURE 3: **Fuel is source of chemical energy**[4]



Electrical Energy – This is the energy that flows through the wires to give power to lights at our homes, schools etc.

1 Photo credit: Vanuatu Team, GGGI
2 Wikipedia, "Mechanical energy", https://en.wikipedia.org/wiki/Mechanical_energy#:~:text=
3 Source: Tropic Thunder Jet, https://tropic-thunder-jet.business.site/
4 Source: Study.com, "Chemical energy, https://study.com/

2.2 Sources of Energy

There are 10 major sources of energy commonly used globally to generate power. These sources are:

1. Solar Energy
2. Wind Energy
3. Biomass Energy
4. Geothermal Energy
5. Tidal Energy
6. Wave Energy
7. Hydro Energy
8. Hydrogen Energy
9. Nuclear Energy
10. Fossil Fuels (Natural Gas, Oil, Coal, Petrol etc.)

The sources of energy is divided into two categories**: Renewable Energy** and **Non-renewable Energy.**

Renewable Energy - Is energy that is generated from sources that are naturally replaced on a human timescale, such as sunlight, wind, rain, tides, waves, and geothermal heat etc. Renewable energy often provides energy in four important areas: electricity generation, heating/cooling, and transportation.

Non-Renewable Energy - Is energy that is generated from source that cannot be readily replaced by natural means at a quick enough pace to keep up with consumption such as fossil fuels: Coal, diesel, petrol, natural gas, hydrogen etc.

2.2.1 Solar Energy

Solar energy is obtained from the sun. Different technologies have been developed to use the Sun's energy. The common energies obtained from the sun are electricity and heat.

FIGURE 4: Sun Light – Source of Energy[5]

2.2.2 Wind Energy

Wind energy is becoming more and more common. Wind turbines are used to convert wind energy into electricity. Domestically, wind energy is also used for drying or separating dust from agricultural products.

FIGURE 5 & FIGURE 6: Separating process using wind[6] & Wind Turbine for Electricity[7]

5 Source: GGGI, Vanuatu.

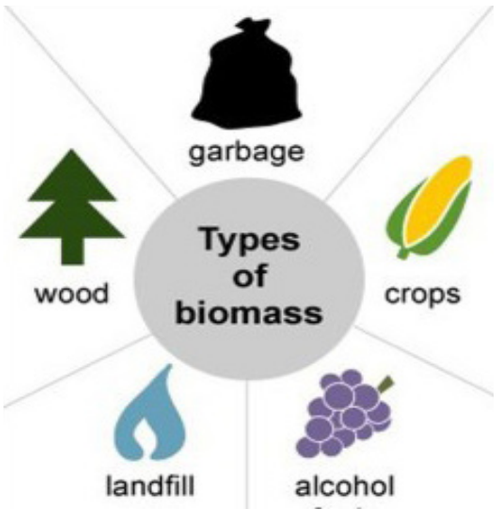
6 Source: Shutterstock images, https://www.shutterstock.com/image-photo/bali-indonesia-may-6-rice-winnowed-141503299

7 Source: Wikimedia Commons, Wind-Turbine, https://upload.wikimedia.org/wikipedia/commons/a/ad/Wind-turbine-icon.svg

2.2.3 Biomass Energy

Biomass is plant or animal material used directly for energy production, or in various industrial processes as the raw substance for manufacturing a range of products with the manufacturing waste used for producing energy. It can be purposely grown energy crops, wood or forest residues, waste from food crops, horticulture, food processing, animal farming, or human waste from sewage plants. Biomass energy can be used to produce electricity and heat.

FIGURE 7: **Types of Biomasses used for Energy**[8]



2.2.4 Geothermal Energy

Geothermal energy is thermal energy generated and stored in the Earth. It is heat derived from deep within the sub-surface of the earth.[9] In general, the deeper the source, the hotter it is. Water and/or steam typically carry the geothermal energy to the Earth's surface for use. Depending on its characteristics, geothermal energy can be used for heating and cooling purposes or be harnessed to generate clean electricity. However, for electricity generation, high or medium temperature resources are needed, which are usually accessed close to tectonically active regions. While it is possible to drill deep enough to get the needed high temperatures, that can be very expensive so most geothermal resources that are being used as energy resources are ones that have been forced near the surface by tectonic actions within the earth and are often in or near volcanic areas.

FIGURE 8: **Geothermal – Steam discharged**[10]

2.2.5 Tidal Energy

Tidal energy is the form of hydropower that converts the energy obtained from tides into useful forms of power, mainly electricity.[11] Tidal energy uses the rise and fall of tides to convert kinetic energy of incoming and outgoing tides into electrical energy. The generation of energy through tidal power is mostly prevalent in coastal areas. But in the Pacific Island region, the tidal range is small and very few sites are appropriate for tidal power generation. Thus, the huge investment is needed, and very limited availability of sites are few of the main drawbacks of tidal energy. Although not yet widely used, tidal energy has the potential for future electricity generation in some areas of the world. Tides are more predictable than energy from the wind and the sun though that regularity can be interrupted by major storms over the nearby ocean. The best sites for tidal generation are those that have a large tidal pool that has a narrow opening to the open ocean as in Figure 9. As the tidal pool fills with the incoming tide, a fast current flow in through the narrow opening. Then as the pool empties during low tides, it flows out equally fast. A turbine in that narrow opening can use those flows to generate electricity.

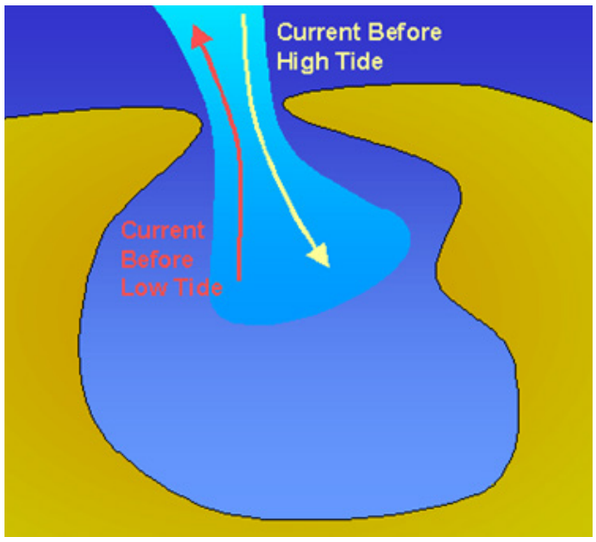
8 Source: WordPress.com, Environment Sustainability Biofuels, https://environmentsustainability2017.files.wordpress.com/2017/10/blog-24.jpg?w=768

9 Adapted from International Renewable Energy Agency (IRENA), https://www.irena.org/geothermal

10 Clean Economy Center, http://cleaneconomycenter.org/benefits-and-disadvantages-of-using-geothermal-energy/

11 Intertek, "Tidal Energy", https://www.intertek.com/energy-water/tidal-energy/

FIGURE 9: **Behavior of tidal current during different tides**[12]



2.2.6 Wave Energy

Wave energy (or wave power) is the transport and capture of energy from ocean surface waves. The energy captured is then used for all different kinds of useful work, including electricity generation and mechanical energy.[13] The main problem with wave energy is the difficulty of doing maintenance and the problem of damage due to major oceanic storms. Although there have been trials of several types of wave generation systems that have worked, none have been of low enough cost to successfully compete with other energy forms available to the islands.

FIGURE 10: **Ocean Waves**[14]

2.2.7 Hydro Energy

Hydro-energy or waterpower is energy derived from the energy of falling or fast-running water, which may be harnessed for useful purposes. Since ancient times, hydro energy from many kinds of watermills has been used for irrigation and the operation of various mechanical devices, such as sawmills, textile mills, trip hammers, dock cranes, domestic lifts, and ore mills. Inherent in the development of hydro energy is the need to have either high volumes of water moving relatively slowly or moderate volumes moving at high speed down a substantial slope. One significant problem in many islands is the seasonality of rains making hydro useful only part of the year but in Fiji and PNG,[15] the resource is constant enough to provide much of the electricity generated and in several other island countries, hydro provides a substantial percentage of electricity though not all months of the year.

FIGURE 11: **Water flowing from a height and with high velocity**[16]

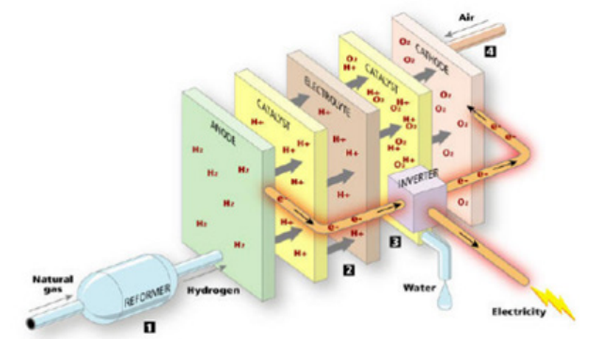
2.2.8 Hydrogen Energy

Hydrogen is a component of water (H2O) and is the most common element available on earth. Water contains two-thirds of hydrogen and can also be found in combination with other elements. Once it is separated, it can be used as a fuel for generating electricity or running an internal combustion engine. Hydrogen is a tremendous source of energy and can be used as a source of fuel with the use of Fuel Cell as shown in Figure 12.

12 Source: The Scuba Tutor, Tidal currents, http://www.scuba-tutor.com/diving-environment/dive-site-conditions/tidal-currents.php
13 Open EI, "Wave Energy", https://openei.org/wiki/Wave_Energy
14 Source: Wqpmag.com, "Water quality https://www.wqpmag.com/water-quality
15 Adapted from the Pacific Energy Update 2018, ADB, https://www.adb.org/sites/default/files/institutional-document/425871/pacific-energy-update-2018.pdf
16 Source: The Conversation, https://theconversation.com/rivers-rain-and-releases-what-happens-when-you-dam-a-waterway-3934

The water is transformed into Hydrogen and Oxygen using Electrolysis process where water is decomposed into the gaseous component's oxygen and hydrogen. Then the hydrogen is used in a Fuel Cell to produce electricity which is used as an electrical energy to run the car motor. The cars do not do the electrolysis process but instead only fills Hydrogen gas as fuel into its high-pressure tank and using Fuel Cells generates electricity to run the motor driving the car.

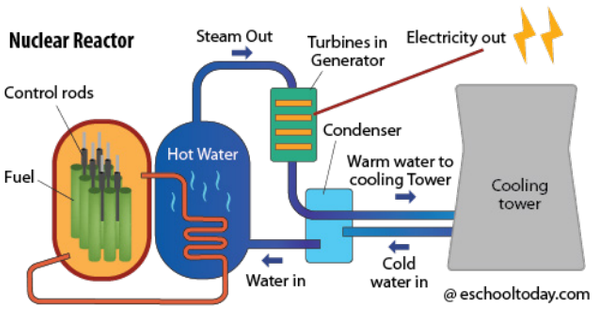
FIGURE 12: Fuel Cell[17] and Hydrogen Car[18]



2.2.9 Nuclear Energy

Nuclear energy is the use of nuclear reactions that release nuclear energy to generate heat, which most frequently is then used in steam turbines to produce electricity in a nuclear power plant.

FIGURE 13: Nuclear Reactor[19]



2.2.10 Fossil Fuels (Natural Gas, Oil, Coal, Petrol etc.)

A fossil fuel is a fuel formed by natural processes, such as anaerobic decomposition of buried dead organisms, containing organic molecules originating through ancient photosynthesis that release energy in combustion.[20] Such organisms and their resulting fossil fuels typically have an age of millions of years, and sometimes more than 650 million years. Fossil fuels contain high percentages of carbon and include petroleum, coal, and natural gas.

FIGURE 14: Types of fossil fuels[21]

- **Coal- is a solid fossil fuel**
- **Petroleum- is a liquid fossil fuel.**
- **Natural Gas**

natural gas

coal

petroleum (oil/gasoline)

17 Source: Know It Info, "What is Uranium Energy", https://knowitinfo.com/what-is-uranium-energy/

18 Photo credit: Worcester Polytechnic Institute FCC Public, http://www.odbornecasopisy.cz/en/post/new-membrane-technology-that-may-help-make-hydrogen-fuel-cell-vehicles-viable--2451

19 Adapted from, KnowItInfo, "What is Uranium Energy?", https://knowitinfo.com/what-is-uranium-energy/

20 Wikipedia, "Fossil fuel", https://en.wikipedia.org/wiki/Fossil_fuel#:~:text=

21 Slideshare.net, "Slide 2 -Fossil Fuels", https://pt.slideshare.net/jbishopgcms/fossil-fuels-5668194

2.3 Global energy use and its impact on environment

The world uses a massive amount of energy to run its huge industries and move its planes, cars, and ships around the globe. Let us look at some numbers of how much energy is being used and how much of it is in which form.

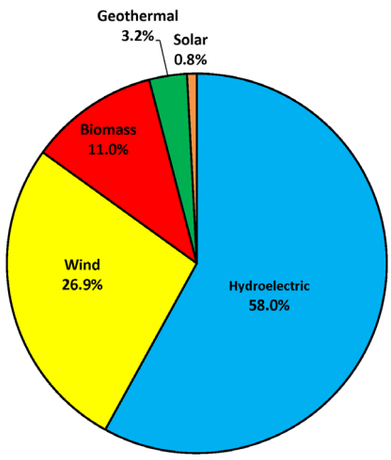
The total amount of electricity consumed worldwide was 19,504 TWh in 2013, 16,503 TWh in 2008, 15,105 TWh in 2005, and 12,116 TWh in 2000. By the end of 2014, the total installed electricity generating capacity worldwide was nearly 6.142 TW (million MW) which only includes generation connected to local electricity grids.[14]

In 2014, the share of world energy consumption for electricity generation by source was coal at 41%, natural gas at 22%, nuclear at 11%, hydro at 16%, other sources (solar, wind, geothermal, biomass, etc.) at 6% and oil at 4%. Coal and natural gas were the most used energy fuels for generating electricity. [14]

In 2016 the total world energy came from 80% fossil fuels, 10% biofuels, 5% nuclear and 5% renewable (hydro, wind, solar, geothermal). Only 18% of that total world energy was in the form of electricity. Most of the other 82% was used for heat and transportation.[22]

Only a small portion of the energy used globally comes from renewable energy sources. In 2016, only around 24 % of the world's energy including transportation and electricity came from renewable energy sources. Figure 15: World Renewable Energy (Electricity) Mix in 201522 gives the breakdown of electricity generated through different renewable energy sources in 2015.

FIGURE 15: Renewable Energy (Electricity) Mix in 2015[22]



As seen in the above figure, hydroelectric power leads the renewable energies followed by wind biomass and geothermal energy. So far only 24% of the world's energy comes from renewable energy sources. Getting energy from non – renewable sources has many impacts for the world.

2.4 Impact of Energy Use Globally

Since most of the world still uses non – renewable energy from mainly fossil fuels, there are lot of negative impacts on the earth. Some these impacts are:

2.5 Global Warming and Sea Level Rise

Greenhouse gases (including CO2, water vapor and aerosols) are found in the atmosphere above the surface of the Earth. Their job is to trap the sun's heat that is reflected off the Earth from the Sun. You have probably experienced the greenhouse effect while sitting in your house on a sunny day. The glass window louvers let in light but keep heat from escaping. Imagine if you closed all the windows and doors and sat inside your house on a very hot day. You will become very hot. If you stay, there all day you will become dizzy and sick. This is what happens when we use fossil fuels. These fuels release gases which prevent the heat from escaping the earth – and we all get hotter each year.

FIGURE 16: Industrial emissions contain greenhouse gases[23]

Now imagine if in that hot house with windows closed, we had a block of ice on a table – what will happen to the ice? Yes, correct – the ice will melt and spill on the floor. When we burn fossil fuels, we release gases called greenhouse gases which act like thick curtains and windows. Similarly, the ice at the north and south poles of the earth are melting due to higher temperatures and this means more and more water gets into the sea. This increases the sea levels on our island coasts and even floods villages at high tides. It also ruins crops by pushing salty water inland.

22 Information adapted from "World Energy Consumption", Wikipedia, May 2021, https://en.wikipedia.org/wiki/World_energy_consumption

23 Source: Wikimedia commons, 'Steam Emission at Asphalt Batch Plant, https://commons.wikimedia.org/wiki/File:STEAM_EMISSION_AT_THIS_ASPHALT_BATCH_PLANT_CONSISTS_OF_85_PERCENT_SAND_DUST,_ACCORDING_TO_THE_AIR_-_NARA_-_542544.jpg

FIGURE 17: **Sea levels rising is threatening our island homes**[24]

2.6 Climate Change

Because the global temperature is rising – our climate gets affected. The world's climate is very delicate and depends on the temperature of the oceans and lands. Due to rising temperatures – the weather pattern changes. Have you noticed this? We get stronger cyclones. We get more floods and more droughts. We have hotter days in the hot season and very cold days in the cold season. This also means that our crops get affected.

FIGURE 18: **Climate change affects our food crops**[25]

2.7 Energy Security

The other major impact of the world using unsustainable energy such as fossil fuels is that countries become dependent on imported oil and fuels for energy. Island countries in the Pacific face very huge challenges when it comes to energy security. With a very limited supply of domestic fossil fuels, they have to import fuels like diesel for their electricity production and transportation. Since we are so far away from the oil rich countries – we have to pay even more to get these fuels. This means a lot of our money goes into paying other countries for fuel. Also, if there is a sudden rise in oil prices or a war that causes shortages in oil or a pandemic or any global event – we are easily affected. This means the island countries are all at the mercy of the global oil supply. We are thus not fully independent and have to rely on other countries in relation to oil and our fuel supply.

2.8 Spillage and Pollution

Fossil fuel often needs to be pumped up from deep inside the ocean and at times pipes and oil rigs get damaged. Oil spills have caused massive damage to oceans, coral, fish, and ocean creatures. The pollution caused by oil spills and oil may have a direct impact on our source of food from oceans as well. Even birds living near the ocean and other land animals are easily killed off in large oil spills along with thousands of fish.

FIGURE 19: **Oil spills are another major impact of fossil fuel use**[26]

24 Source: SPREP, July 2013, https://www.sprep.org/news/sea-level-solomon-islands-predicted-rise-over-8mm-coming-century?__cf_chl_jschl_tk

25 Adapted from OXFAM International, https://farmbizafrica.com/images/Climate-change.jpg

26 SlideShare, Slide 7 Water Pollution, July 2015, https://www.slideshare.net/Hossian/water-pollution-50095046

ACTIVITY 2

Describe what is renewable energy? Why should we use Renewable Energy? Discuss and share your knowledge with others in the class.

Answer:

Renewable Energy - is energy that is collected from resources, which are naturally replaced on a human timescale, such as sunlight, wind, rain, tides, waves, and geothermal heat etc. Renewable energy often provides energy in four important areas: electricity generation, heating/cooling, transportation.

Why should we use Renewable Energy? – Its clean; Free; does not damage the environment; gets naturally replaced (does not get finished).

Encourage the learner to share their experiences and understanding.

ACTIVITY 3

Identify different types of energy sources and mark "Renewable Energy" or "Non-Renewable Energy". For each figure indicate what is the source? (Answer is provided in the table).

	FIGURE 20: Wind[27]	Renewable Energy
	FIGURE 21: Fossil Fuel (Coal)[28]	Non-Renewable Energy
	FIGURE 22: Biofuel[29]	Renewable Energy

27 Wikimedia Commons, "Blowing wind", https://commons.wikimedia.org/wiki/File:Blowing_wind.jpg

28 Lumen learning.com, "Energy Independence", https://courses.lumenlearning.com/boundless-politicalscience/chapter/energy-and-environmental-policy/

29 Green Living, "Making Biodiesel at Home, https://www.google.com/search?q=%E2%80%9D%3B+https%3A%2F%2Fgreenliving.lovetoknow.com%2FMaking_Biodiesel_at_Home&rlz=1C1GCEA

 FIGURE 23: Biomass[30]	Renewable Energy
 FIGURE 24: Hydro (Water)[31]	Renewable Energy
 FIGURE 25: Solar[32]	Renewable Energy
 FIGURE 26: Geothermal[33]	Renewable Energy

30 Wikimedia Commons, "Sugar cane", https://commons.wikimedia.org/wiki/File:Sugar_Cane_rows.jpg

31 Wikimedia Commons, "Hydro dams", https://commons.wikimedia.org/wiki/File:Hydro_dams.jpg

32 Source: GGGI, Vanuatu.

33 Clean Economy Center, http://cleaneconomycenter.org/benefits-and-disadvantages-of-using-geothermal-energy/

ACTIVITY 4

1. What are some negative impacts of using fossil fuels (like petrol)?

Answer: Fossil fuels like petrol are expensive and cause pollution. They give out unhealthy smoke which is bad for our health and also harms the planet by increasing the concentration of greenhouse gases.

2. Discuss in your groups about the problems you are facing in your community regarding weather. Try to think of what has changed over the years.

Answer: There can be different answers here – we may expect them to say that there are more cyclone and stronger cyclones and weather patterns have changed. They may talk about poor crops and rising sea levels, low catches when fishing and higher prices of fuel and other imported items. Diseases in crops, diseases in humans such as dengue and COVID19 etc.

3. What do you think can fix the changing climate?

Answer: The whole world has to think of Mother Nature and stop using harmful fossil fuels. We need to use the natural renewable energy only. Renewable energy is safe to use and will reduce the impact of climate change.

3

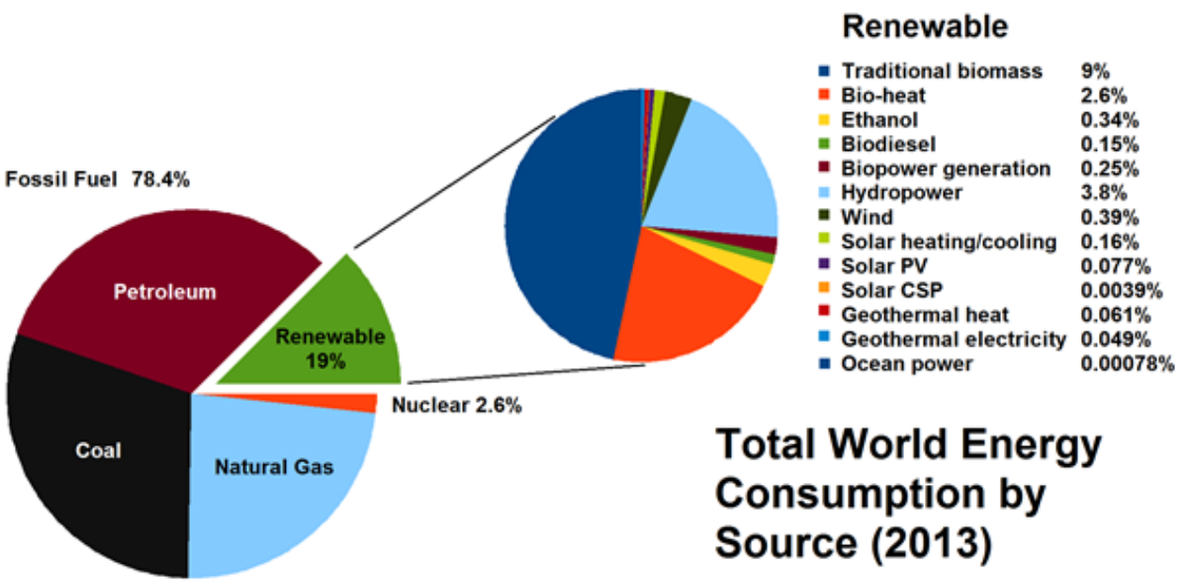
Renewable Energy Technologies

Renewable energy is energy that is collected from renewable resources, which are naturally replenished (restored) on a human timescale.[34] It is considered clean energy with no to minimal effect on the environment. Renewable energy often provides energy to the following areas:

- Electricity generation
- Heating and cooling
- Transportation

On the other hand, a non-renewable energy is energy produced from natural resource that cannot be readily replaced by natural means at a quick enough pace to keep up with consumption. This has great potential to damage the environment. The diagram below shows different types renewable and non-renewable energy consumption in the world.

FIGURE 27: Renewable and non-renewable energy source[35]



3.1 How to use renewable energy

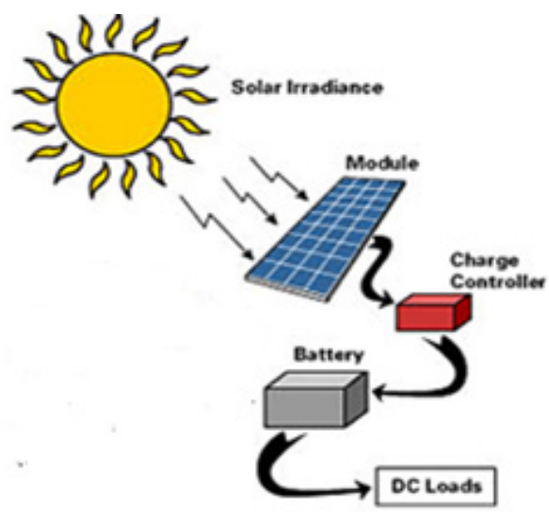
There are various ancient and modern technologies available that are used to convert raw renewable resource into useful energy. In addition to the available technologies, scientists are continuously researching to build more efficient technologies. In this section, different current technologies will be discussed to identify how renewable energy is converted into useful energy.

3.2 Solar Energy

Solar energy can be used by capturing the sun's energy and turning that into electricity or heat:

For electricity, we need to use Solar PV modules which converts sunlight into electricity. This electricity is in a form of DC (direct current) power that can charge batteries for later use.

FIGURE 28 & FIGURE 29: Electricity from Solar Energy[36]



34 Wikipedia, "Renewable Energy", https://en.wikipedia.org/wiki/Renewable_energy
35 Adapted from Power Technology, https://www.power-technology.com/features/featurethe-worlds-most-used-renewable-power-sources-4160168/
36 Source: GGGI, Vanuatu.

For heat, we can use solar collectors. Solar collectors helps to capture heat from the sun and transfer that heat into water, which provides hot water. We can also use solar energy for traditional drying such as drying kava, fish, etc.

FIGURE 30: Heat from Solar Energy[37]

FIGURE 31: Kava Drying[38]

Advantages

- Solar panels have no moving parts and require very little maintenance.
- Solar energy is available in high amounts in the Pacific Region.
- Smaller solar home power systems can be easily installed without building new dams or civil works.
- Contributes to creating green jobs.
- Solar energy is available every day in varying amounts.
- Solar energy is pollution free and emits no greenhouse gases to warm the earth.

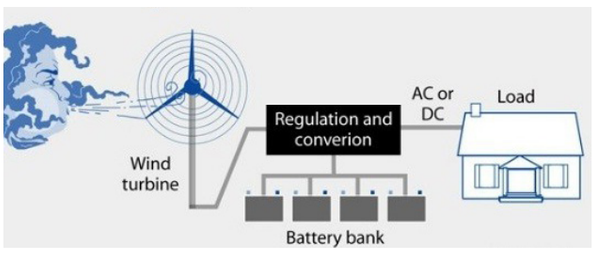
Disadvantages

- Solar energy is only available in the day, but battery can be used to store energy for nighttime use.
- Solar energy storage requires batteries which are expensive and need to be replaced often.
- Solar energy on a large scale requires lots of land area for installation.
- High initial costs for materials and installations.
- Appliances that run on DC are more expensive than AC powered ones.

3.3 Wind Energy

The kinetic energy (wind-blown) in wind can be harvested by employing a wind turbine. The energy in the wind turns the propeller like blades spaced around a rotor. The rotor is connected to the main shaft which drives the generator to produce electricity. Figure 32 below shows the detail of wind power system and the components of a wind turbine. It is very uncommon to see residential homes use wind turbines however it's largely used as commercial and referred as wind farm as shown in Figure 34.

FIGURE 32: Wind Power System[39]



37 GGGI Vanuatu

38 Adapted from the Fiji Sun, "Kava Demand Creates Trade Opportunity Between Fiji, Madang, August 2018, https://fijisun.com.fj/wp-content/uploads/2015/11/Kava-1-750x403.jpg

39 Source: www.energy.gov, adapted from, "What is Solar-Wind Hybrid Power Plant? Solar Mango, http://www.solarmango.com/ask/2015/10/23/what-is-a-solar-wind-hybrid-power--plant/

With reference to Figure 33: Components of wind turbine, refer to the function of the following components:

- Blades – Lifts and rotates when wind passes over them and causes the rotor to spin.
- Rotor – The blades and hub together form the rotor that converts the wind energy to rotational energy.
- Gear Box – Connects the low-speed shaft turned by the rotor to the highspeed shaft and increases the rotational speed to operate the generator.
- Generator – Produces AC electricity.
- Anemometer – Measures the wind speed and relays wind speed data to the controller.
- Controller – Starts up and shuts down the machine at designated wind speeds.
- Pitch system – Turns blades out of wind to control rotor speed and to prevent rotor from turning in winds that may be too high or too low.
- Brake – Stops the rotor in emergencies.
- Wind vane – Measures wind direction and communicates with yaw drive to align the turbine with respect to the wind.
- Yaw drive – Aligns the turbine to face the wind when the wind direction changes.
- Tower – Supports the turbine structure. Taller towers allow turbines to capture more energy hence generate more electricity.
- Nacelle – Houses the gear box, shafts, generator, controller and brake.

FIGURE 33: Components of wind turbine[40]

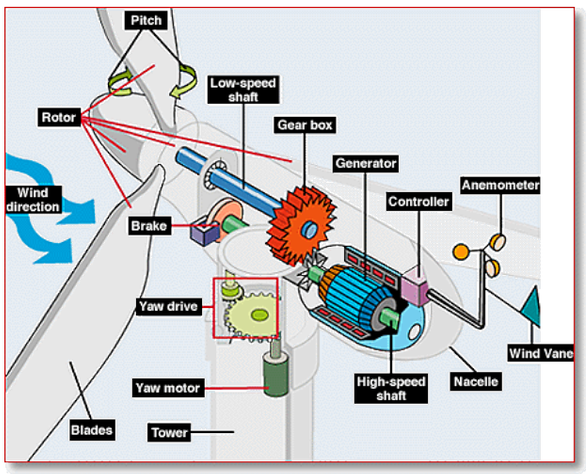


FIGURE 34: Active wind farm on Efate, Vanuatu[41]

40 SlidePlayer, "How do wind turbines work?", https://slideplayer.com/slide/8820889/

41 Photo credit: Vanuatu Team, GGGI

Advantages

- Wind energy is often available in reasonable amounts in island countries.
- Wind turbine is simple to install in case of home scale for power.
- Wind is available all the time even at night in different amounts.
- Wind energy is pollution free and emits no greenhouse gases to warm the earth.

Disadvantages

- Wind turbines are expensive and need maintenance regularly.
- Need to measure wind velocity to ensure on average days you have enough wind to generate electricity.
- Wind may be available but not enough to produce power all the time.
- We cannot predict how much power will be produced since wind keeps changing.
- Wind turbines spoil the image of landscapes, and some are noisy.
- Wind turbines can kill birds and bats.

3.4 Biomass Energy

Biomass energy is where a plant or animal material is used for energy production (heat and electricity). It can be purposely grown energy crops (sugarcane), wood or forest residues, waste from food crops, animal farming (manure), or human waste from sewage plants.

Burning of biomass plants releases carbon dioxide but it's considered renewable energy because new plant absorbs carbon dioxide back while growing. Biomass can be converted into the energy using the following most common method:

- Burning of plants (Thermal Process) – The plant material is burnt to produce heat which can then be used to produce steam to produce electricity. Most commonly this method is used in rural communities for cooking.

FIGURE 35: Wood (Biomass) used for cooking[42]

FIGURE 36: Sugar mill in Fiji - Burning sugarcane bagasse to generate electricity[43]

- Chemical/Biochemical process – This is where biomass is used to generate biogas (Methane) and biofuel (biodiesel or bioethanol). The biogas and biofuel are burnt (Thermal process) or used in either boilers or engines to generate energy.

FIGURE 37: Biogas use in Tuvalu[44]

42 Source: Biomass Stoves in Bengaluru, https://dir.indiamart.com/bengaluru/biomass-stoves.html

43 Source: The Fiji Sugar Corporation Ltd.

44 Source: Tweet by GIZ Pacific, https://twitter.com/GIZPasifika/status/1125605100439756800

Advantages

- Biomass is readily available in reasonable amounts in island countries with natural forests or where there are large commercial agriculture farms.
- Very easy to use – simple as burning to gain heat energy.
- Available free or at very low cost.
- Safe to store for later use without the need for a battery etc.

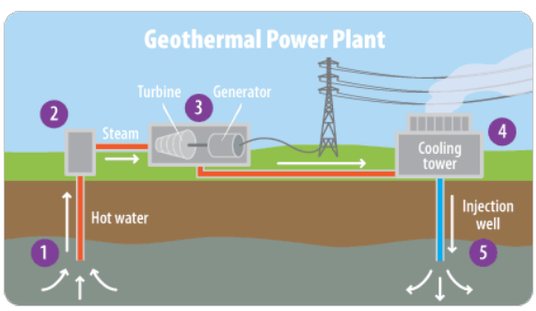
Disadvantages

- Requires complex machinery to generate electricity.
- Burns to release carbon dioxide and smoke as byproducts.
- Takes time to re-grow so harvesting should be done at a limited pace when the growth is to be used specifically for fuel.
- Burning biomass or biofuels create health hazards.
- It is not an efficient as fossil fuels.
- Biomass plants requires a lot of space.
- Could lead to deforestation.

3.5 Geothermal Energy

Geothermal energy is the thermal energy created and stored in the Earth. A geothermal power plant works by tapping into (thermal energy) steam or hot water reservoirs underground; the heat (usually steam) is then directed to pass through a turbine which rotates the turbine connected to an electrical generator. When the generator rotates, it produces electricity. After steam passes the turbine, it goes to a cooling tower to change the steam into water and is then pumped back into a well (earth) or if near the coast, out to sea.

FIGURE 38: Geothermal Technology[45]



Advantages

- Geothermal energy has an almost limitless supply once a source if found.
- Geothermal energy does not fluctuate a lot and allows for steady power generation.
- Geothermal energy uses hot water heated from the ground which can be cooled and re used.
- Geothermal energy can also be used for air- conditioning (cooling or heating).
- Geothermal energy is generally pollution free and emits no greenhouse gases to warm the earth.

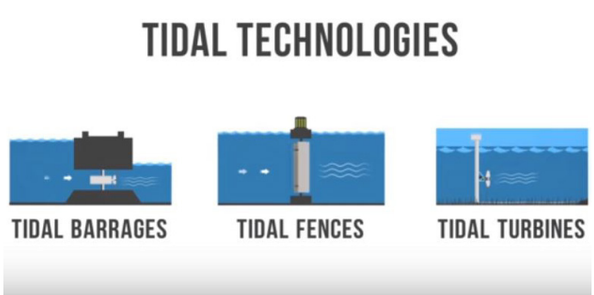
Disadvantages

- Geothermal energy is only available at some sites in the Pacific
- Geothermal plants are large and require very expensive equipment to start making electricity.
- Geothermal energy is often too expensive for home scale even if the site is close to a home.
- Geothermal energy runs the risk of triggering earthquakes to due to alterations to earth structure.

3.6 Tidal Energy

Tidal energy is the form of hydropower that transforms the energy obtained from tides into electricity. During high and low tide, the movement of water forces itself through the turbine creating enough thrust to turn the turbine. The turbine is connected to generator creating electricity.

FIGURE 39: Tidal Technology[46]



45 Source: EPA- Student's Guide to Global Climate Change, https://mbgna.umich.edu/geothermal-energy-what-it-is-how-it-works/

46 Source: NRG Initiative, Tidal Power, December 2015, https://nrginitiative.files.wordpress.com/2015/12/tidal-energy-101.jpg

Advantages

- Tidal energy is always available in different amounts at the site.
- Tidal energy can be used to power very large-scale electricity generators for a whole community.
- Tidal energy can be accurately predicted for an entire year.
- Tidal energy can be easily controlled and planned for grid connection.
- Tidal energy is pollution free and emits no greenhouse gases to warm the earth.
- Tidal energy system is inexpensive to maintain.
- Has high density than other renewable energy forms.

Disadvantages

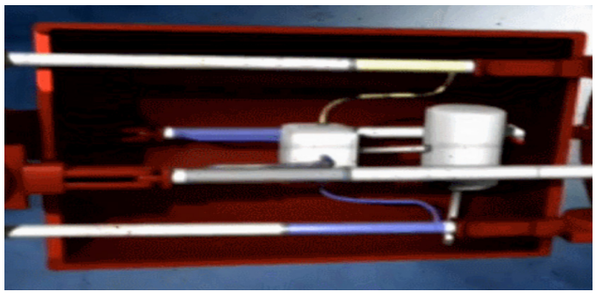
- Tidal energy is only available in the ocean at some locations.
- Initial costs relating to underwater turbine and constructions are very high.
- Tidal energy requires a lot of maintenance and special materials to work properly.
- Affects marine animals and plants.

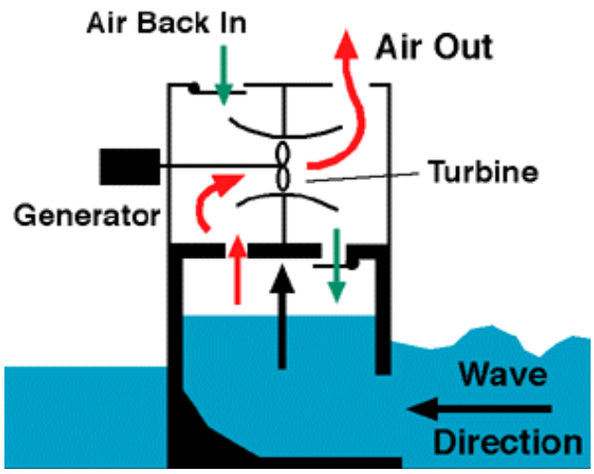
3.7 Wave Energy

Wave energy is the transport and capture of energy by ocean surface waves. A plant that harnesses wave power is a wave energy converter. While the waves create a motion, the fluid is pushed through a hydraulic motor connected to electrical generator producing electricity. There are a number of different types of wave energy devices under development some using hydraulics, some use mechanical linkages and some use compressed air.

FIGURE 40: Wave Converter[47]

FIGURE 41: How power is generated in one type of wave energy converter[48]





Advantages

- Wave energy is always available in different amounts at the site.
- Wave energy can be used to power very large-scale electricity generators for whole community.
- Wave energy is largely available to coastal communities.
- Wave energy does not need to use the land on the island.
- Wave energy is pollution free and emits no greenhouse gases to warm the earth.
- Wave energy is easily predictable and can be used to calculate the amount that it can produce.

Disadvantages

- Wave energy generation is only available in the ocean at some locations.
- While wave energy is always available – it fluctuates a lot and so its power will keep changing.

47 Source: Wikipedia, Wave Power, https://en.wikipedia.org/wiki/Wave_power#/media/File:Pelamis_at_EMEC.jpg

48 The Renewable Energy Website, Tidal Power Turbine Alternatives, http://www.reuk.co.uk/wordpress/tidal/introduction-to-tidal-power/

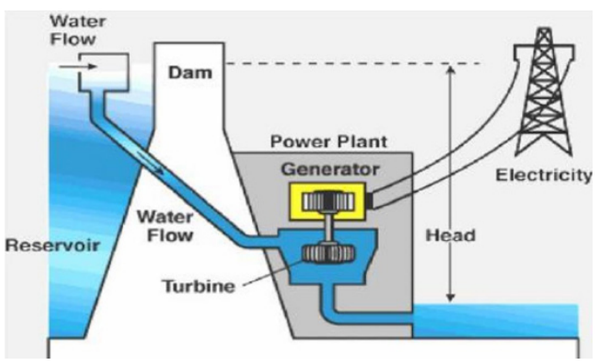
- Wave energy requires expensive turbine and large civil works or under water constructions to be feasible.
- Wave energy requires a lot of maintenance and special materials to work properly.
- It is very difficult to avoid serious damage from major oceanic storms.
- Only power plants and towns near the ocean will benefit directly from it.

3.8 Hydro Energy

Hydro energy is power derived from the energy of falling or fast-running water. This is commonly used technology such as Sarakata Hydro on Santo. However, this is dependent on rainfall. There are also small (Pico or Micro) hydro dams that are used to produce electricity for household or communities, similar to the Talise Hydro on Maewo.

FIGURE 42: Sarakata Hydro-Santo, Vanuatu[49]

FIGURE 43: Hydro energy technology[50]



Advantages

- Hydro energy is always available in different amounts at the site so long as there is adequate rain to keep the required volume in the stream.
- Hydro energy can be used to power very largescale electricity generators for whole community.
- Pico hydro energy can be used to power single homes easily.
- Hydro energy is very steady so it can be easily controlled and planned for grid connection.
- Hydro energy is pollution free and emits no greenhouse gases to warm the earth.
- Most of the larger Pacific islands and inland communities have many rivers and mountains so hydro is very suitable for them.

Disadvantages

- Hydro energy is not available on smaller islands without rivers and mountains.
- Hydro turbines need to be properly installed by creating dams or digging up ditches to install piping.
- Hydro energy requires regular maintenance especially during heavy rains when silt and debris can clog turbines and filters.
- Lower level of water during dry seasons could affect power generation.

49 Source: Catalogue of Rivers for Pacific Islands, Vanuatu, http://www.pacificwater.org/_resources/article/files/Vanuatu.pdf

50 Source: Slideshare.net, https://www.slideshare.net/salmanJailani/study-about-the-types-of-power-plants-and-how-electricity-is-produced

3.9 Hydrogen Energy

Hydrogen energy involves the use of hydrogen fuel to generate energy. Hydrogen fuel is a zero-emission fuel burned with oxygen. It can be used in fuel cells or internal combustion engines. A fuel cell is an electrochemical cell that converts the chemical energy of a fuel and an oxidizing agent into electricity through a pair of redox reactions. It has begun to be used in commercial fuel cell vehicles, such as passenger cars, and has been used in fuel cell buses for many years. It is also used as a fuel for spacecraft propulsion.

FIGURE 44: **Hydrogen fuel cell bus**[51]

Advantages

- Has no bad emissions and its only output is clean water.
- Hydrogen can be generated and stored for later use – it is portable as well.
- Variety of RE can be used to generate hydrogen gas.
- Very easy to use with fuel cells as there are no moving parts – high efficiency.

Disadvantages

- Hydrogen is extremely dangerous and can explode easily.
- Initial equipment to generate hydrogen is expensive.
- The technology is very advanced and cannot be serviced easily.

TABLE 3: **Comparison between Various Renewable Energy Source**

Type of Renewable Energy	Availability	Scalability	Who can install, operate, and maintain?	Storage requirement	Environmental Impacts
Solar Energy	Only during the day when there is sunlight.	Easy to scale up.	Any trained personal.	Needs battery storage.	Waste materials after useful life of the system.
Wind Energy	Mostly when it's windy.	More wind turbines could be added.	Only trained qualifies technicians.	Needs battery storage.	Cleared land and vegetations.
Geothermal Energy	Readily available.	Depends on availability of resource.	Only trained and qualified technicians.	No need of storage.	Alterations to earth structure within.
Tidal Energy	Always available.	Possible for scale up.	Only trained and qualified technicians.	No need of storage.	Could affect marine animals and plants.
Wave Energy	Always available.	Possible for scale up.	Only trained and qualified technicians.	No need of storage.	
Biomass Energy	Readily available	Possible for scale up.	Any trained personal.	No need of storage.	Releases carbon dioxide and smoke.
Hydro Energy	Readily available, but could be affected during dry seasons.	Possible.	Only trained personnel.	No need of storage.	Construction involves damage to environment as a result of digging of diversion of water.
Hydrogen Energy	Depends on availability of hydrogen fuel.	Possible.	Only trained personnel.	Can be stored for later use.	None.

51 Source: Wikipedia, Hydrogen Fuel Cell Bus, https://en.wikipedia.org/wiki/File:Hydrogen_fuel_cell_bus.jpg#/media/File:%20%20Hydrogen_fuel_cell_bus.jpg

ACTIVITY 5

Identify, draw, and discuss in your class what type of energy sources you have seen being used in your local area or country. Indicate whether it's a renewable or non-renewable energy?

Answer:

The learner may identify and draw:

1. Sun – used for drying, use of Solar PV panel to generate electricity or hot water.
2. Wind – used for separation of dust, use of wind turbine to generate electricity.
3. Water (Hydro) – Used in hydro dams to generate electricity.
4. Diesel/petrol – to run vehicles, boat etc.
5. Some may indicate some other sources (refer to notes for other sources of energy).

Refer to notes to identify which are renewable and non-renewable.

Encourage the learner to draw how different energy sources are or can be used.

ACTIVITY 6

Discuss in class which renewable energy technology would you prefer for your community and why?

Answer:

Expect learner to provide many different reasons. Some common technology would be:

- Solar – easy to install, readily available parts and equipment, look good.
- Hydro – have excess to streams, robust system, less maintenance.

4

Renewable Energy & Community

While renewable energy can help your household by providing electricity and energy for appliances, it can also start to build a better and stronger community. Renewable energy can play a very important role in changing the community for the better. Let's look at what effects renewable energy can have on your community.

4.1 Community Bonding

During construction or installation of community level renewable energy, the entire community is involved. Just like digging a large well for the community or building the community hall – everyone feels proud to work for their community benefit. With many people working together and learning new things – there is a lot of fun and laughter involved and helps keep the community bond strong. Compared to just installing at your house – where you may feel bad for your neighbor not having the renewable energy to use for lighting etc – community level renewable energy brings peace to everyone knowing that all will equally benefit. Bonds are also strengthened with external donors and volunteers who come to help out in these projects.

FIGURE 45: **Community Projects Build Bonds**[52]

4.2 More people – Less cost

Renewable energy devices are expensive to install. So, it is often hard for single homes to invest in renewable energy which is enough to meet all their needs. As renewable energy systems become larger - they are also more efficient. For community level renewable energy for whole village or province – the costs are shared by a lot of people, and you usually end up paying less for the energy you will receive. In some cases, government, and non- government organizations (NGO) are also happy to help in community efforts to raise money for renewable energy projects.

52 Source: Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Locals_thank_Australia_for_funding_rural_road_rehabilitation_and_maintenance_in_Malekula,_Vanuatu_(12779057305).jpg#/media/File:Locals_thank_Australia_for_funding_rural_road_rehabilitation_and_maintenance_in_Malekula,_Vanuatu_(12779057305).jpg

FIGURE 46: **Dividing costs means each person pays less**[53]

4.3 Shared work, community ownership – reliable energy

As you know, work is shared in the community in big feasts or when external officials come to visit. How work is shared depends on the event and the village headman. This division of labor has worked well for many years. Renewable energy systems need regular checkup and maintenance to work properly for a longer time. In the case of single home renewable energy systems – someone in the home may get sick or busy or even forget to carry out maintenance. But with community level – if people are well trained then several people can take turns to look after the system. If one person is busy or sick – another person can check the system and carry out maintenance. This means that there will be more reliable power supply and less breakdowns. Also, the system components will last for longer because they are well cared for.

FIGURE 47: **With more people involved maintenance is easier**[54]

4.4 Economic Benefits

Large scale community based renewable projects create more economic benefits for the community. For example, with electricity being generated – women in the community can buy sewing machines and sew dresses to sell at the local market. This brings in income to the entire community. With large enough renewable systems – an ice making machine can be powered and a freezing station can be powered. This can be very useful for fishermen in the community who can keep the fish for longer and even sell it to middlemen at a later date. The ice can be sold to other fishermen passing through the community. All these brings in income to the community which can be re-invested into building community halls, health centers, more classrooms and so much more. With so many storms in the region – income from renewables can be used to repair damages caused by cyclones or floods.

FIGURE 48: **Income gained from renewable energy projects can be used to rebuild communities**[55]

4.5 Community Responsibility

As Pacific islanders we value our land and sea. We are very close to nature. Won't it bother us that we are harming nature – our land and sea by using fossil fuels? As a responsible community we need to stop causing harm to the community and its precious resources by reducing our use of fossil fuels. You can say this will not reduce the global emission which are far bigger, and this is true, but we can always set an example for others to follow. Our leaders are always in international forums trying to convince the world to go more into renewables. By starting to lead by example – we can bring about change in the neighboring community and then it spreads to other communities to the point that the world will notice and start to change.

53 Windpower Engineering &Development, August 2019, https://www.windpowerengineering.com/pattern-energy-confirms-third-party-interest-in-company/

54 Source: ProCar Reviews.com, https://procarreviews.com/wp-content/uploads/Removing-Car-Battery-1024x682.jpg

55 Source: Humanity House.org, January 2017, https://humanityhouse.org/wp-content/uploads/2017/01/UNDP%E2%80%99s-Response-to-Cyclone-Pam-Vanuatu.jpg

The resources need to be handed down to future generations just as properly as they were handed down from previous generations. For this to happen we must live without causing pollution and harm to nature. Renewable energy is the best way to do this and enjoy a quality life at the same time.

FIGURE 49: Coastal erosion effects are directly linked to irresponsible use of fossil fuels which cause global warming[56]

56 WikiVisually, https://wikivisually.com/wiki/Eita,_Kiribati

ACTIVITY 7

In groups, discuss the following questions.

1. How does renewable energy help the community?

Answer: It brings the community together and builds better relations. Community level renewable energy systems are cheaper and better since everyone is involved and all benefit from it.

2. Is your community responsible to reverse or mitigate climate change?

Answer: Yes. Every community must play its part. Even though we are a small country we must lead by example. By going for renewables, we set example for larger communities to follow. If we don't change – they won't, and we will all suffer.

Discussion and Questions

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