

EXERCISE 1: OVERVIEW OF RENEWABLE ENERGY - ANSWERS

1. In-pipe hydropower

The Californian city of Fontini obtains half of its drinking water from a reservoir in the hills above the city and half from groundwater. Water from the reservoir arrives at the town's Sandhill water treatment facility at a pressure of 12 bars and groundwater is pumped electrically to the surface at the same pressure.

The treatment facility requires water at a pressure of 1 bar to operate and the town has replaced its pressure reduction valves with a small hydro turbine that will reduce pressure and generate 2,300 MWh of electricity each year.

What is the annual production of electricity from renewable energy at the facility?

1,150 MWh - pumped water is not renewable energy, but it does improve energy efficiency



Lawmakers and water company officials cut the ribbon for the small hydropower project.

2. Wind-powered water pumping

A windmill with a mechanical pump raises groundwater for a cattle farm in South Dakota. When the water tank is full, the windmill charges a battery that is used to power an electric pump when the wind is not blowing.

The power consumption of the electric pump is 15 kW and it operates for 1,000 hours per year. This pumping provides one-third of the water used on the farm and the rest comes from the mechanical pump powered directly by the windmill.

What is the annual production of wind energy on the farm?

At least 15 MWh (from the battery charging). The mechanical pumping doesn't count, even through the total amount of energy used could be calculated as 45 MWh (i.e. electricity used x 3).



Windpump in South Dakota, USA.

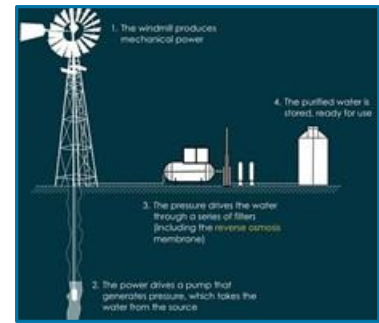
3. Wind-powered desalination

A wind-powered desalination system has been tested in the coastal village of Ocachu in Mexico. The windmill raises groundwater with a low salt content and creates the pressure required for desalination using reverse osmosis. When the wind is not blowing, a generator is used to operate an electric pump that raises water and generates the pressure for desalination.

In the first year of operation, the windmill provided 90% of the energy required to operate the plant and an additional 50 MWh was provided by the diesel generator.

How much wind energy was produced for desalination?

None, mechanical pumping doesn't count. Again, the energy from mechanical pumping could be estimated as 9 x 50 MWh or 450 MWh, but it does not count.



Aeolus wind-powered desalination system.

4. Renewable waste

In the city of Kung Wei in China, waste is turned into energy at a large incinerator and various landfill sites (with biogas recovery) around the city. The average composition of the waste (by weight) is:

- Paper and card:	25%	REN
- Hard plastics	25%	
- Food:	20%	REN
- Wood:	10%	REN
- Textiles:	5%	REN
- Soft plastics	5%	
- Metal	5%	NO ENERGY
- Glass	5%	NO ENERGY

The municipal waste incinerator generates 18,000 MWh of electricity each year and electricity generated from biogas at the landfill sites amounts to another 8,000 MWh.

How much bioenergy is produced each year from these facilities?

Waste = 60%/90% x 18,000 MWh = 12,000 MWh
Landfill = 8,000 MWh, so the total = 20,000 MWh



Municipal solid waste incinerator, China

This assumes that the energy content (per tonne) is the same for all these materials, which is unlikely. Food waste is likely to be wet and have a low energy value.

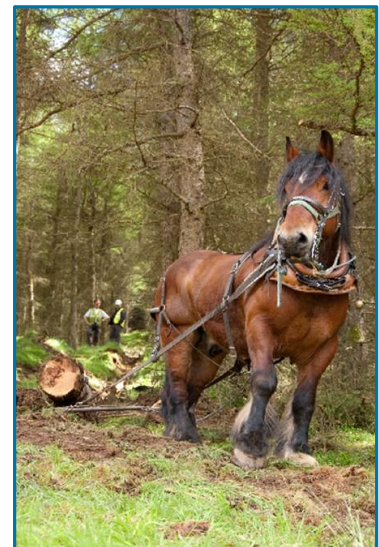
5. Animal power

Jim Johnstone Forestry Co. in the United Kingdom recently replaced their forestry tractor with horses. They use these horses at production sites to take cut trees from inside the forest to the main road.

The horses have reduced the annual fuel consumption at the company by 6,000 litres a year, which is equal to about 235 gigajoules (GJ).

Considering the fuel that has been saved, is the company producing renewable energy and reducing its CO₂ emissions now?

The company is not producing renewable energy (animal power doesn't count), but it has reduced its emissions.



Log extraction using horses, Johnstone Forestry, UK

6. Variable or intermittent energy resources

Which of the following types of renewable energy are variable resources? (tick any that are variable)

- Hydropower
- Tidal energy
- Ocean energy
- Wave energy
- Wind energy
- Solar PV
- Concentrated solar power
- Geothermal energy
- Bioenergy from bagasse
- Sugar cane ethanol

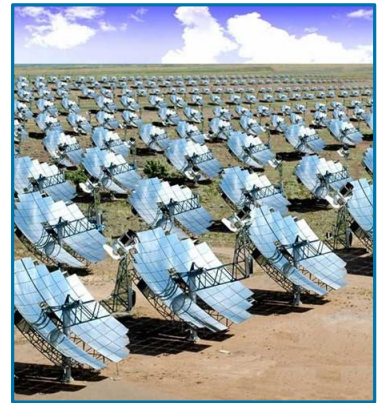


The term “variable” is imprecise (and should be avoided), but it usually means sources of energy that are unpredictable in the short-term.

7. CSPV, CSP and CST

What are the differences between concentrated solar PV, concentrated solar power and concentrated solar thermal energy?

- **Concentrated solar PV (CSPV) plants produce electricity, although some waste heat may be recovered from cooling water.**
- **Concentrated solar power (CSP) plants produce electricity or combined heat and power (CHP).**
- **Concentrated solar thermal plants produce heat only.**
- **CSPV is more suitable for off-grid (small-scale) applications. The others are generally large-scale plants.**



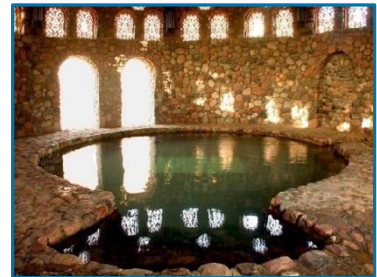
Stirling Energy System's 300 MW solar power plant in California.

8. Geothermal springs (baths)

A few kilometres outside the city of El Tur, a hot spring flows from the mountain of Gebel El Tur into a carved stone house known as the “*Lord Moses' bath*” or Hammam Moussa. The water from the spring has a constant temperature of 27° C and the bath is a popular tourist destination.

Can the water from such springs be considered as a type of renewable energy?

Low-grade geothermal heat may be counted as renewable energy if it meets a need that would otherwise be met by another type of energy. In this case, it probably would not count because the demand is for a leisure activity, not heating.



Hammam Musa (Moses' Bath), Egypt

9. Deep water source cooling (air conditioning)

Deep water source cooling occurs when a large body of naturally cold water is used as a heat sink. Deep water in lakes, oceans and rivers has a temperature of 4-10° C all year round and, in summer, this can be pumped to the surface, passed through a heat exchanger and used for cooling. Such systems are already used in a number of large buildings around the World and in a district cooling system in Toronto, Canada (with a capacity of 207 MW).

Can this be considered as a type of renewable energy?

Although cooling is important, only positive thermal energy flows (i.e. heat production) are usually measured in energy statistics.



Excelsior Hotel, Hong Kong, one of several hotels using seawater air conditioning

10. Electricity from renewables

Rank the main sources of renewable energy in terms of how well they can be used to meet varying electricity demands such as peak loads. (*high/medium/low*)

- Hydropower	High
- Marine energy (TIDAL)	Medium
- Solar PV	Low
- Concentrated solar power	Medium
- Wind energy	Low
- Geothermal energy	Low
- Bioenergy from solid biofuels	Medium
- Bioenergy from biogas	Medium

