

Water –A bigger picture:

Tides ,Bores, Electricity Generation and it's Earthly Origins

What are they...causes them –and why should we care

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What is a simple definition of gravity?

- Gravity is a force which tries to pull two objects toward each other.
 - Anything which has mass also has a gravitational pull.
 - The more massive an object is, the stronger its gravitational pull is.
 - Earth's gravity is what keeps you on the ground and what causes objects to fall.
- **and makes water run downhill**



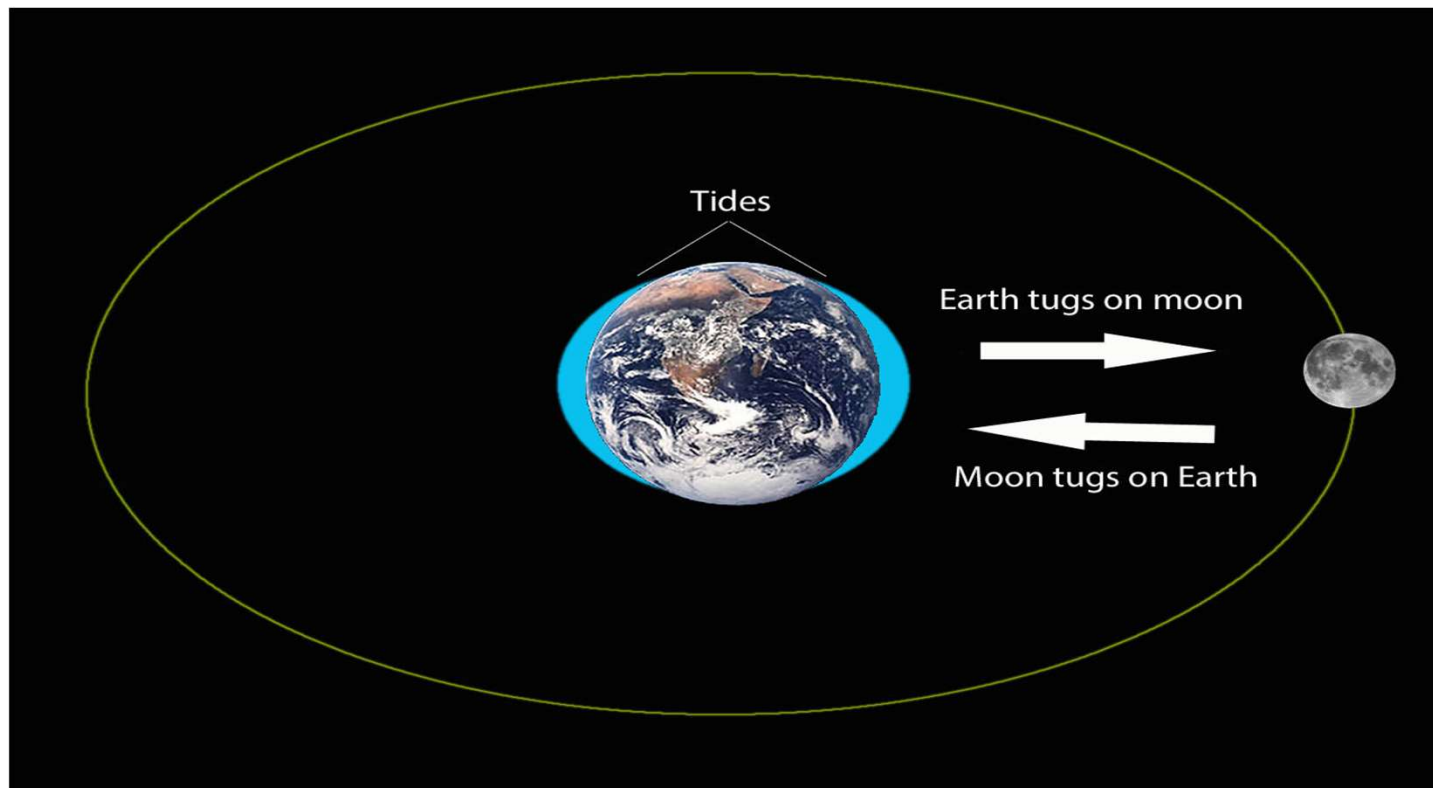
Tides: a definition

- Tides are the rise and fall of the levels of the ocean.
- They are caused by the gravitational pull of the Sun and Moon as well as the rotation of the Earth.

The Short Answer:

- High and low tides are caused primarily by the moon.
- The moon's gravitational pull generates something called the tidal force.
- The tidal force causes Earth—and its water—to bulge out on the side closest to the moon and the side farthest from the moon.
- These bulges of water are high tides.

Gravitational pull — works both ways





Cycles of a Tide

Tides cycle as the Moon rotates around the Earth and as the position of the Sun changes. Throughout the day the sea level is constantly rising or falling.

- 1. The sea level rises**
- 2. High tide is reached**
- 3. The sea level falls**
- 4. Low tide is reached**
- 5. repeat**



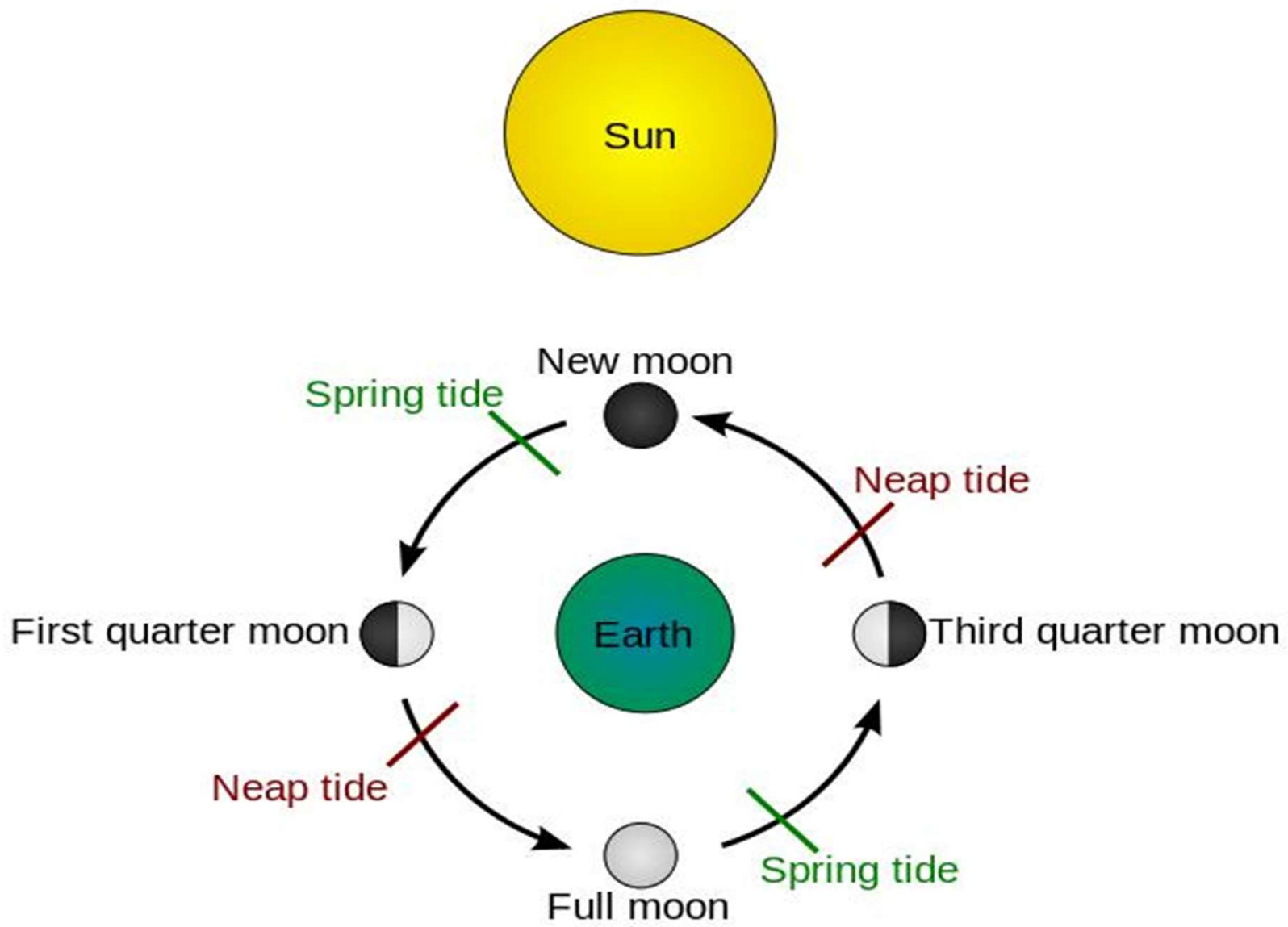
--- and repeat

- Can happen once or twice a day depending on the location of the area to the Moon.
- Tides that happen once a day are called diurnal.
- Tides that happen twice a day are called semidiurnal.
- As the Earth rotates in the same direction as the Moon, the cycle is actually slightly longer than a day at 24 hours and 50 minutes.



Why doesn't the sun cause tides?

- The Sun causes tidal effects just like the moon does, although they are somewhat smaller.
- When the earth, moon, and Sun line up—which happens at times of full moon or new moon—the lunar and solar tides reinforce each other, leading to more extreme tides, called spring tides.
- Tides are influenced more by the moon than the sun **because, the moon is closer to the earth than the sun,** hence its gravitational force becomes more effective than that of the sun.





Tidal Currents

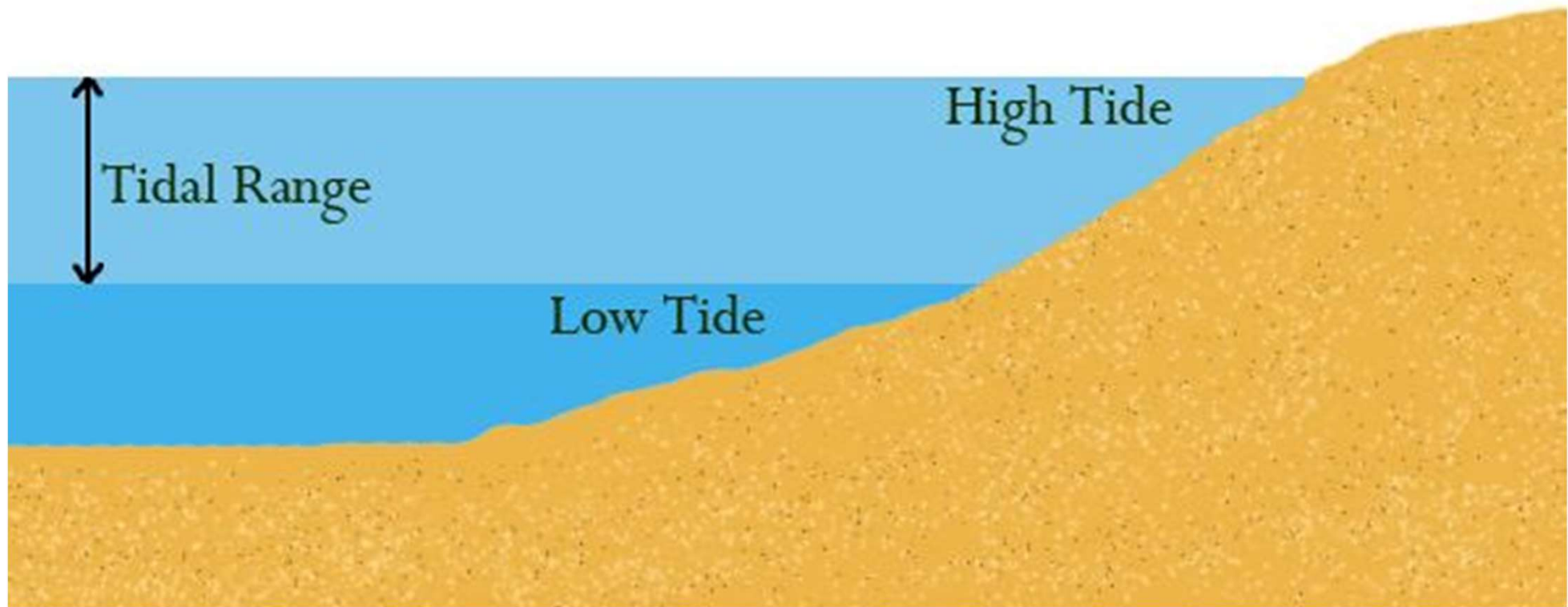
1. When the sea level is rising or falling, water is flowing to or from the sea. This flow causes tidal currents
2. - An incoming tide occurs as sea level rises towards high tide. Water flows towards the shore and away from the sea.
3. Ebb tide - when sea level is dropping towards low tide. Water flows away from the shore towards the sea
4. Slack water - At the exact time of high tide or low tide there is no current.



Tidal Range

- ---is the difference in sea level between low tide and high tide.
- Varies in different locations depending on the location of the Sun and the Moon as well as the topography of the shore line. --- next slide !
- In the open ocean the tidal range is typically around **2 feet.**
/60cm
- Tidal ranges can be much larger near the shore.
- The Bristol Channel has the second highest tidal range in the world, only exceeded by the Bay of Fundy in Canada.---
40 feet

Easier than words!



Types of Tides

- High - where the sea level is at its highest.
- Low - where the sea level is at its lowest.
- Spring - when the Sun and the Moon are aligned to combine for the largest tidal range of the highest high tide and the lowest low tide.
- Neap - when the tidal range is at its smallest. This occurs during the first and third quarters of the Moon.



What is a (tidal) 'bore'

- Tidal bores are spectacular surges of water that travel inland in some estuaries on the highest tides.
- Of the hundred or so worldwide, about twenty occur in England, Scotland and Wales.
- They are perhaps one of the natural wonders of the world and the best known is the Severn bore



What's a bore 2

- The largest annual tides occur around the times of the Spring Equinox in the month of March and the Autumn Equinox during the month of September
- Further reinforced during the period of the full moon or the new moon phases, leading to the highest of all tidal bore waves.

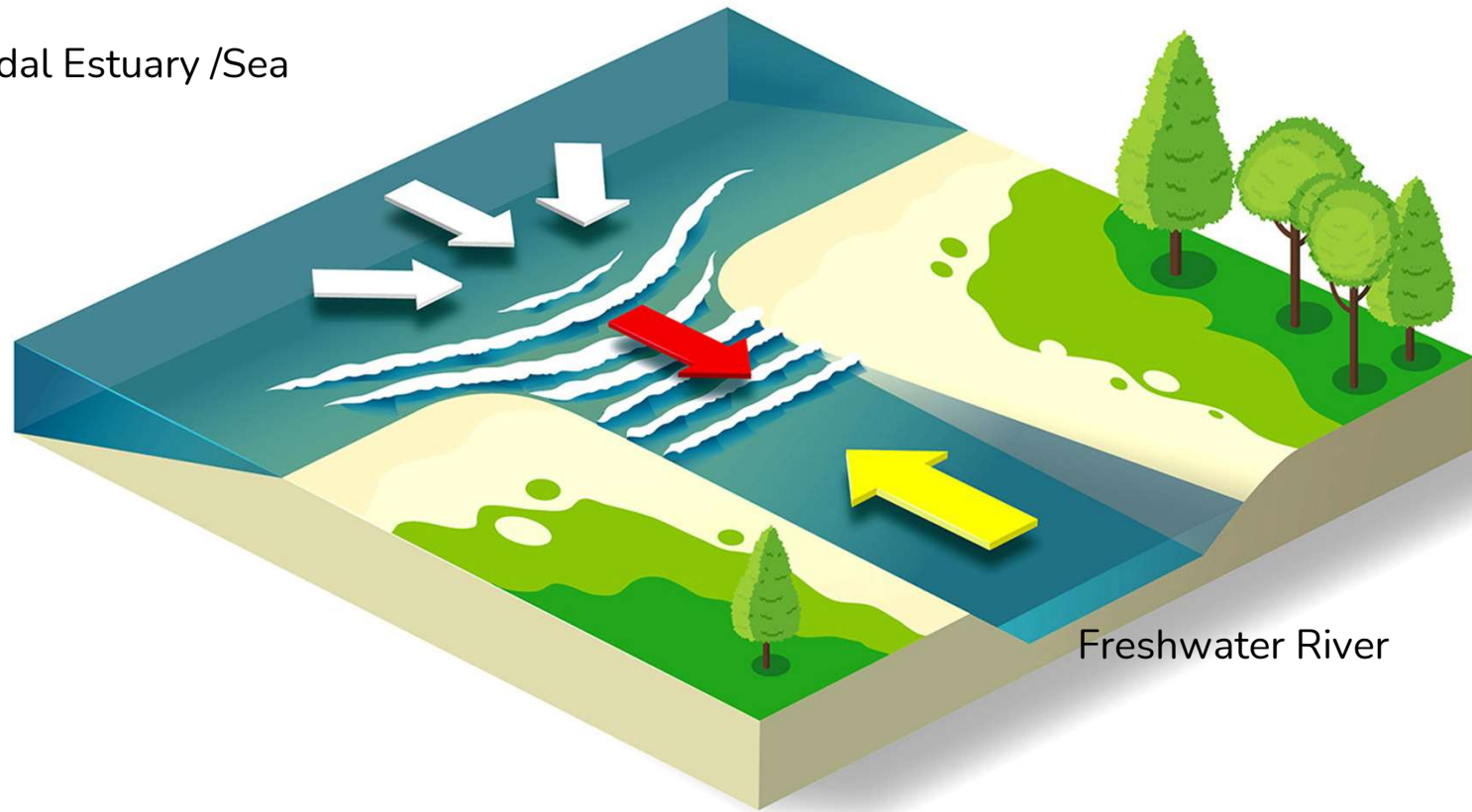


What causes a tidal bore ?

- Tidal bores, or tidal surges, river bores or aegirs, occur **when a shallow river with a narrow sea outlet, situated on a wide, flat estuary, surges upstream against the natural flow of the river's current, causing the incoming tide to form a wave, or a series of waves.**
- Tidal bores **can occur on a daily basis, but they are at their highest during times of very high tides.**
- **High tides** occur during the phases of a full moon or new moon, when the gravitational force of both the sun and the moon reinforce one another.

Tidal Bore – The How

Tidal Estuary /Sea



Tidal bores – locations in England, Scotland and Wales –10 best



Morecambe Bay



The **Wiggenhall Wave**



- Occurs in the Great Ouse, inland from the port of King's Lynn. It sometimes travels several miles upstream.
- The name Wiggenhall Wave was coined by local resident
- The bore attains a height of around one meter and travels to the Norfolk village of Wiggenhall, a distance of about ten miles.
- On the inside cover of a local Parish Register there is perhaps the earliest written record of wave watching. — recorded in 1558,

Second largest bore in the world, is on the

River Severn.



- **The largest and best-known tidal bore in the UK.**
- **In the right conditions it attracts large crowds of spectators, plus surfers and kayakers to ride the wave.**
- **It begins in the wider parts of the Severn Estuary and on some occasions reaches Maisemore near Gloucester, where it ends on hitting a weir.**

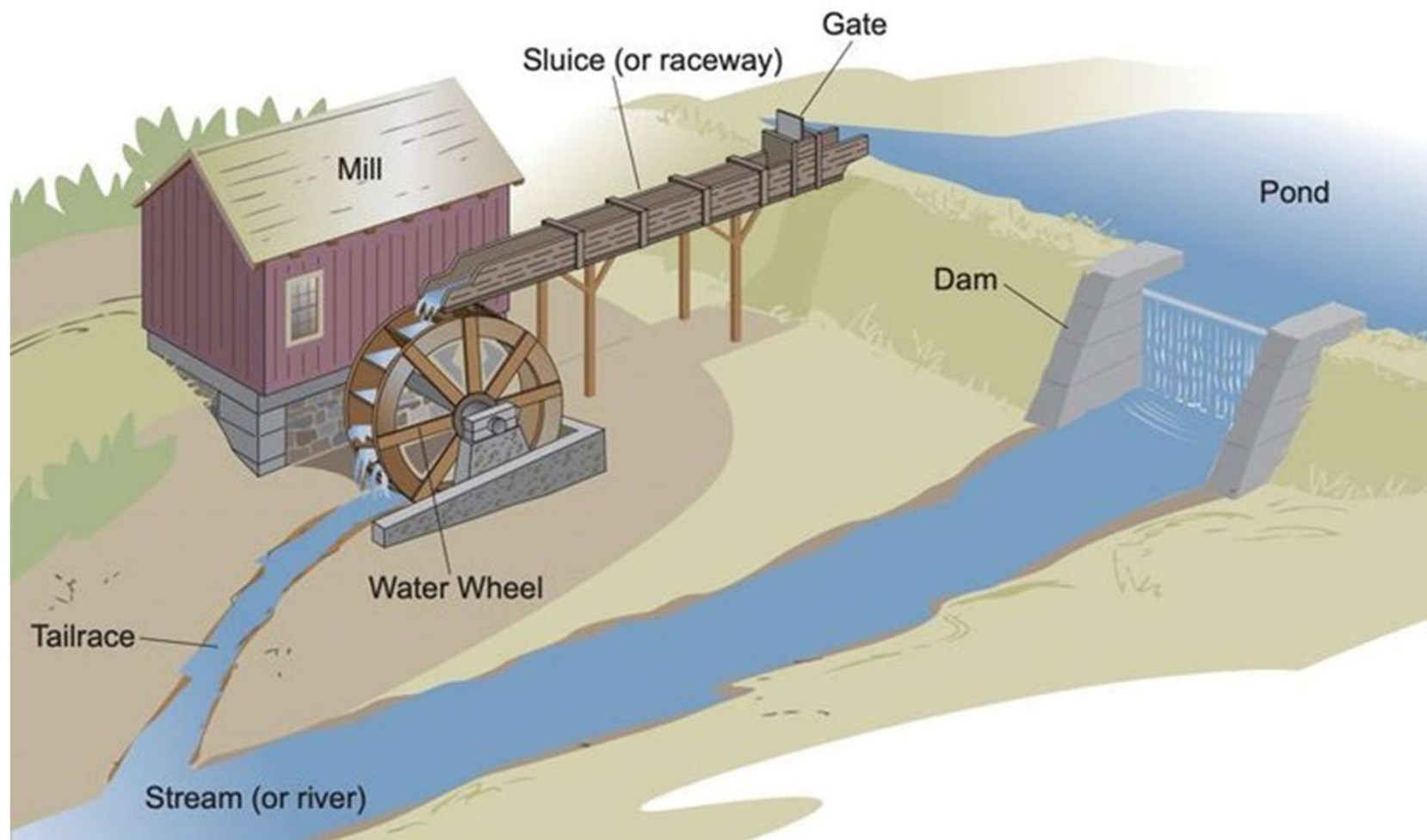
When I was there it was cold and dark !





Water and Gravity – useful power source

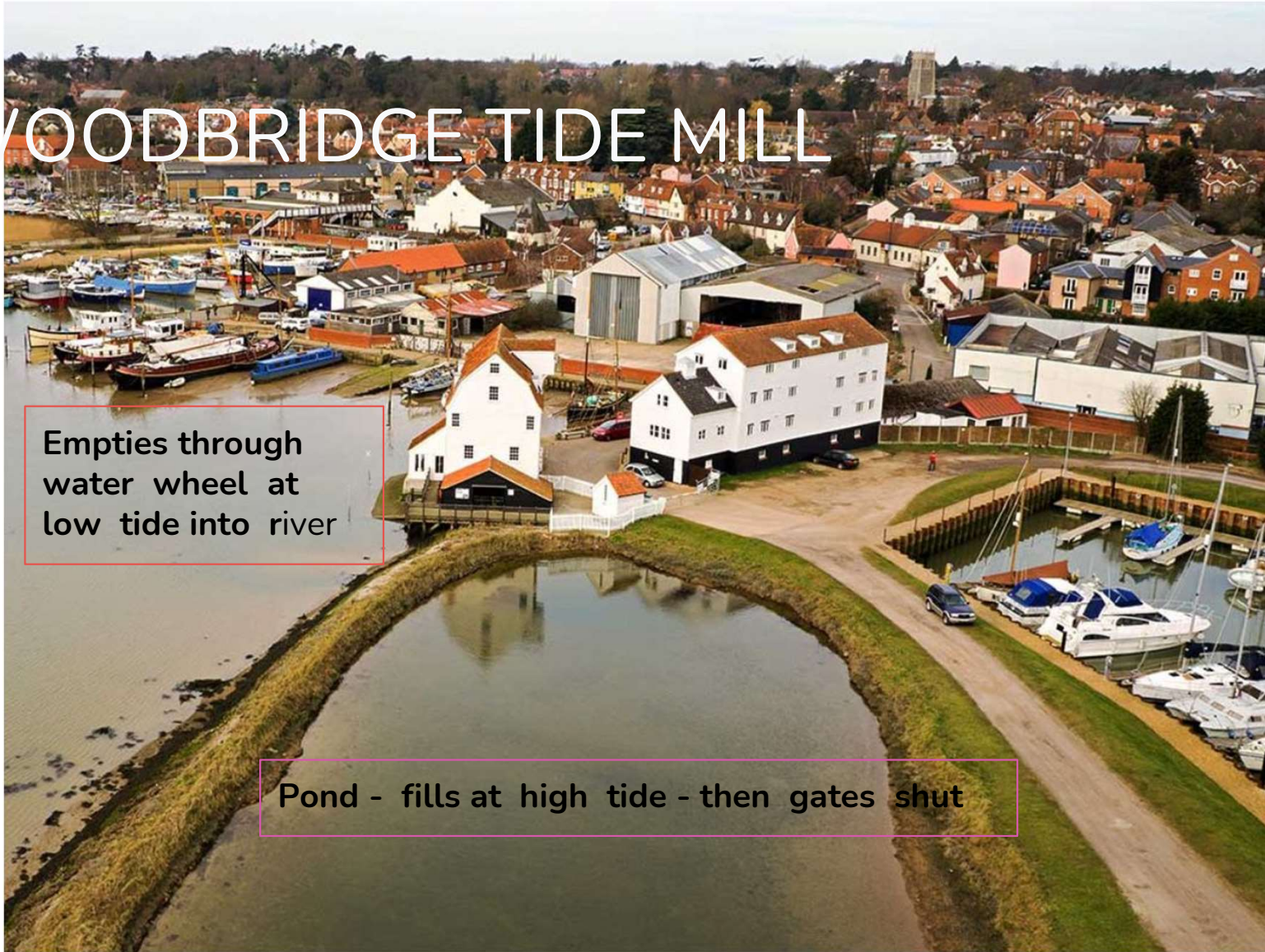
- **Water power**, diverted from rivers and channeled through water mills,-- was a more reliable source of energy than wind and became common throughout the world.
- Approx 2000 years ago, the Greeks, Romans, and Chinese were some of the earliest to adapt the idea of using water power captured by a water wheel for grinding grains, making iron, and sawing wood.
- Example: locally Pakenham Mill – towards BSE – not so common in East Anglia - flat and dry – And Woodbridge tide Mill - stored water at high tide stored and run through as low tide



WOODBIDGE TIDE MILL

Empties through
water wheel at
low tide into river

Pond - fills at high tide - then gates shut



Hydro electricity generation

- All streams and rivers flow downhill. – our old friend gravity once again
- Before the water flows down the hill, it has potential ‘useable’ energy because of its height.
- Hydropower systems convert this potential energy into kinetic energy in a turbine, which drives a generator to produce electricity — about 16% of all world electricity generation

So how much electricity do you get ?

$$P = m \times g \times H_{\text{net}} \times \eta$$

P = power, measured in Watts (W).

M = mass flow rate in kg/s (numerically the same as the flow rate in litres/second because 1 litre of water weighs 1 kg)

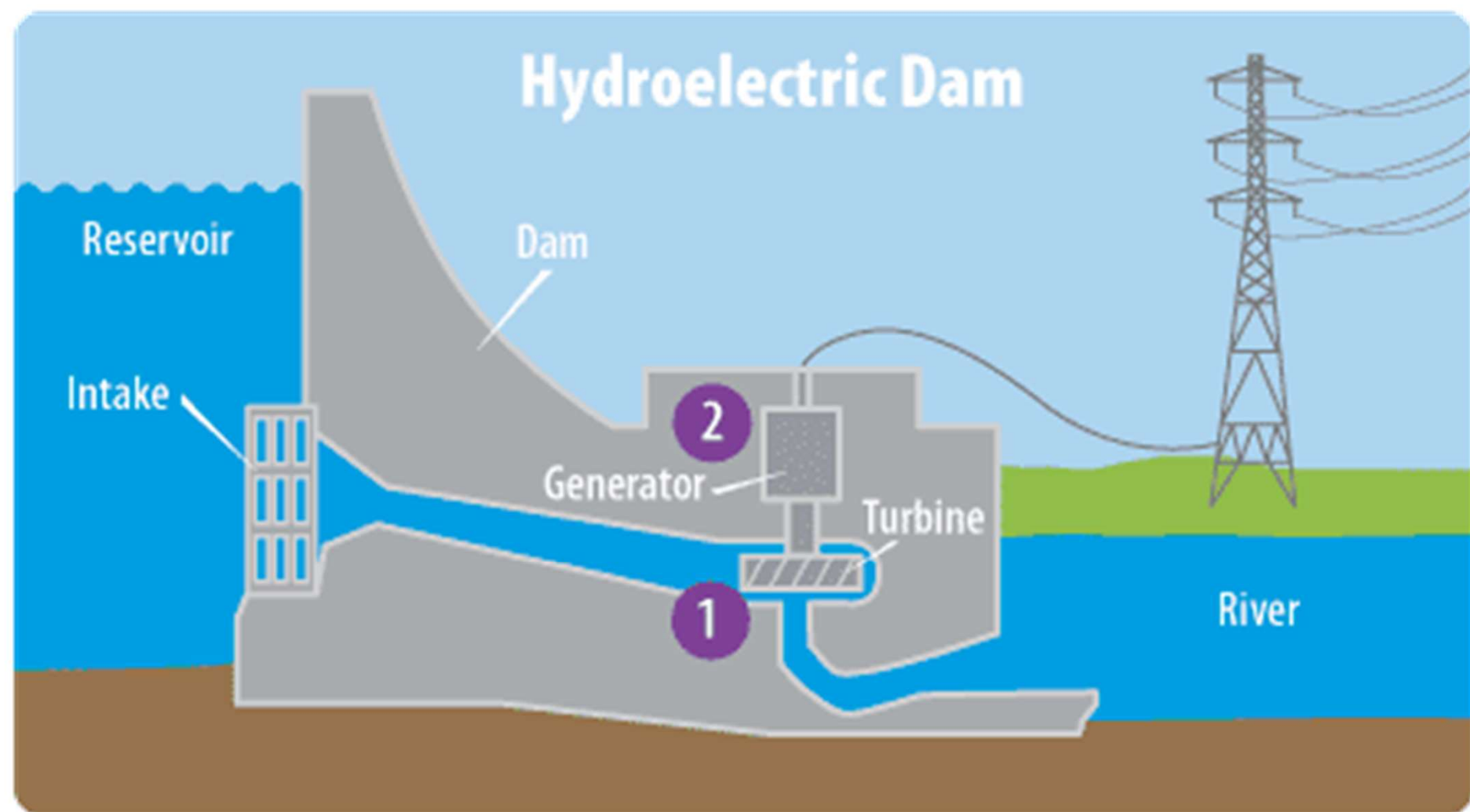
G = the gravitational constant, which is 9.81m/s²

H_{net} = the net drop. This is the gross drop measured at the site, less To keep things simple drop losses can be assumed to be 10%, so H_{net}=H_{gross} x 0.9

H = the product of all of the component efficiencies, which are normally the turbine, drive system and generator

N = For a typical hydro system the turbine efficiency would be 85%, drive efficiency 95% and generator efficiency 93%,

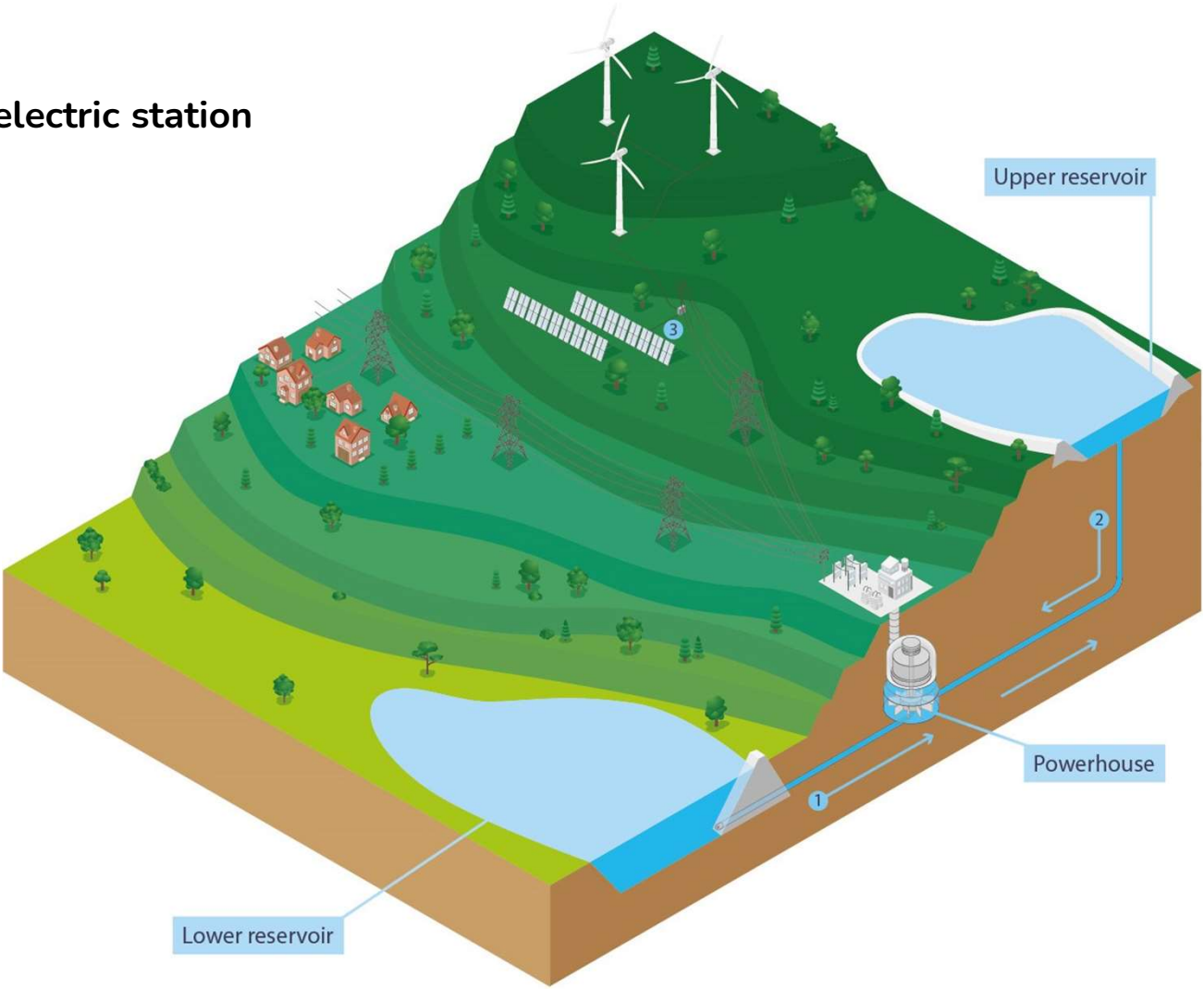
Hydroelectric Dam



Pumped hydropower storage – a variable version

- **Also — uses the force of gravity to generate electricity using water that has been previously pumped from a lower source to an upper reservoir.**
- **The water is pumped to the higher reservoir at times of low demand and low electricity prices. At times of high demand - and higher prices - the water is then released to drive a turbine to generate electricity.**
- **The energy storage capacity of a pumped hydro facility depends on the size of its two reservoirs, while the amount of power generated is linked to the size of the turbine.**

Pumped Hydro electric station

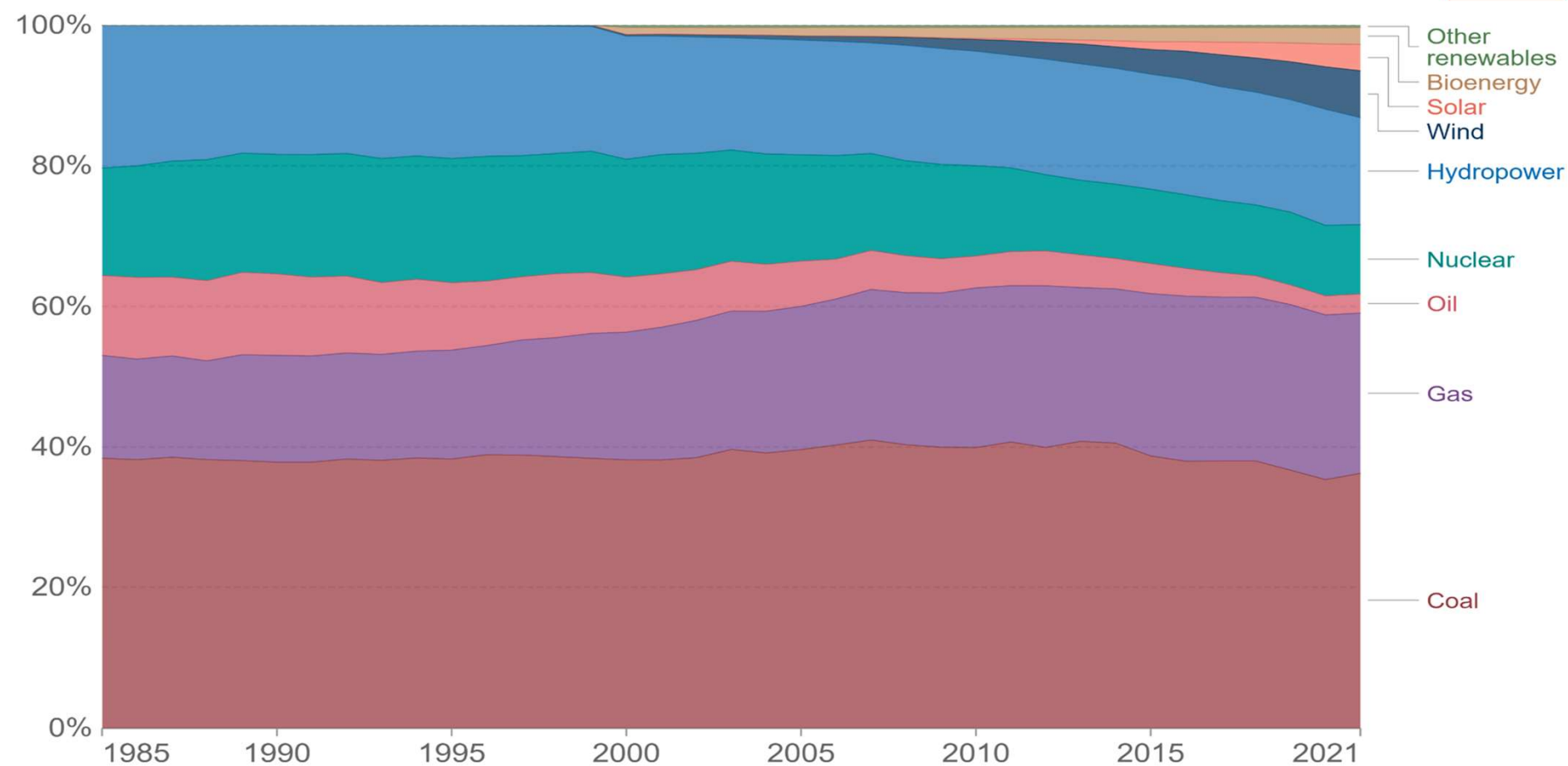


World's biggest battery

- **Pumped storage hydropower can be seen as the world's largest battery technology, accounting for over 94 per cent of installed global energy storage capacity, ahead of lithium-ion and other battery types.**
- **The International Hydropower Association (IHA) estimates that pumped hydro projects worldwide store up to 9,000 gigawatt hours (GWh) of electricity.**
- **— - a resurgence of interest with more than 100 projects in the pipeline **estimates that pumped hydropower storage capacity is expected to increase by almost 50 per cent – by 2030.****

Electricity production by source, World

Our World
in Data



Source: Our World in Data based on BP Statistical Review of World Energy (2022); Ember (2023)
Note: 'Other renewables' includes waste, geothermal, wave and tidal.

OurWorldInData.org/energy • CC BY

Earth's water – How much is there ?

- Some 70 %of Earth's surface is covered by oceans, —BUT they make up just a small fraction of the mass of the planet. 0.023% (1 part in 400) of the total mass of Earth,
- A much smaller amount is estimated to exist in ice, lakes, rivers, groundwater, and atmospheric water vapor.
- A significant amount of water is also stored in Earth's crust, mantle, and core. Unlike molecular H_2O that is found on the surface, interior water exists primarily in hydrated minerals or as trace amounts of hydrogen bonded to oxygen atoms in anhydrous minerals.
- While it is difficult to estimate is the total water content of the 'inside'--, approximately three times the mass of the Earth's oceans is estimated could be stored there— Total still around 1% the mass of the earth



Where on earth does water come from on earth ?

Multiple geochemical studies conclude that **asteroids are most likely the primary source of Earth's water.**

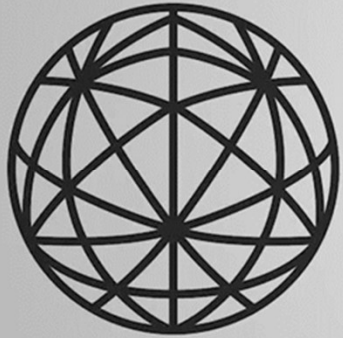
– more specifically – Carbonaceous chondrites—which are a subclass of the oldest meteorites in the Solar System—these have isotopic levels most similar to ocean water.

Meteorite:-- is a solid piece of debris from an object, such as a comet, asteroid, or meteoroid, that originates in outer space and survives its passage through the atmosphere to reach the surface of a planet or moon.

Several groups of carbonaceous chondrites, notably, contain high percentages (3% to 22%) of water, as well as organic compounds.

Short Video from PBS

youtu.be/UdPpxljvu0I?t=4



BRILLIANT



AND finally - almost breaking news

NEWS RELEASE 27-AUG-2020

Meteorite study suggests Earth may have been wet since it formed
Enstatite chondrite meteorites, once considered 'dry,' contain enough water to fill the oceans -- and then some

Peer-Reviewed Publication

WASHINGTON UNIVERSITY IN ST. LOUIS

A new study finds that Earth's water may have come from materials that were present in the inner solar system at the time the planet formed -- instead of far-reaching comets or asteroids delivering such water. The findings published Aug. 28 in *Science* suggest that Earth may have always been wet.

THE END

