



Renewable Energy

Solar Energy



Biomass Energy



Geothermal Energy



Wind Energy



Renewable Energy

Tidal Energy



Wave Energy



Hydroelectric Power



Solar Energy



Biomass Energy



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Hydroelectric Power



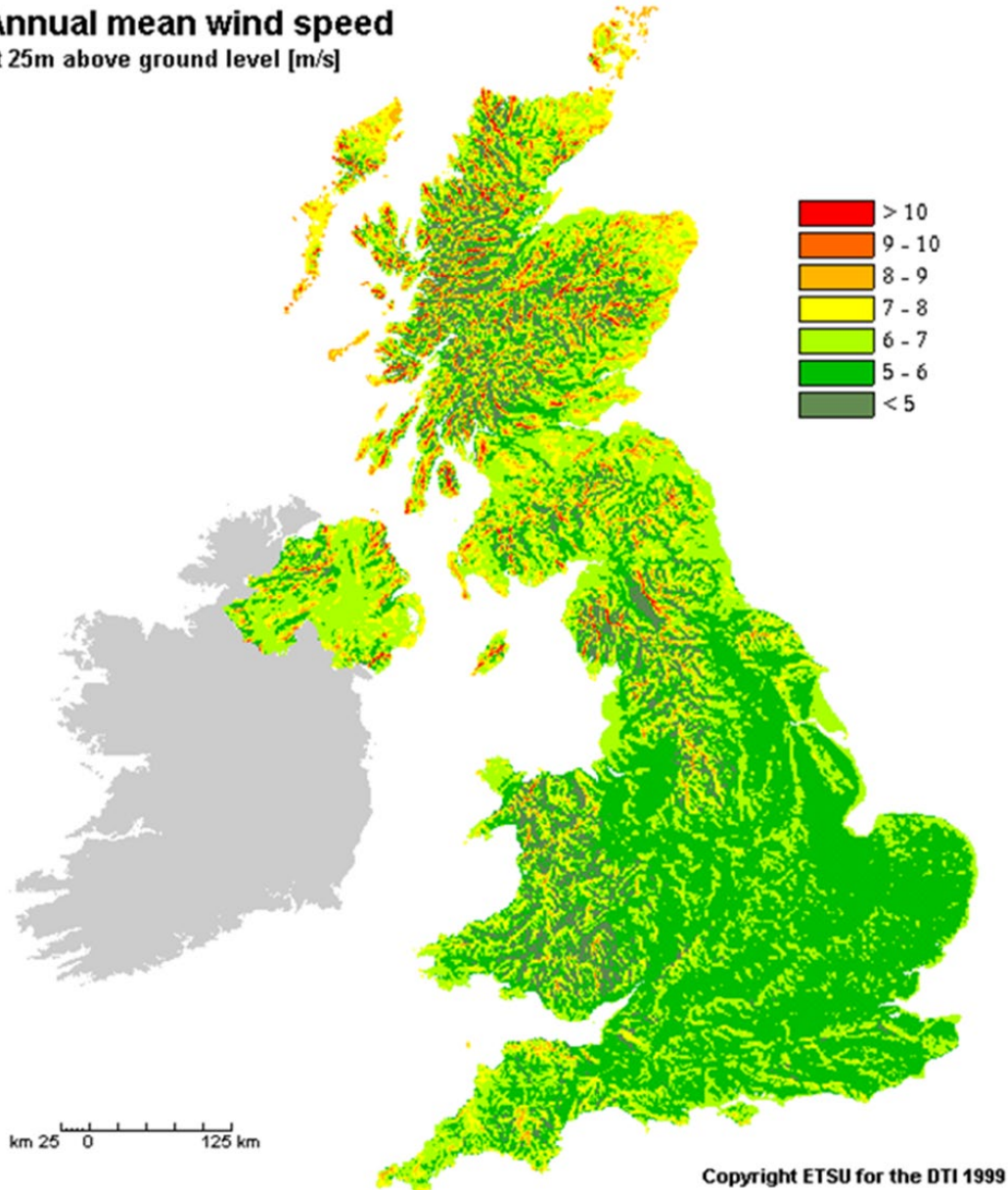


Wind

Wind is a form of solar energy caused by a combination of three concurrent events:

- The sun unevenly heating the atmosphere
- Irregularities of the earth's surface
- The rotation of the earth.

Annual mean wind speed
at 25m above ground level [m/s]

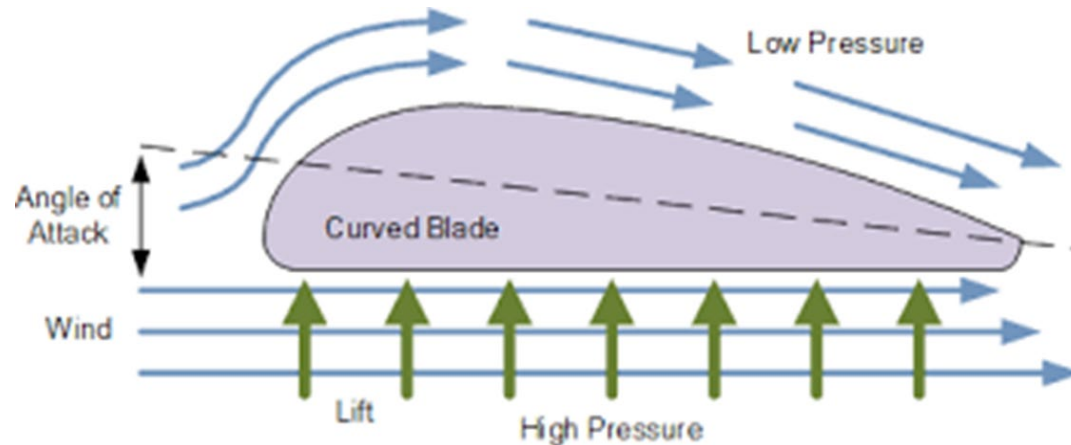


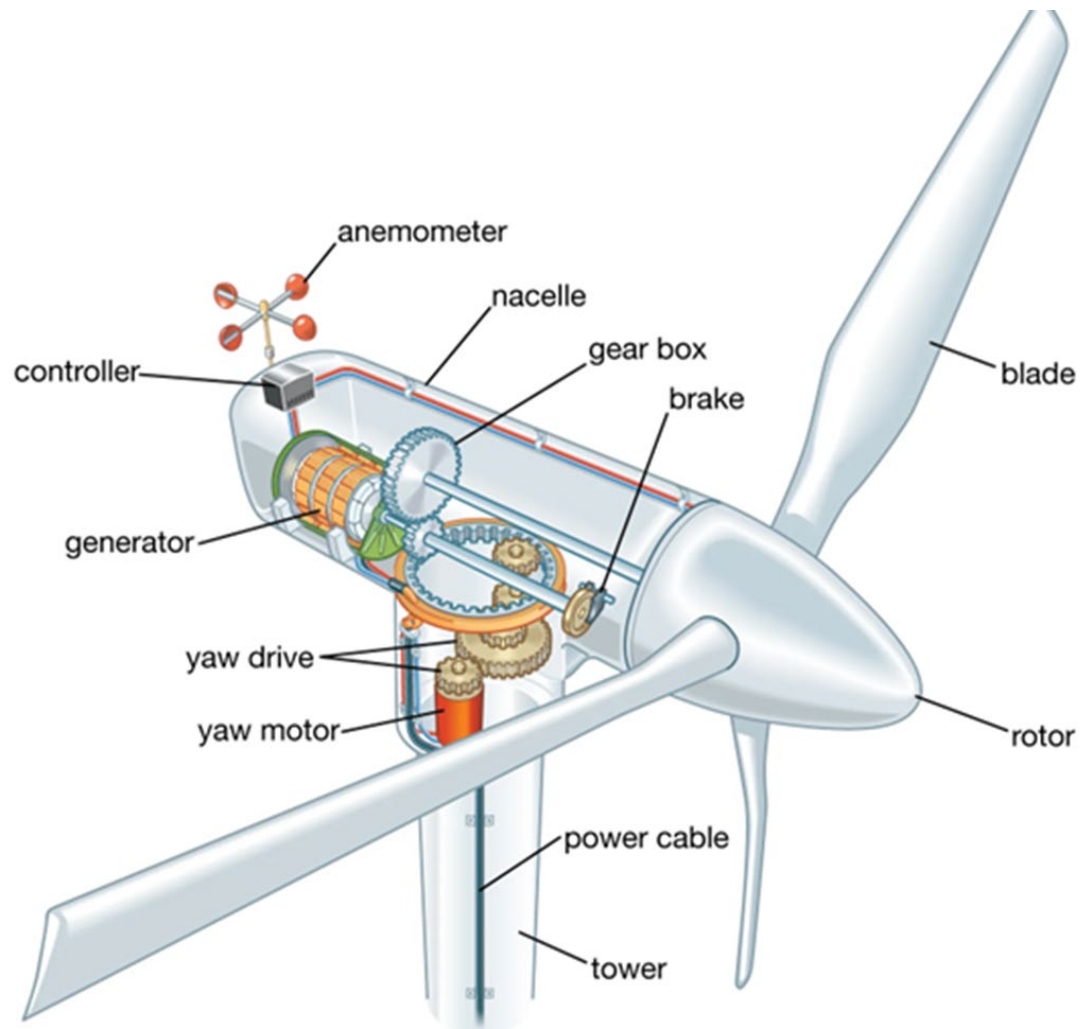
Wind

Wind flow patterns and speeds vary greatly across the United Kingdom and are modified by bodies of water, vegetation, and differences in terrain

Wind

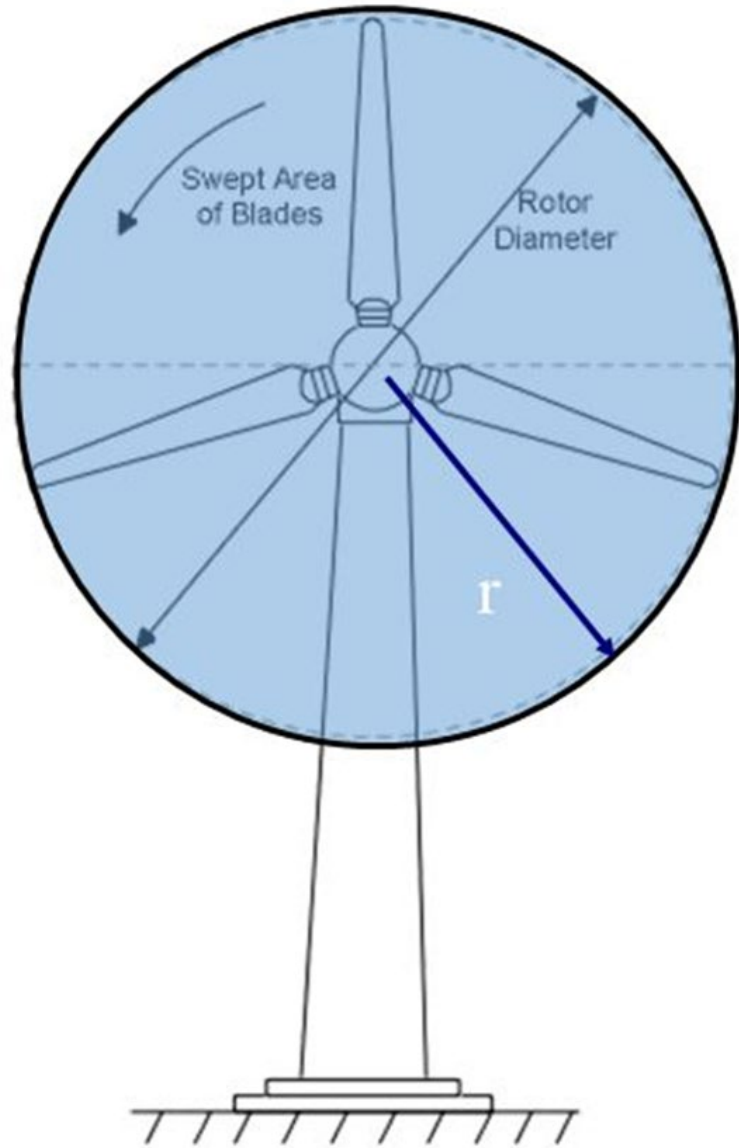
- When wind flows across the blade, the air pressure on one side of the blade decreases.
- The difference in air pressure across the two sides of the blade creates both lift and drag. The force of the lift is stronger than the drag and this causes the rotor to spin.





Wind

The rotor connects to the generator, either directly (if it's a direct drive turbine) or through a shaft and a series of gears (a gearbox) that speeds up the rotation and allow for a physically smaller generator.



Wind

The potential power in the wind is given by the following equation:

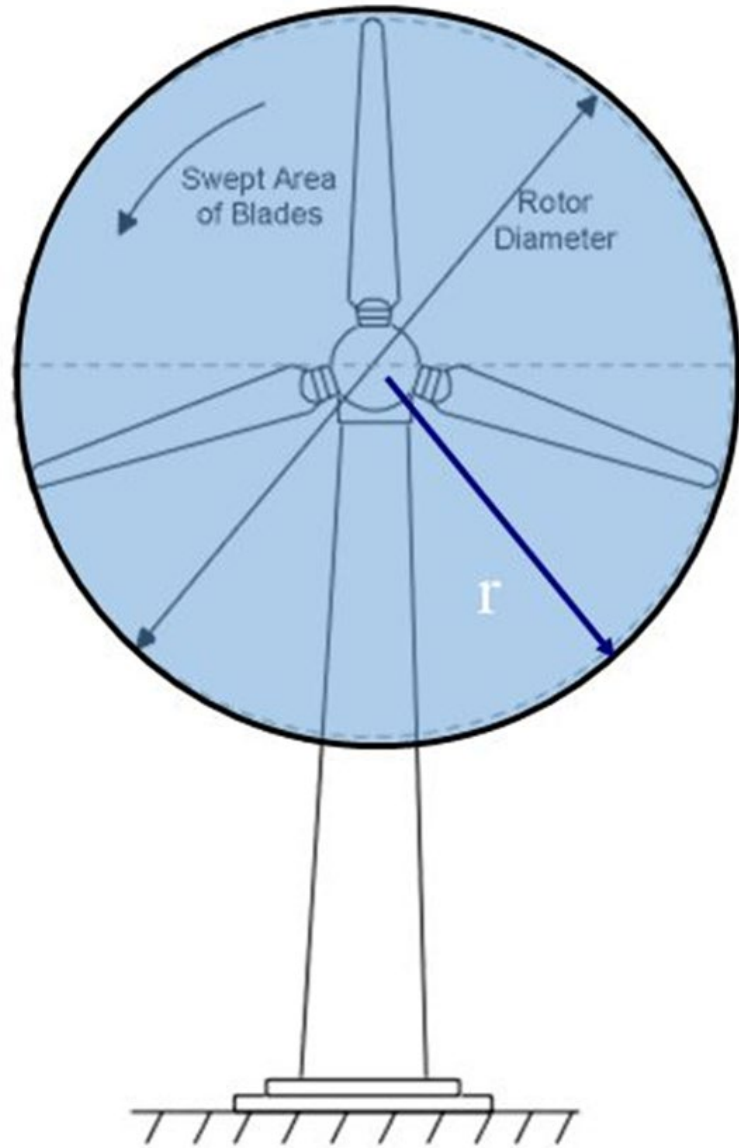
$$Power (W) = \frac{1}{2} \rho A v^3$$

Power = Watts

ρ = density of the air in kg/m^3

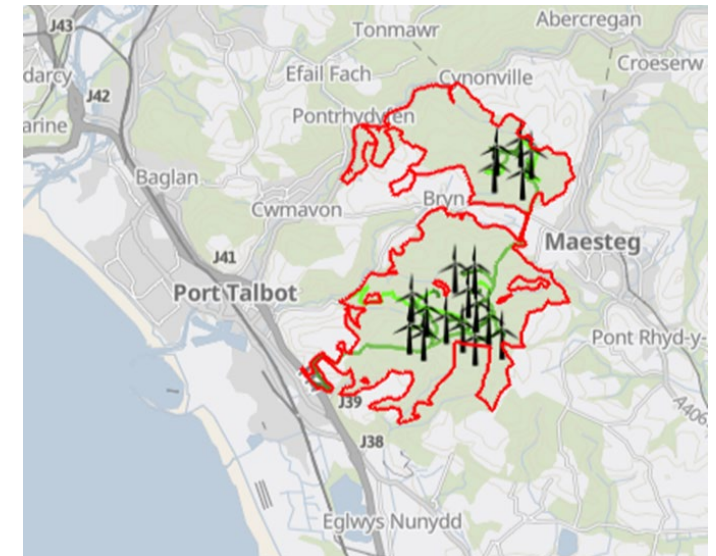
A = cross-sectional area of the wind turbine in m^2

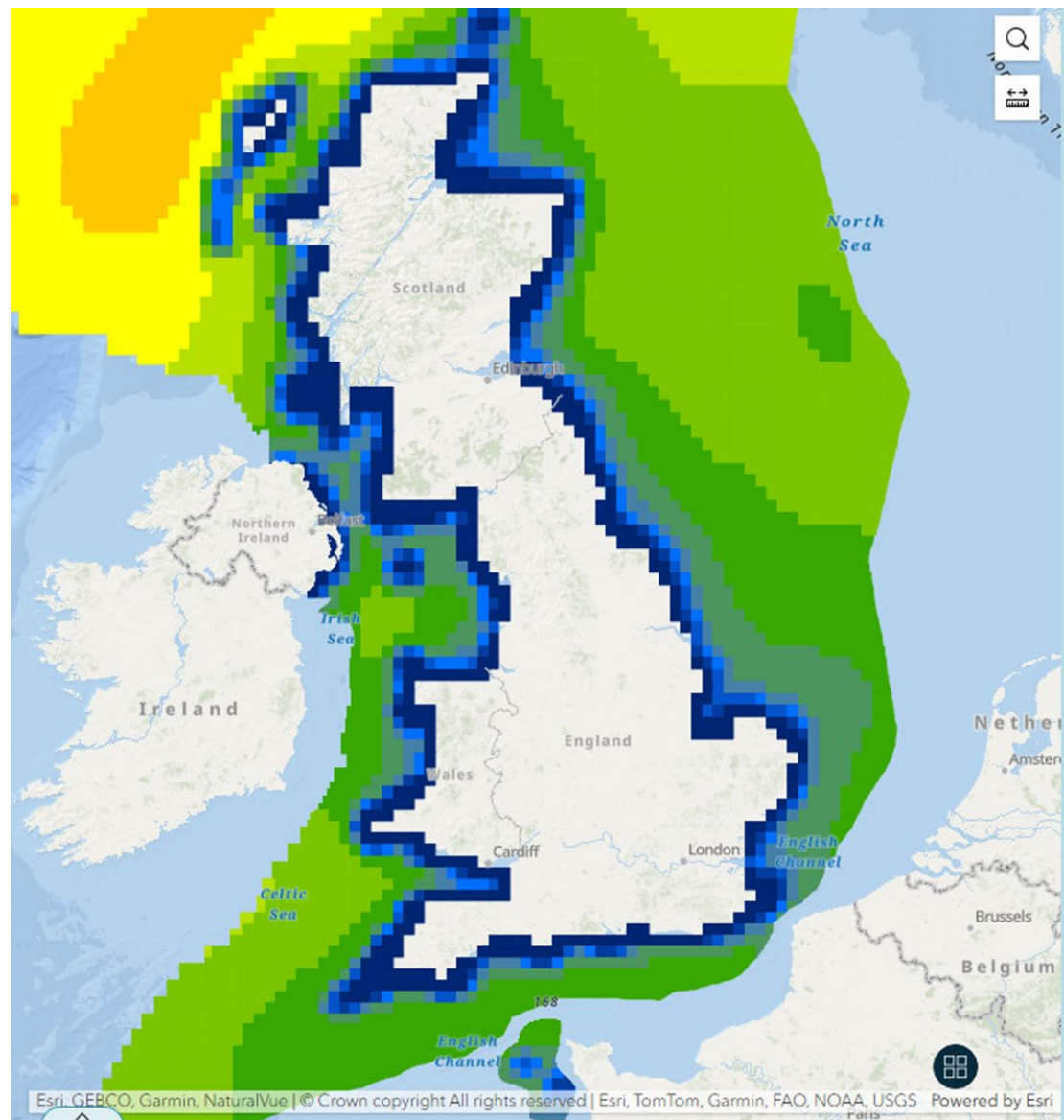
v = velocity of the wind in m/s



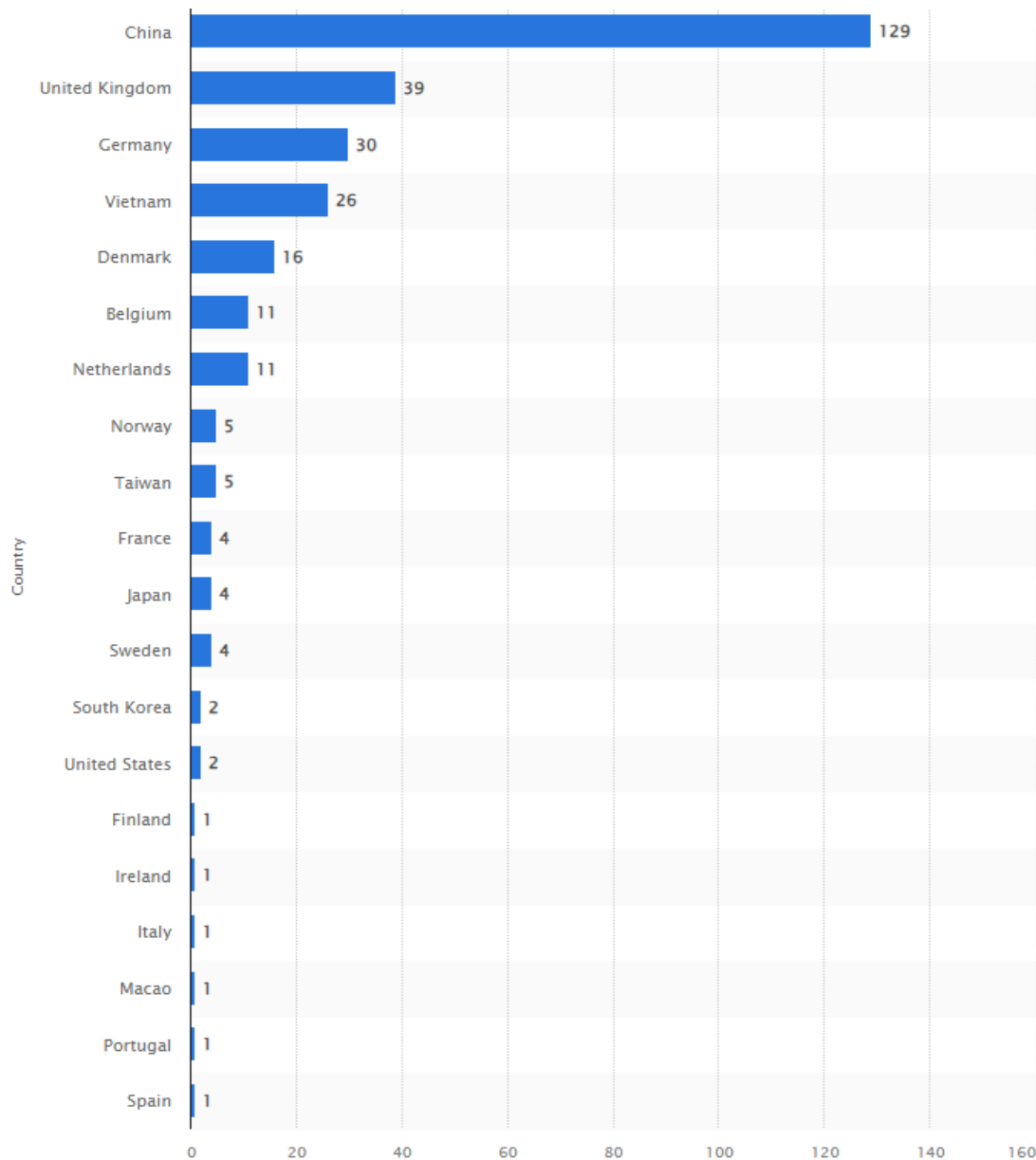
Wind

Calculate the average power available for a single turbine at Y Bryn Onshore Wind Farm with rotor diameter of 150m.





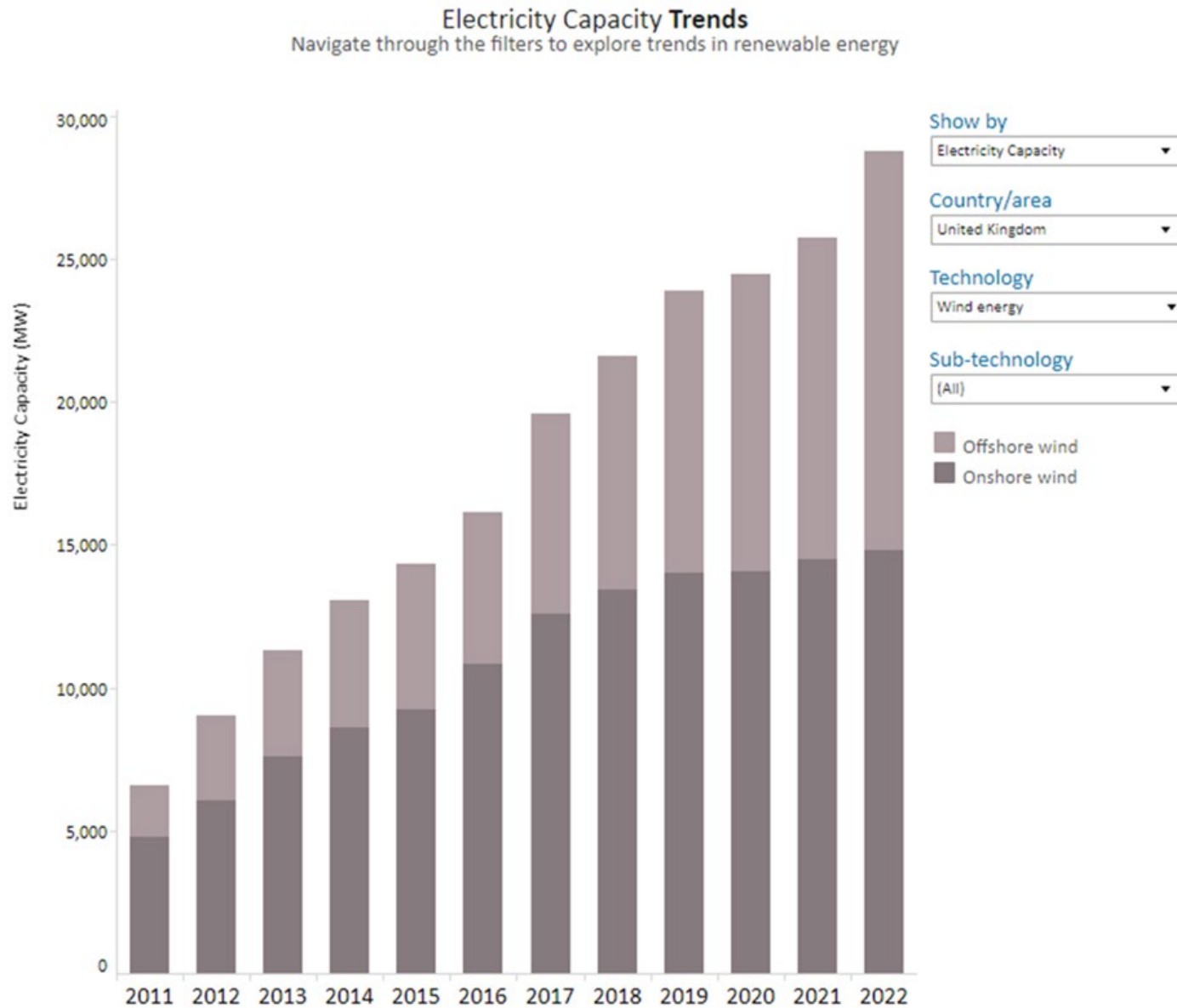
Offshore Wind



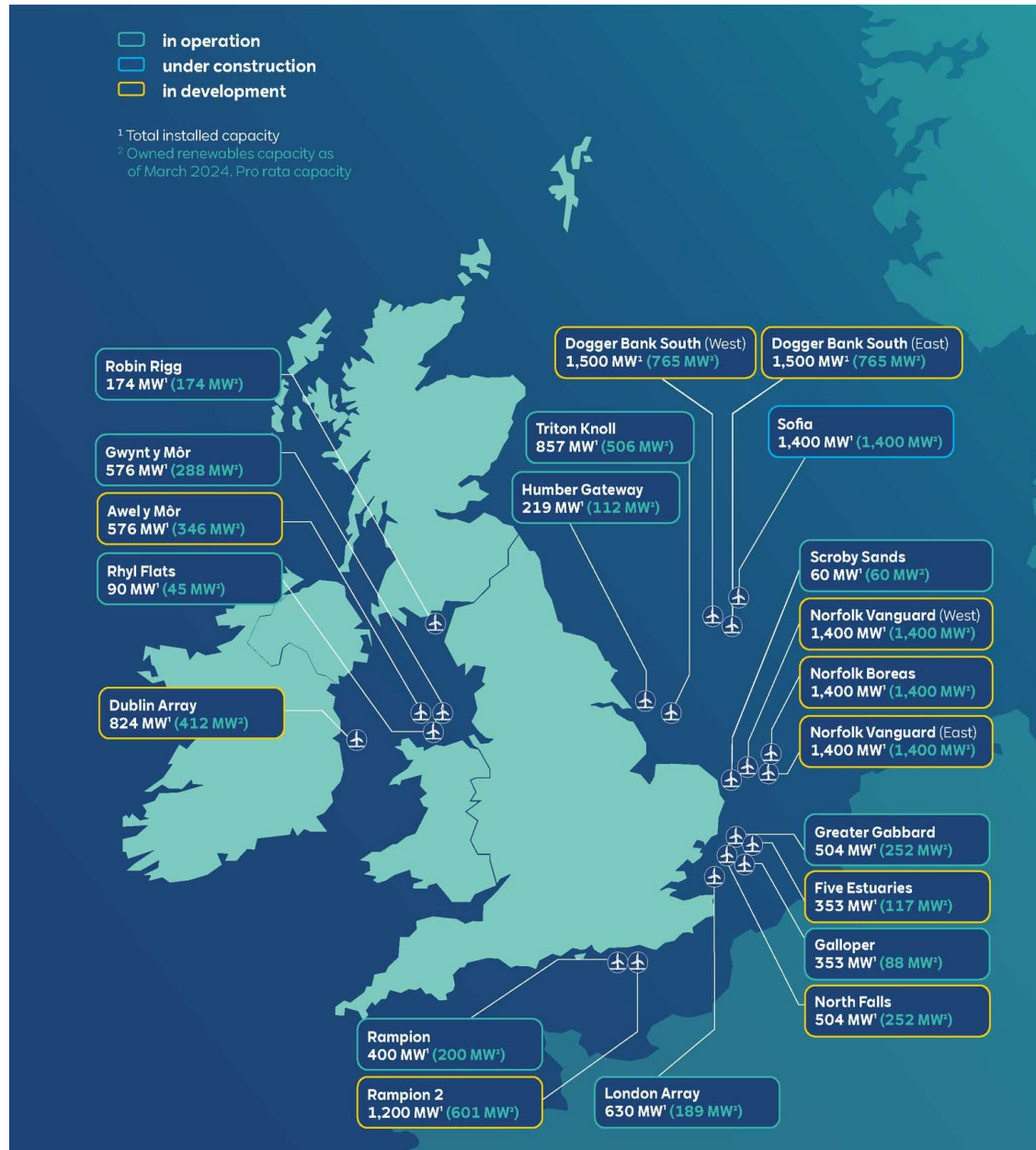
Offshore Wind

Offshore wind power is gaining popularity as a key renewable energy source because of its many advantages over onshore wind.

Offshore Wind

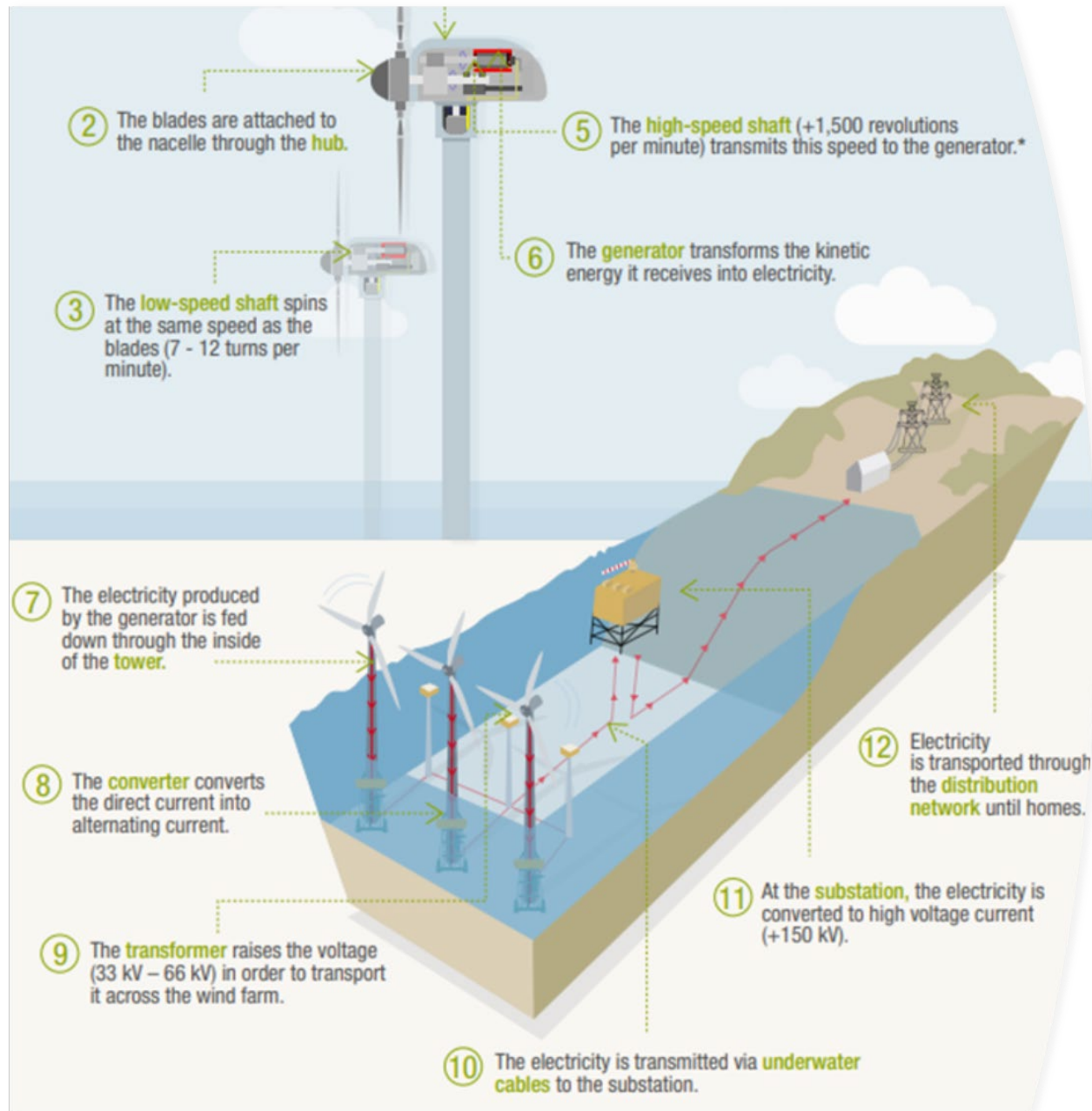


Offshore Wind



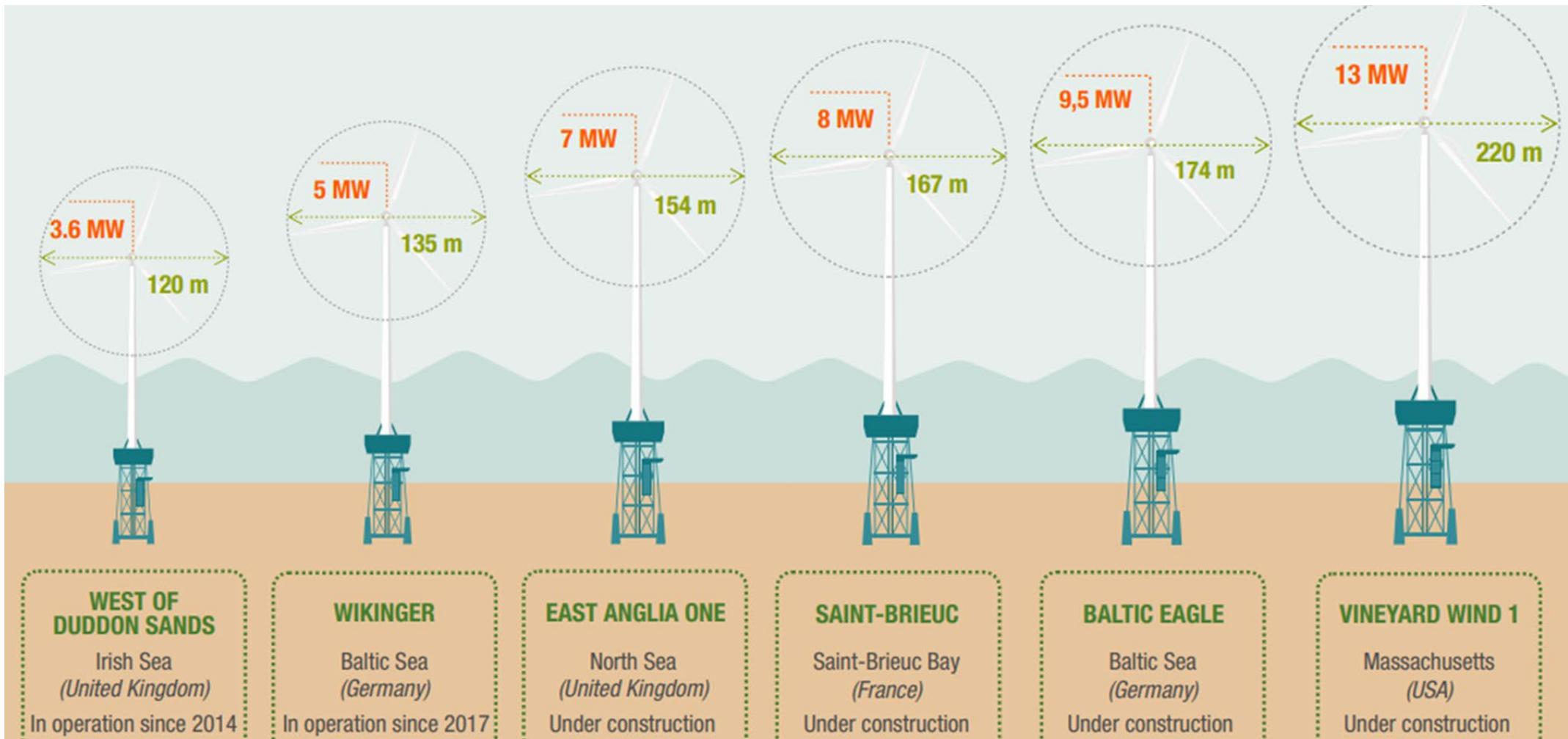
Offshore Wind

The choice of foundation for an offshore wind turbine (OWT) structure is influenced by several factors, including water depth, seabed conditions, environmental loading, and economic considerations.

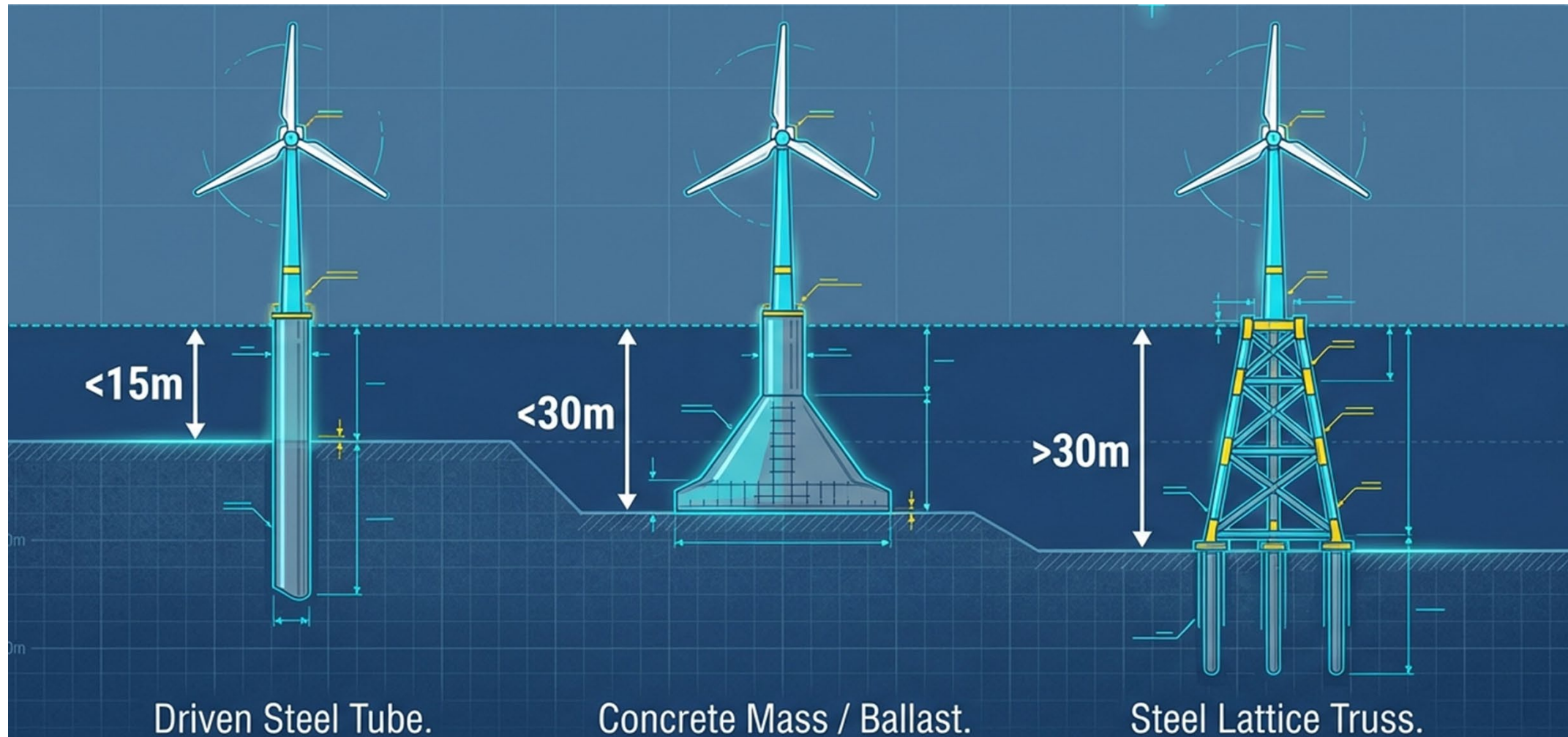


Offshore Wind

Offshore Wind



Offshore Wind

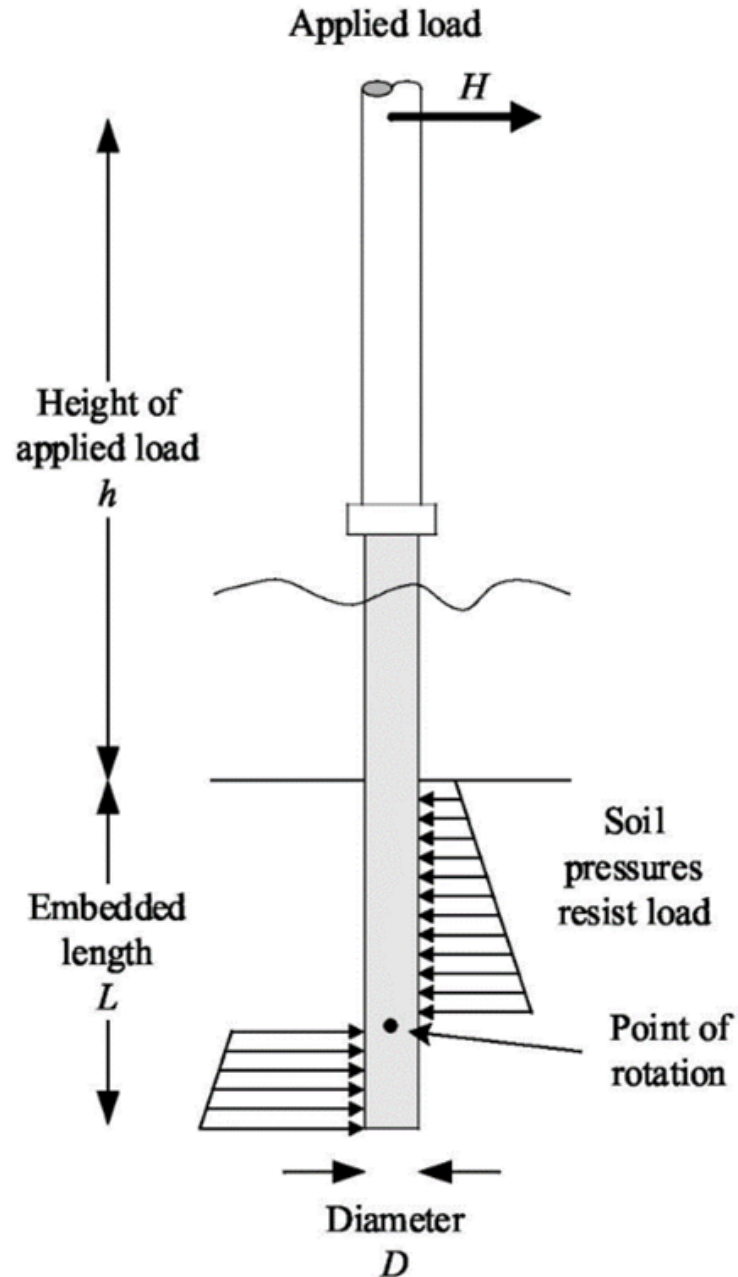




Offshore Wind

A monopile is a single, large-diameter steel tube driven into the seabed.

It is currently the preferred foundation choice for OWTs because of its simple configuration, relatively low cost, established supply chain, and engineering optimisation in recent years.

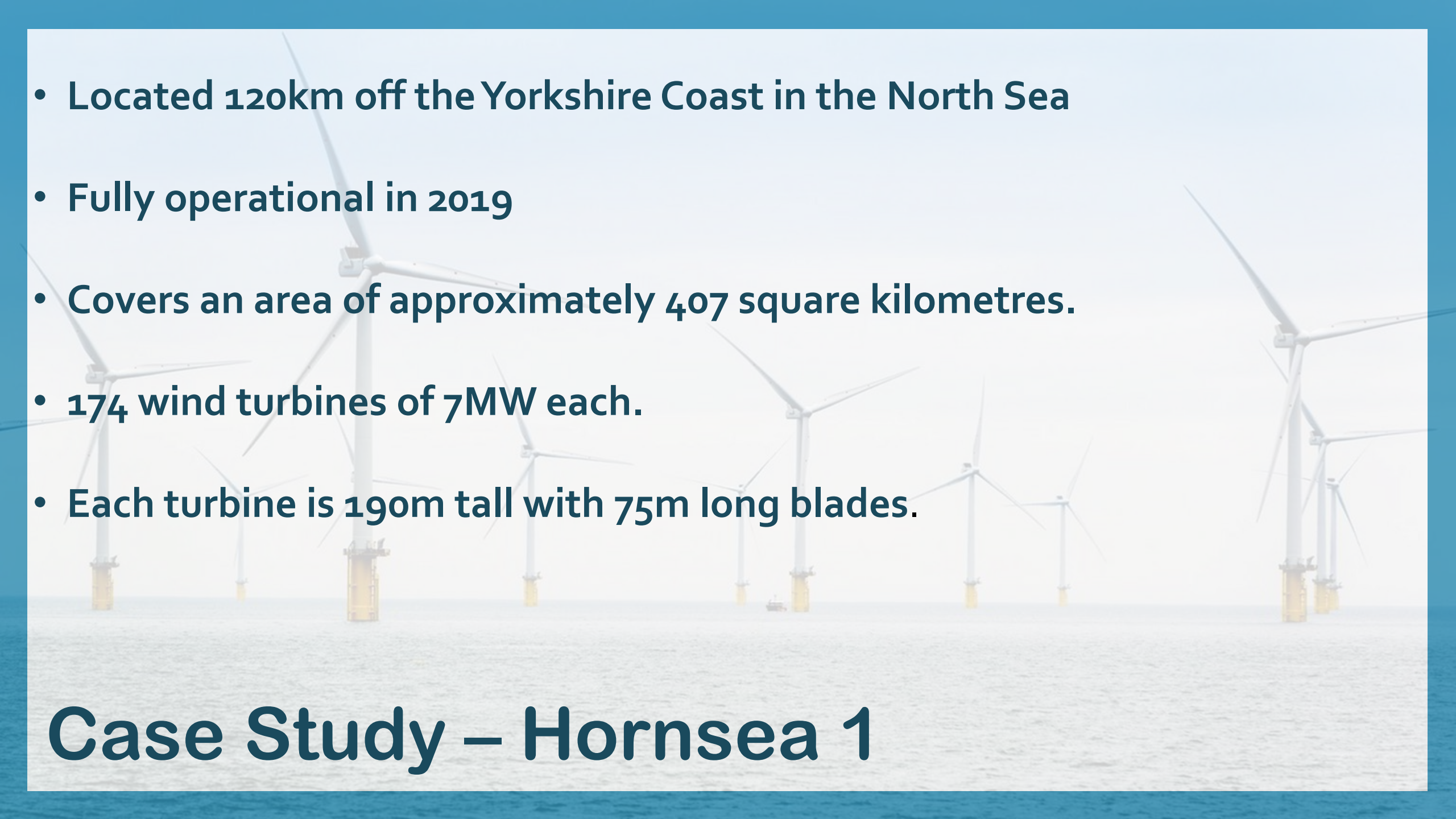


Offshore Wind

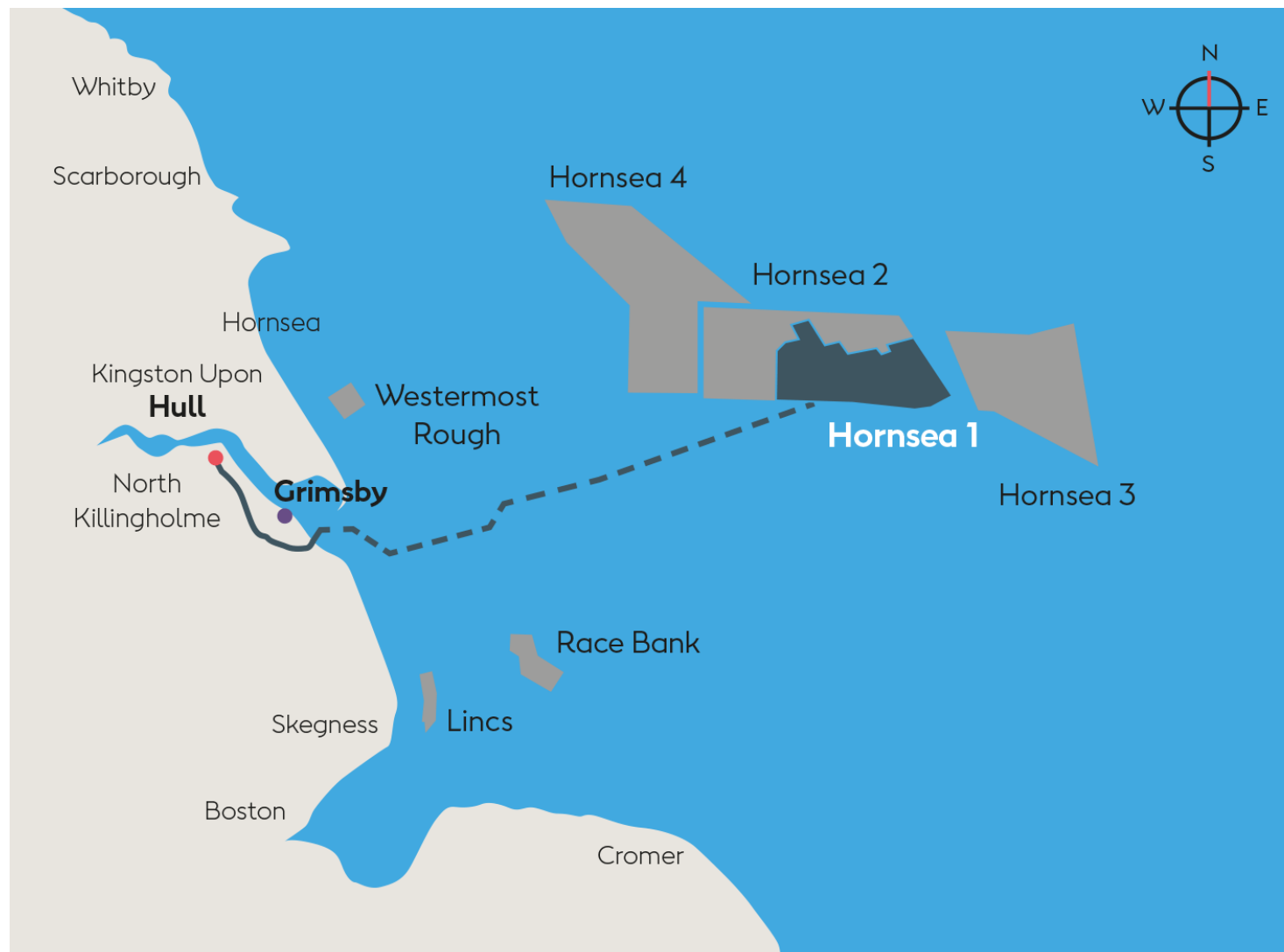
Gravity-based foundations and monopiles have load transferred to the ground through overturning moments, thus lateral loading dictates the design.



Case Study – Hornsea 1

- 
- Located 120km off the Yorkshire Coast in the North Sea
 - Fully operational in 2019
 - Covers an area of approximately 407 square kilometres.
 - 174 wind turbines of 7MW each.
 - Each turbine is 190m tall with 75m long blades.

Case Study – Hornsea 1



Hornsea One Offshore Wind Farm



Cable Corridor / Route

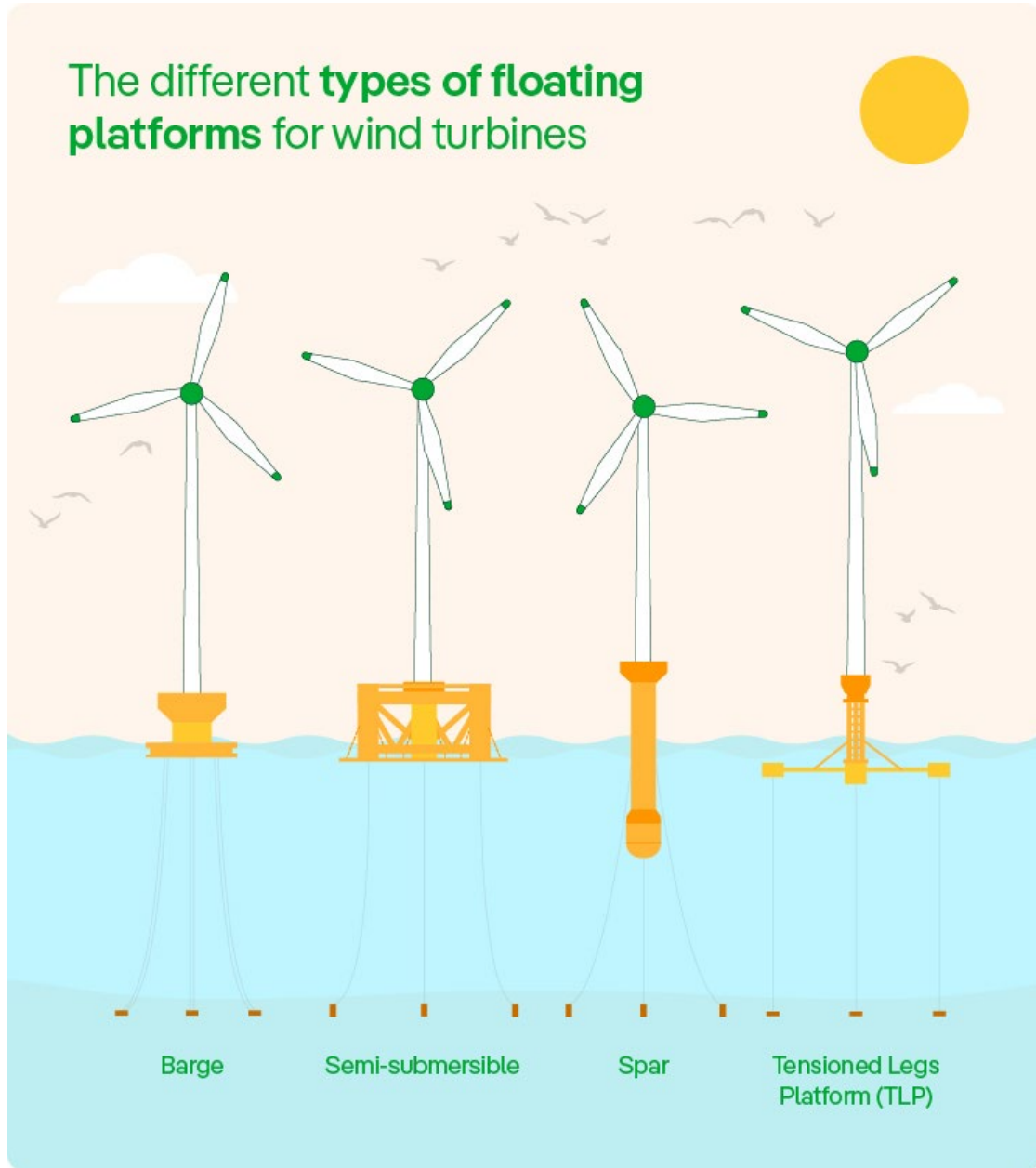


Onshore Substation



Operations and Maintenance Base

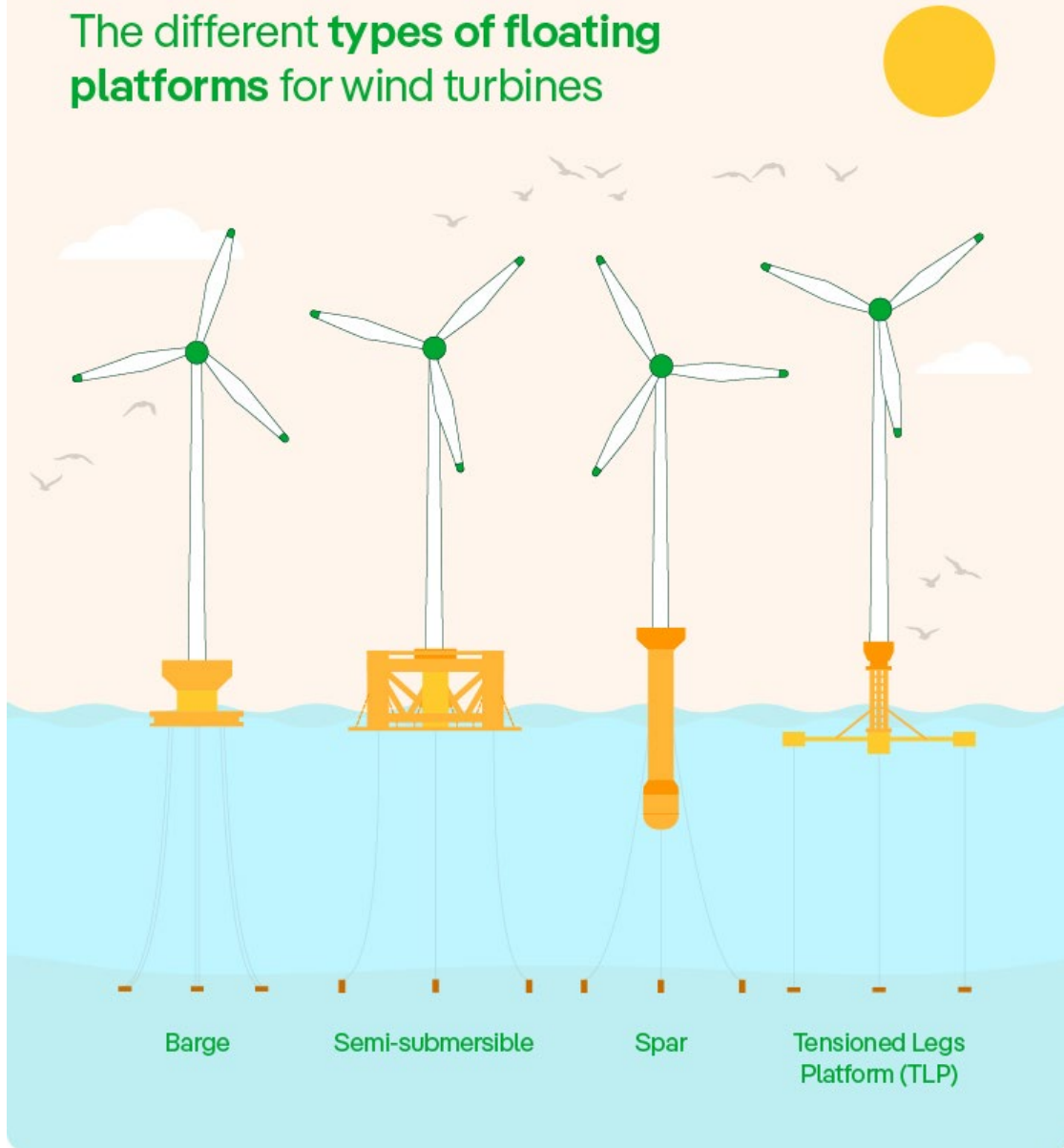
The different **types of floating platforms** for wind turbines



Floating Wind

Floating wind farms are made up of wind turbines that are placed on floating structures and stabilised by moorings and anchors, and the design of the structure distributes the masses and weights.

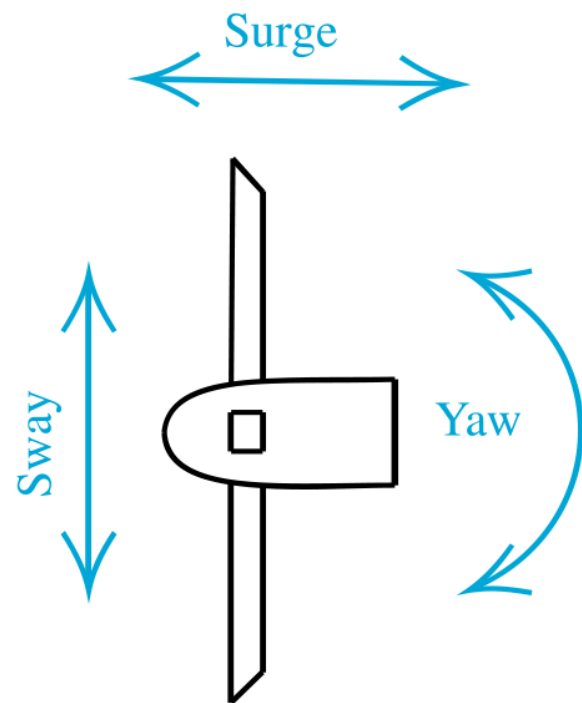
The different **types of floating platforms** for wind turbines



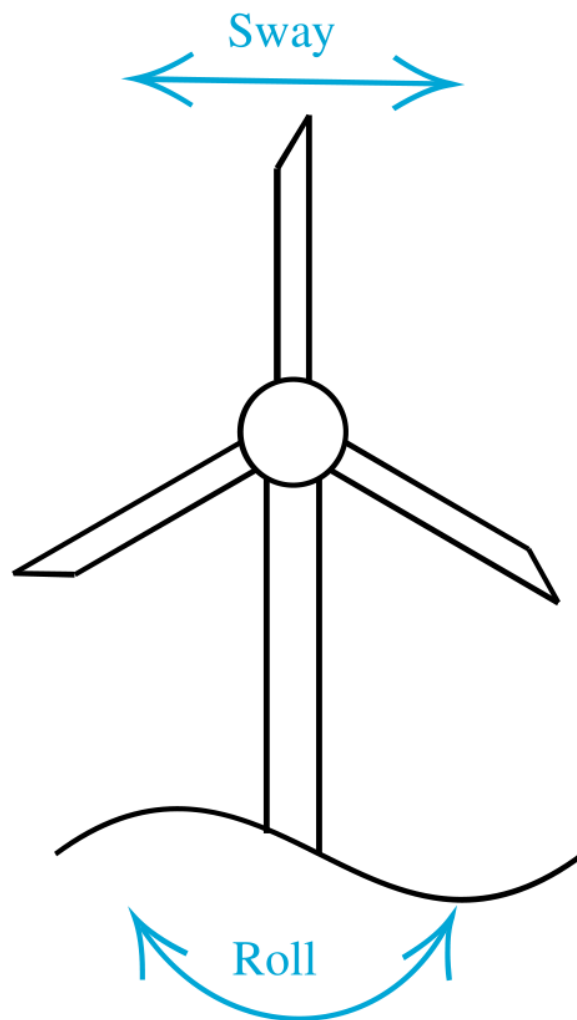
Floating Wind

What are the movements of a floating platform?

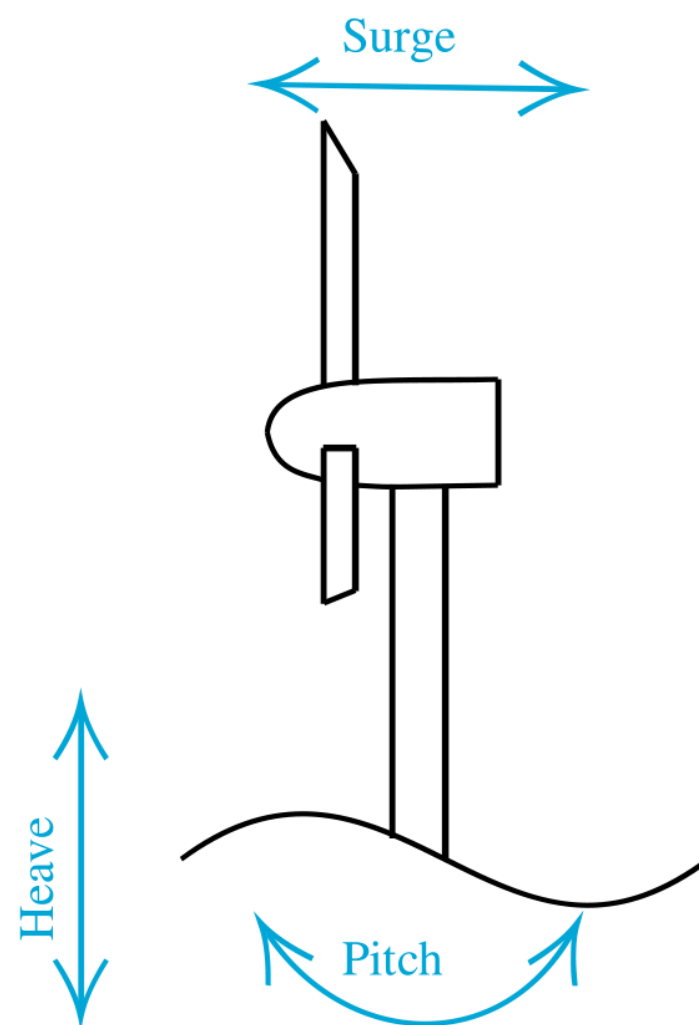
Top View

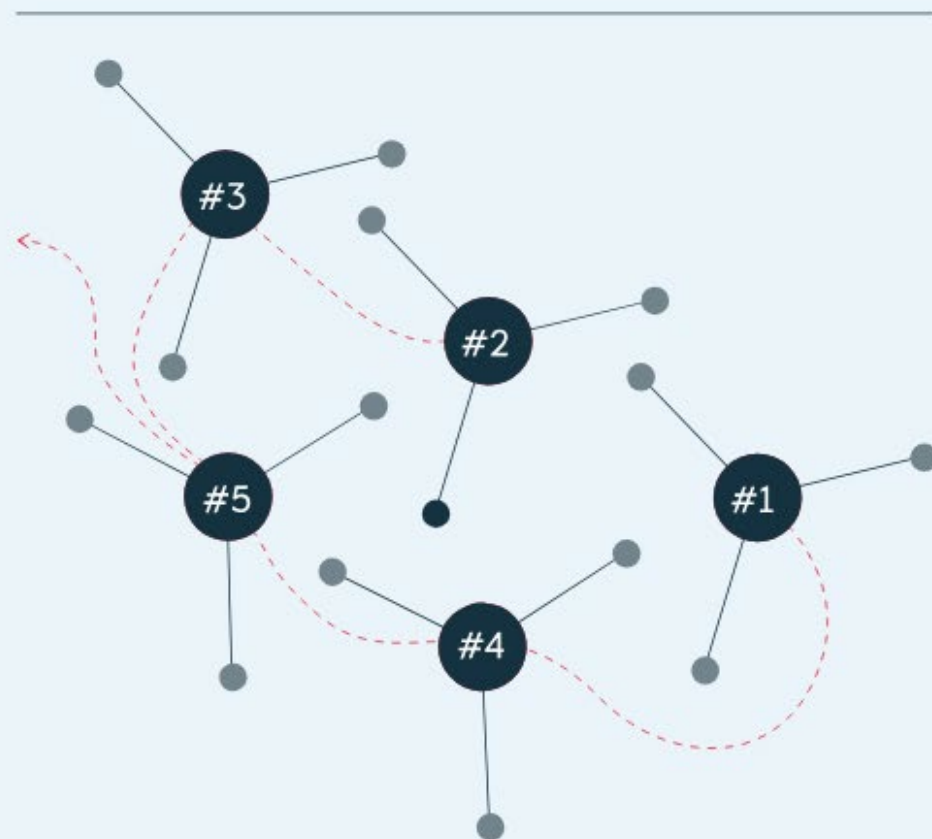


Front View

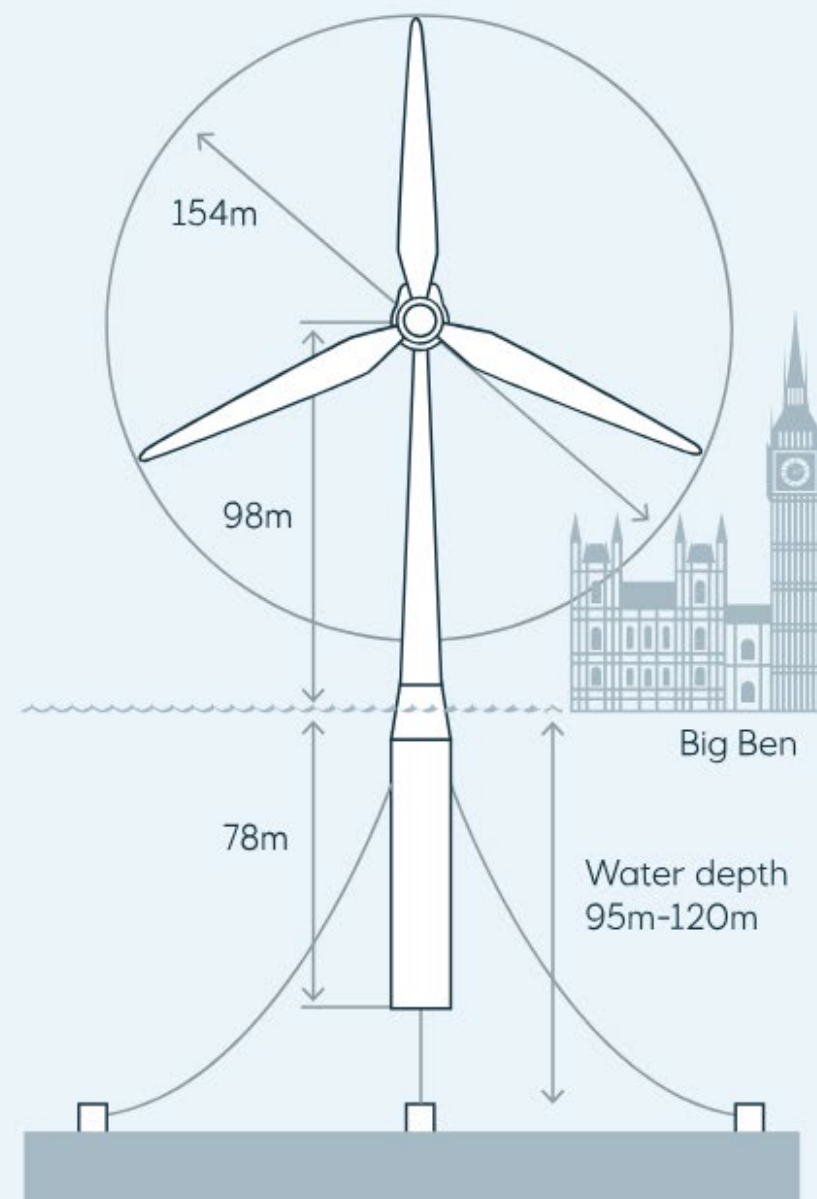


Side View





- Turbine
- Anchor
- Mooring line
- - - Electrical line



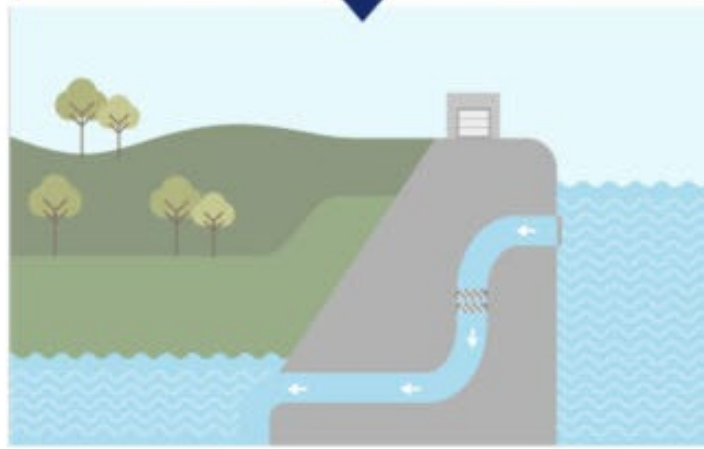


HYDROELECTRIC

DIVERSION FACILITY



IMPOUNDMENT FACILITY

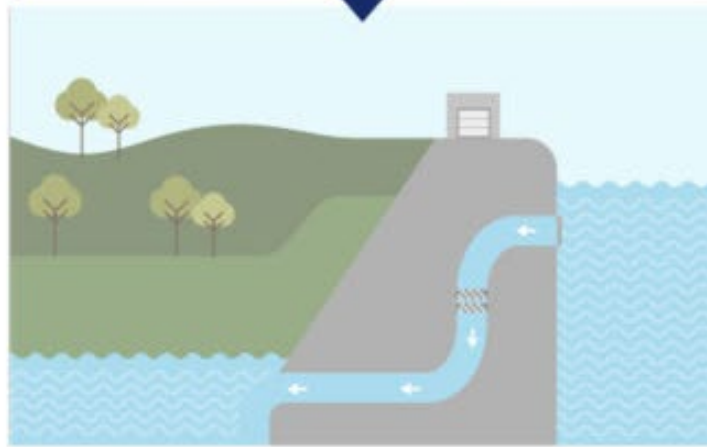


HYDROELECTRIC

DIVERSION FACILITY



IMPOUNDMENT FACILITY



PUMPED STORAGE FACILITY



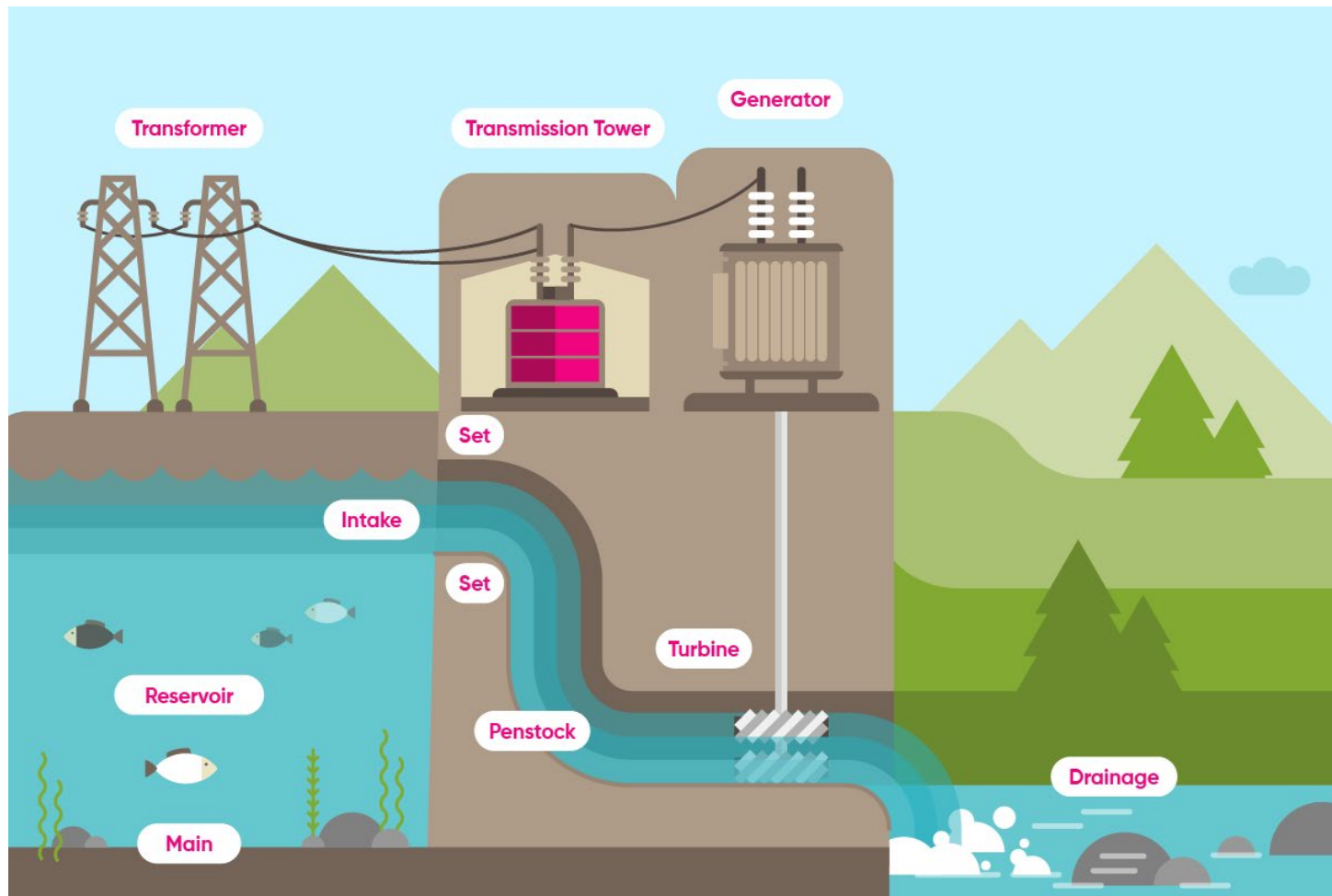
HYDROELECTRIC



Hydroelectric

The most common type of hydroelectric power plant is an impoundment facility.

An impoundment facility, typically a large hydropower system, uses a dam to store river water in a reservoir.



Hydroelectric

Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity.



Hydroelectric

Different types of forces acts on a dam structure such as water pressure, self weight, wave pressure etc.

Determination of various forces which acts on the structure is the first step in the design of dams.

These forces are considered to act per unit length of the dam



Hydroelectric

Forces acting on a Dam Structure:

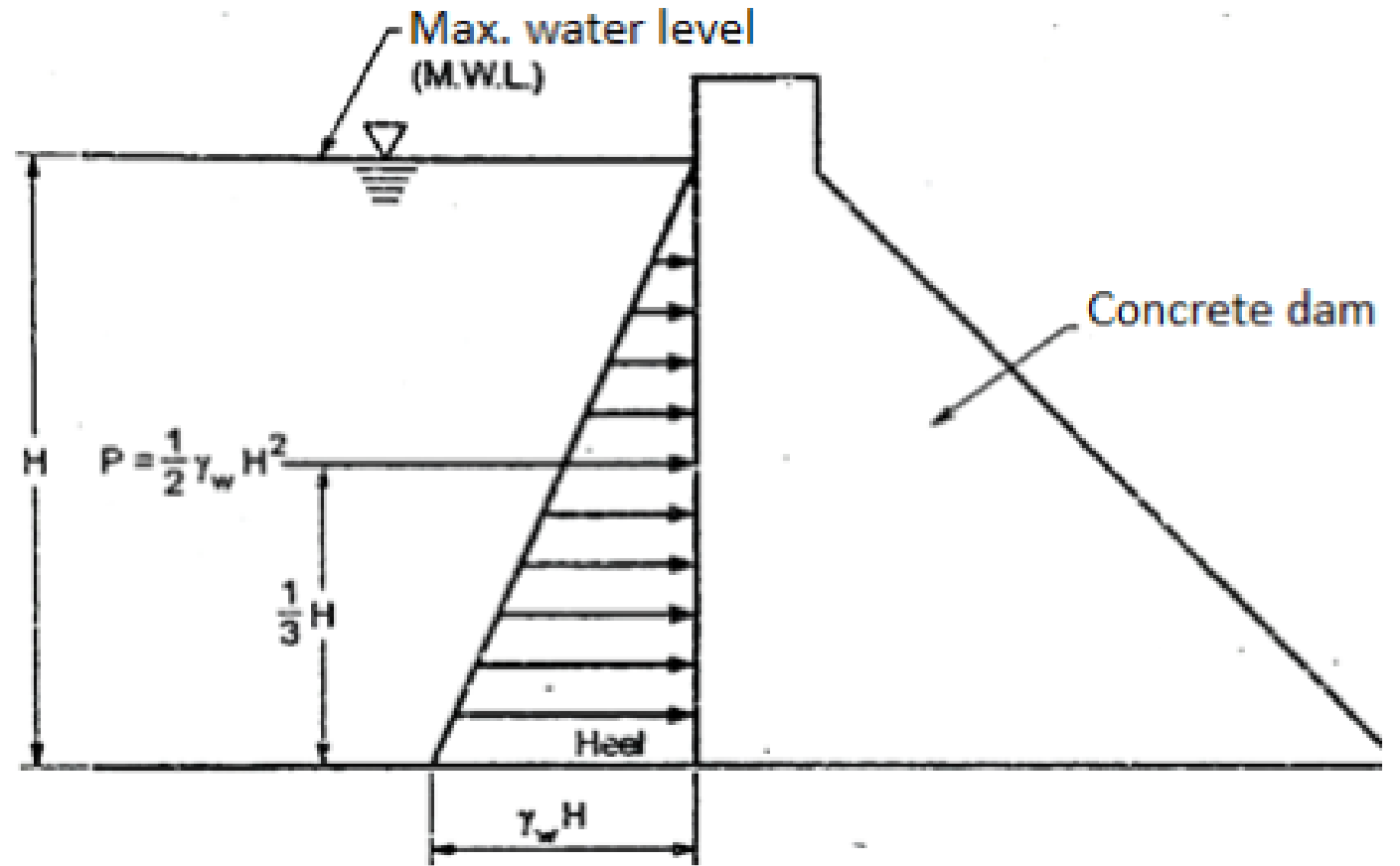
1. Water pressure (Hydrostatic)
2. Uplift pressure or seepage loads
3. Earthquake forces
4. Self weight of the dam
5. Silt pressure
6. Wave pressure
7. Ice pressure
8. Wind Pressure
9. Thermal Loads

Hydroelectric

Water pressure (Hydrostatic)

$$P_w = \frac{1}{2} \gamma_w H^2$$

- P_w = Hydrostatic Pressure
- γ_w = Unit Weight of Water
- H = Water Depth

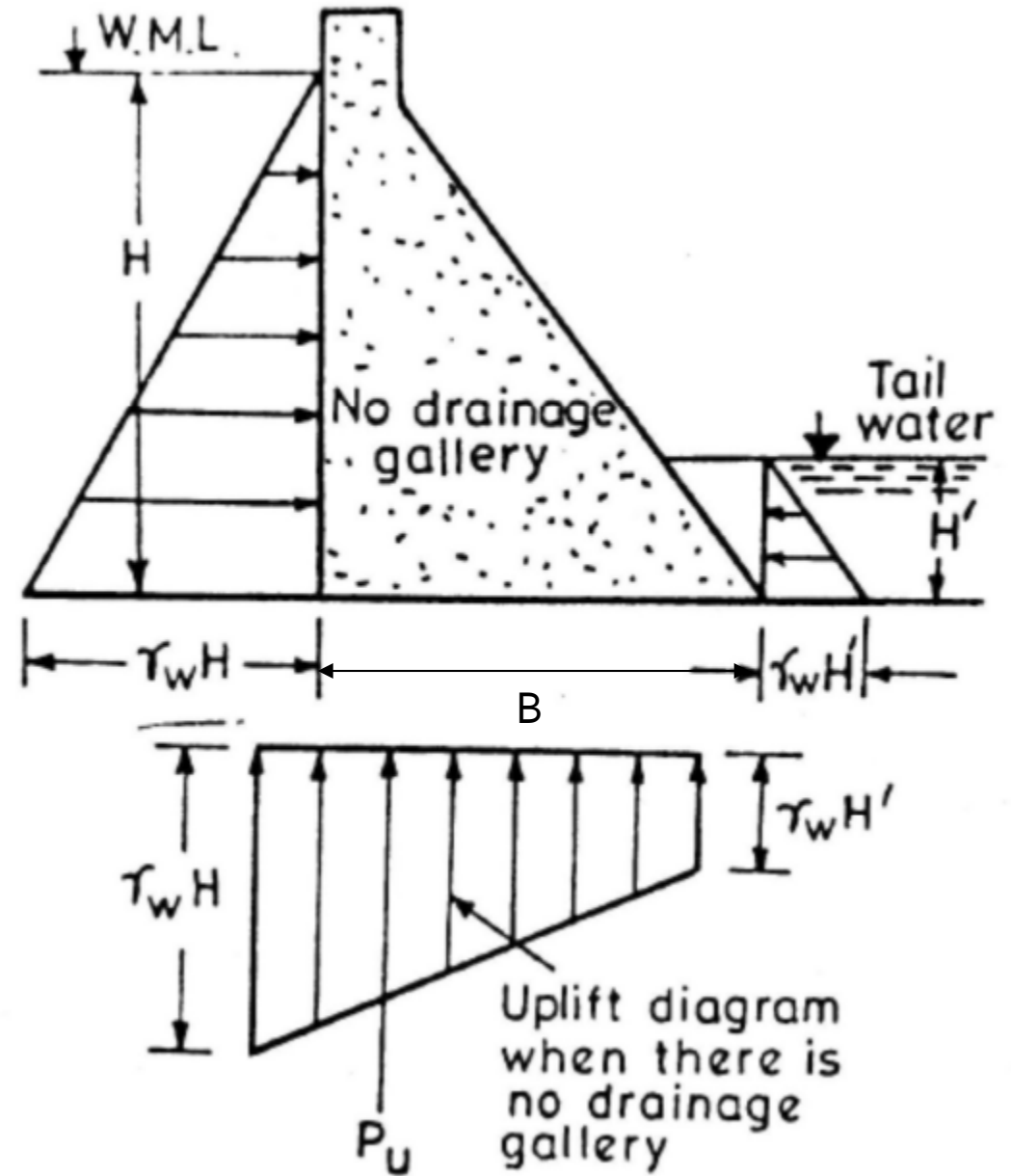


Hydroelectric

Uplift Pressure

$$P_u = \frac{1}{2} \gamma_w H B$$

- P_u = Uplift Pressure
- γ_w = Unit Weight of Water
- H = Water Depth
- B = Width of Dam

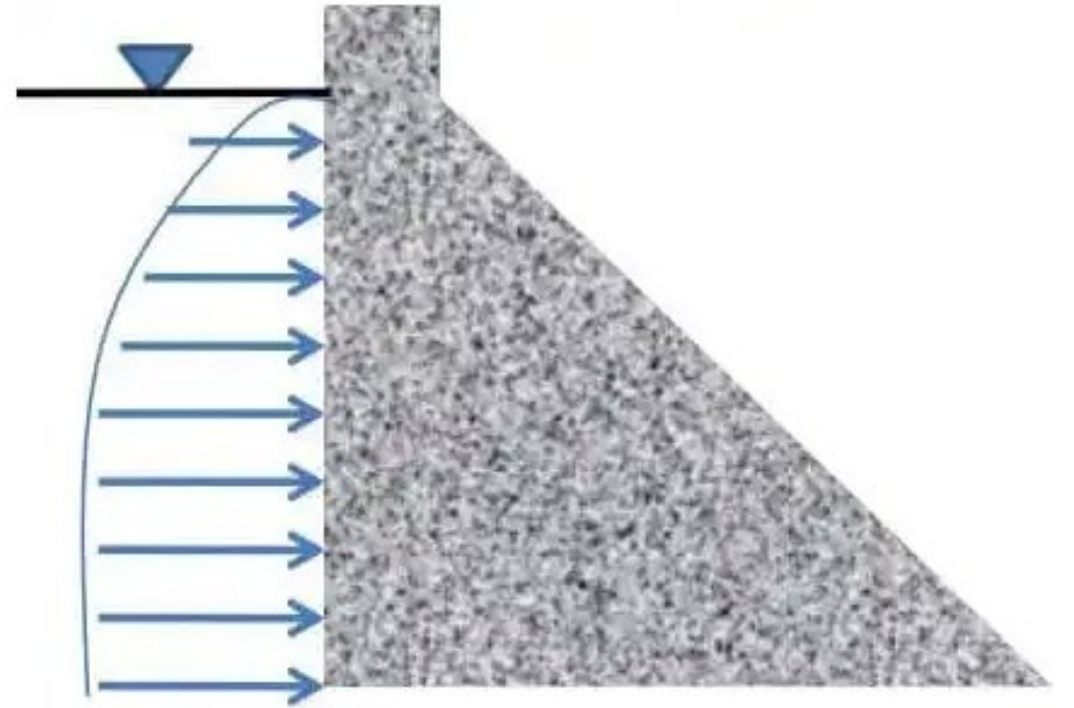


Hydroelectric

Earthquake Forces

Dynamic loads created due to earthquakes must be considered in the design of all major dams.

Earthquakes produce waves in every possible direction. However, they must be resolved into vertical and horizontal components for the design purposes.

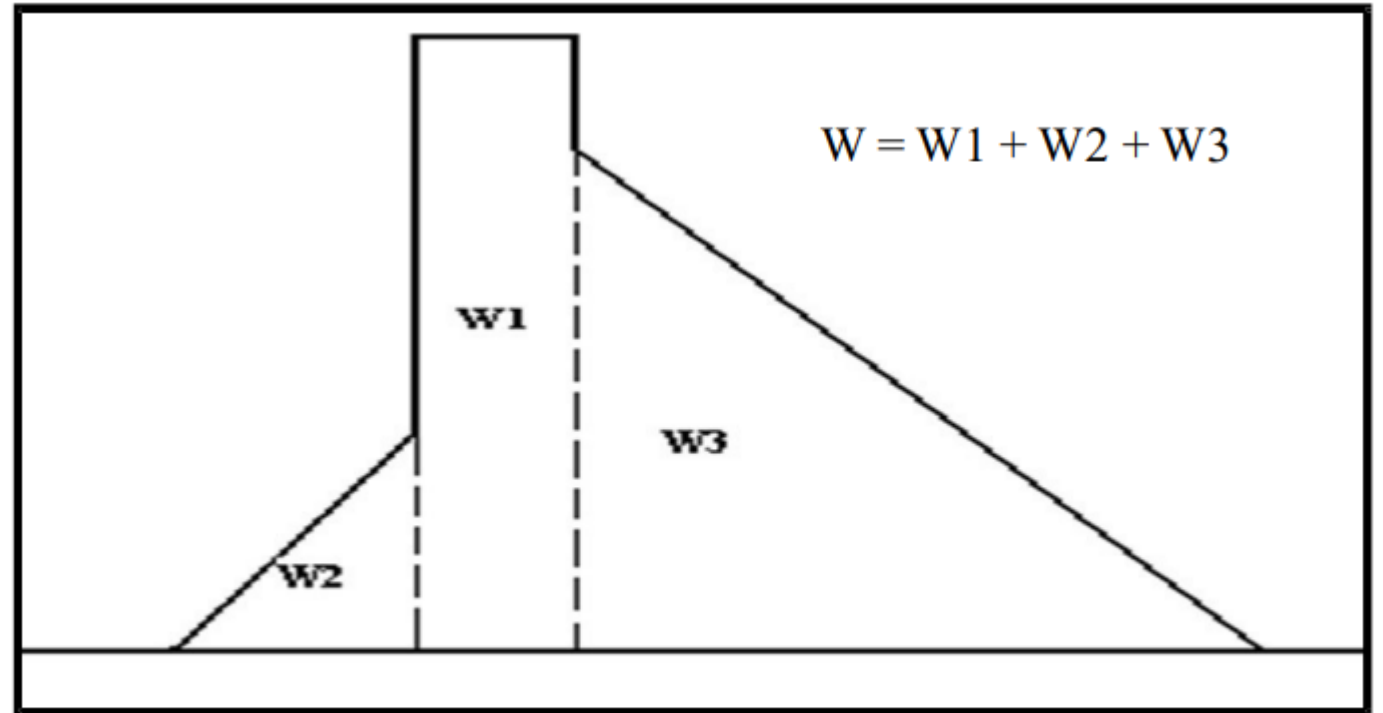


Hydroelectric

Self Weight

Weight of the dam is the major resisting force.

Total weight of the dam acts at the centre of gravity.



Weight = Volume per unit length x Density of material

Hydroelectric

Silt Pressure

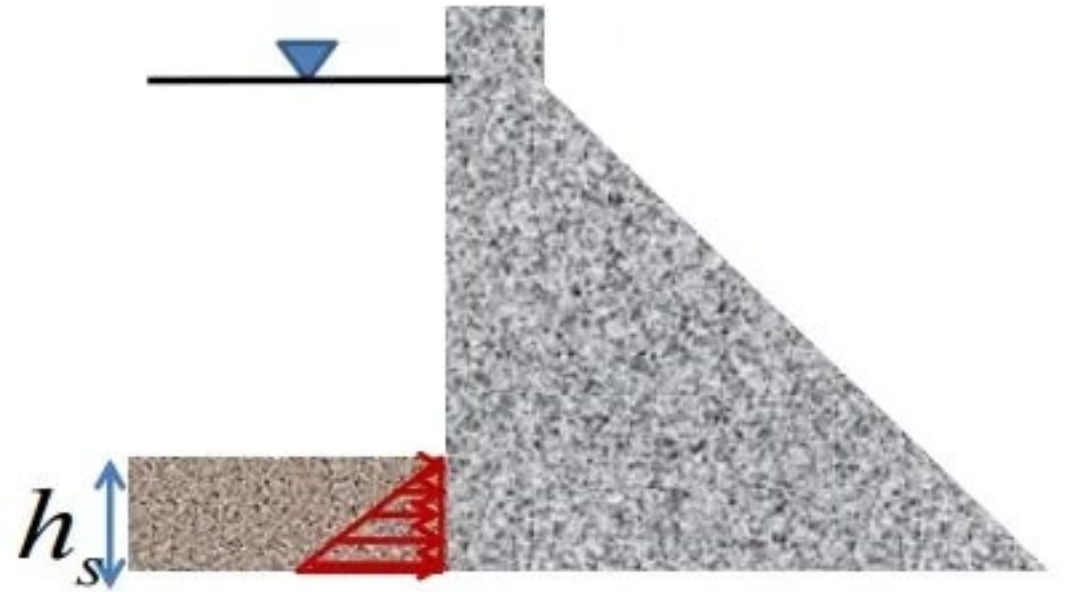
Silt deposited in the reservoir results in a force acting horizontally on the upstream face.

$$P_{silt} = 0.5\gamma_s h^2 K_a$$

γ_s = Unit Weight of Silt

h = Height of deposited Silt

K_a = Active Earth Pressure



Hydroelectric

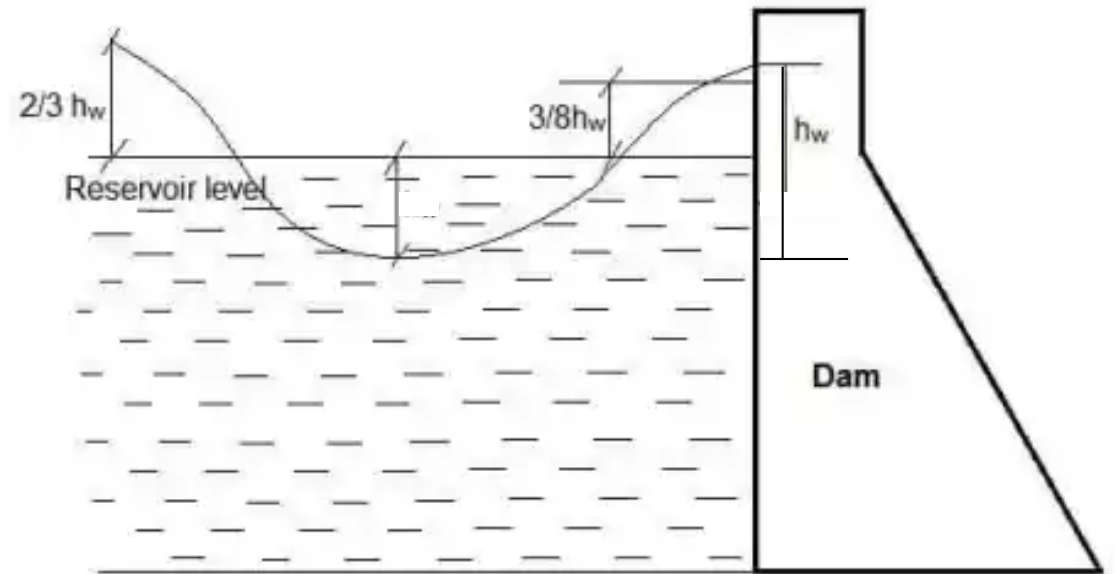
Wave Pressure

Waves are generated on the surface of the reservoir by the blowing winds, which exert a pressure on the upper part of the dam above the water level

$$P_{wave} = 2.4\gamma_w h_w$$

h_w = Wave Height

γ_w = Unit Weight of Water



Hydroelectric

Ice Pressure

The ice which may be formed on the water surface of the reservoir in cold countries may melt and expand.

The dam face is subjected to the thrust and exerted by the expanding ice.

This force acts linearly along the length of the dam and at the reservoir level.

The magnitude of this force varies from 250 to 1500 kN/sq.m depending upon the temperature variations.

On an average, a value of 500 kN/sq.m may be taken under ordinary circumstances.



Hydroelectric

Wind Pressure

A minor force acting on a dam.

Normally taken as 1 to 1.5kN/m²



Hydroelectric

Thermal Loads

Thermal loads are very critical for concrete dams.

During the construction and after the construction effect to the temperature variations shall be monitored.

If it exceeds the limiting values, there will be issues in durability of concrete





Hydroelectric

The potential power from hydroelectric is given by the following equation:

$$P = \eta \rho g h Q$$

η = Percentage Efficiency

ρ = Density of Water

h = Head

Q = Flow Rate



Hydroelectric

A hydroelectric dam has an impoundment area storing 10 million cubic metres of water at a height of 60m. Assuming water is released at a controlled rate of $400\text{m}^3/\text{s}$ and the system operates at 85%, calculate the power output.



Hydroelectric

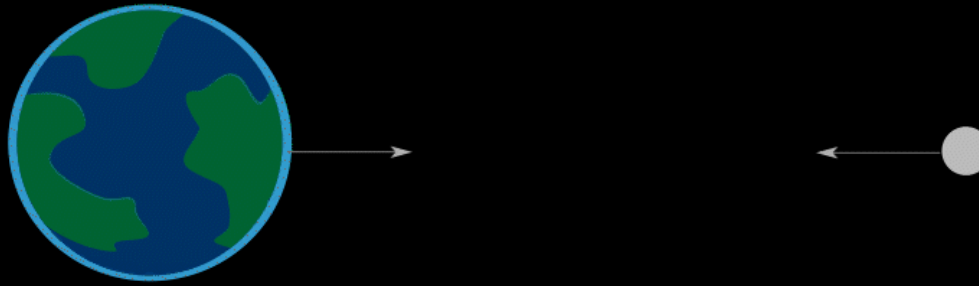
A run-of-river hydroelectric diversion facility channels water from a river through a turbine before returning it downstream. The system has a flow rate of $250\text{m}^3/\text{s}$, a head height of 30 m and a system efficiency of 88%.





Tidal

Tidal energy is a form of power produced by the natural rise and fall of tides caused by the gravitational interaction between Earth, the sun, and the moon.



NOT TO SCALE

TIDE GENERATION

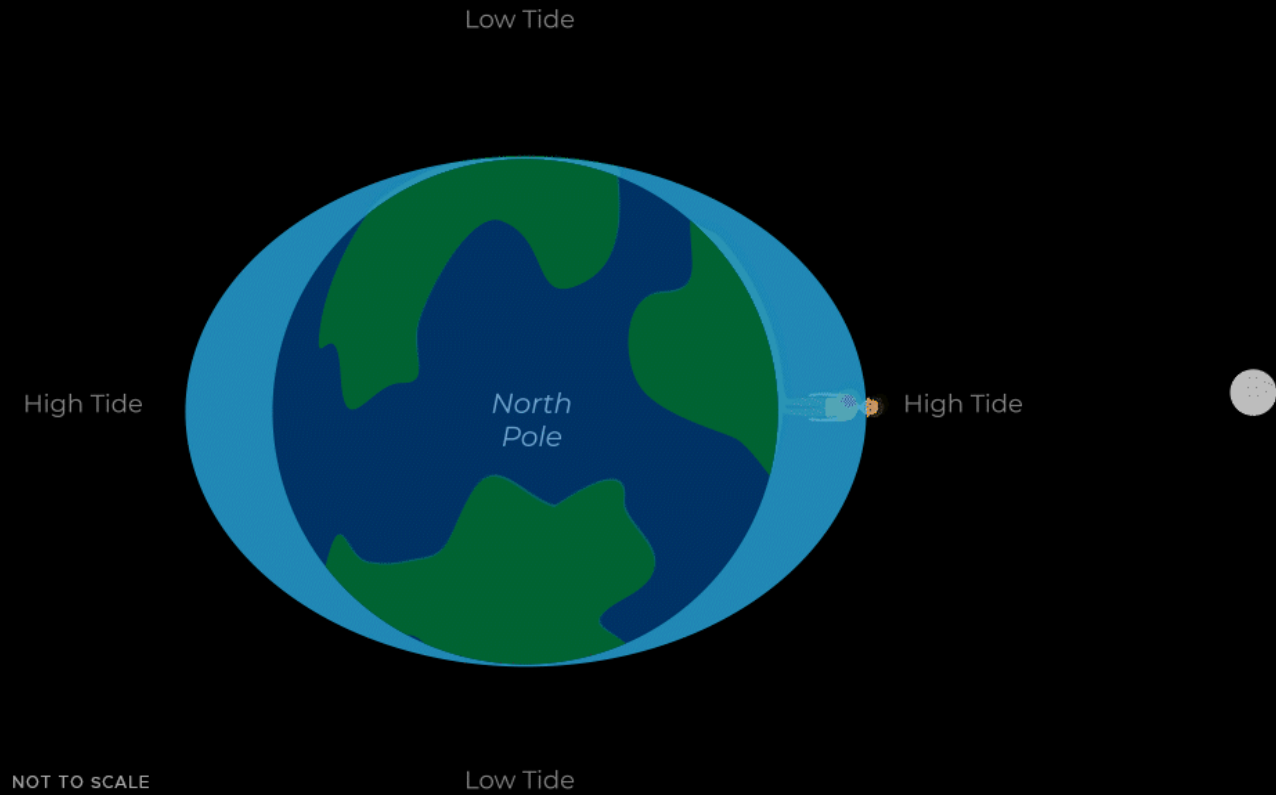


Moon

Net Tide Generating Force

NOT TO SCALE

TIDE GENERATION

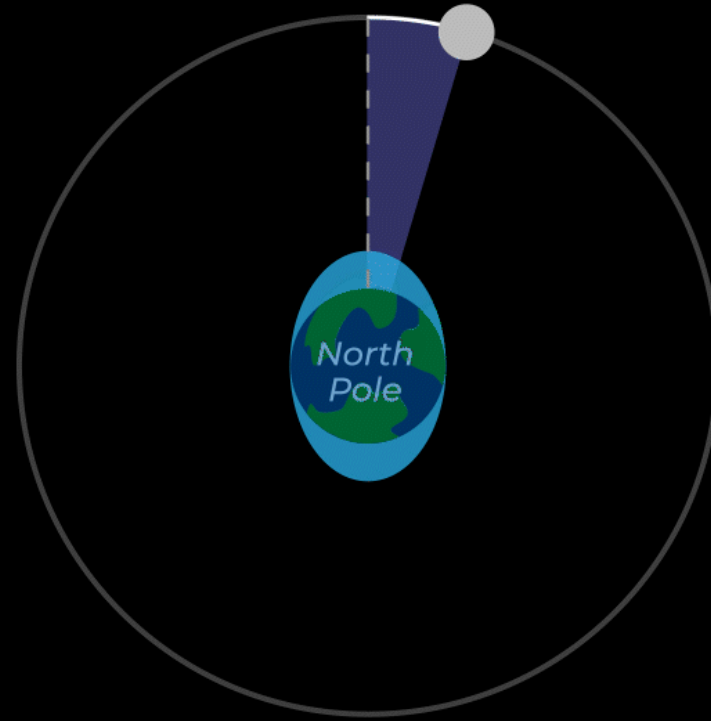


TIDE GENERATION

Tidal lag

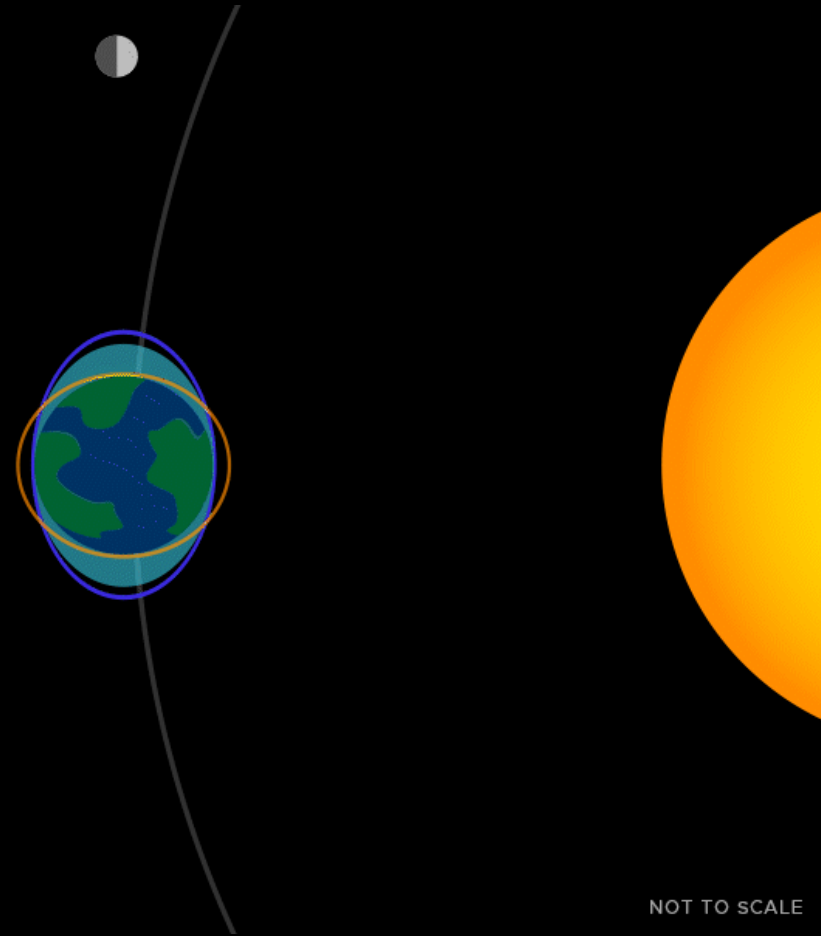
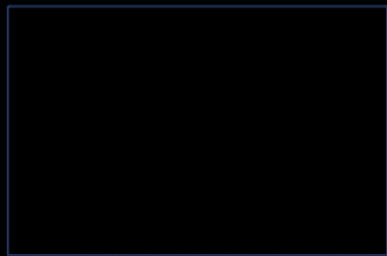


NOT TO SCALE



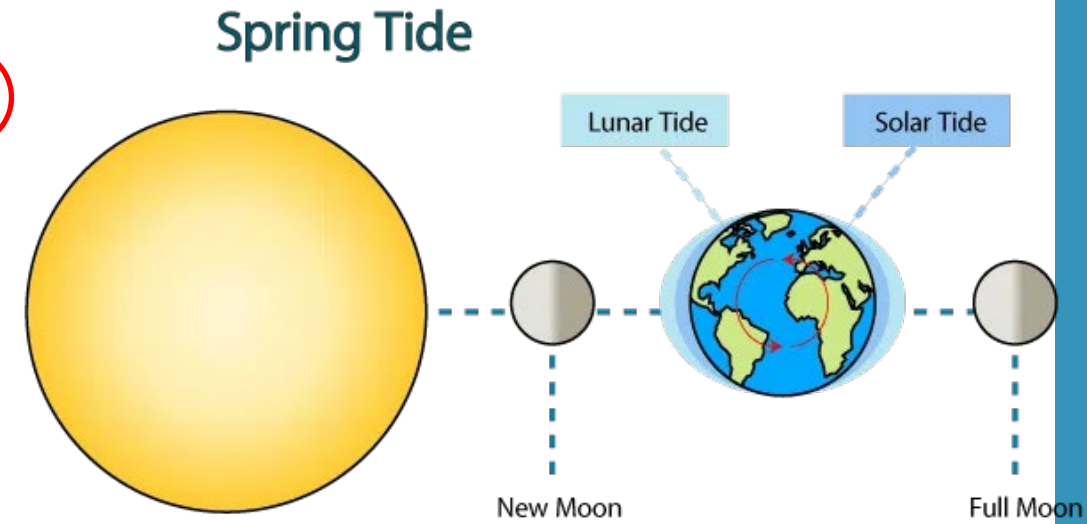
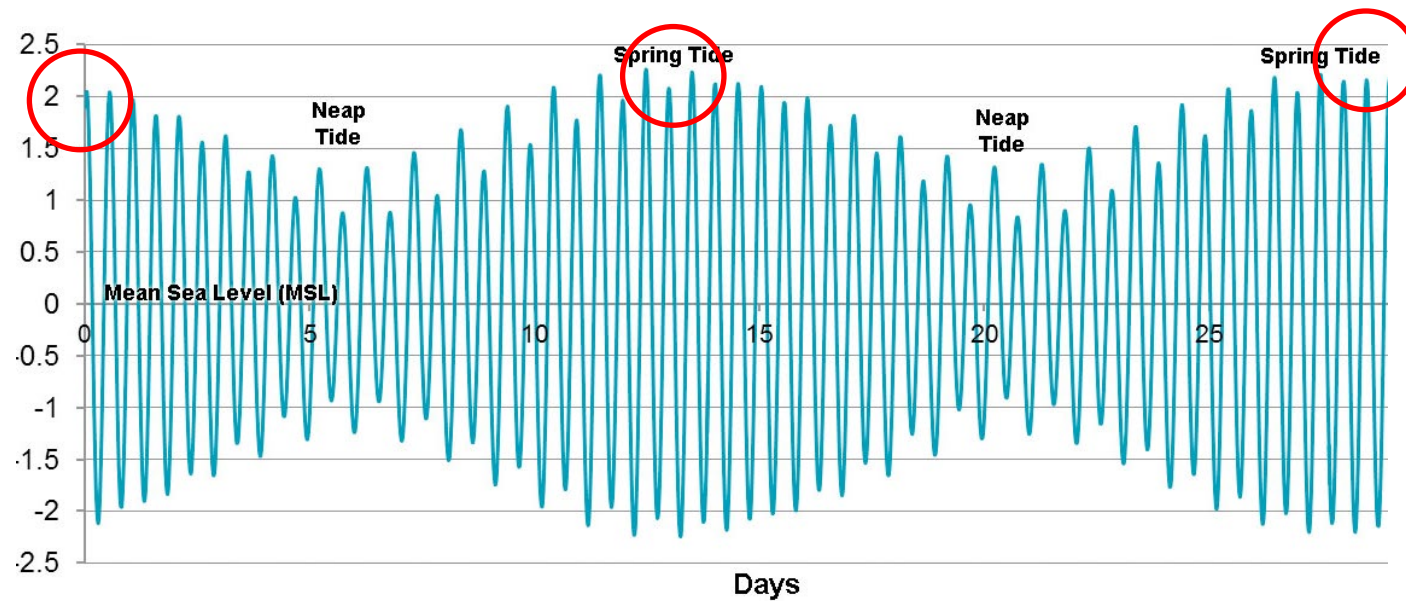
TIDE GENERATION

- Solar Tide
- Lunar Tide
- Resulting Tide

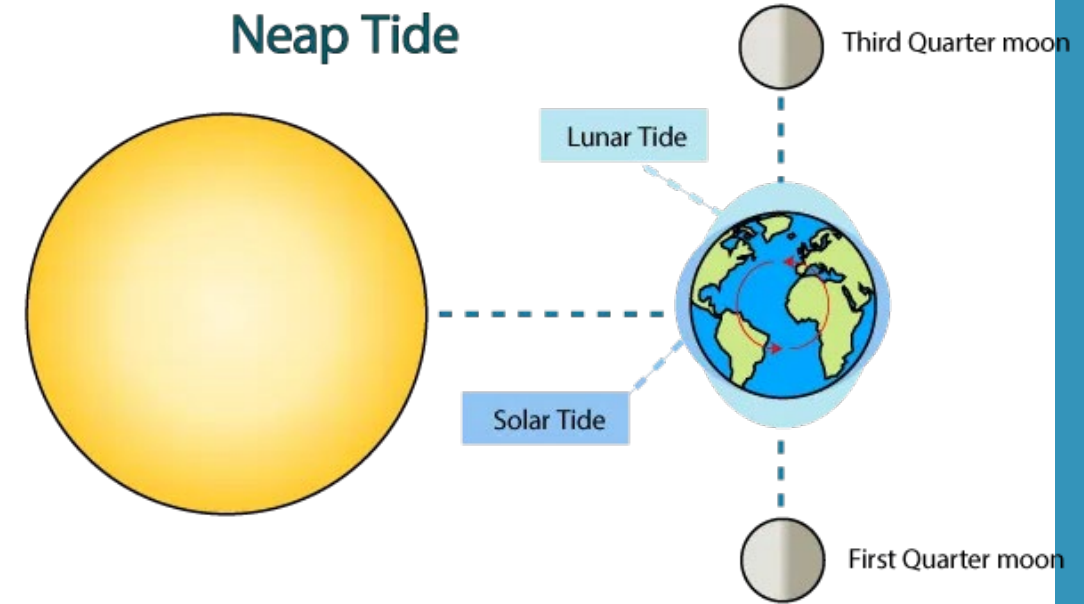
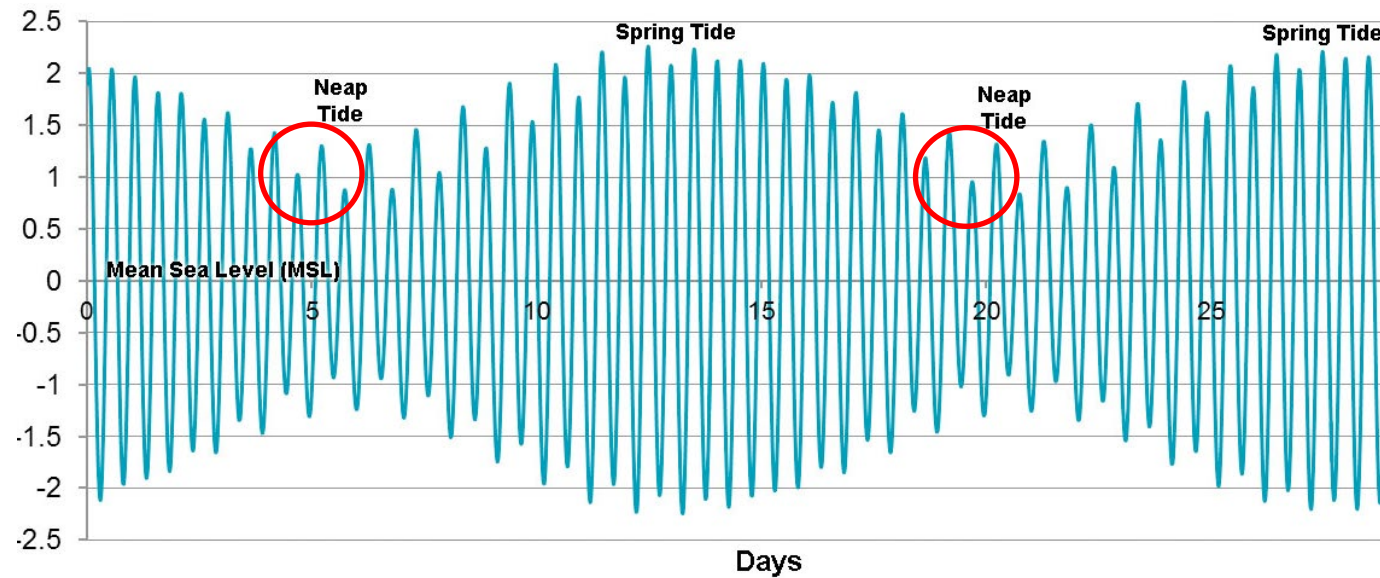


TIDE GENERATION

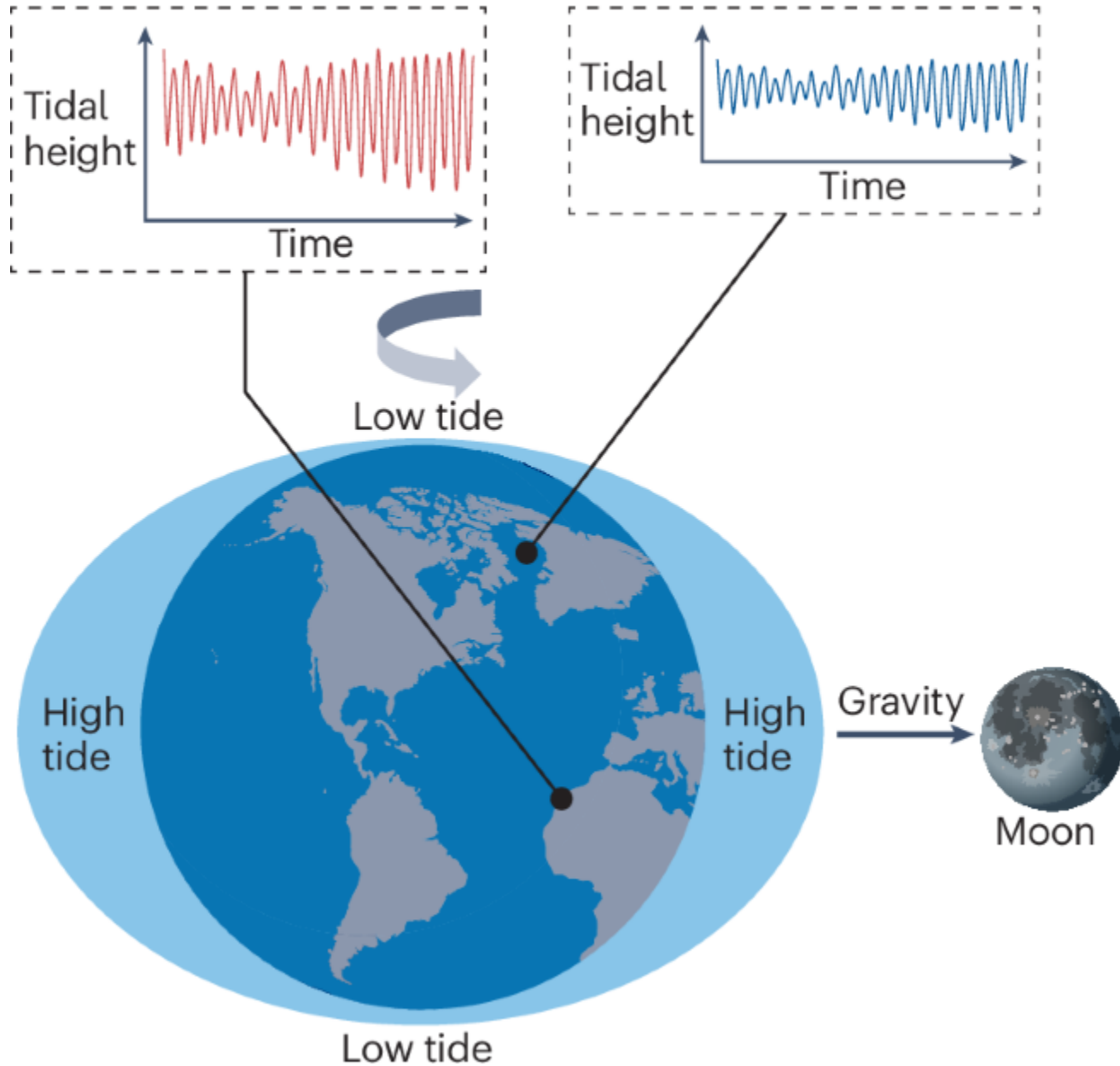
Tidal Resource



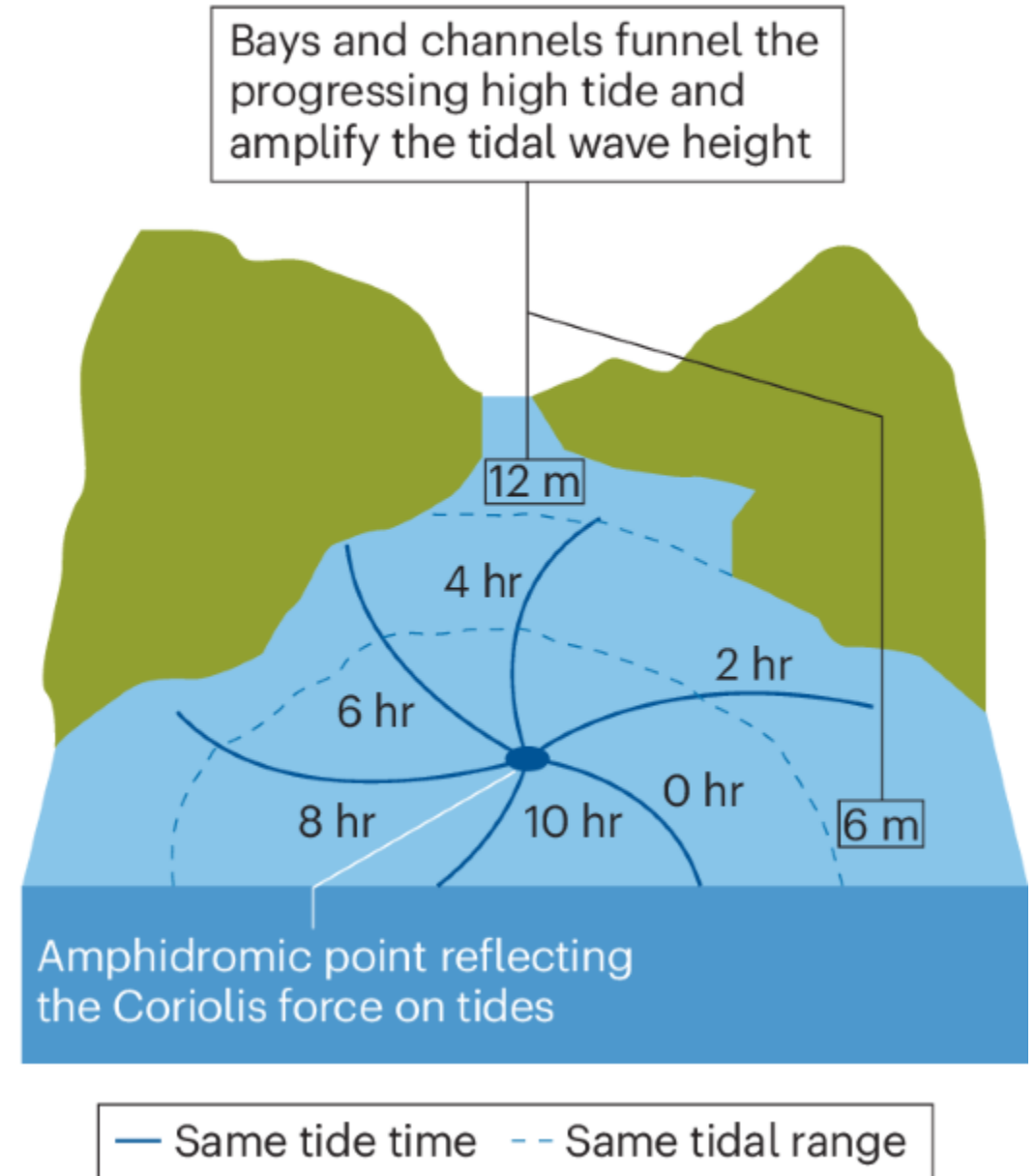
Tidal Resource



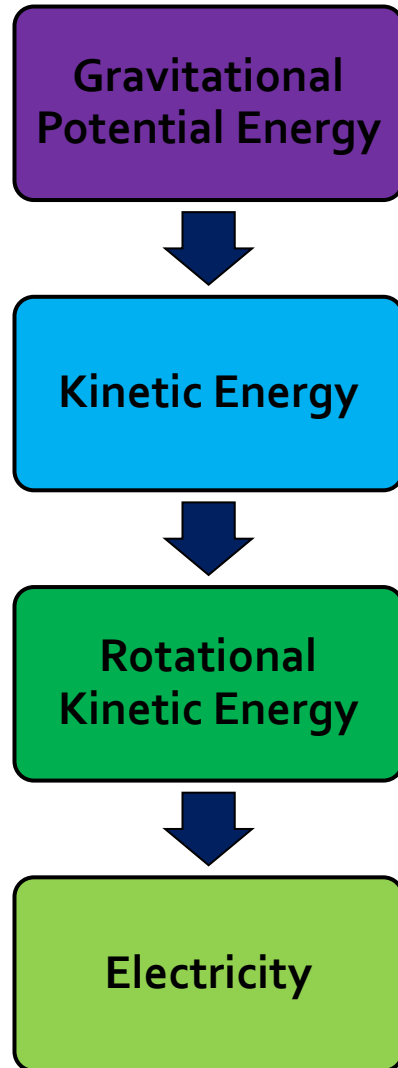
a Factors driving tides



b Tidal funnelling and amphidromic points



Tidal Range



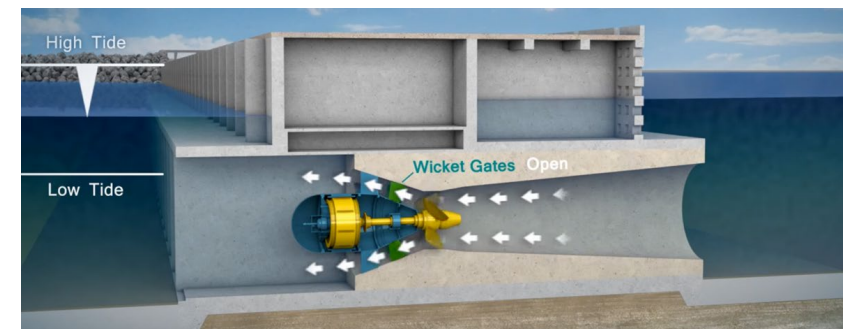
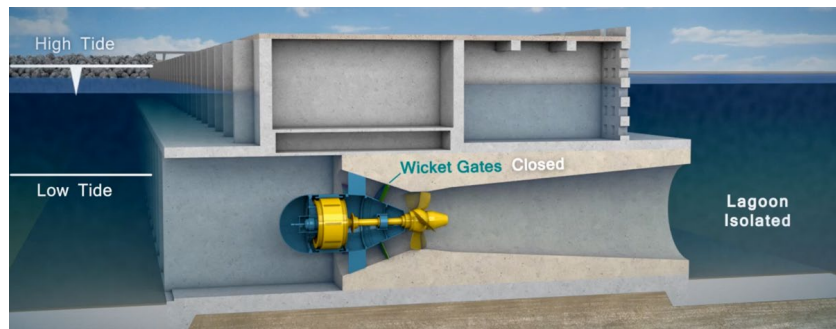
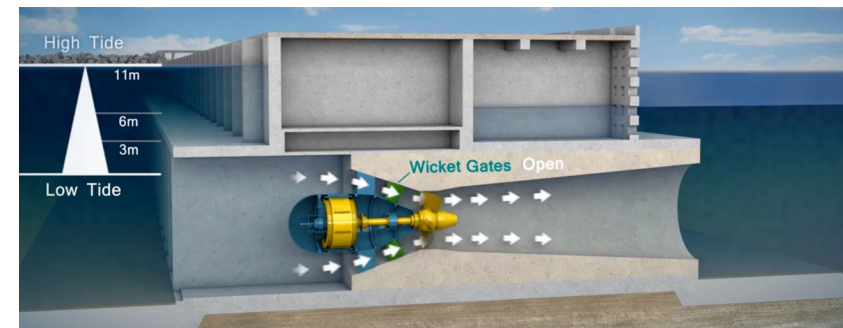
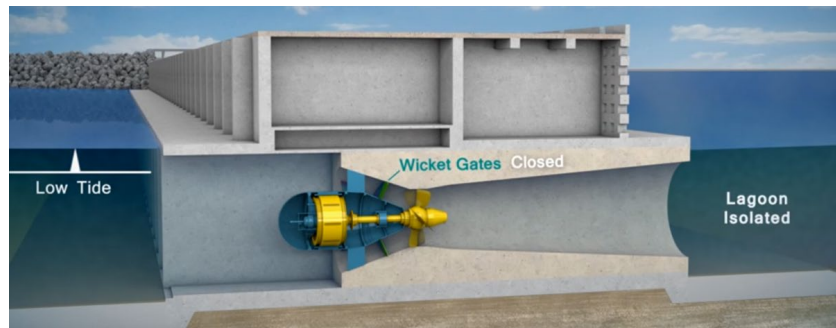
- Tidal barrages are built across estuaries and are designed to extract gravitational potential energy from the rise and fall of tides.
- Energy is extracted by directing water through turbines located in passages within the barrage.



Tidal

There are currently three different ways to get tidal energy: tidal streams, barrages, and tidal lagoons.

Tidal





Tidal

The potential power from hydroelectric is given by the following equation:

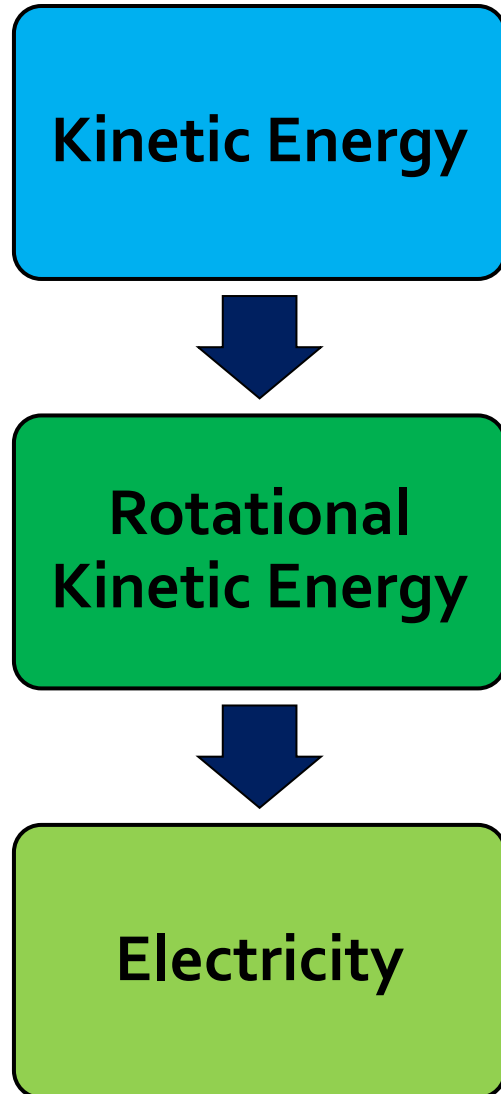
$$P = \frac{1}{2} A \rho g h^2$$

A = Surface Area

ρ = Density of Water

h = Head (Tidal Range)

Tidal Stream



- Tidal stream systems generate electricity from the kinetic energy of moving water — the natural currents created as tides flow in and out of coastal areas, straits, or around headlands.
- It's like how wind turbines generate energy from moving air, except underwater.

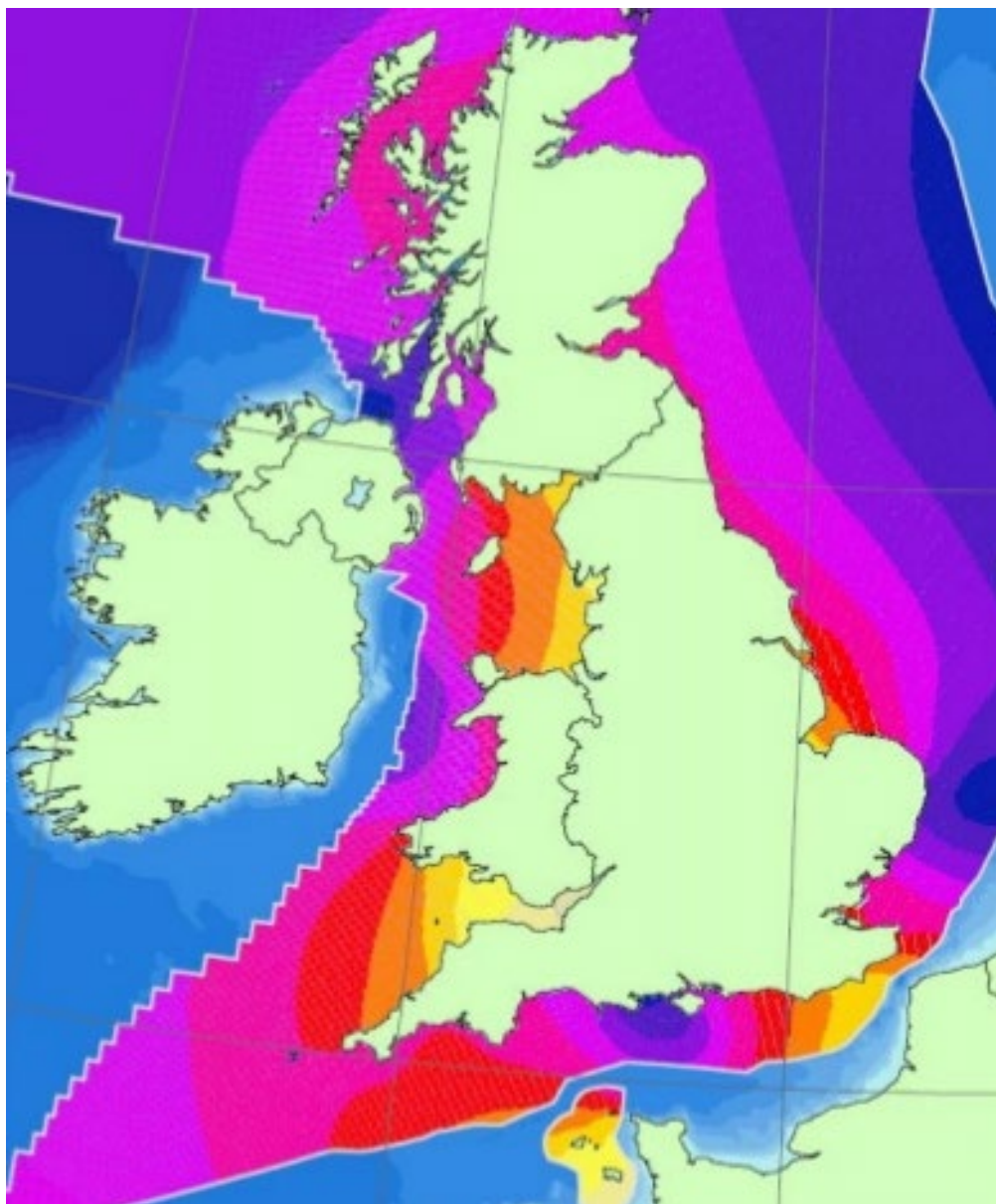


Tidal

Placing turbines in tidal streams is complex, because the machines are large and disrupt the tide they are trying to harness.

The environmental impact could be severe, depending on the size of the turbine and the site of the tidal stream.

Turbines are most effective in shallow water.

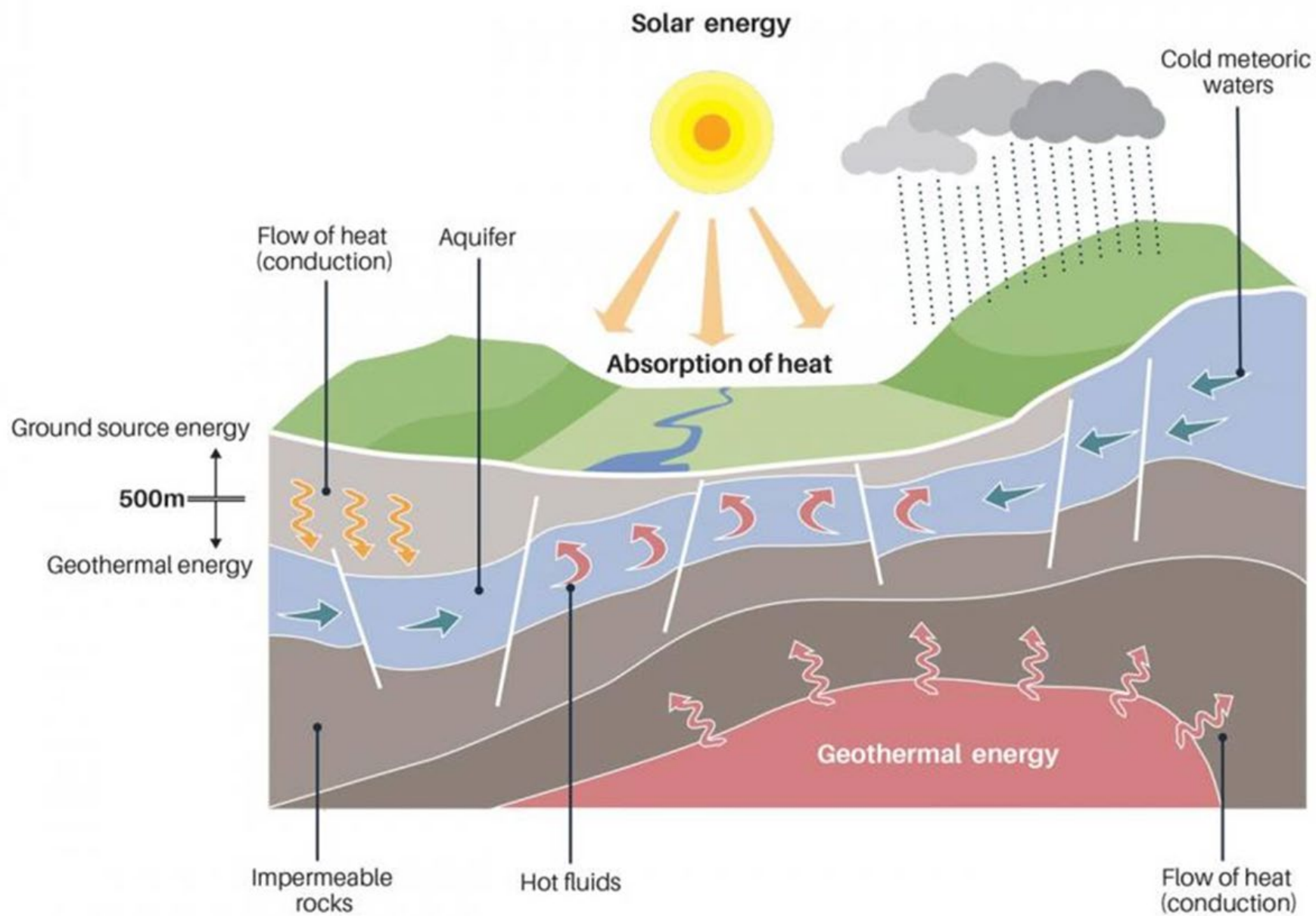




Geothermal

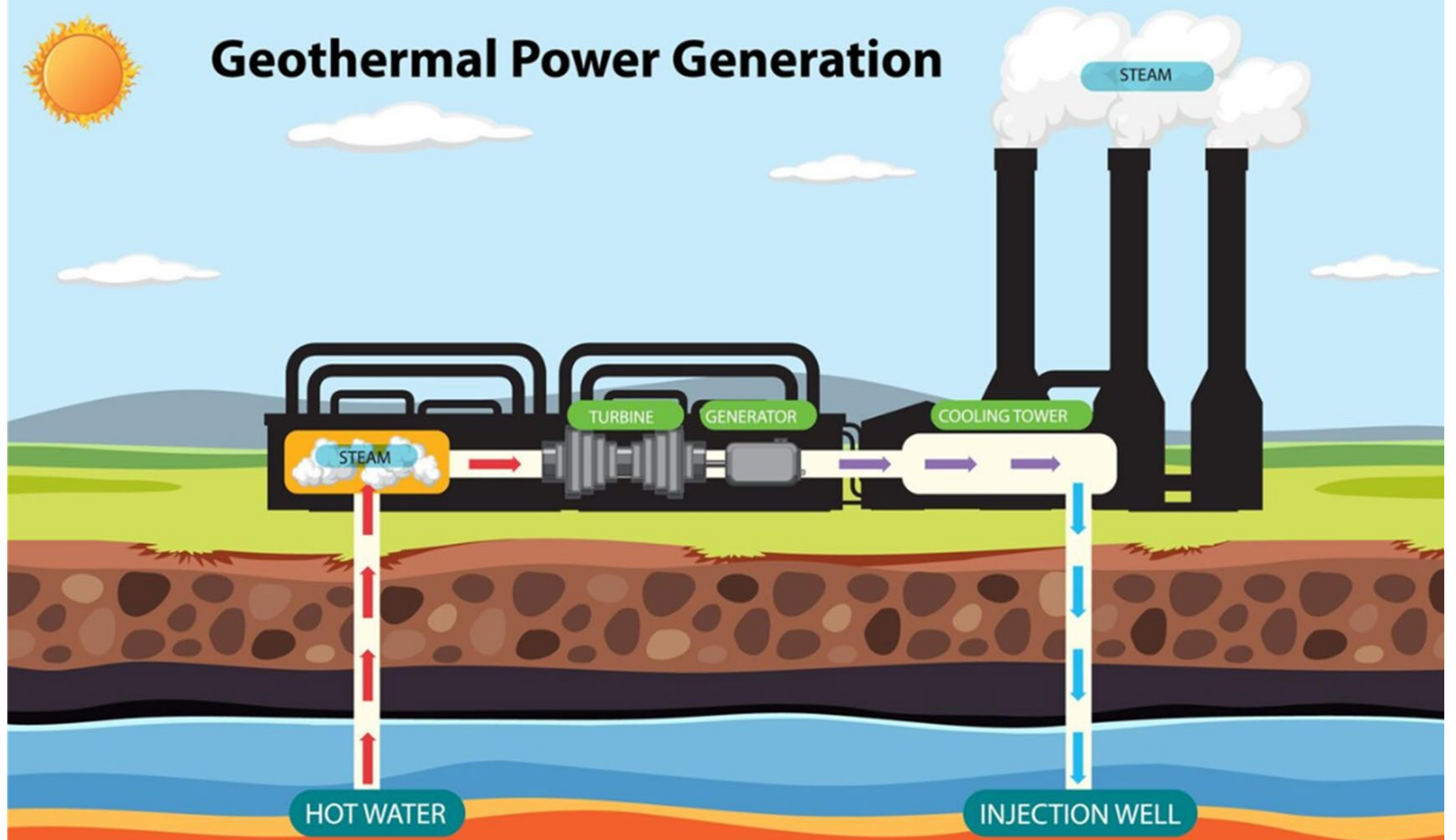
Geothermal energy is all energy stored in the form of heat beneath the surface of the solid earth.

It is a reliable and constant source of low-carbon, renewable heat that is not dependent on weather conditions.

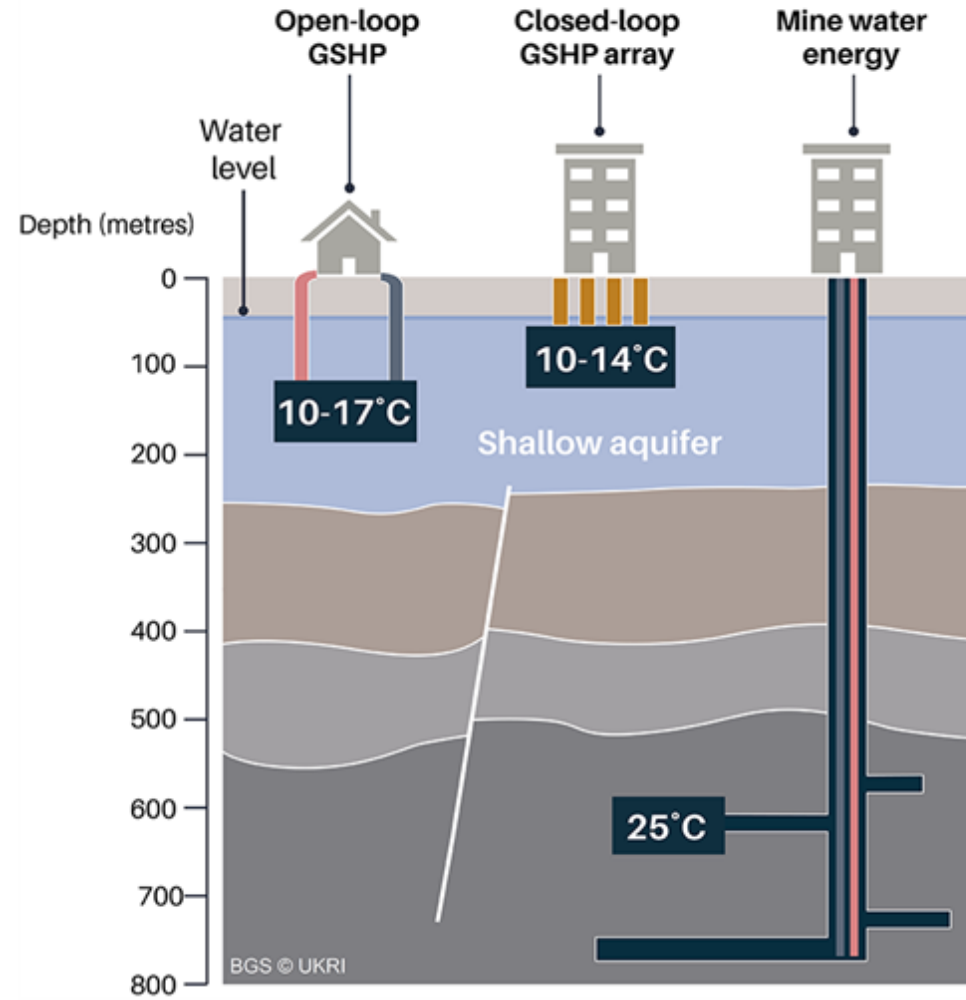




Geothermal Power Generation



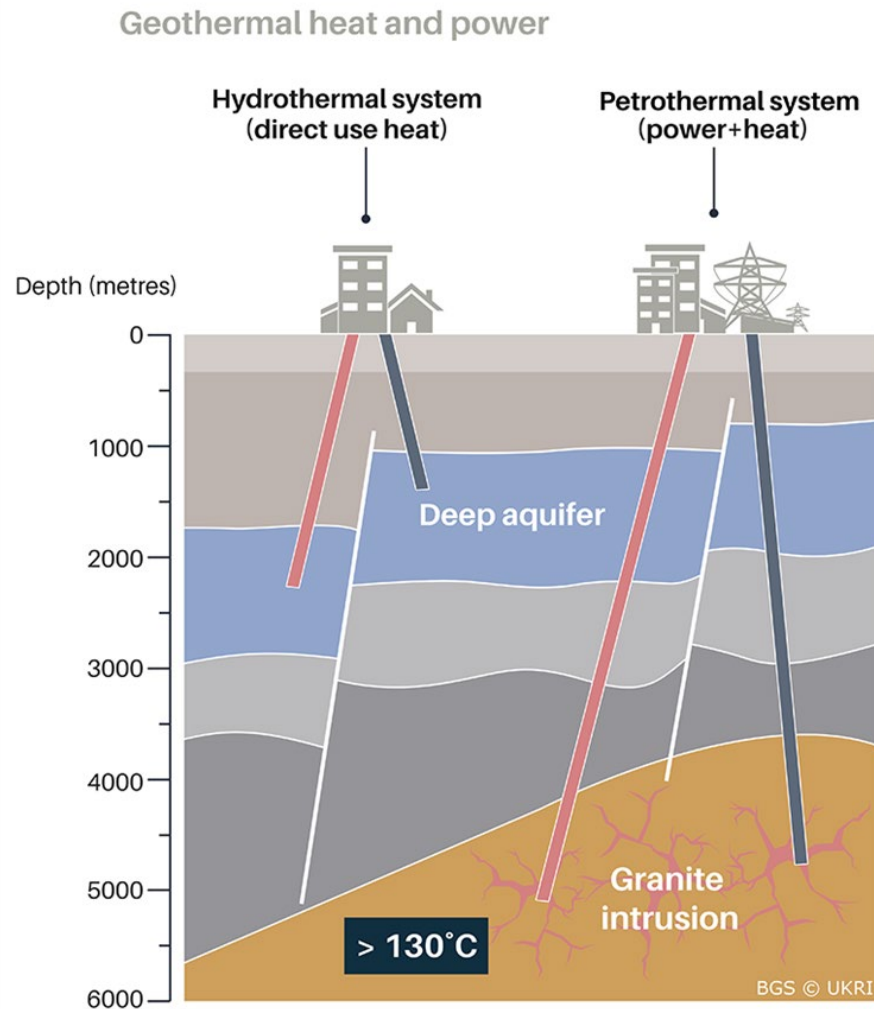
Ground source heating and cooling



Geothermal

The systems use ground-source heat pumps to transfer the heat from the source to the building for (space and water) heating and cooling.

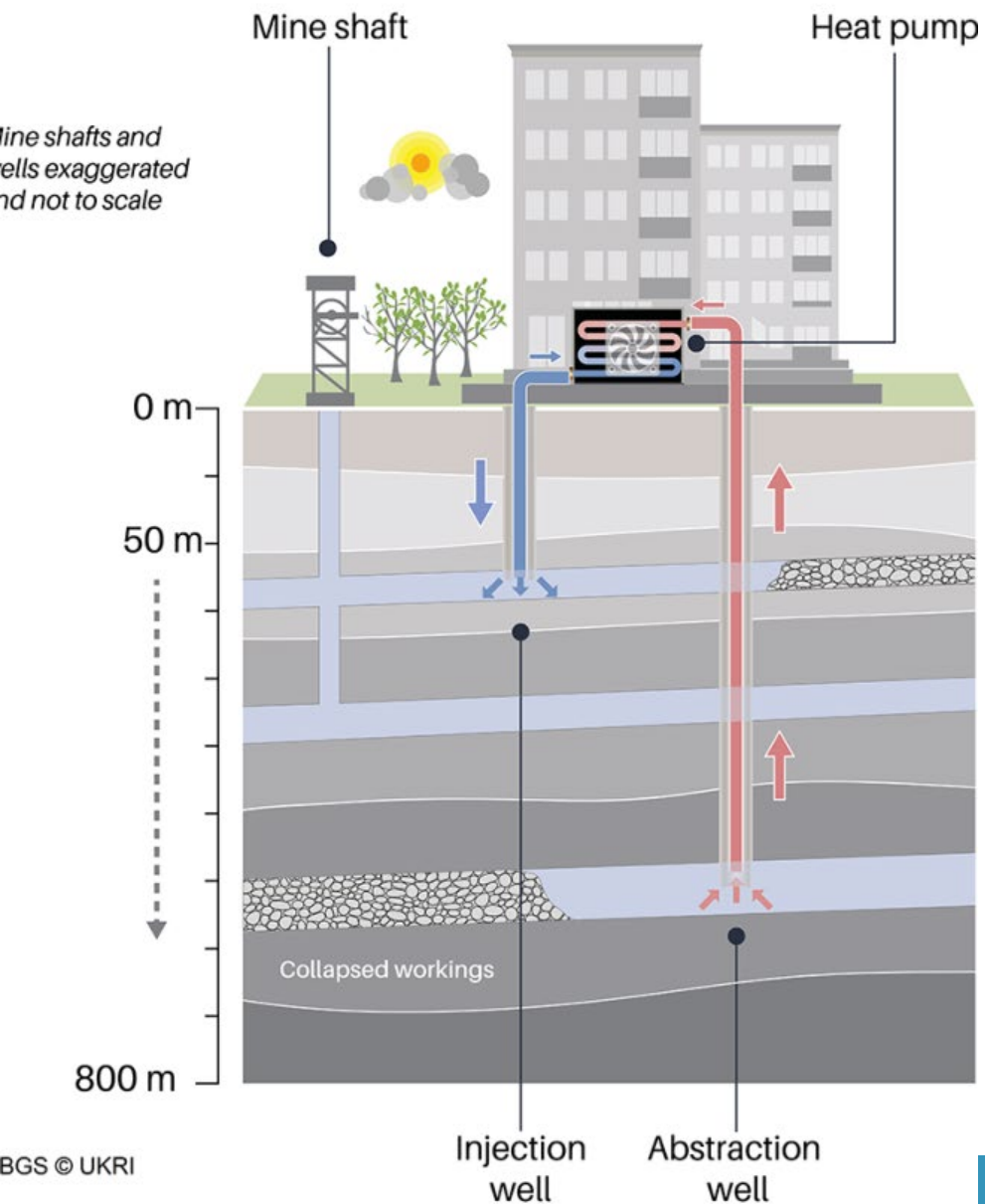
There are two main technologies: closed-loop and open-loop systems.



Geothermal

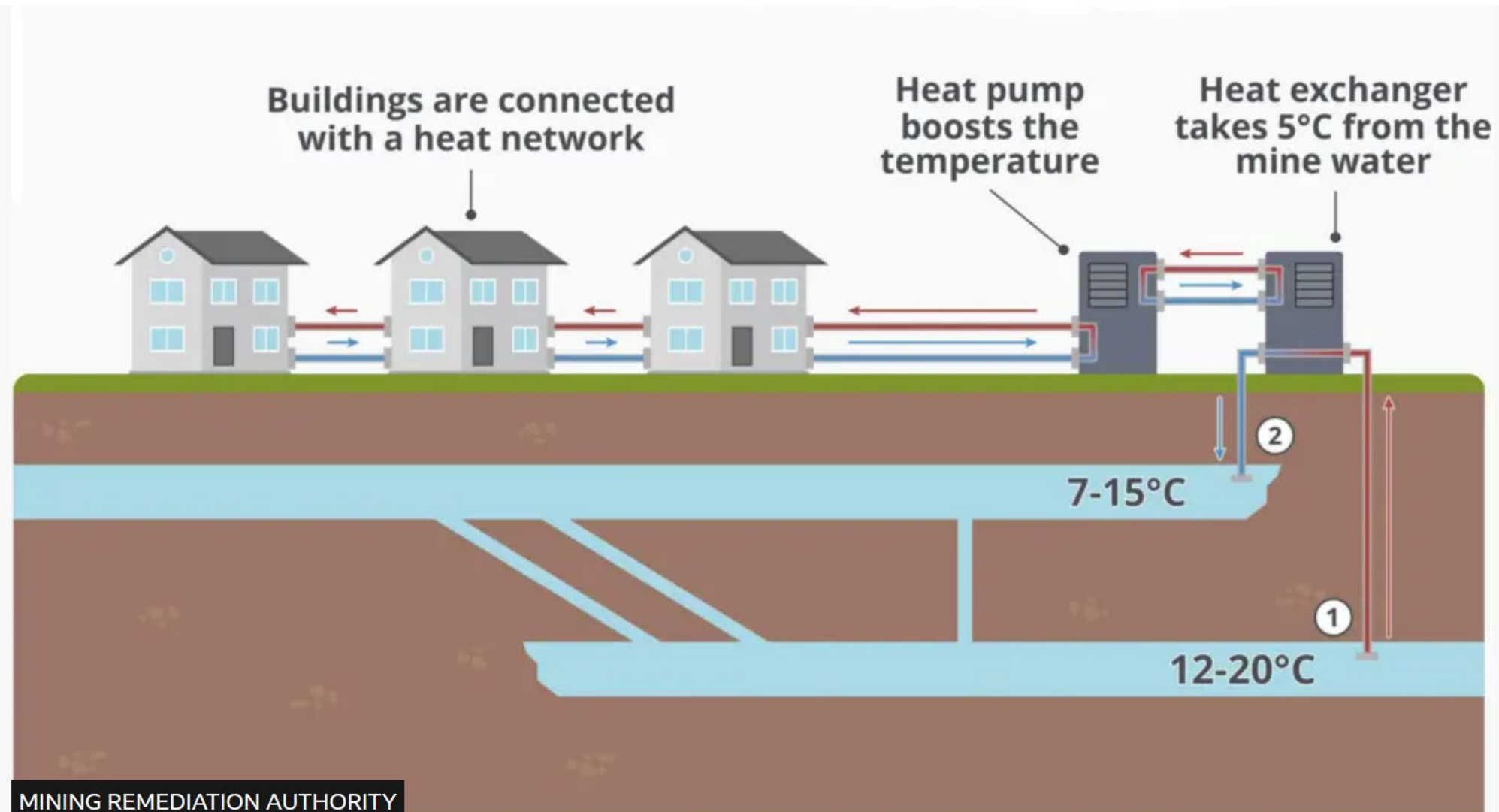
Exploitation of deep geothermal systems requires the drilling of deep wells to reach temperatures that are high enough for direct use (without a heat pump).

In the UK, deep geothermal prospects occur in specific geological settings, including deep sedimentary basins and radioactive granites



Geothermal

- The water within abandoned, flooded mines can be used for geothermal heating, cooling and underground thermal energy storage.
- In these systems, the interconnected galleries, roadways and shafts create a large groundwater resource with very high volumes available to develop large-scale ground-source heat pump systems.
- Water temperatures in the flooded mines are similar to ambient groundwater temperatures (10 to 15°C)



MINING REMEDIATION AUTHORITY

When done at scale, energy centres could be built within communities to boost the temperature of the water from underground