DIREKT

Small Developing Island Renewable Energy
Knowledge and Technology Transfer Network

Renewable Energy Capacity Building Workshop for North Pacific
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The University of the South Pacific
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Basic awareness in Renewable Energy for Decision-makers

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Outline

Session 1

1. **Overview of Renewable Energy (RE)**
2. **Basic requirements for RE**

- (Exercise 1 – Know your energy – problem-solving kit)

Session 2

3. Learning about the technology: efficacy and economics

4. Prospects and opportunities

(Exercise 2 – RE requirements for the North Pacific – assessment by participants)

(Exercise 3 – A North Pacific RE Decision Matrix)

Session 1

1. Overview of Renewable Energy (RE)

Why RE is needed in the PICs

- Energy needed to sustain and develop economy
- PICs generally do not have fossil fuel resources – high costs of importation, supply chain issues
- RE seems to be the natural alternative.

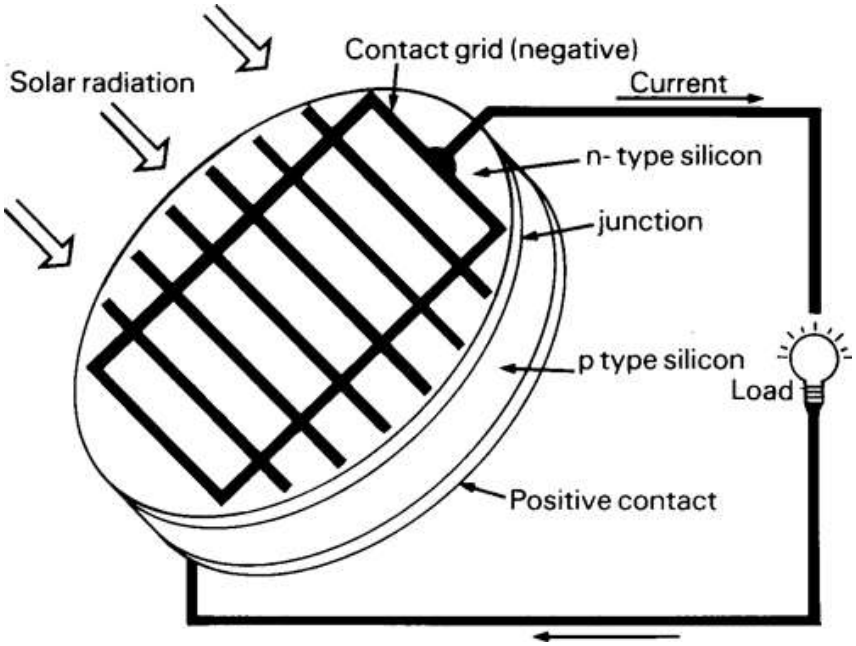
Types of RE

- Main types of RE in use today
  - Hydro
  - Wind
  - Solar
  - Geothermal
  - biomass, biofuels
  - ocean energy (tidal, wave, OTEC).
- But MUST consider maturity and market-readiness of the technology

Types of tech (cont) – Solar Photovoltaic (PV)

Solar PV or solar thermal

Solar PV panels built up from solar cells



Types of tech (cont)

- Hydro – range of large to nano-hydro technologies, from Gigawatts to ~100W. All using turbines to convert potential energy stored in water to electrical energy

The 3 Gorges dam – source: Encyclopedia of the Earth

Nanohydro dam at Tiko's farm, Savu village, Fiji

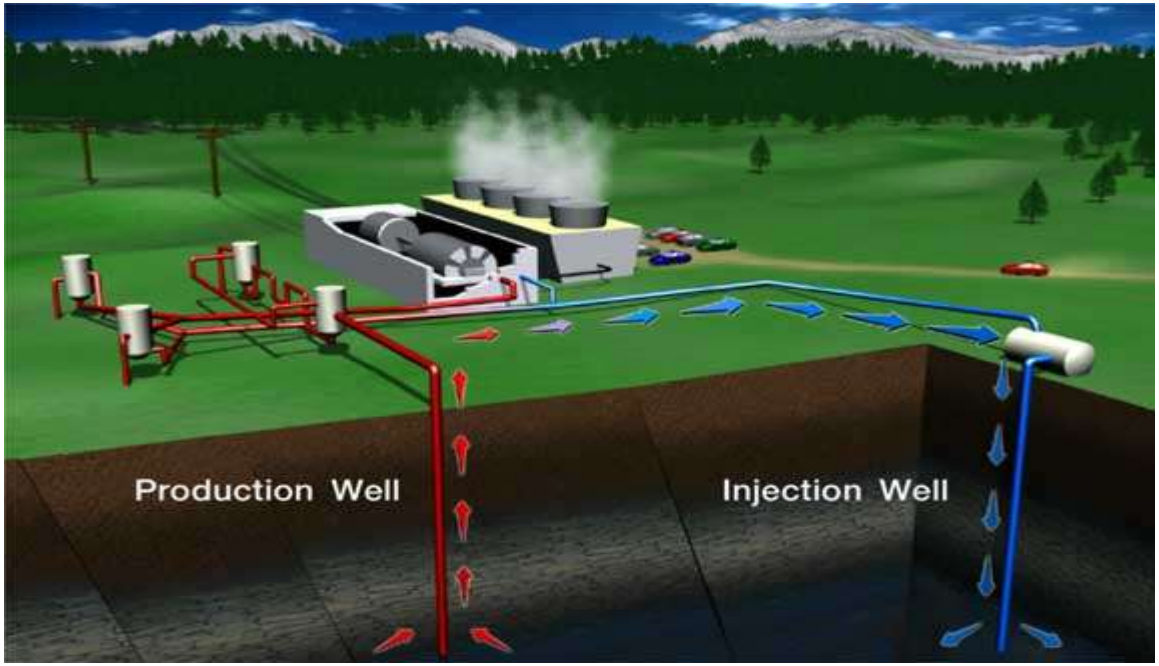
Types of tech (cont) – Wind energy

- Wind turbines convert kinetic energy of wind to electrical energy

Wind turbines (cont.)

Types of tech (cont) –Geothermal energy

- Geothermal energy stored underground to electrical energy
- Supplies 13% of NZ electrical power demand



Source: geothermal.marin.org

Types of tech (cont) Biomass and biofuels

Biomass

- use directly in thermal power plants as fuelwood
- convert to liquid biofuels and use in transportation and powergen

Gasification power plants

- convert biomass to syngas (mixture of CO and H_2) in gasifiers, then use this fuel to drive gas turbines
- Waste to energy plants are essentially incineration plants or gasification plants

Types of tech (cont) - biogasification

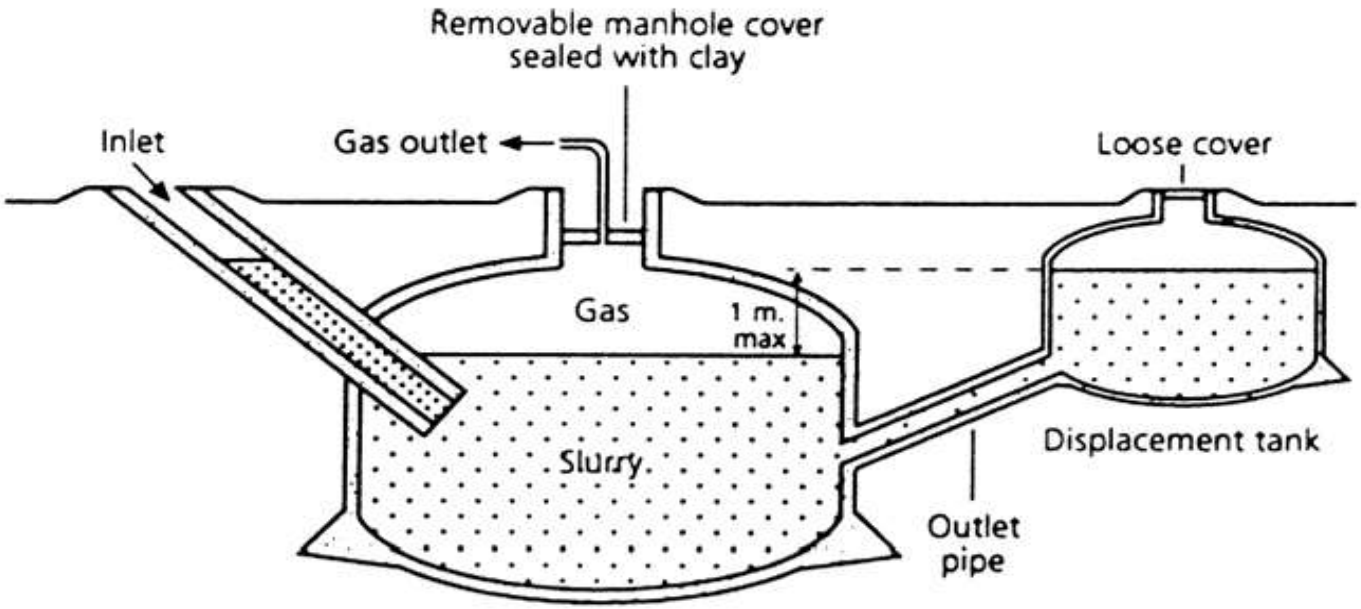
Biogasification system; Source: Energy Summit – Samoa presentation

Types of tech (cont) - Biofuels

- Vegetable oils, biodiesel, ethanol, blends, hybrid fuels
- Vegetable oils can be used to drive diesel engines – but harmful to unmodified engines
- Biodiesel through trans-esterification of vegetable oils – has superior fuel properties
- Ethanol through fermentation
- Also methanol and butanol

Types of tech (cont) - Biogas

- Biogas is mixture of methane (CH_4) and carbon dioxide (CO_2) – only CH_4 is energy-rich
- Biogas produced through anaerobic digestion of biomass, in biodigesters, landfills, sewage systems etc
- Biodigesters used for cooking fuel for farms, schools etc
- Landfill gas potential for electricity generation



Fixed-Dome Biogas Digester

Types of tech (cont) Ocean Energy

- Wave, tidal, OTEC (Ocean thermal energy conversion)
- Tidal energy at Rance River, France, but few other places
- Various technologies for wave energy, mostly still under development or pilot project stage.
- OTEC has problems

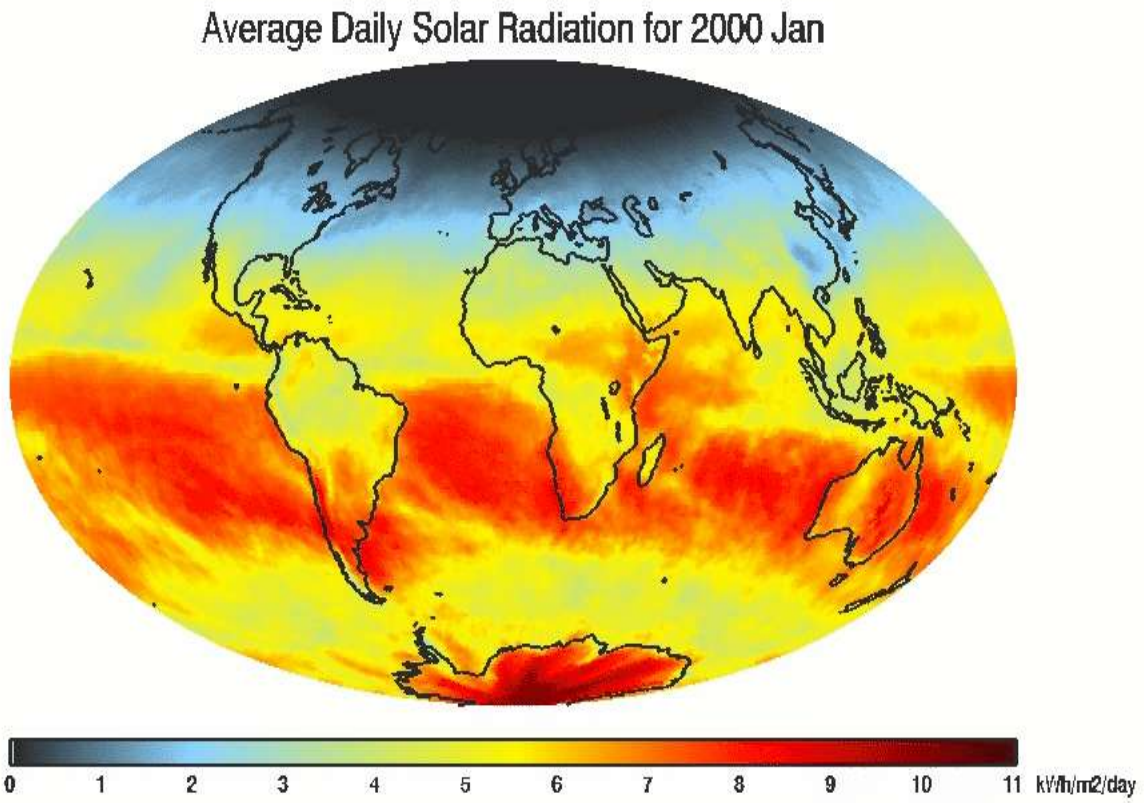
2. Basic requirements for the use of RE (what we need before we can use it)

- RE resources
- RET – must be tested and market-ready
- Human resources – technical and scientific, business expertise, policy and legal expertise
- Institutional mechanisms – enabling legislations and regulations, standards, research and business infrastructure

a) RE Resources

Solar resources

- Measured in kWh/m^2/day or suns
- Varies with latitude
- Seasonal variations



Source: NASA

Resources (cont)

Wind resources

Wind speed

- Rated maximum power given by

$$P_r = \tfrac{1}{2} C_p A \rho u^3$$

  - where A = area swept by rotor, ρ = density of air, u = wind speed
    C_p = the power coefficient

- The power coefficient has a theoretical maximum value of 16/29 = 0.59, and actual values usually much smaller
- Cut-in speed of ~ 3 m/s
- Wind regimes

RE Resources (cont) Hydropower

- Hydropower technology the most mature technology
- Power(kW) = 10QH – central equation for resource assessment and design

  Q = flow rate (m^3/s), H = head (m)

RE Resources (cont)

Geothermal

- Not really a renewable resource
- Pre-requisite – volcanic geology
- Available in PNG
- Potential in Fiji, Vanuatu etc

RE Resources (cont) Biomass and biofuel

Biomass

- Fuelwood forests
- Forestry/timber-milling residues, MSW

Biofuels

- Vegetable oils as biofuels or biofuel feedstock
- Coconut, palm oil, soy, peanut, rape seed, castor, pongamia, jatropha (inedible)
- Land and water resources needed for feedstock production

Survey of RE resources in the PICs

Country	Geog	Solar (kWh/ m^2/day)	Wind	Hydro	Biomass/fuel	Geothermal	Ocean	
Nauru	21 km^2	Yes (5.8)	?	No	No	No	No	
Kiribati	32 atolls	Yes (5.7)	No – atolls	No	CNO (5500Mton)	No	No	
PNG	mountaneous	Yes (6)	Yes – 19 sites	**Yes** (1400MW)	Timber, palm oil	Yes (1 station)	No	
S.I.	6 volc.Is	Yes	No data	Yes (JICA 330MW)	CNO	Maybe	No	
Samoa	2 volc is	Yes (6)	~ 3m/s	**Yes** (issues)	5%CNO blend	No	No	
Fiji	2 volc	Yes	Yes - Butoni	yes	Timber, CNO	?	?	

Source: JICA study

b) Mature technology and other requirements

- Mature technology is one that has been tested, proven and is market ready- not all RE technologies are mature
- Example : Small Pacific Island state needs to reduce its import bill and promote development through RE
- Country is made up of one volcanic island and many small low-lying coral atolls and scattered over a vast region.
- Which technology to use?
- Which resources exist?
- What are the other requirements?

Mature technology (cont)

Type of RE	Is the technology mature	RE Resource availability in the country	Human and other resources
Solar	yes	yes	?
Wind	yes	yes	?
Hydro	yes	no	?
geothermal	yes	no	?
biomass	yes	yes	?
Biofuel	Yes?	?	?
Tidal	?	?	?
wave	?	?	?
OTEC	???	?	?

Learning clinic

- Exercise 1 – Know your energy – problem-solving kit

Session 2

3. Learning about the technology: efficacy and economics

- How viable is it to use a renewable energy technology (RET)?
- What factors must we consider to ensure we have made a wise choice?
- Performance:
- Rated capacity, efficiency, capacity factor

- Rated capacity = maximum capacity, all things being well
- Efficiency = Output energy of the RE system /Input energy to the system
- OR
- Efficiency= Output power of the system/Input power to the system
- Capacity Factor = Actual Energy produced by the system/Energy expected from the rated capacity

Efficacy and economics (cont)

- Economics:
- Lifetime, payback period, cost of energy
- 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.
- Cost of energy = total cost/power rating
- = the cost incurred per kW of power produced.

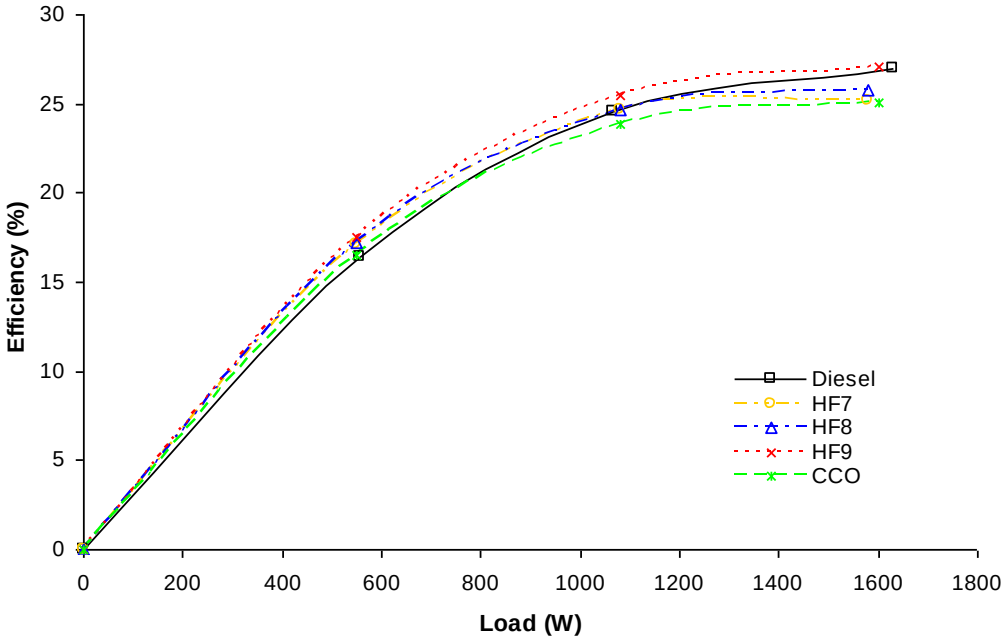
Comparison of technologies

RET	Technology efficiency	Capacity Factor	Lifetime	Cost/kW	Payback period	Commercial availability
Wind	~40%	10-25%	> 25 yrs maintenance reqd	~$10,000	<25 yrs	Yes
PV	12-15%	~50%	20-25 yrs	~$25,000	25-35 yrs	Yes
Micro-Hydro	90%	~100 %	>25 yrs low maintenance	$2000-5000	5-10 yrs	Yes
Biomass	< 60%	Biomass availability	~25 yrs	-	< 25 yrs	Yes
Biofuel	< 60%	Biofuel availability	~25 yrs	-	< 25 yrs	Yes/No

Load-Efficiency considerations

- We usually use our power sources without thinking about the efficiencies involved.
- A little thought can show us how we can use a power supply such as a diesel genset more wisely, and be more environmentally friendly.

Load-efficiency case study



Effect of load on efficiency for 'CCO/Ethanol/Octanol' (CCO-E-O) hybrid fuel.

Table of load v efficiency for genset

Load (Watts)	200	400	600	800	1000	1200	1400	1600
Efficiency (%)	6.5	12.5	17	21.5	23.5	25	25.5	26.0

Cost of using the diesel genset

Load (Watts)	Energy output/ hour (MJ)	Efficiency (%)	Input energy (MJ)	Volume of fuel (litres)	Total cost at $2.00/litre)
200	0.72	6.5	11.1	0.29	0.58
400	1.44	12.5	11.52	0.30	0.60
800	2.88	21.5	13.40	0.35	0.70
1600	5.76	26.0	22.15	0.58	1.17

Economics of using the genset

- If one family uses 400W for one hour, it costs $0.60
- If two families use 400W for one hour each, it costs them a total of 2 x $0.60 = $1.20
- But if the two families share 800W supply, it will cost them a total of $0.70, or $0.35 each!
- Also, they will be producing less CO_2 emissions!

4. Prospects and opportunities

- Biofuels, waste to energy and fuelwood gasification plants, ocean energy – what are the possibilities for the North?
- resource requirements (land availability for feedstock plantation – edible and non-edible vege oils, copra)

(Exercise 2 – RE requirements for the North Pacific – assessment by participants)

(Exercise 3 – A North Pacific RE Decision Matrix)