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An Introduction to the Renewable Energy Resources

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Renewable Energy Technologies

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Energy Sources

- **Non-renewable:** A non-renewable resource is a **limited** natural resource that **cannot** be re-made or **re-grown** in a **short amount of time** at a **scale** comparable to its **consumption**.



- **Renewable:** Renewable resources are **unlimited** natural resources that **can be** replenished in a **short period of time**.



Renewable Energy Sources

- Renewable energy is energy generated from **natural resources**—such as **sunlight**, **wind**, **rain**, **tides** and **geothermal heat**—which are renewable (naturally replenished).

- **Solar energy**
- **Wind**
- **Hydropower**
- **Biomass**
- **Ocean energy**
- **Geothermal**
- **Waste to Energy**


Solar Energy

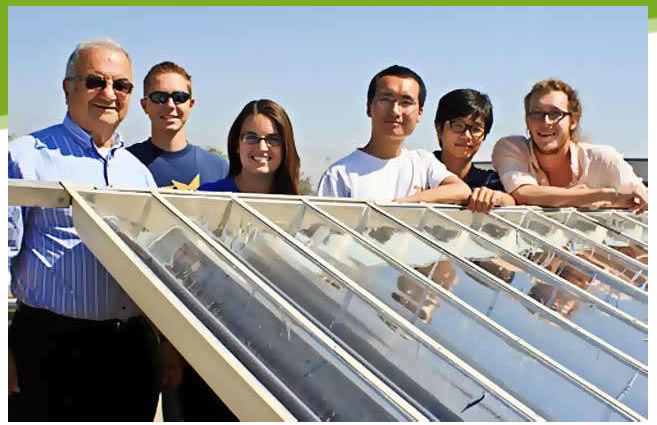
What Is Solar Power?

- **Solar power** is one of the best renewable energy sources available because it is one the cleanest sources of energy.

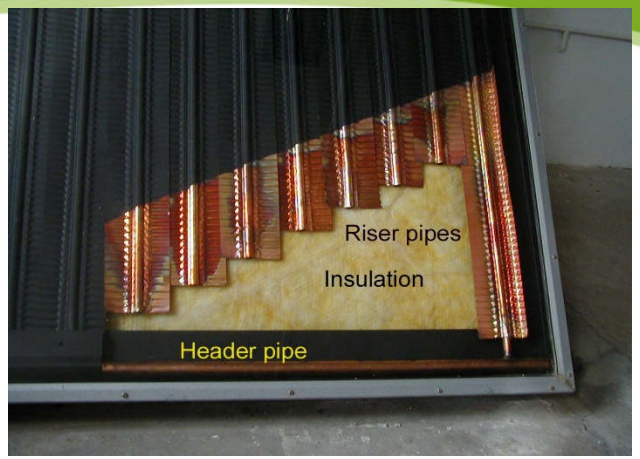
- Solar power is the conversion of **sunlight** into **electricity** either directly by using **photovoltaics** or **concentrated solar power**.

Solar Electricity Generation

Different Types of Solar Collectors



Compound Parabolic Concentrator

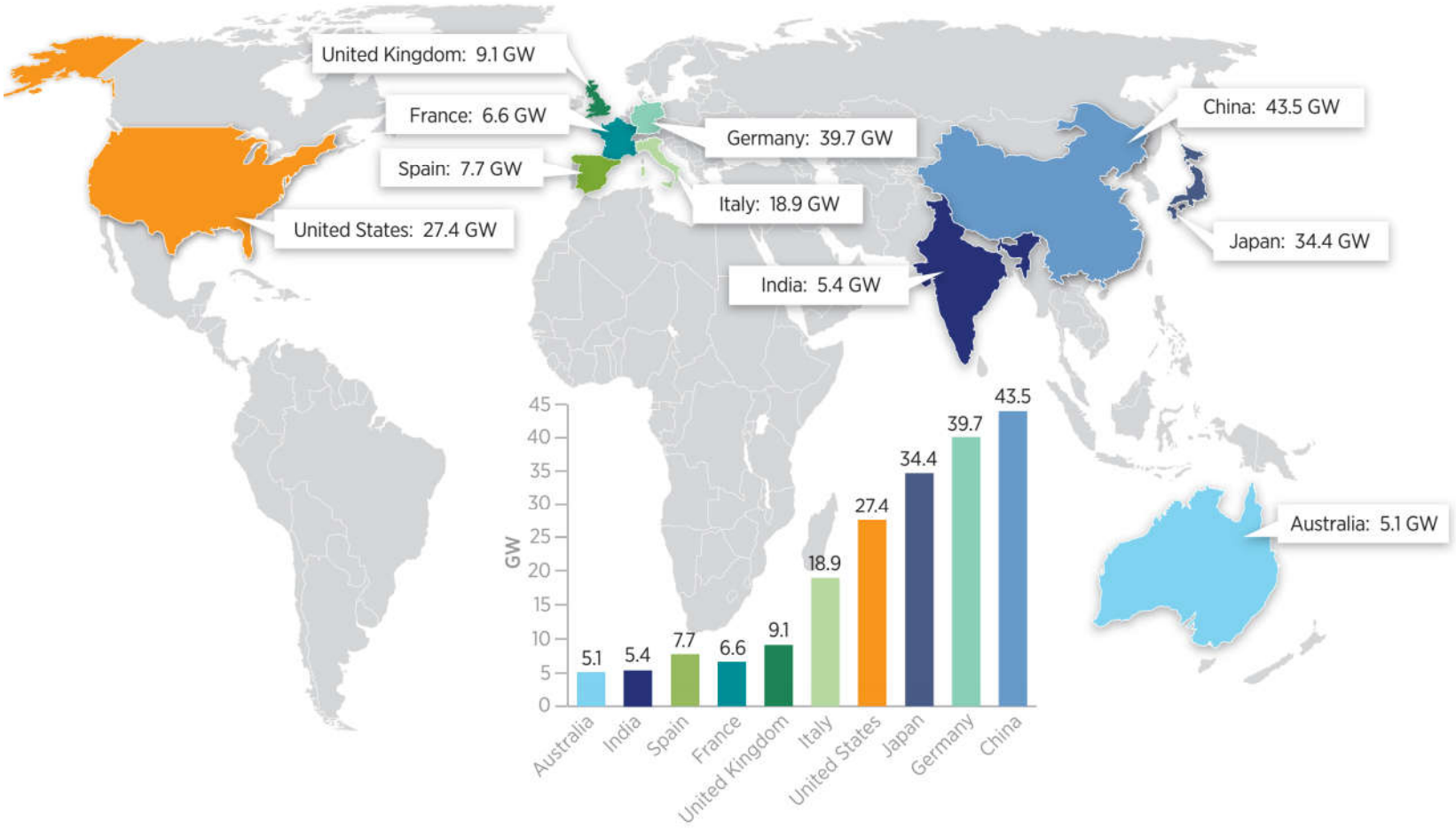


Flat-plate Collector

Parabolic through Concentrator

Evacuated-tube Collector

Cumulative Solar Electricity Capacity (2015)

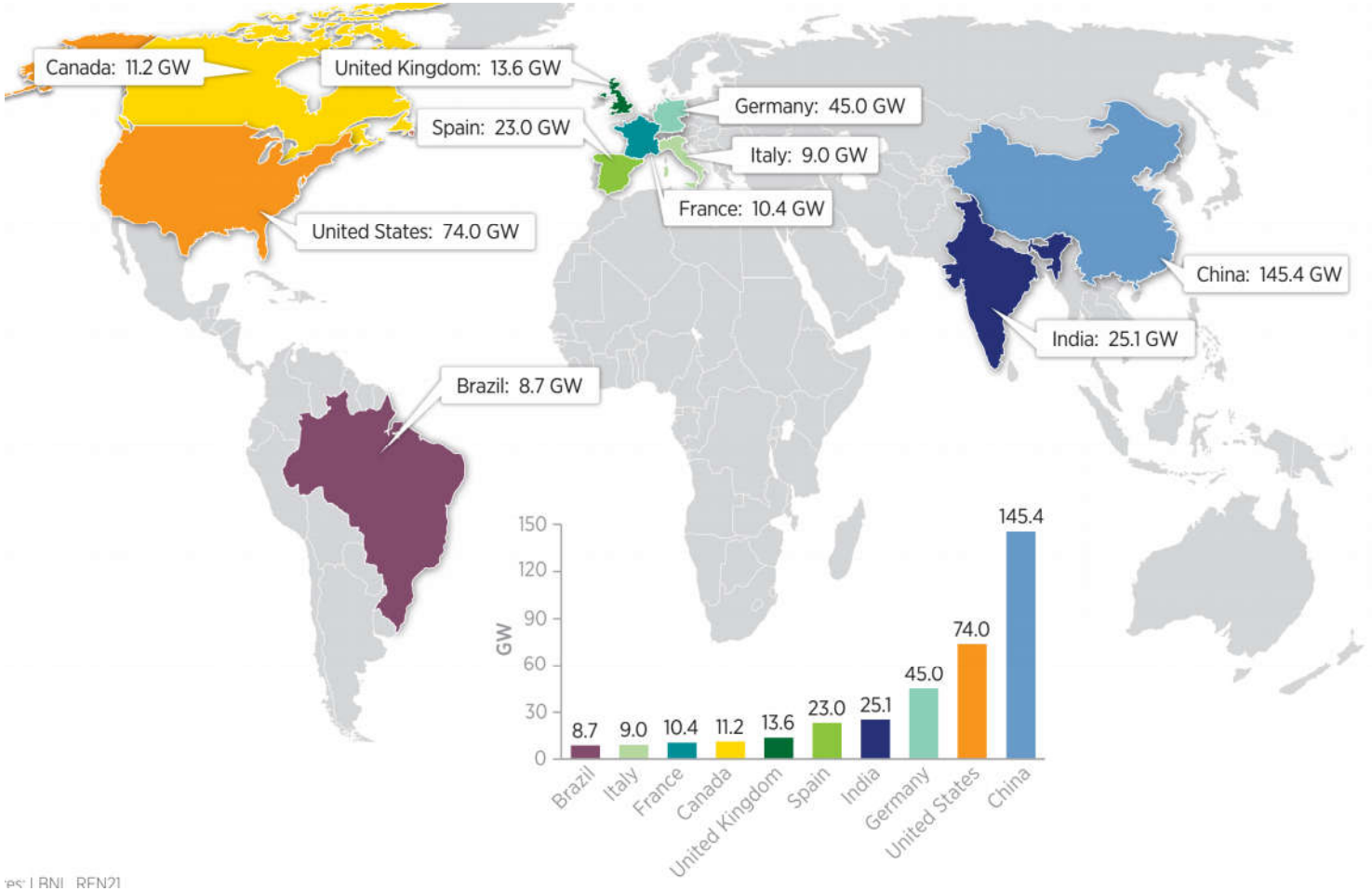


Wind Energy

Why Wind Energy?

- **Clean, zero emissions**
  - NOx, SO_2, CO, CO_2
  - Air quality, water quality
  - Climate change
- **Reduce fossil fuel dependence**
  - Energy independence
  - Domestic energy—national security
- **Renewable**
  - No fuel-price volatility

Cumulative Wind Electricity Capacity (2015)



Modern Wind Turbines

Pros

- **Omni-directional**
  - Accepts wind from any direction
- **Components can be mounted at ground level**
  - Ease of service
  - Lighter weight towers
- **Can theoretically use less materials to capture the same amount of wind.**

Cons

- **Rotors generally near ground where wind is poorer.**
- **Centrifugal force stresses blades.**
- **Poor self-starting capabilities.**
- **Requires support at top of turbine rotor.**
- **Requires entire rotor to be removed to replace bearings.**
- **Overall poor performance and reliability.**


Image courtesy of BP Wind Energy

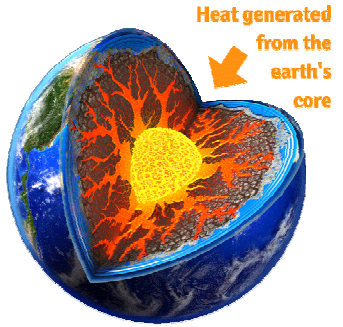

RAMBIZ


GREENPEACE

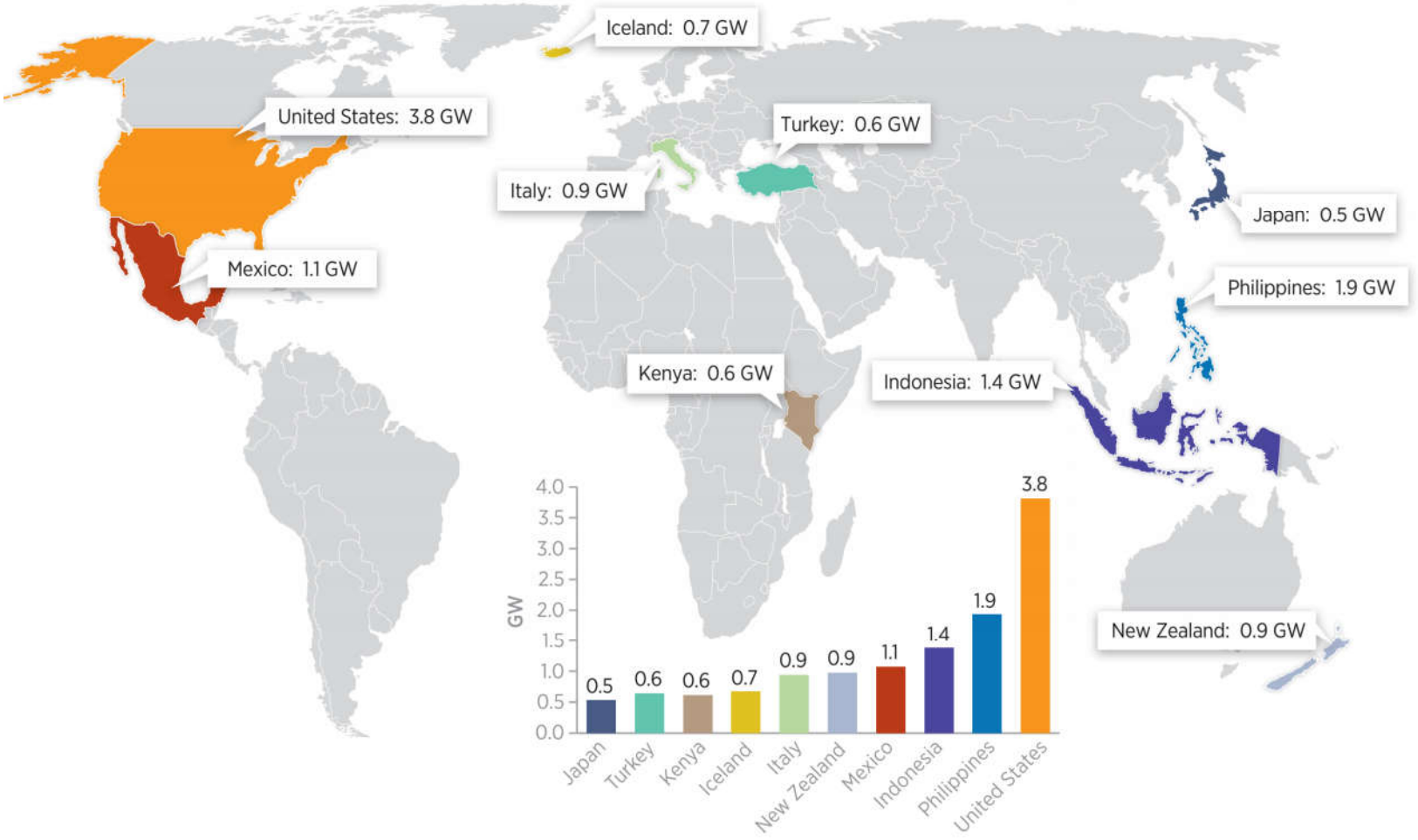
Geothermal Energy

Geothermal Energy

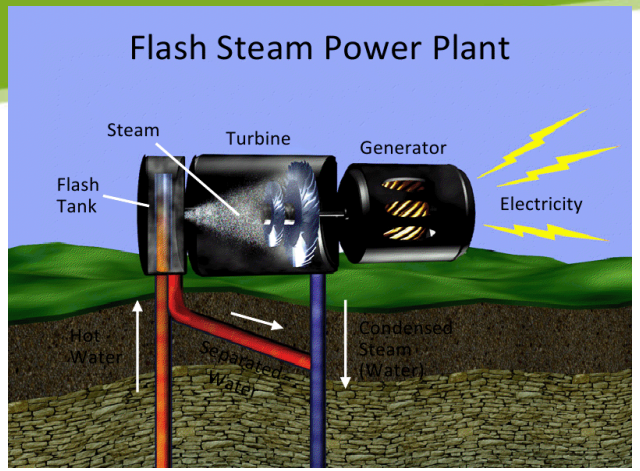
- **Geothermal heat** is the only renewable energy source created naturally by the **Earth** itself.
- Approximately **6400 km** below the Earth's surface is the core, where temperatures can reach **5000°C**.
- These reservoirs can be tapped for a variety of uses, such as to generate **electricity** or to **heat** buildings.
- The geothermal energy potential in the **10 km of the Earth's crust** amounts to **50,000 times** the energy of all **oil** and **gas** resources in the world.

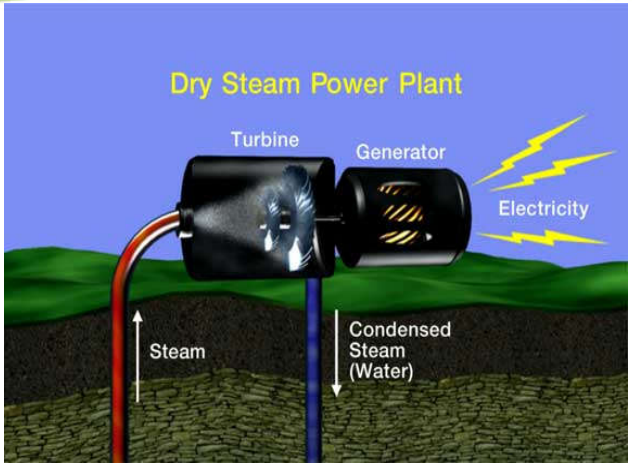


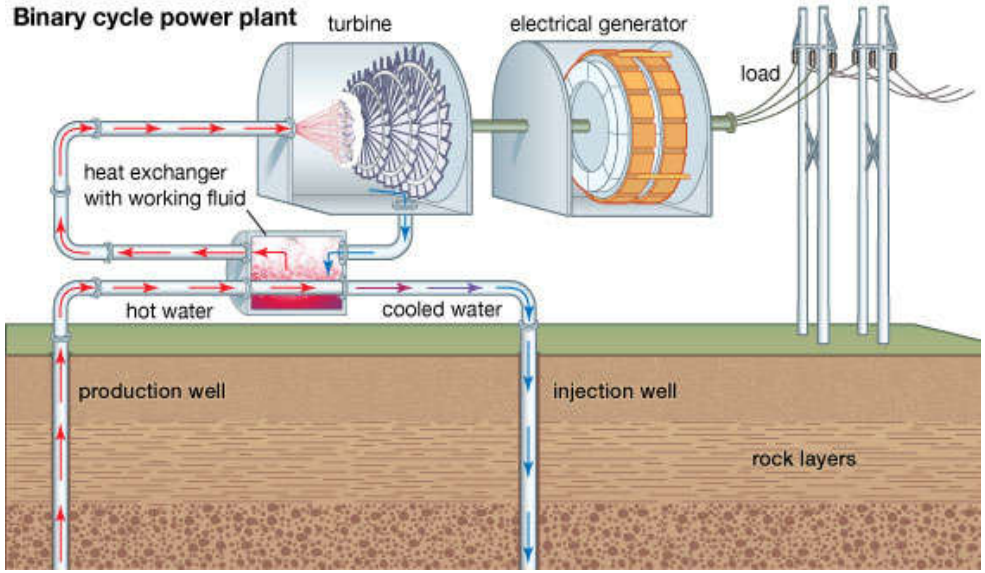
Cumulative Geothermal Electricity Capacity (2015)



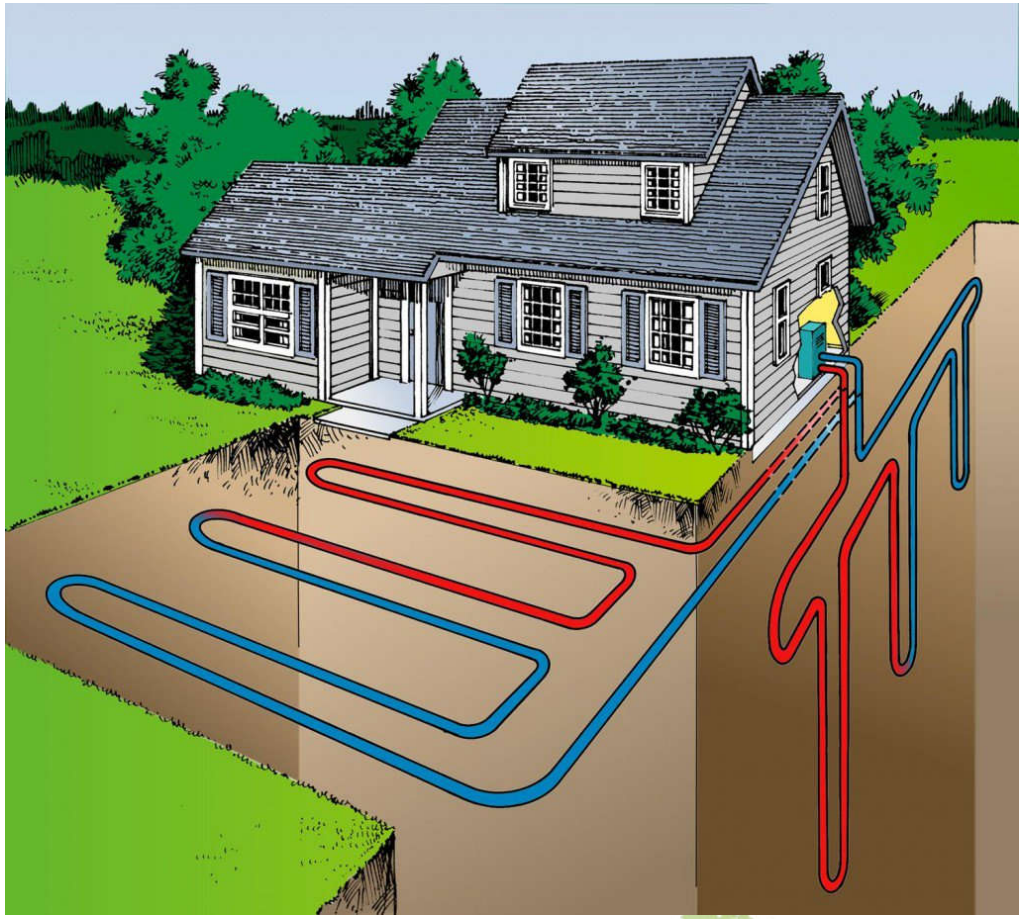
Geothermal Power Plant Technologies

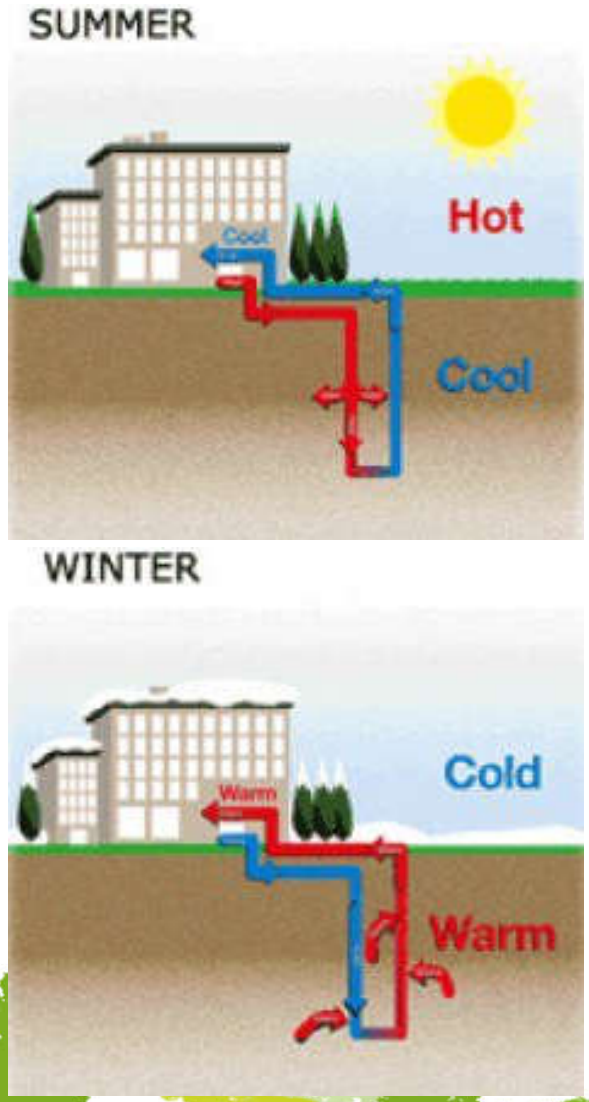




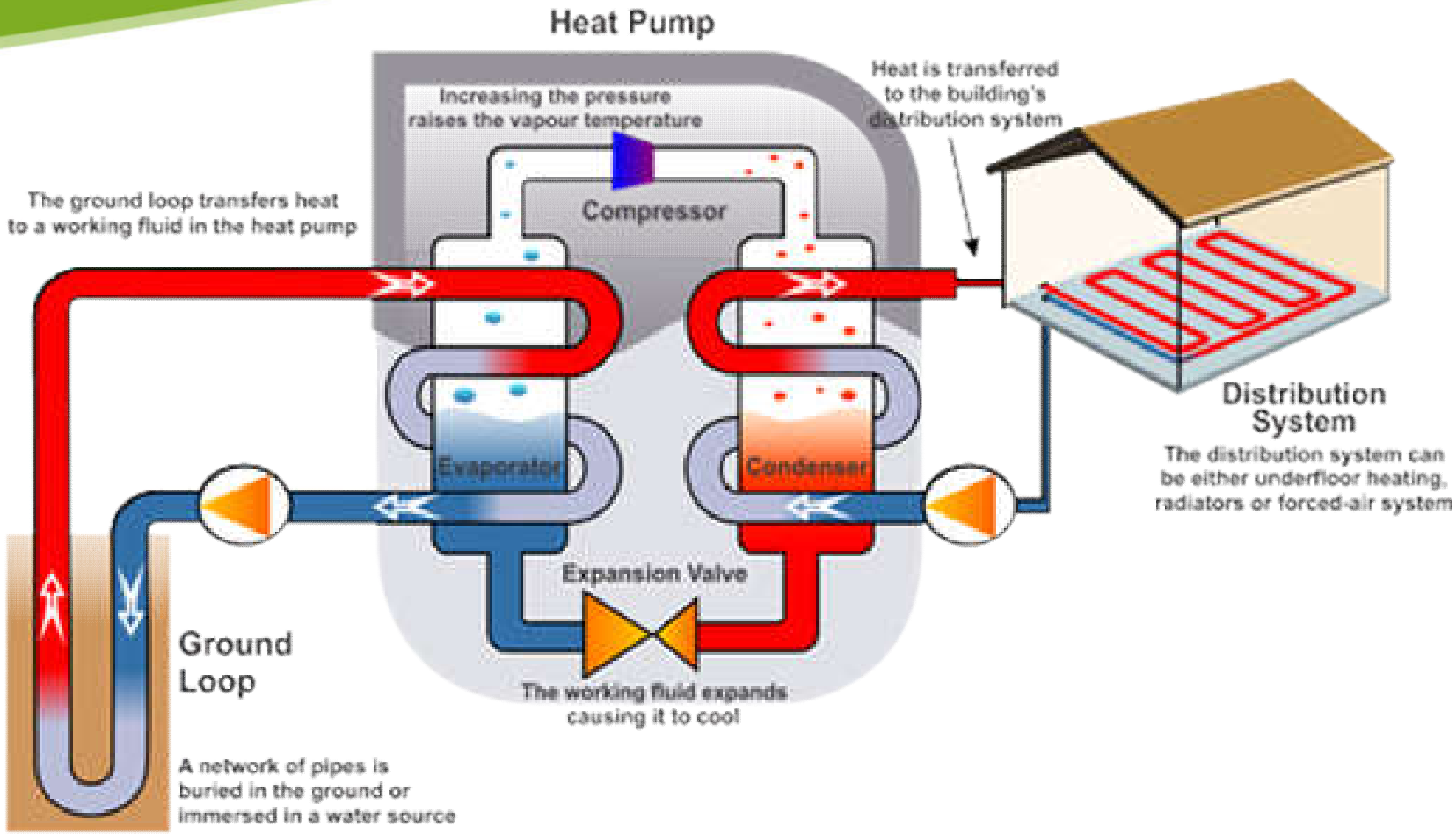


Geothermal Heat Pump Operating In Summer and Winter Modes





Geothermal Heat Pump



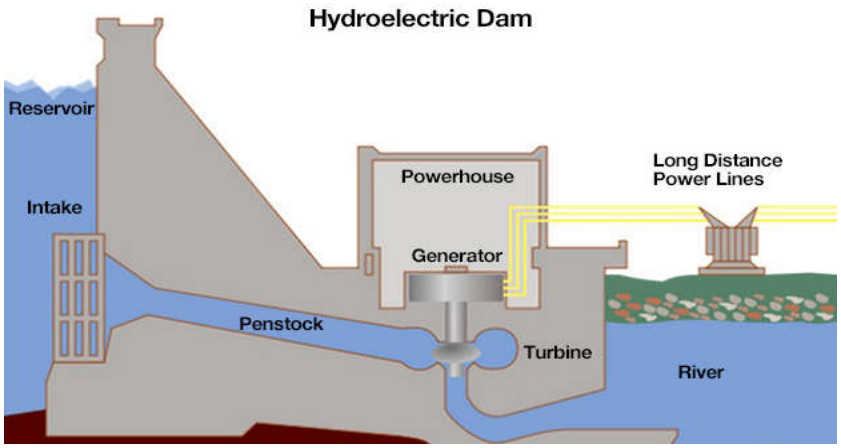

Hydropower

Hydropower

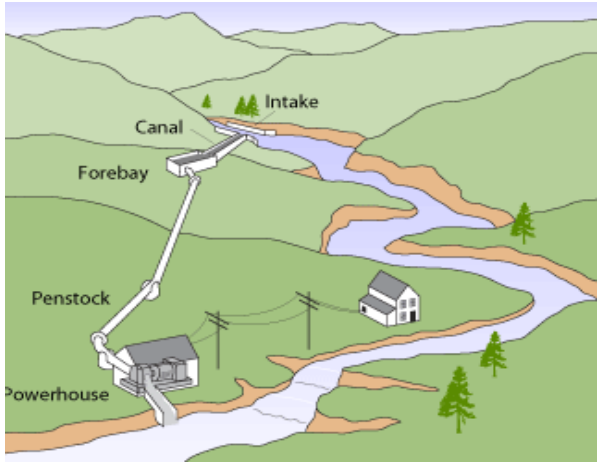
- **Hydropower** or **water power** is power derived from the energy of **falling water** or **fast running water**, which may be harnessed for useful purposes.
- **Flowing water** creates energy that can be captured and turned into **electricity**. This is called **hydroelectric power** or **hydropower**.
- The most common type of hydroelectric power plant uses a **dam** on a **river** to store water in a reservoir.

Hydropower Plants

Impoundments

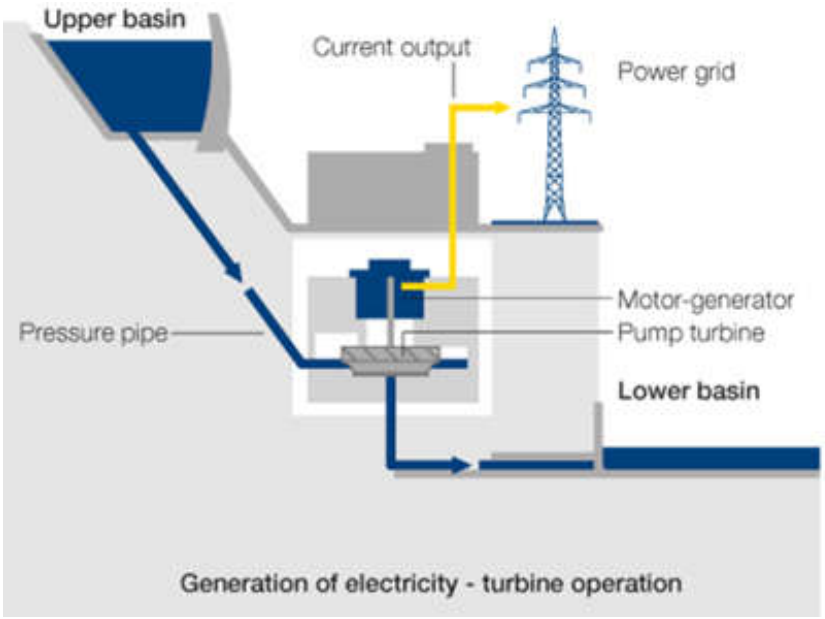


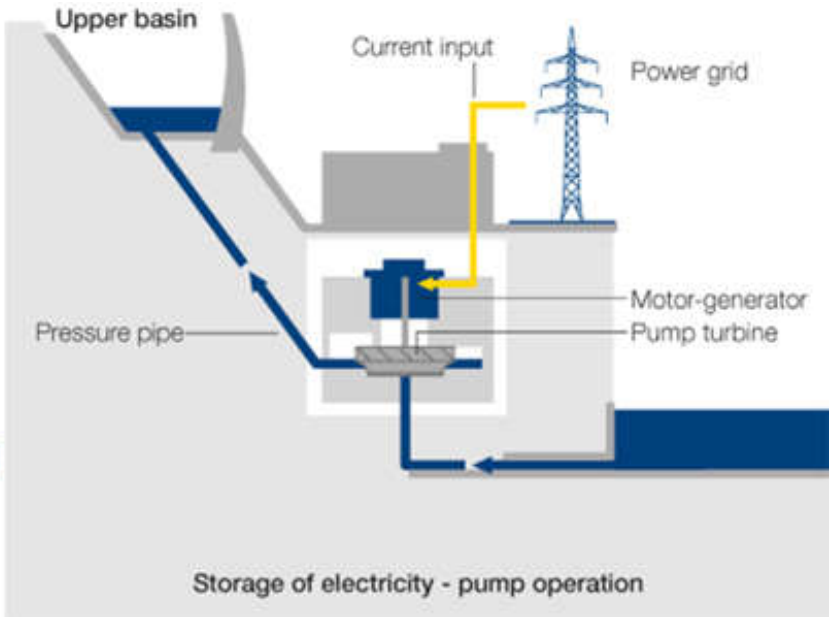
Diversion

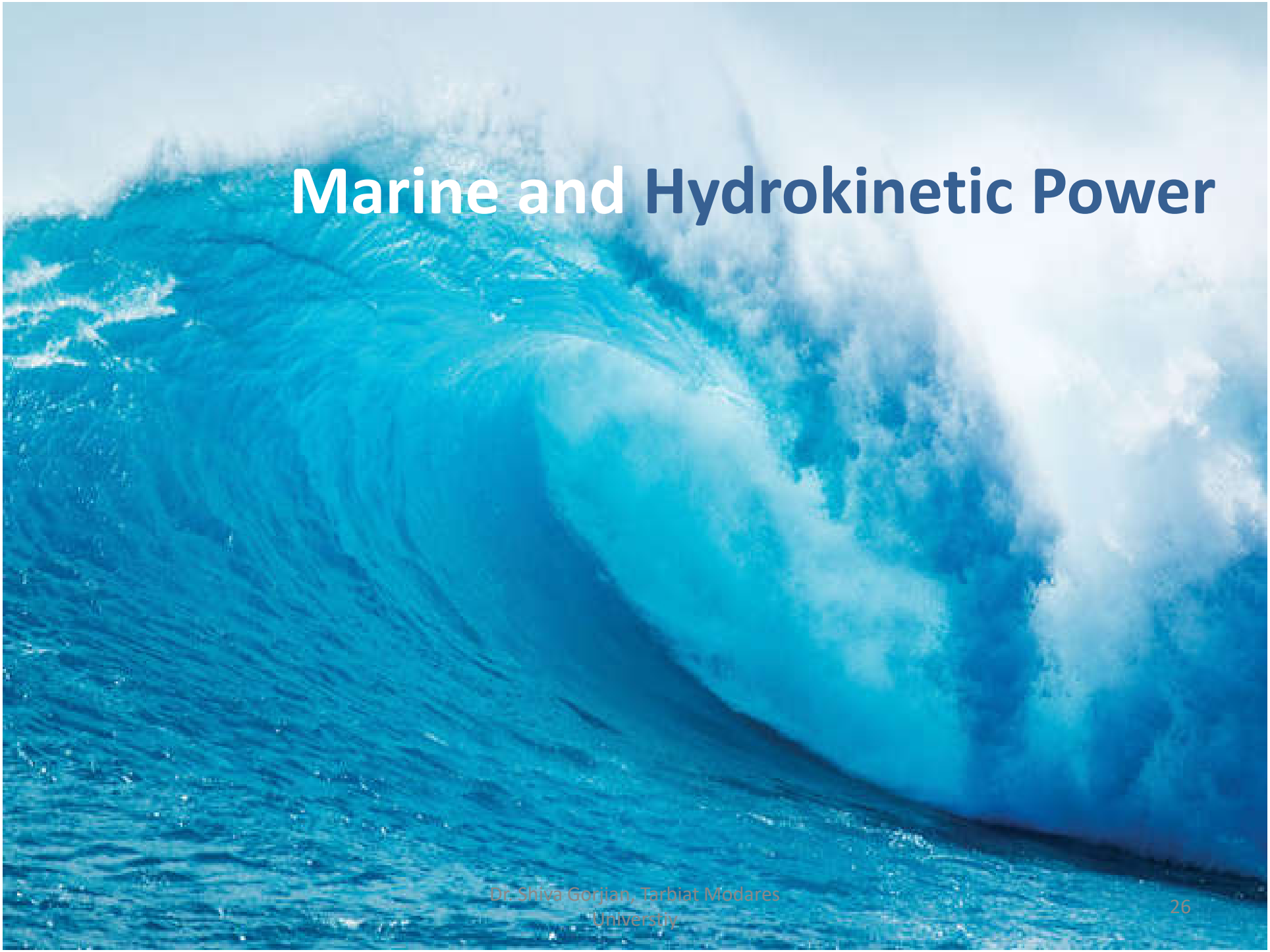


Pumped Storage Hydropower Plant

- When **demand** for electricity is **low**, a pumped storage facility stores energy by pumping water from a lower reservoir to an upper reservoir.
- During periods of **high electrical demand**, the water is released back to the lower reservoir to generate electricity.







Marine and Hydrokinetic Power

Marine and Hydrokinetic Energy

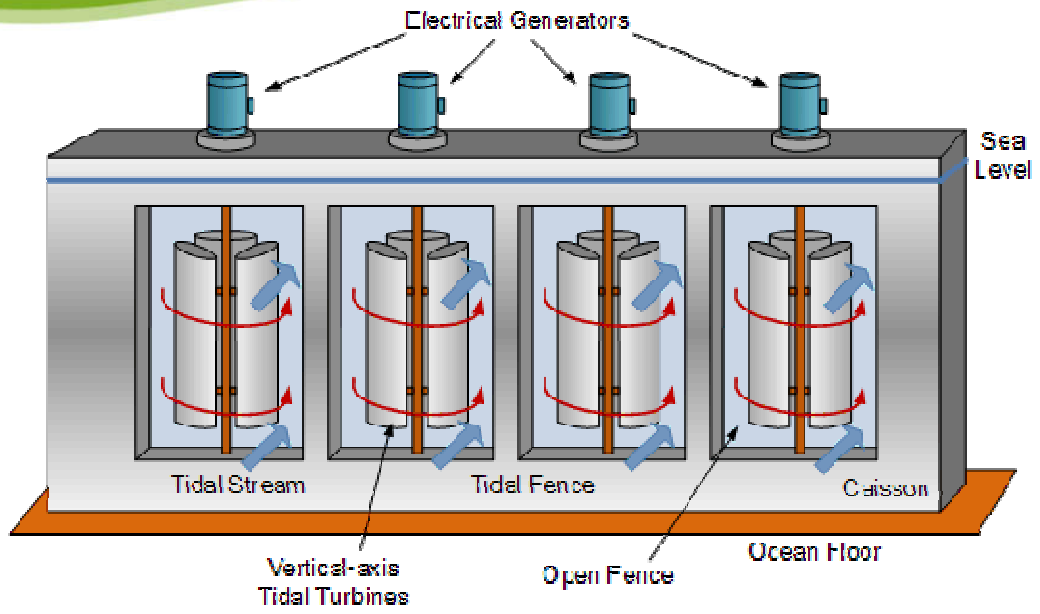
- **Marine** and **hydrokinetic energy** systems, a new generation of water power technologies offers the possibility of generating **electricity** from water without the need for **dams** and **diversions**.

- The **ocean** can produce two types of energy:
  - **Thermal energy** from the sun's heat.
  - **Mechanical energy** from the **tides** and **waves**.

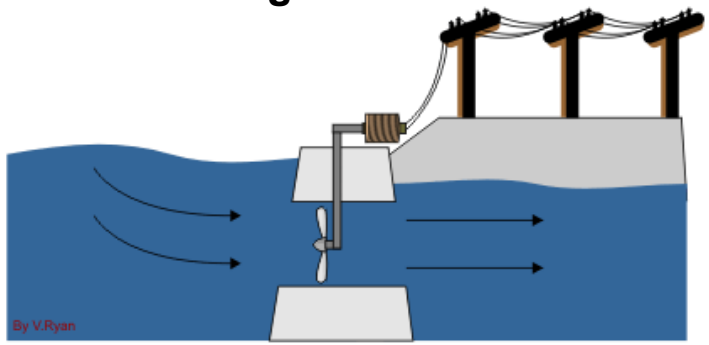
- The three most well-known generating technologies for deriving **electrical power** from the **ocean** are:
  - **Tidal power**
  - **Wave power**
  - **Ocean thermal energy conversion (OTEC).**

Tidal Energy Technologies

Tidal Fences

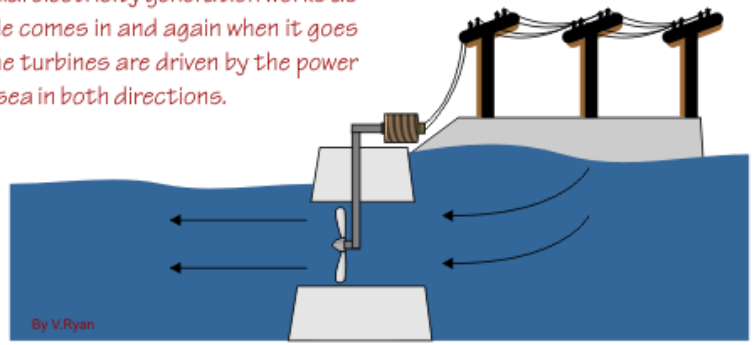


Tidal Barrages



TIDE COMING IN

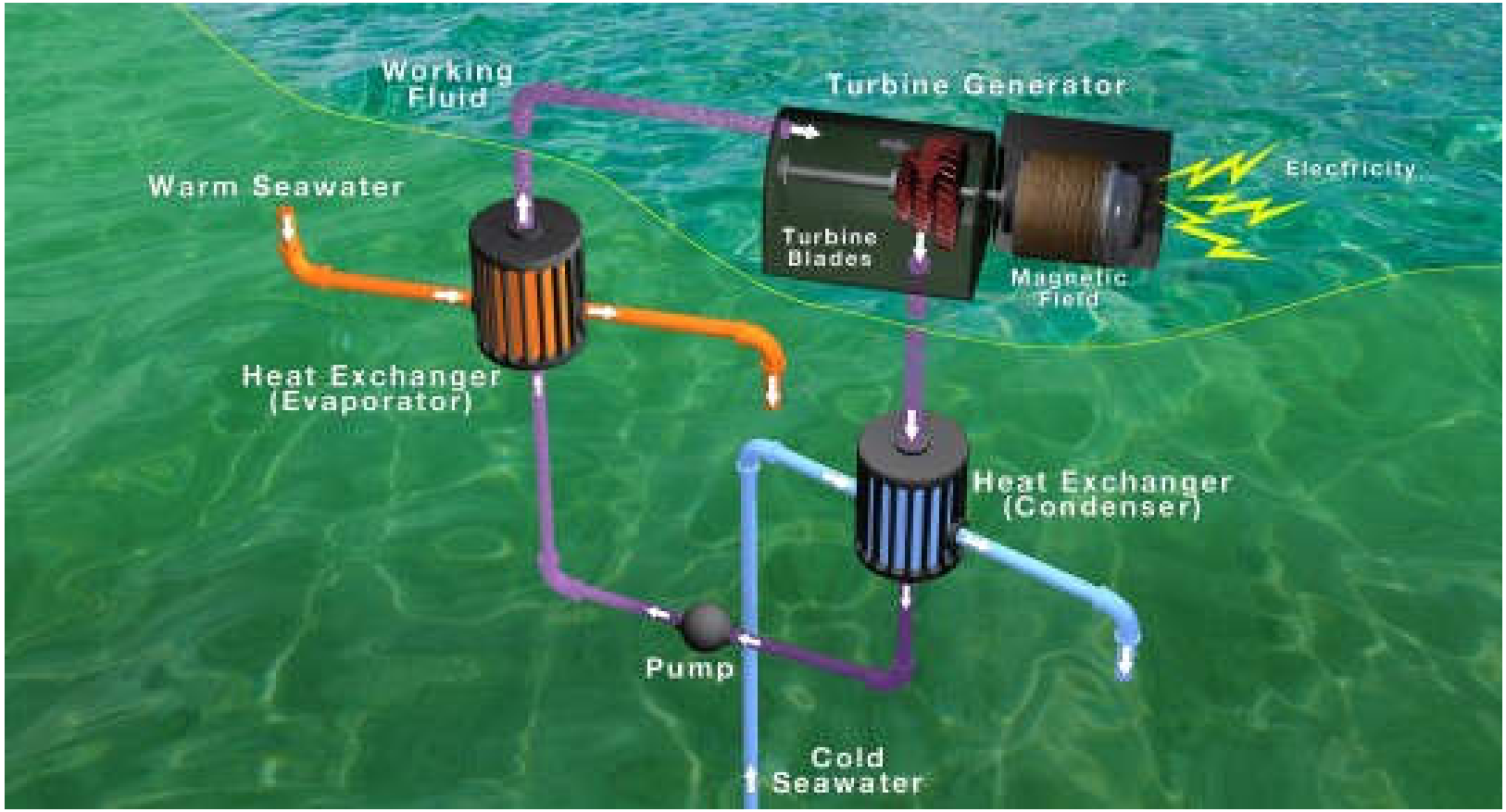
This tidal electricity generation works as the tide comes in and again when it goes out. The turbines are driven by the power of the sea in both directions.



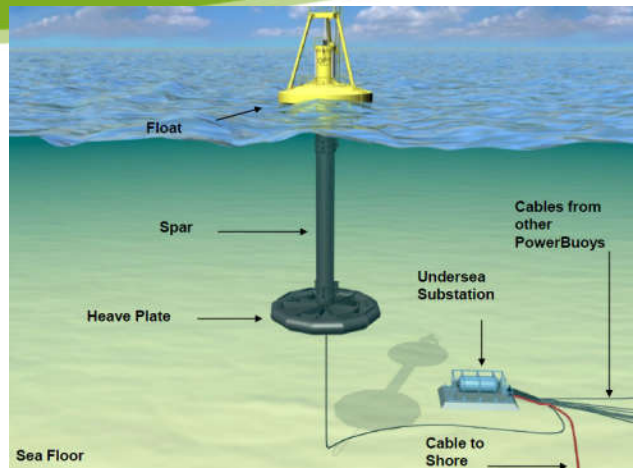
TIDE GOING OUT

Tidal Turbines

Ocean Thermal Energy Conversion

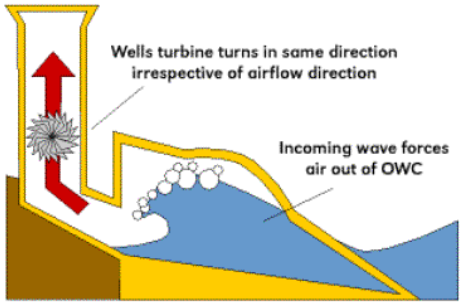


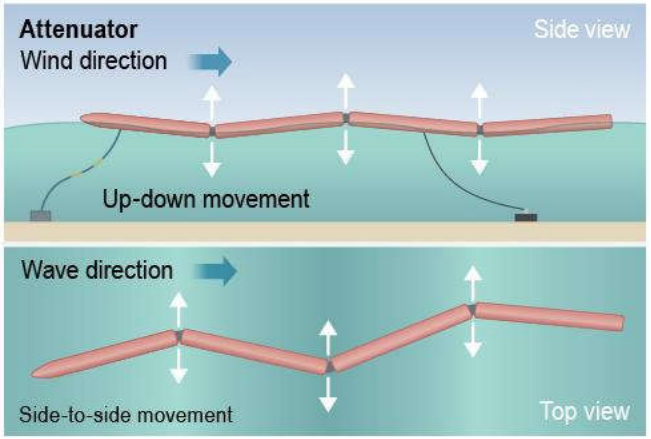
Wave Energy

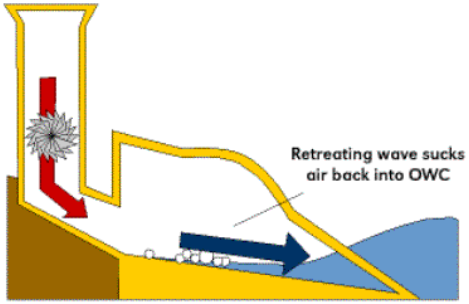


Point Absorber

Terminator








Biopower

Biomass

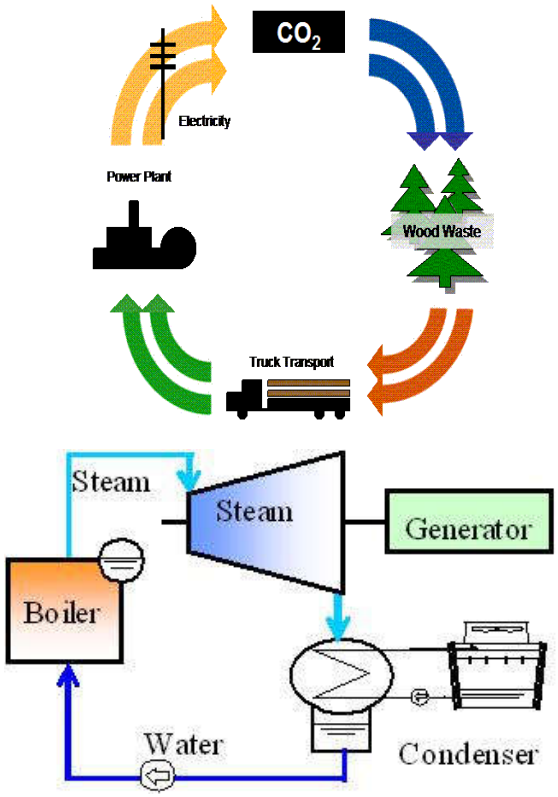
- One of the **promising** sources of renewable energy is **biomass**.
- **Biomass** is the feedstock used to produce **bioenergy**.
- **Bioenergy** is a general term for energy derived from materials such as **straw**, **wood**, or **animal wastes**.
- Such materials can be **burned directly** to produce heat or power, and also can be converted into **liquid biofuels**.

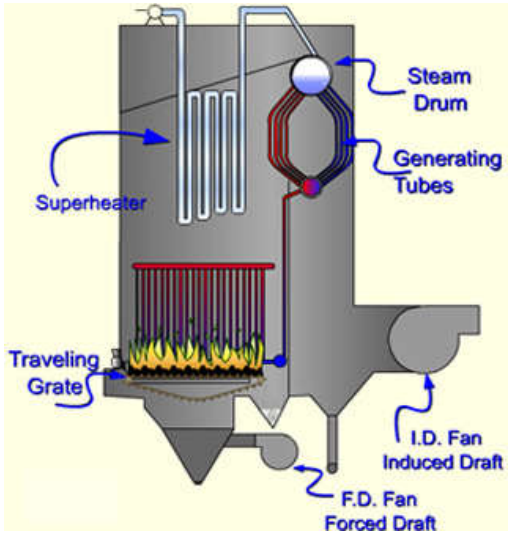
Types of Biomass

“On average, biomass is made of 75% carbohydrates and 25% lignin”.

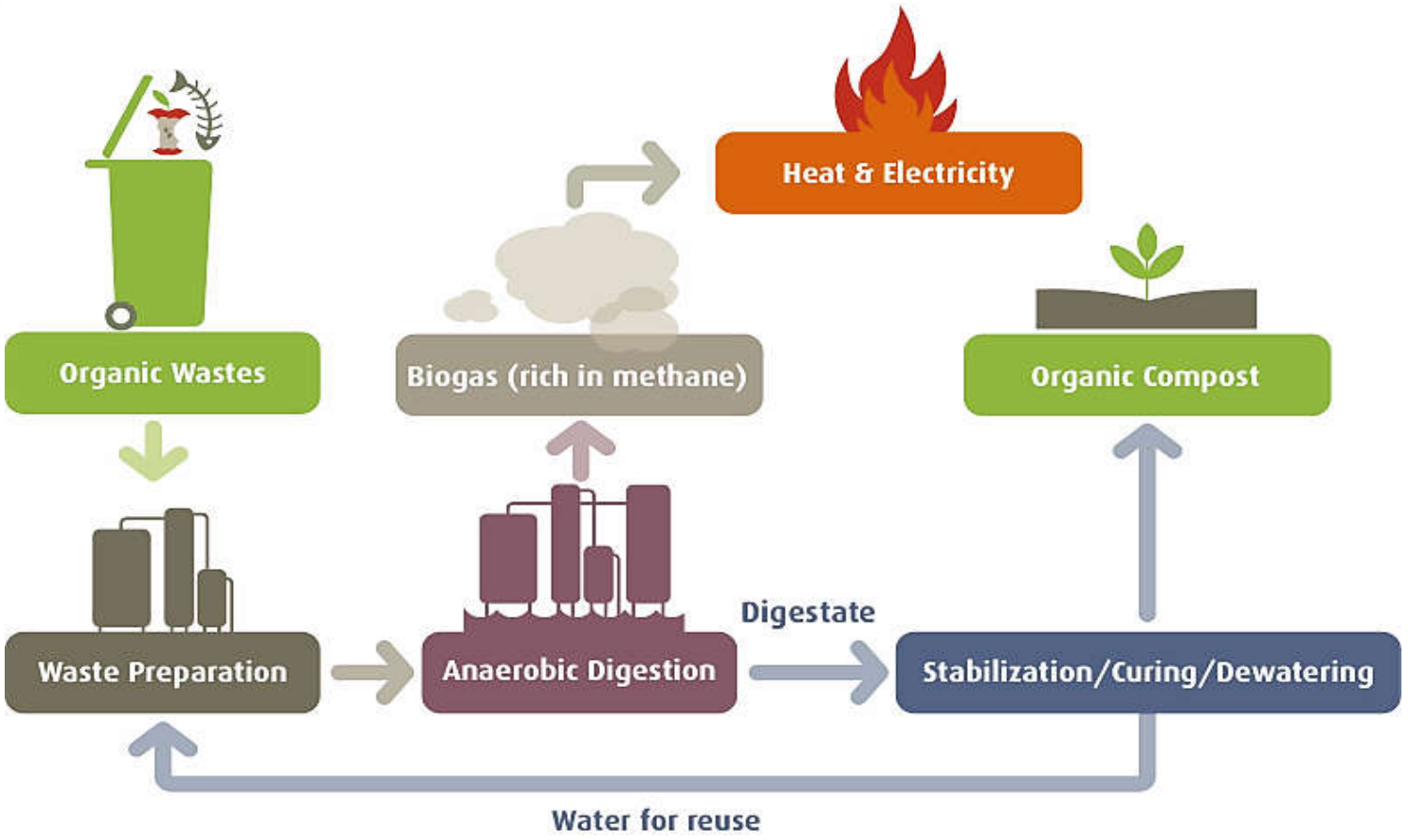
Biomass Direct Combustion

- There are two main components of a **combustion–based** biomass plant:
  - **Biomass-fired boiler.**
  - **Steam turbine.**





Anaerobic Digestion

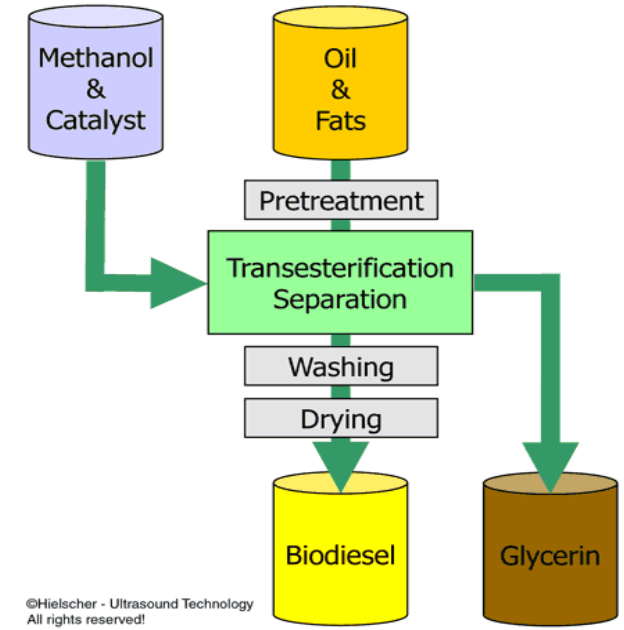


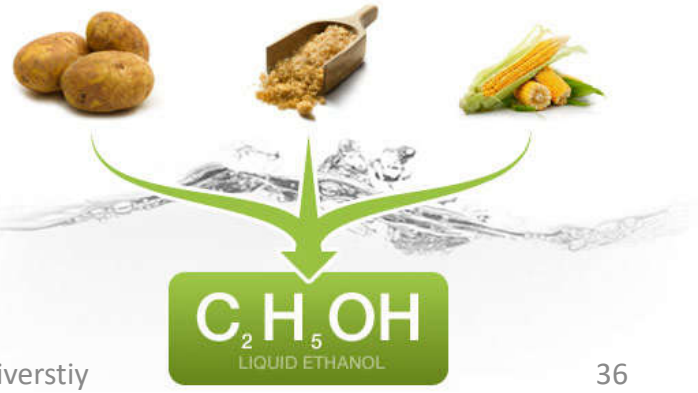
Biodiesel and Bioethanol Production

- **Biodiesel** refers to a **vegetable oil** or **animal fat-based** diesel fuel which is typically made by chemically reacting lipids (**vegetable oil, soybean oil, animal fat**) with an alcohol producing fatty acid esters.

- **Bioethanol** is an **alcohol** made by **fermentation**, mostly from carbohydrates produced in **sugar** or **starch crops**.

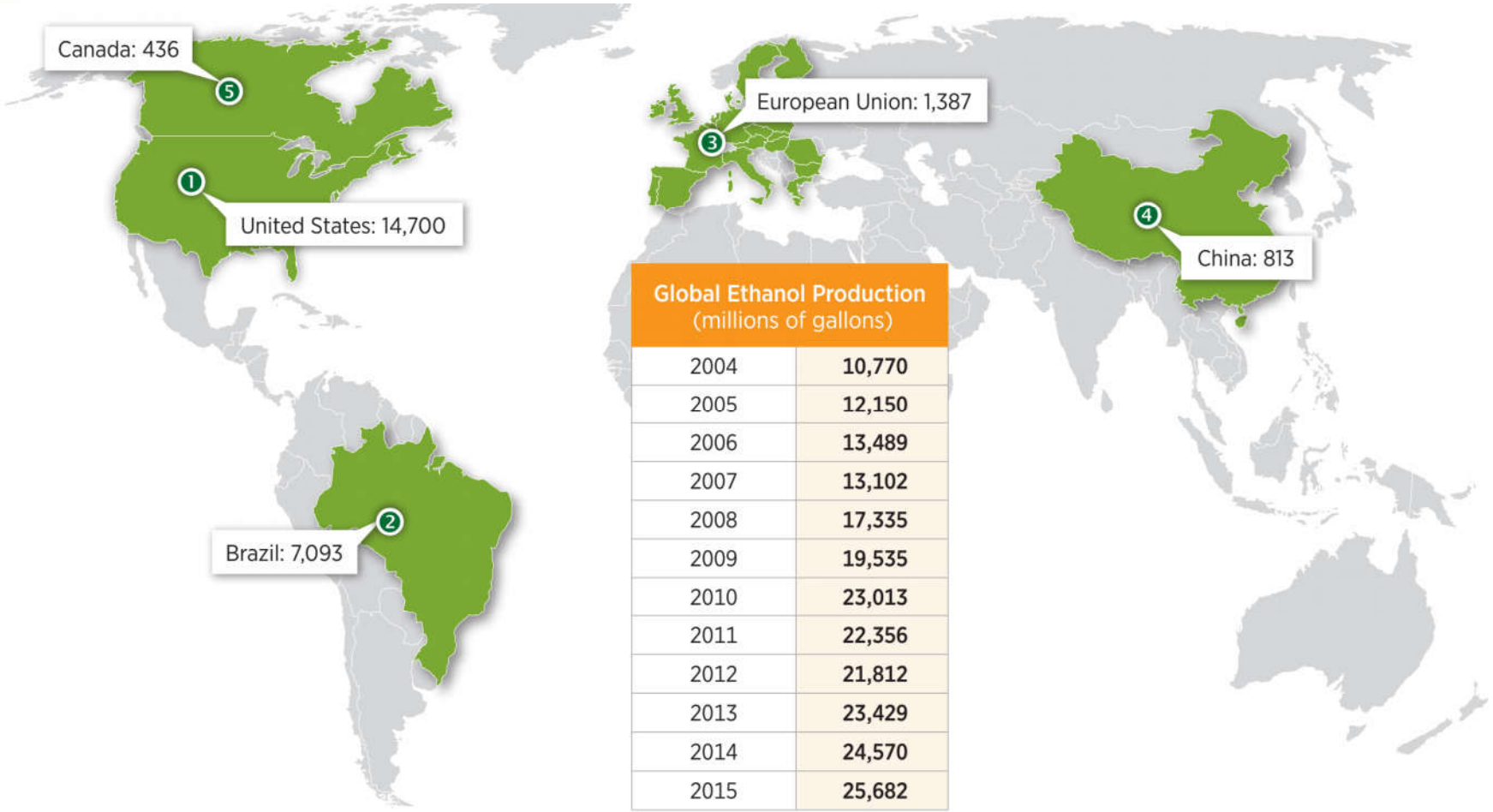
- **Cellulosic biomass**, derived from non-food sources, such as **trees** and **grasses**, is also being developed as a feedstock for **ethanol production**.





Global Ethanol Production

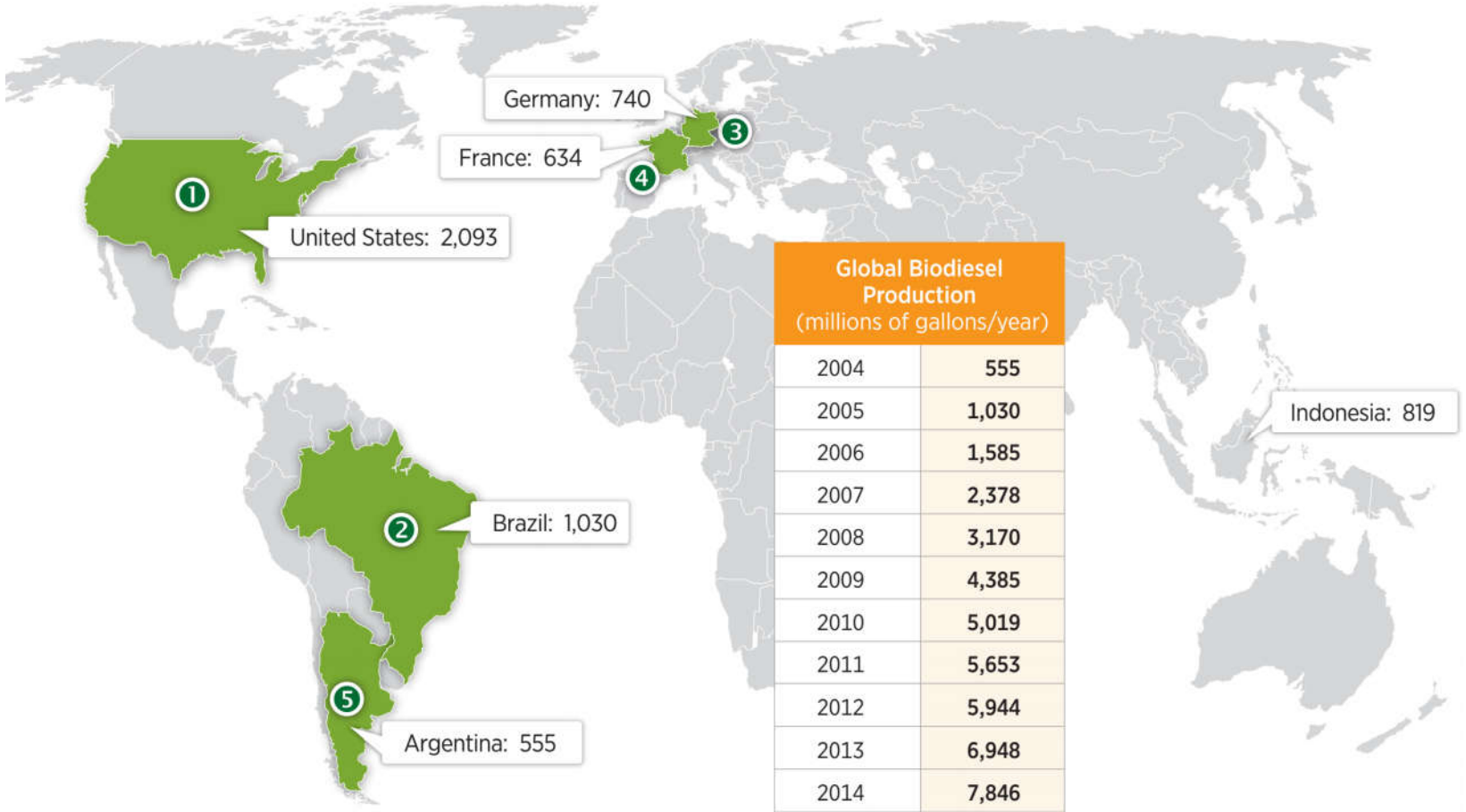
Top Five Regions (2015) Ethanol Production (millions of gallons)



Global Ethanol Production (millions of gallons)	
2004	10,770
2005	12,150
2006	13,489
2007	13,102
2008	17,335
2009	19,535
2010	23,013
2011	22,356
2012	21,812
2013	23,429
2014	24,570
2015	25,682

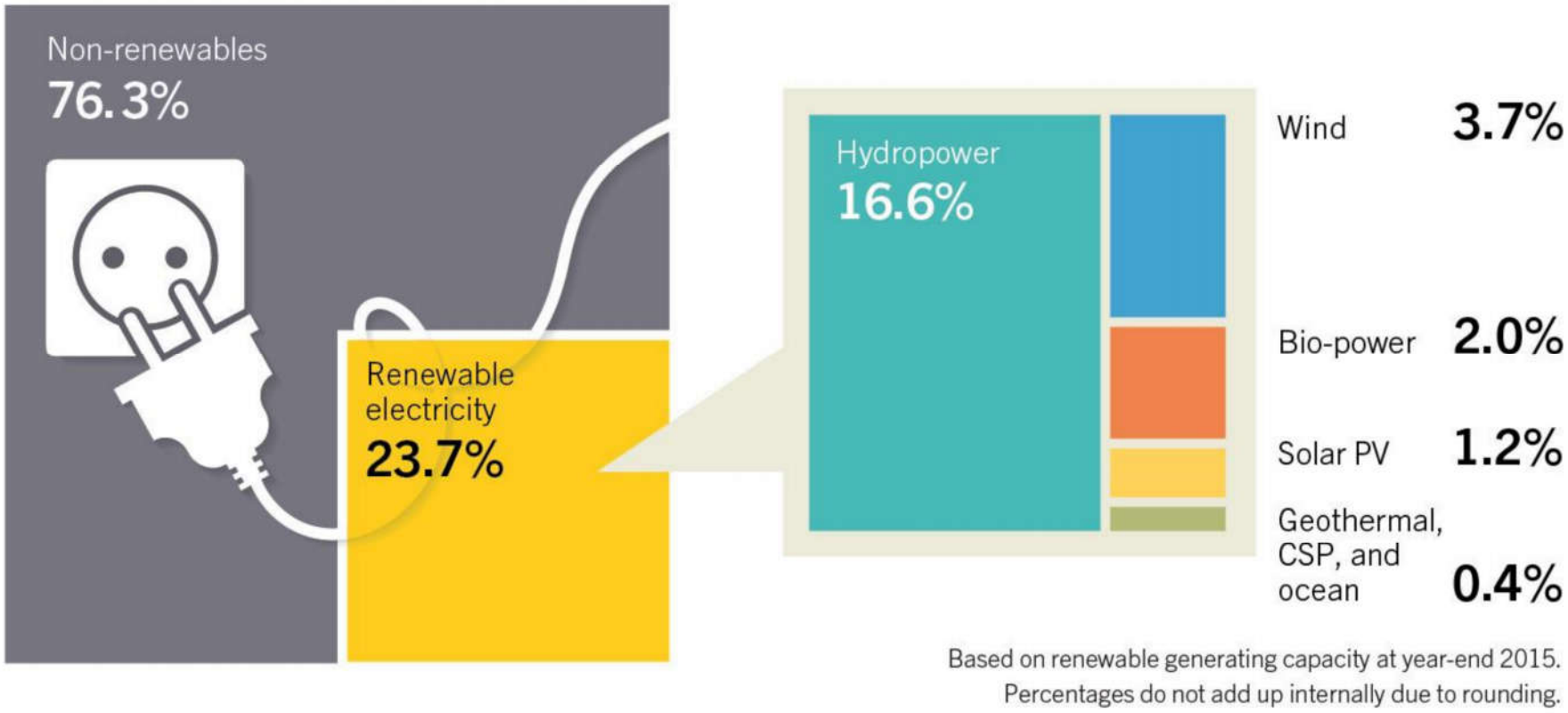
Global Biodiesel Production

Top Countries (2015) Biodiesel Production (millions of gallons/year)



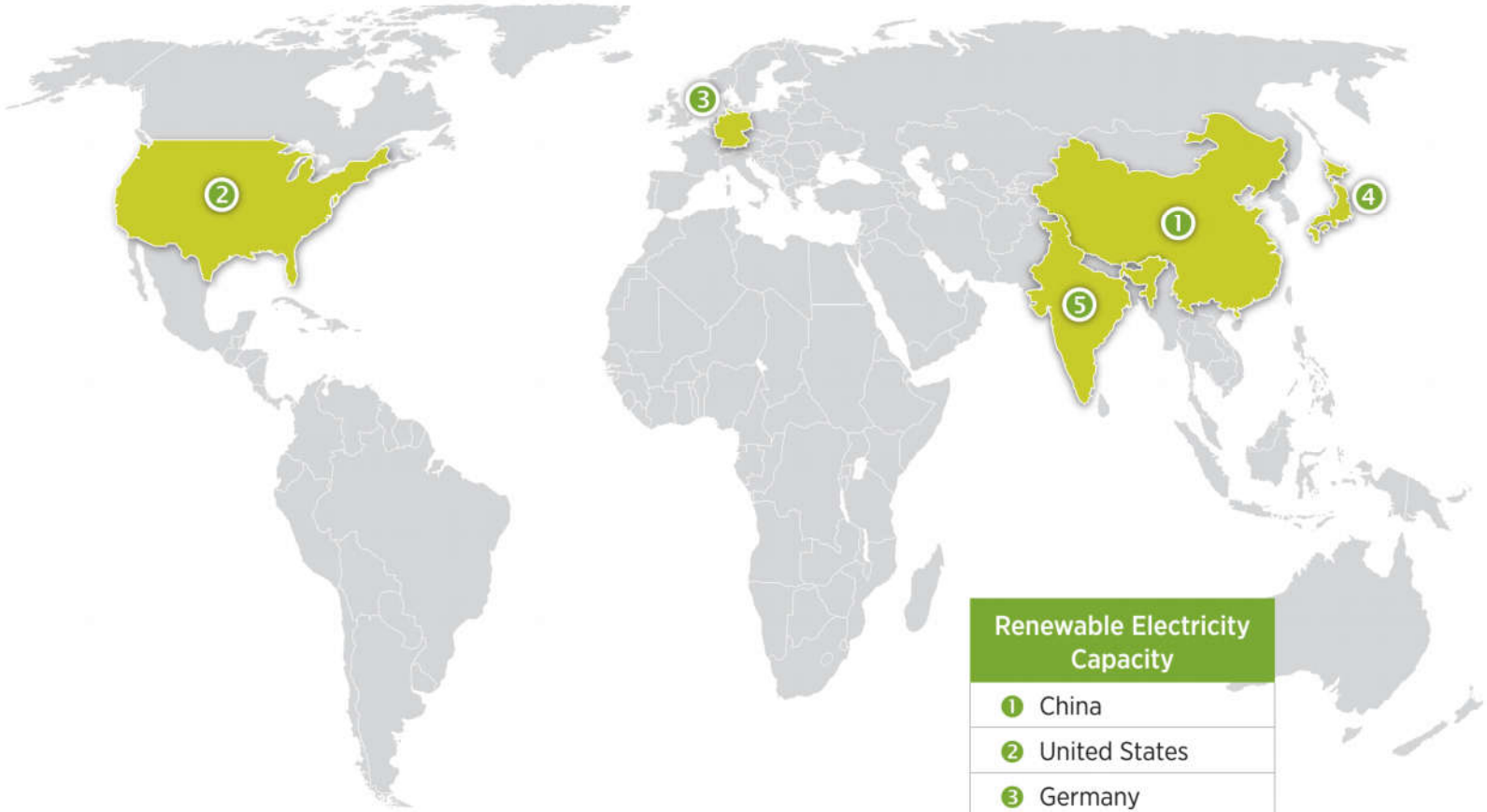
Global Biodiesel Production (millions of gallons/year)	
2004	555
2005	1,030
2006	1,585
2007	2,378
2008	3,170
2009	4,385
2010	5,019
2011	5,653
2012	5,944
2013	6,948
2014	7,846
2015	7,952

Estimated Renewable Energy Share of Global Electricity Production, End-2015

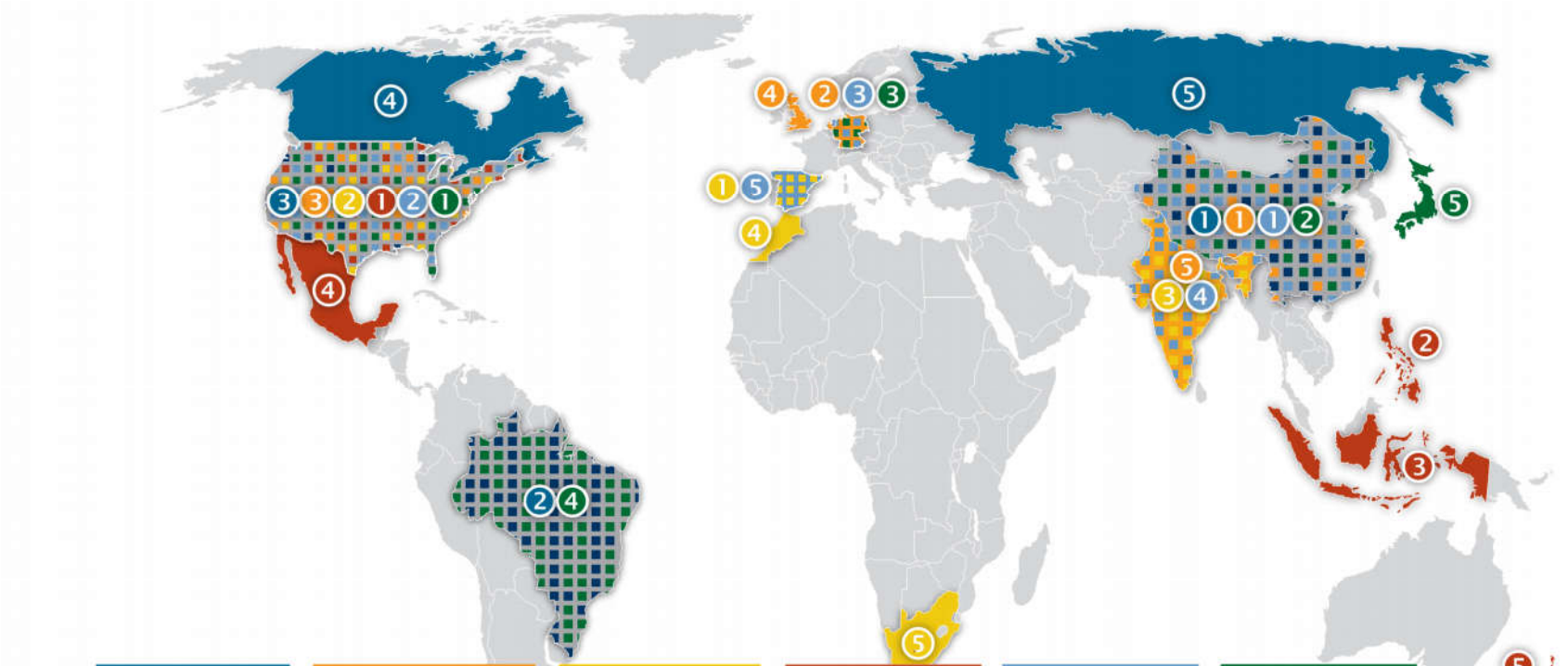


Based on renewable generating capacity at year-end 2015.
Percentages do not add up internally due to rounding.

Top Countries for Renewable Electricity Installed Capacity (2015)



Top Countries with Installed Renewable Electricity by Technology (2015)



Hydropower	PV[1]	CSP	Geothermal	Wind	Biomass
1 China	1 China	1 Spain	1 United States	1 China	1 United States
2 Brazil	2 Germany	2 United States	2 Philippines	2 United States	2 China
3 United States	3 United States	3 India	3 Indonesia	3 Germany	3 Germany
4 Canada	4 United Kingdom	4 Morocco	4 Mexico	4 India	4 Brazil
5 Russia	5 India	5 South Africa	5 New Zealand	5 Spain	5 Japan

It is time for a sustainable energy policy which puts consumers, the environment, human health, and peace first.

--DENNIS KUCINICH

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