My father rode a camel. I drive a car. My son flies a jet airplane. His son will ride a camel.

Sheik Rashid bin Saeed Al Maktoum (1982)

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SES 194

Energy in Everyday Life

Renewables and Hydroelectric

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Renewable energy means a source that isn't significantly depleted by using it. Examples include

Sunlight - the Sun will rise and shine again tomorrow

Wind - driven by the Sun

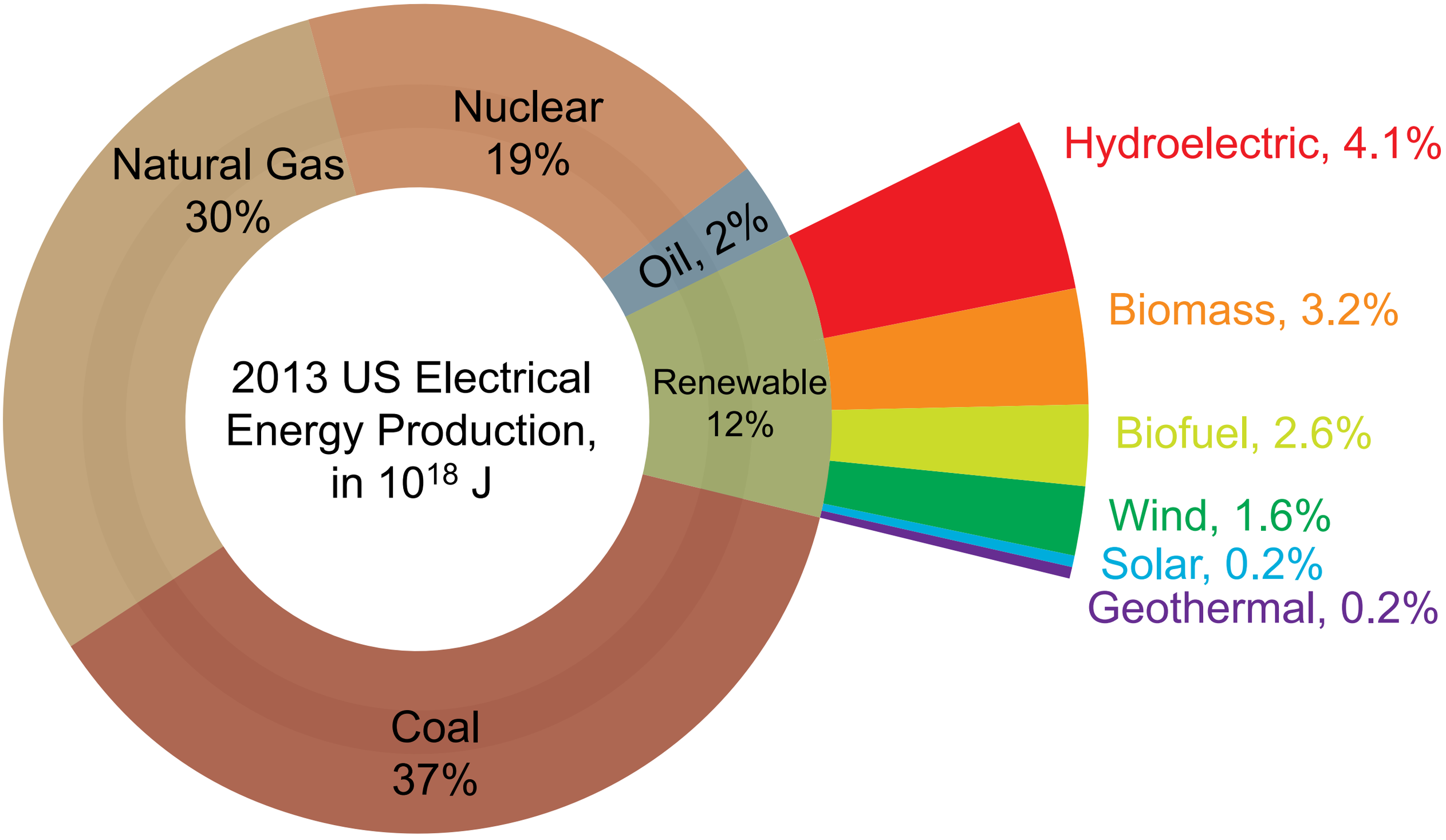
Ocean currents - driven by Sun

Biomass - algae and crops grows again, driven by the Sun

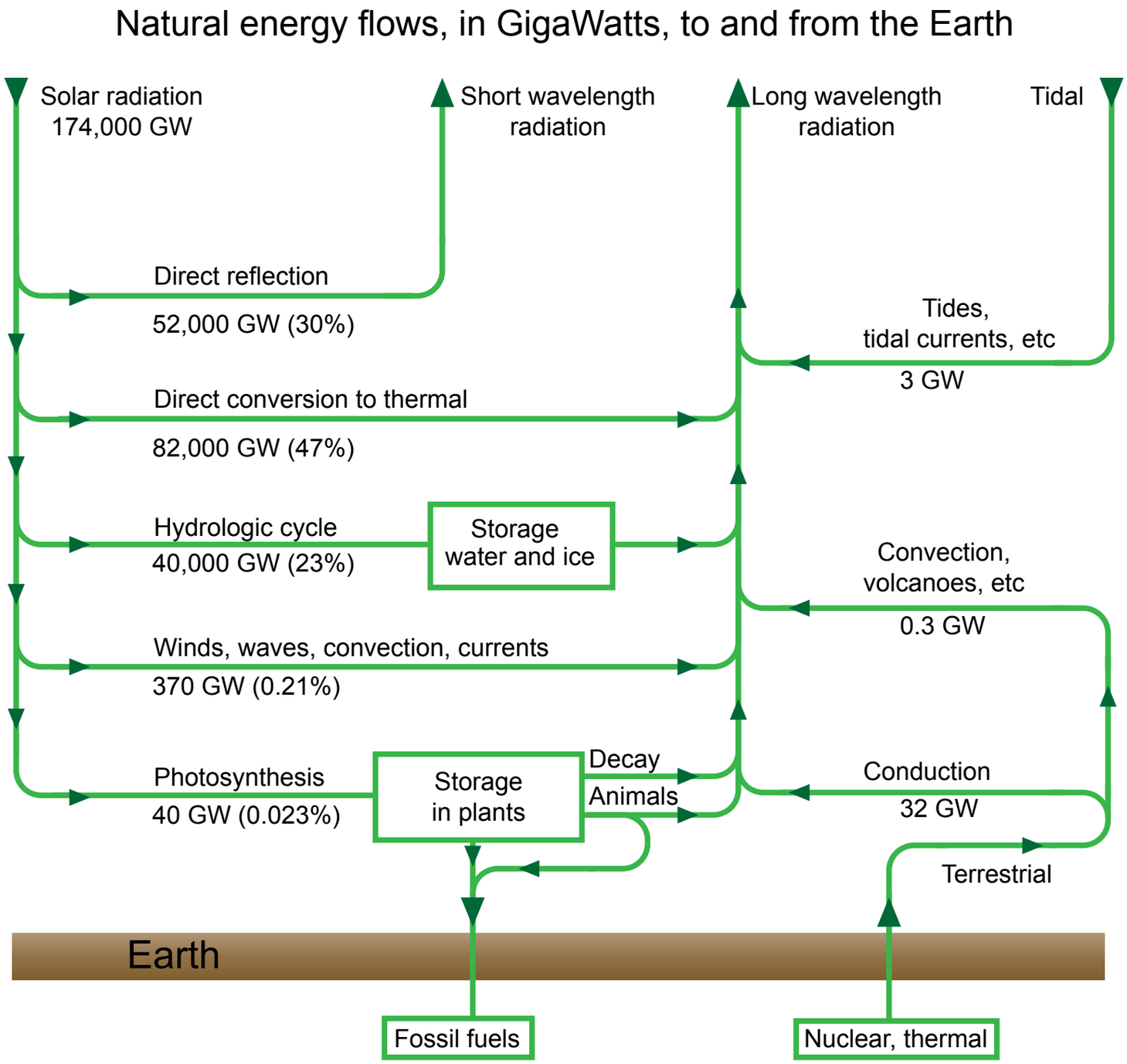
Hydrological cycle - it will rain again, driven by the Sun

Geothermal - Earth will continue to radiate heat

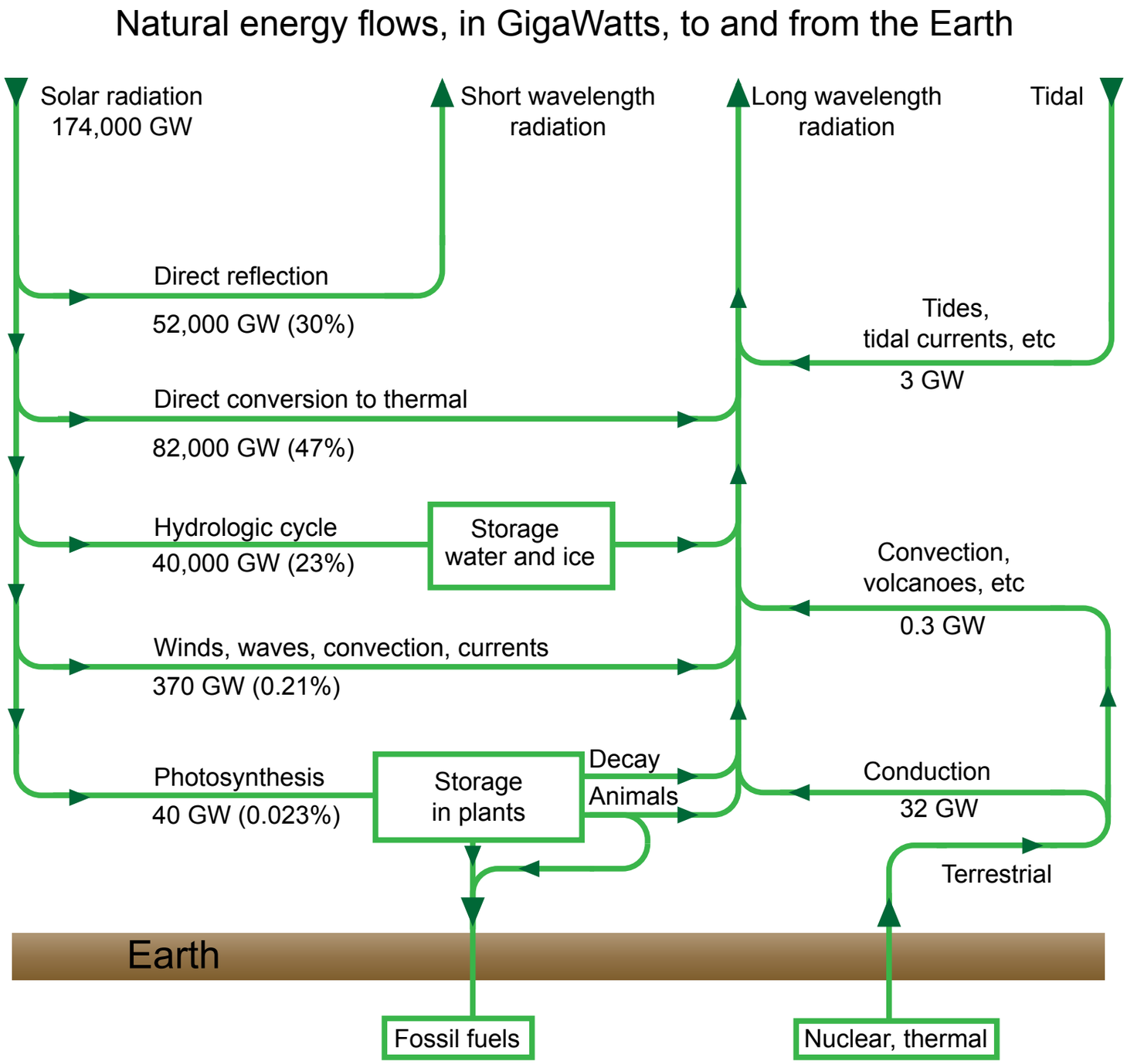
Tidal Motion - Sun and Moon will continue their orbital dance


2013 US Electrical Energy Production, in 10^{18} J
Natural Gas 30%
Nuclear 19%
Oil, 2%
Renewable 12%
Coal 37%
Hydroelectric, 4.1%
Biomass, 3.2%
Biofuel, 2.6%
Wind, 1.6%
Solar, 0.2%
Geothermal, 0.2%

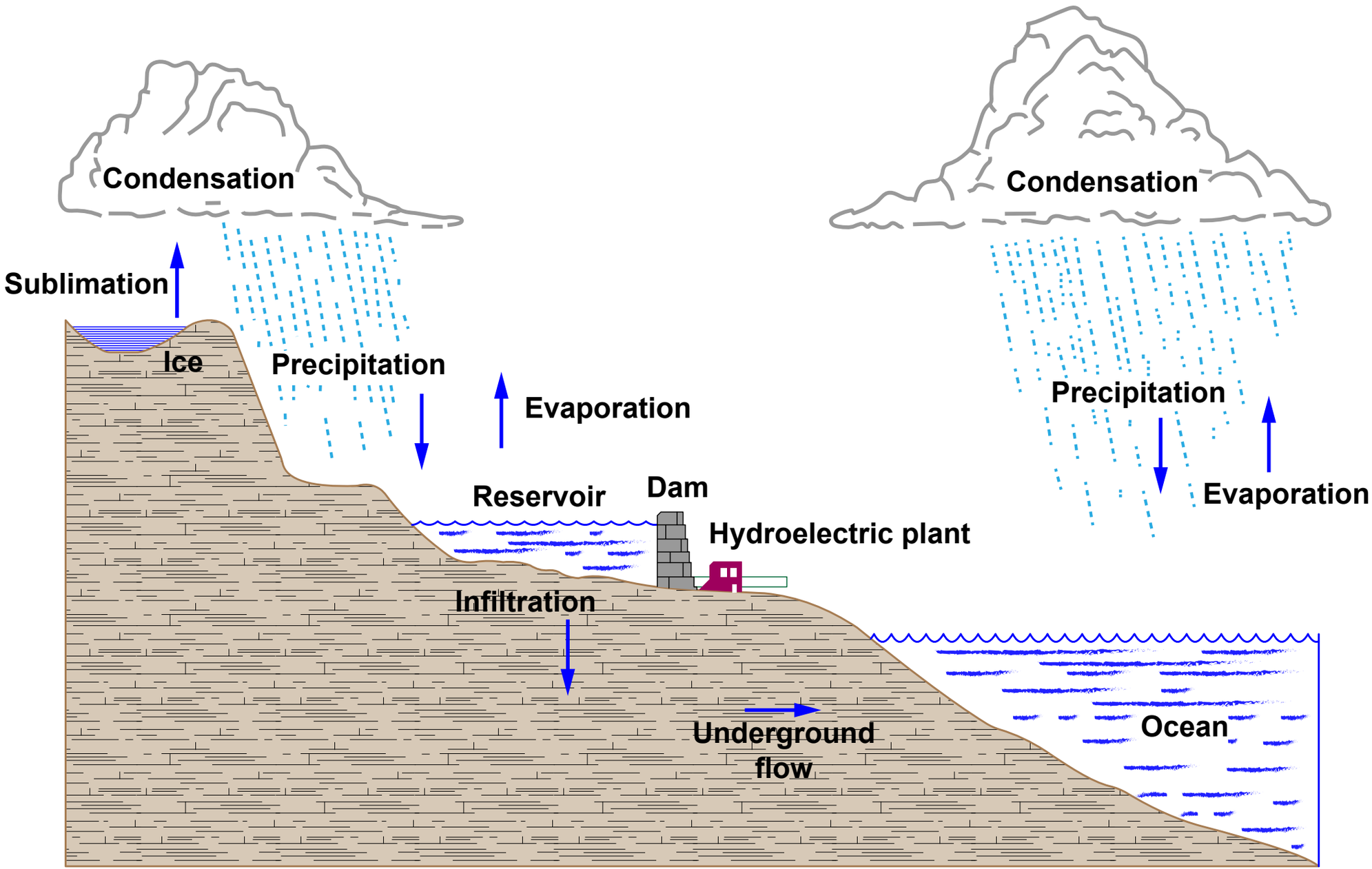
The energy incident on Earth from the Sun is balanced by the energy losses: energy in = energy out.
~30% is reflected back into space by clouds,
~70% is absorbed but thermally re-radiated back into space.



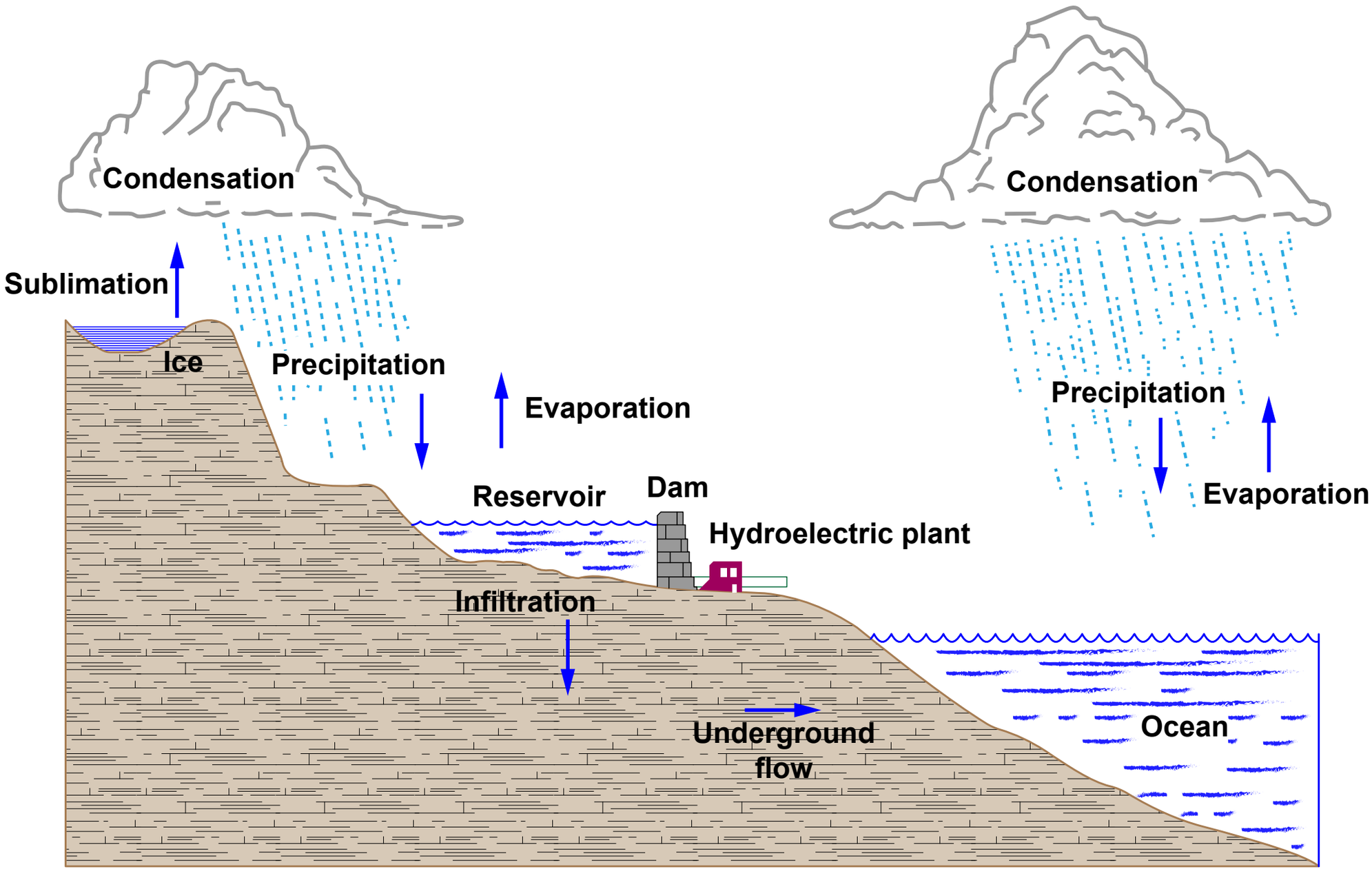
A small percentage of the incident energy heats the air/land, drives the weather, ocean currents and photosynthesis. Let's see what can be tapped from the hydrologic cycle.



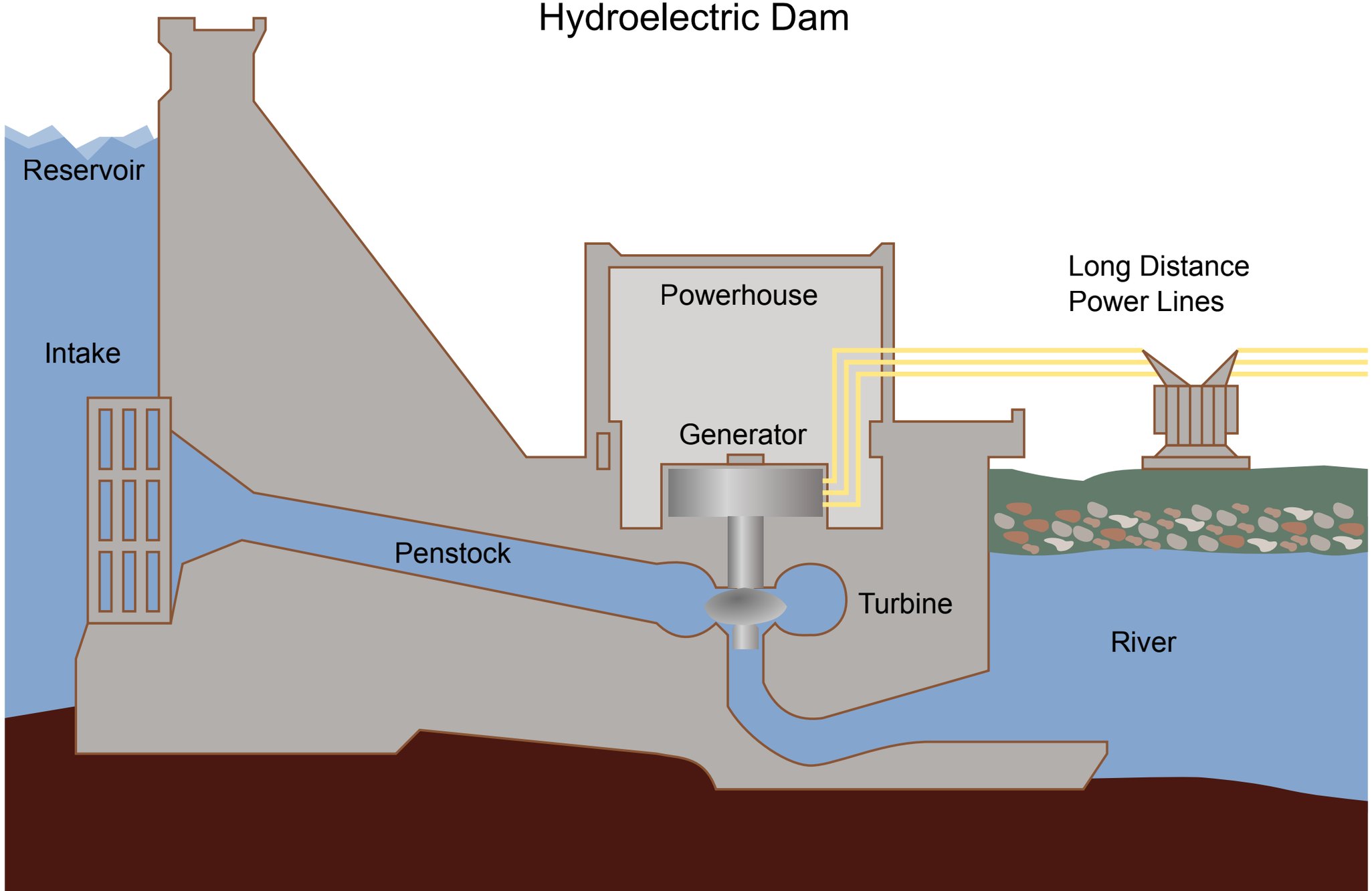
23% of Sun's incident energy goes into the hydrologic cycle. It takes energy, ~2 MJ, to evaporate 1 kg water, but only ~ 0.1 MJ to lift 1 kg to the troposphere. So ~96% of the incident energy is in evaporation, ~4% in lifting against gravity.



When water vapor condenses in clouds the evaporation energy is released, but radiated into space. When it rains, the gravitational energy is released, mostly as kinetic energy.



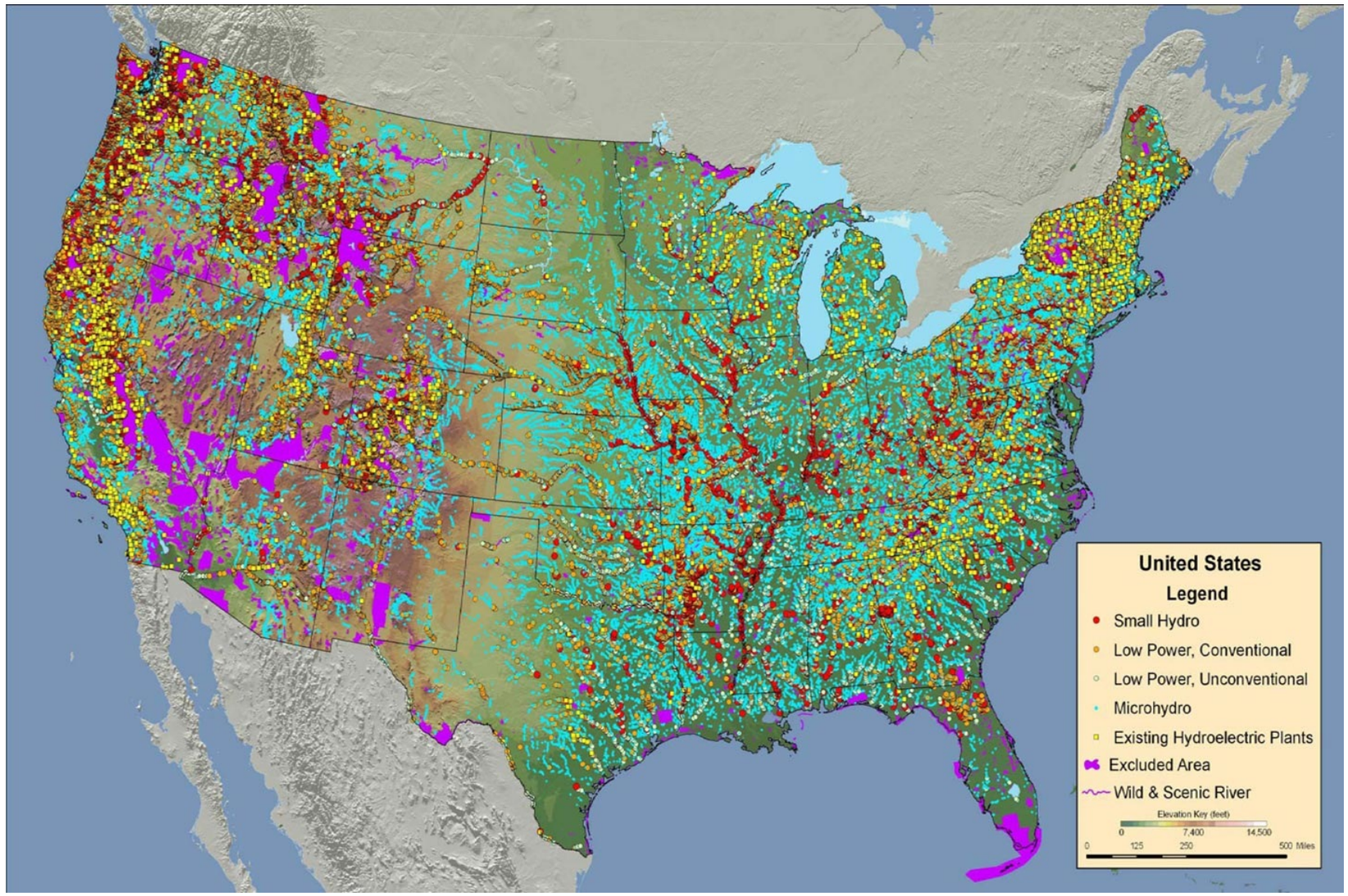
Hydroelectric plants use this *tiny* left-over energy: the same energy that drives the flow of streams and rivers. Damming a river concentrates the potential energy in one location for easier access.



In the US, the biggest hydroelectric facility is the Grand Coulee on Columbia River. With an yearly flow rate ~6,000 m^3/s falling ~100 m, about 6 GW of power is produced.

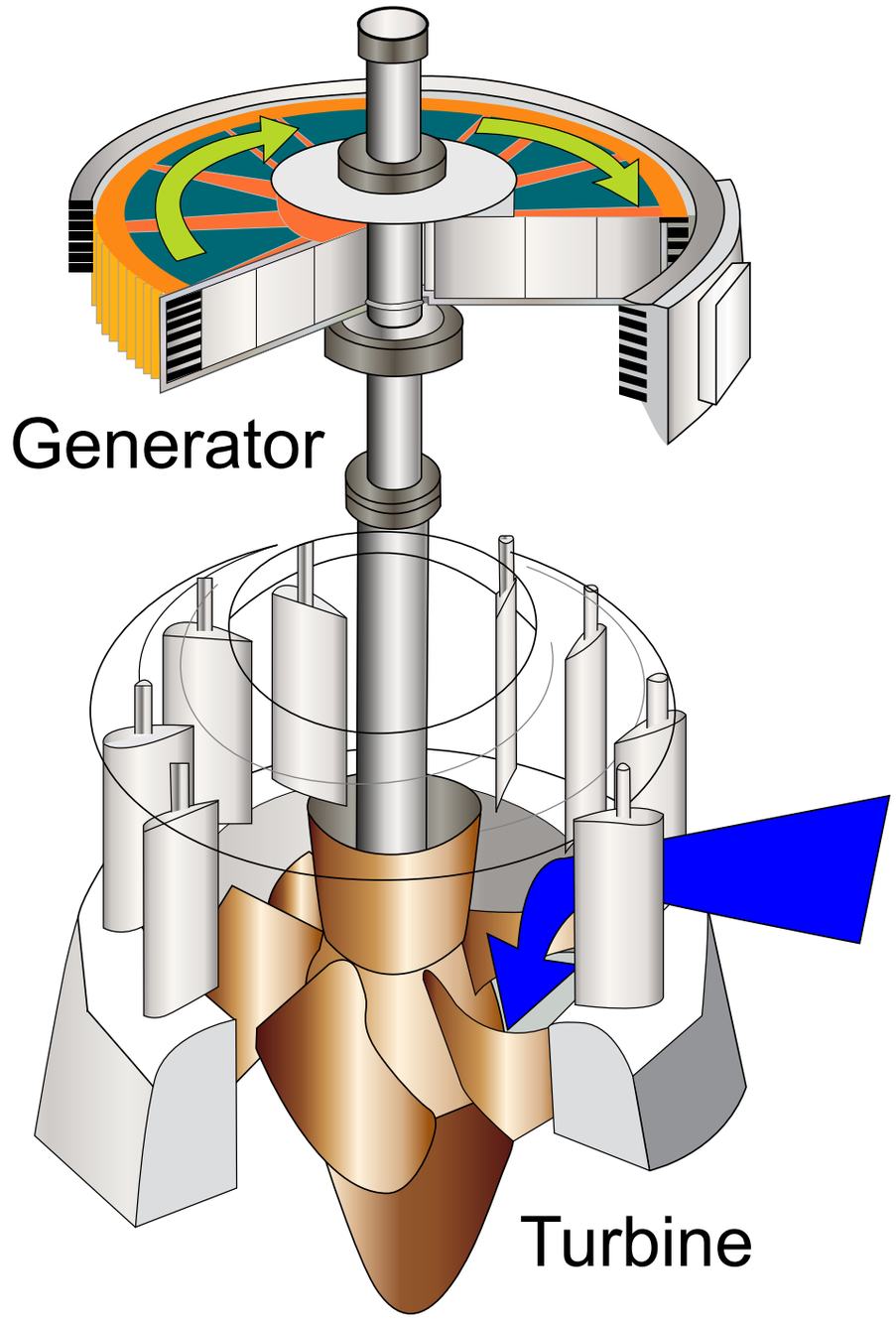
11 other big dams in the US are in the 1-2 GW range and large nuclear plants are usually 2-4 GW.

Some 40,000 GW of solar power goes into evaporation, which is ~2 × 10^{10} kg/s of evaporated water, ~4 mm/day off the ocean's surface (replenished by rain). We gain access to only ~2% of the rain's kinetic energy and use only ~1%.



That is, in the USA, we're almost tapped-out: ~ 50% of the remaining potential is in a larger number of small-scale units.

Though very efficient and seemingly environmentally friendly, dams do have issues: silt limits their lifetime to 50-200 years; habitat loss for fish and animals; wrecks stunning landscapes (e.g., Glenn Canyon in Utah).



Hydroelectric is a nice “freebee” handed to us by the Sun and while it isn’t THE answer to our appetite for energy, it has a key role to play well into the future.