DIREKT

Small Developing Island Renewable Energy
Knowledge and Technology Transfer Network

Tonga Renewable Energy and TERM Workshop

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Deciding to Go Renewable – A Basic Awareness Kit

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Part A: Basic Facts

1.	Facts	What you need to know
	1. Why we need energy We need energy for: • Domestic needs • industrial needs • transportation • power generation (also for making war, going to outer space, discovering the origin of the universe ….)	Primary energy and end-use energy: • Energy is often transformed into another form before it is used. For example, coal, diesel or biomass is burnt to produce electricity in power plants. • The original energy is called Primary energy, and the final form (e.g. electricity) is the end-use or final energy.

Basic Facts ...

2.	Fact	What you need to know
	2. What forms of energy do we use? Common forms of energy: • Oil, Coal, Natural gas • solar energy • hydro energy • wind energy • biomass energy • geothermal energy • ocean energy • nuclear energy.	• All energy, except nuclear and geothermal energy, come from the sun. • Energy can be divided into renewable energy and non-renewable energy

Basic facts ..

<table>
<tr><th>3.</th><th>Fact</th><th>What you need to know</th></tr>
<tr><td></td><td>3. What is renewable energy (RE) and why is it important?
Renewable energy is energy derived from a source that will not run out
Examples are solar energy, wind energy, hydro energy, biomass energy, ocean energy
If the source will run out, it is called Non-Renewable energy
RE can be available from indigenous resources, is usually clean and can be more economical than fossil fuel energy.</td><td>Although geothermal energy will run out, it is classified as renewable energy

<table><tr><th>Non-renewable</th><th>Renewable</th></tr><tr><td>Oil, petrol, diesel</td><td>Solar, wind, hydro</td></tr><tr><td>LPG, LNG</td><td>Biomass and biofuel</td></tr><tr><td>Coal</td><td>Ocean (tidal, wave, OTEC)</td></tr><tr><td>Nuclear</td><td>Geothermal *</td></tr></table></td></tr>
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Basic facts ..

<table>
<tr><th>4.</th><th>Fact</th><th>What you need to know</th></tr>
<tr><td></td><td>3. What are the necessary requirements for the use of RE?

i) RE resources must exist in sufficient quantity, and must be spread out over time. E.g. to use wind energy, you must have wind available throughout the year.</td><td>
<table>
<tr><th>Type of resource</th><th>Example</th></tr>
<tr><td>Continuous resource</td><td>Hydro</td></tr>
<tr><td>Periodic resource</td><td>Solar</td></tr>
<tr><td>Intermittent resource</td><td>wind</td></tr>
</table>
</td></tr>
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Basic Facts ..

5.	Fact	What you need to know
	3 (cont.) ii) The Renewable Energy Technology (RET) must be mature, ie must have been tried, tested and be available in market-ready (i.e. off-the-shelf) form. • Market-ready technologies: Wind, solar, hydro, biomass • Non-market ready technologies: Ocean energy (wave, OTEC), fuel cells	Some RE stakeholders (including businesses and academics) will try and hard-sell their favourite technologies to you – beware!

Basic facts ..

6.	Fact	What you need to know
	4. What are the other requirements needed to facilitate RE in your country? • Human capacity • institutional capacity • Policy and legislation	• human capacity = scientific and technical, administrative, entrepreneurial • not all PICs have the necessary policies and legislations in place to enable the introduction of all forms of RE technology • Capacity building in energy is an essential criterion for the success of energy projects in the PICs

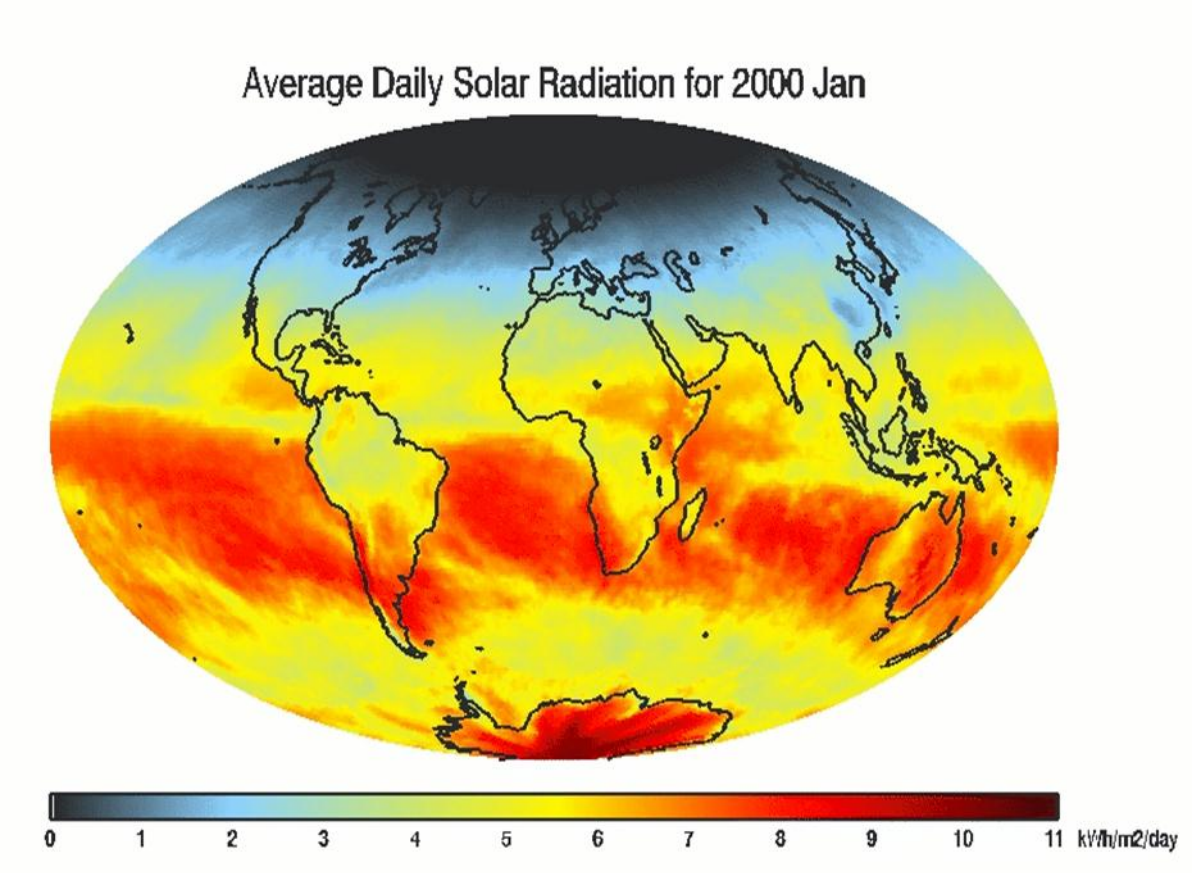
Basic Facts ..

7.	Fact	What you need to know
	5. Using Solar Energy • Two common types: Solar Thermal and Solar Photo-Voltaic (Solar PV) • Solar thermal system: solar energy → heat energy • Solar PV system: solar energy → electrical energy • Solar energy is available everywhere on globe • Solar energy varies with latitude and season	1. Resource availability (number of sun-hours/day, number of no-sun days) must be ascertained first before you install your PV system. 2. Stand-alone and grid-connected PV systems. 3. Batteries cost a lot and have a short life-time (5-6 years) only as compared to the panel lifetime (~25 years).

Using solar energy – availability of solar resources

Solar resources

- Measured in kWh/m2/day or sun-hours/day
- Varies with latitude and seasons



Source: NASA

Basic facts..

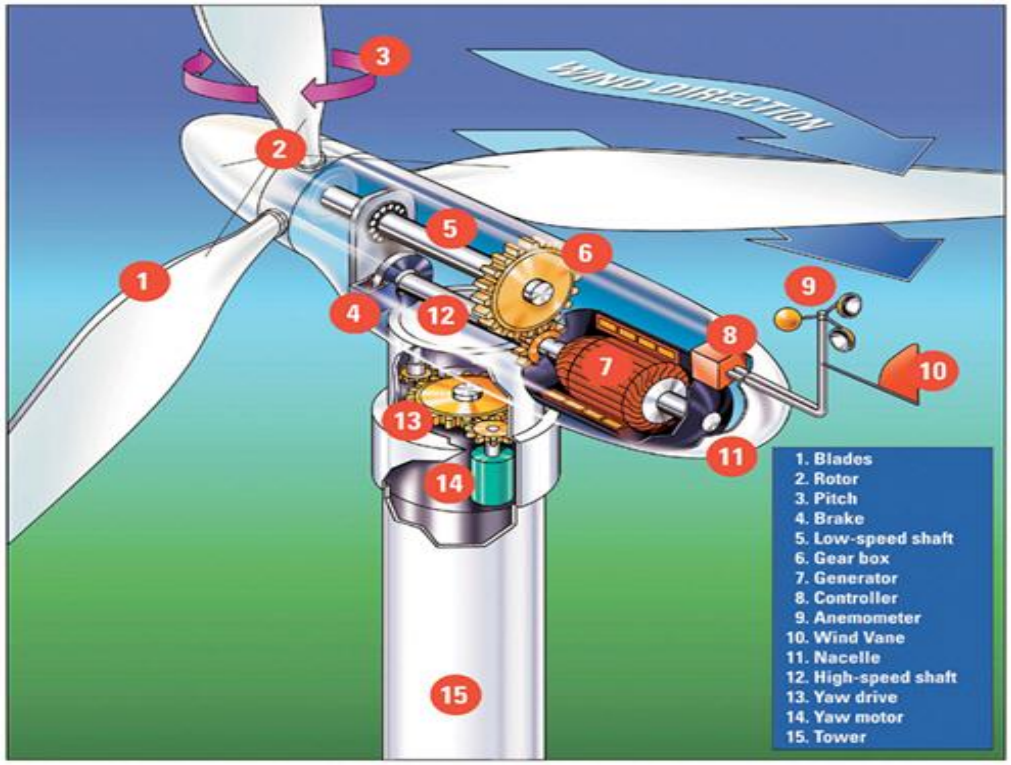
8.	Fact	What you need to know
	6. Using Wind Energy i) the technology Power in wind $P_r \sim u^3$ (u = wind speed) Max power that can be utilized =59% Cut-in speed ~ 2m/s, cut-out speed ~ 30m/s ii) resource availability must be ascertained over at least a year	• wind energy supply is intermittent

Wind energy technology

Wind turbines convert the kinetic energy of wind to electrical energy

Wind turbines cont

Wind Turbines cont. – how electricity is generated



Picture source: google

Basic Facts ..

9.	Fact	What you need to know
	7. Using Hydro energy Power in water → Turbine → Generator Large hydro and small hydro: • Large hydro –(MW-GW) power for national grids • Mini-hydro schemes for villages (Bukuya, viti Levu (100kW) Buca (30kW)) • micro/nano hydro – village stream level power, ~ 1 kW or lower • Power available at jet is given by P = 10 QH Q = volume flow rate of water H = head (height between water source and turbine)	Global capacity in 2011: 1,010 GW China, Canada, Brazil, US and Russia produced 52% 1kW = 1 kilowatt = 1,000 Watts 1 MW = 1 megawatt = 1,000,000 Watts = 1 million Watts 1 GW = 1 gigawatt = 1000 MW= 1000 million Watts 1 TW = 1 Terawatt = 1000GW

Using hydro cont. – the large and the small in hydro

The 22 GW three gorges dam, China

Picture Source: Encyclopedia of the Earth

A 44W nano-hydro scheme at Tiko's farm, Savu village, Fiji

Using hydro – turbines large and small

A Pelton wheel turbine used in large hydro schemes

The turbine used at Tiko's nano-hydro system

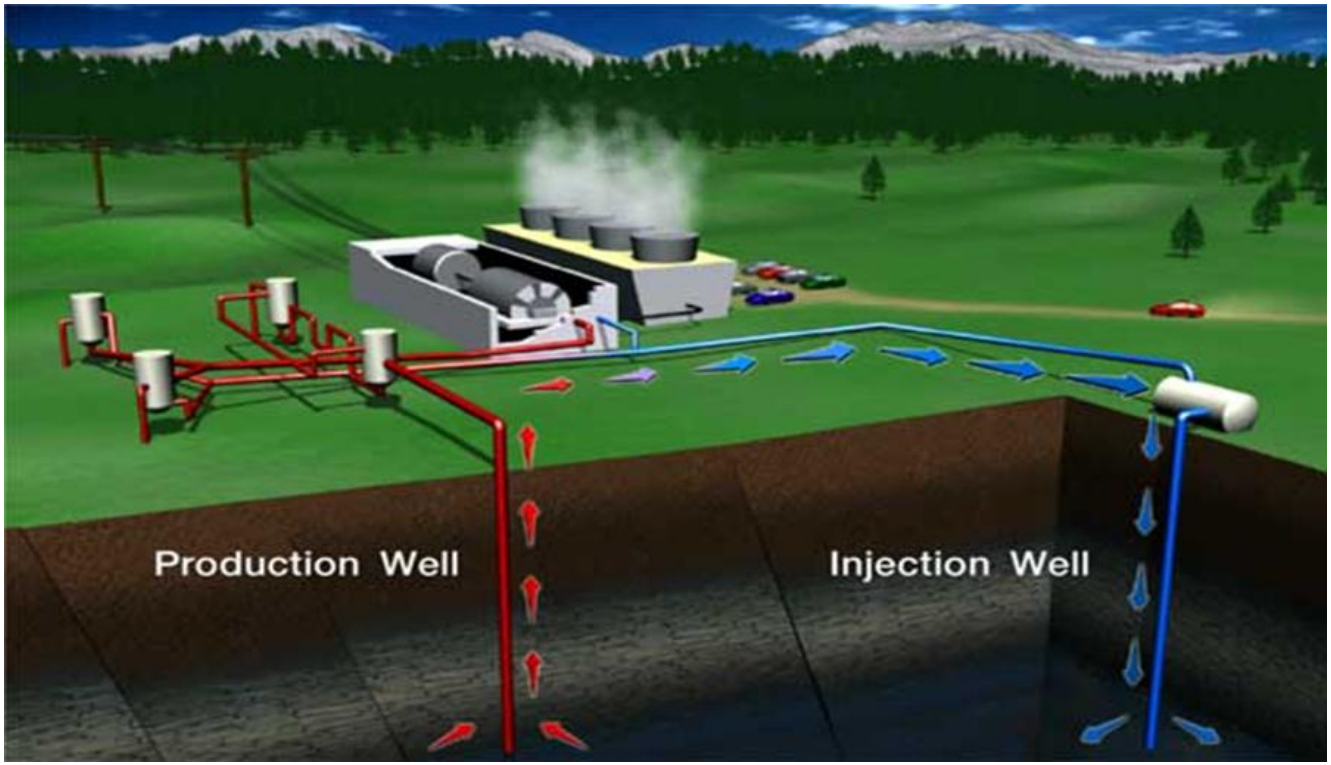
Basic facts ..

10.	Fact	What you need to know
	8. Biomass energy • Biomass energy = energy in organic matter, captured from solar energy through photosynthesis. • Several forms of biomass: Solid - wood, forestry and crop residues, municipal solid waste • Liquid – biofuels (ethanol, biodiesel) • Gas - biogas, landfill gas, syngas • Uses: cooking, power generation, conversion to secondary fuels through pyrolysis/gasification. Cooking: Wood stove Power generation: biomass → heat engine → generator Heat engine can be a i) steam engine ii) gas turbine iii) reciprocating engine (piston engine)	Biofuels for transportation: i) ethanol blends for petrol engines: E10 = 10% ethanol, 90% petrol ii) biodiesel for diesel engines: Made from vege and other oils and fats; Biodiesel has better fuel and emission properties than petroleum diesel, except NOx emission is higher; B5=5% biodiesel, 90 petroleum diesel. Blends up to B20 acceptable for normal engines

Basic facts..

11.	Fact	What you need to know
	9. Geothermal power Power from geothermal energy - from hot water reservoirs or geothermal gradient underground (hot rock > 40 C/km) Not really renewable Global capacity ~ 11 GW	Geothermal power available in 24 countries USA (3.1GW), Philippines (1.9GW), Indonesia (1.2 GW), Italy (0.9GW), NZ 0.8GW, Iceland 0.6GW, Japan 0.5 GW. In 2011, 26% of electricity in Iceland was from geothermal, 18% in the Philippines, 13% in NZ

Geothermal power cont.



Source: geothermal.marin.org

Basic facts ..

12.	Fact	What you need to know
	10. Ocean energy • Includes Wave, Tidal (barrages and turbines), Osmotic Pressure, and Ocean Thermal Energy Conversion (OTEC). • Only 3 tidal installations were operational in 2010 • Most significant was 240 MW plant on the estuary of the Rance River, near Brittany, France. • However recent upsurge in interest (UK, Portugal)	• Least mature technology • Only tidal energy reached commercial maturity by end of 2010

Part B: Assessing Renewable Energy

1. Fact and Fiction about Renewable Energy

13	Statement	Fact
1.	***All Renewable Energy is mature and market-ready technology***	• Some are and some are not. • Hydro technology has been available for a long time. • Pilot projects on OTEC have been running for a long time.
2.	***Renewable Energy (e.g. solar PV) can meet the entire energy needs of your home.***	• The capacity of technologies such as wind and solar PV to provide for the required needs are very limited. • E.g. huge investments will be required to meet all the electrical demands of an ordinary home using solar PV.
3.	***Renewable Energy Technology (RET) (e.g. solar PV) is cost effective.***	• Only true for some RETs. • Look at the payback period (i.e. the period at which you break-even). • Only the smallest systems are cost-effective. (But aid is free!)

Assessing RE ..

14.	Statement	Fact
4.	***An RET delivers the power or energy it says it will deliver.*** For instance, a wind turbine with a **rated capacity** of 10 kW will deliver 10 kW of power when installed.	This is almost never true. The power or energy delivered depends on • The peak power the technology is designed to deliver (i.e. its rated capacity), and • the availability of RE resources Capacity factor = Actual energy produced / Theoretical energy = Actual (average) power x time / Rated power x time

RET	Capacity factor
Hydro	~100%
Solar PV	~40%
Wind	~15%

Assessing RE..

2. What factors decide whether we have made a wise choice?

Performance and Economics

Performance: efficiency, rated capacity, capacity factor

- Efficiency = useful energy output/ total energy input
- (Not important as long as RE is free)
- Rated capacity = peak power the RET is designed to deliver
- Capacity factor = Actual energy output over a period/ Rated energy output over the period

Assessing RE ..

Economics: lifetime, payback period, cost per kW

- Lifetime = expected length of time system will remain productive
- Payback period (simple payback period) = number of years it will take to pay back for the capital and operation and maintenance costs of the system from the savings made by using this technology
- ***Must be significantly shorter than the lifetime.***
- Cost per kilowatt = total cost/power rating
  = the cost incurred per kW of power produced.

Assessing RE..

Comparison of technologies

(For a ~ 5 kW system)

RET	Technology efficiency	Capacity Factor	Lifetime	Cost/kW	Payback period	Commercial availability
Wind	~40%	10-25%	> 25 yrs, maintenance recquired	~$10,000	< 25 yrs	Yes
PV	12-15%	~50%	20-25 yrs	~$25,000	15-25 yrs	Yes
Micro-hydro	90%	~100%	> 25 yrs, low maintenance	$2000-5000	5-10 yrs	Yes
Biomass	< 60%	Biomass availability	~ 25yrs	-	< 25 yrs	Yes
Biofuel (Transp.)	< 60 %	Biofuel availability	~ 25 yrs	-	< 25 yrs	Yes/no

Thank you for your attention!