Heat Content of the Earth's Energy Resources Calculations

Crude Oil

Assuming that the proven global petroleum reserves are 1.2×10^6 million barrels, taking the heating value of crude is 6100 TJ/Mbbl, the energy content of the world petroleum reserves is 7.4×10^{21} J.

Atmospheric Vapor

Assuming that the bottom kilometre of the atmosphere contains 10 kg of water vapour per square metre. Taking the latent heat of water as 2.5×10^6 J/kg, the latent heat content of the bottom kilometre of the atmosphere is 25×10^6 J/m^2. Taking the area of the earth as 510×10^{12} m^2, the latent heat content of the bottom 1 km of the atmosphere is 13×10^{21} J.

The latent heat contained in the bottom layer of the atmosphere is approximately twice that of the world petroleum reserves.

Tropical water

Tropical cyclones require a minimum sea temperature of 26 °C. Sea surface temperatures in the tropics are typically in the 28 to 31°C range. Taking the sensible heat of water as 4190 J/kg, the heat required to raise the temperature of the top 100 m of the ocean by 3 °C is 10^9 J/m^2.

Assuming that tropical ocean cover 20% of the earth' surface, the heat content of the warm water is 128×10^{21} J, 17 times the heat content of the world proven oil resources.

Tropical oceans are a huge heat reservoir. The useful heat content of the top 100 m of tropical oceans is 10 times greater than the latent heat content of atmospheric water vapor.

Assuming a solar insolation of 100 W/m^2, the time required to raise the temperature of a layer of water 100 m thick by 3 °C is 115 days.

The heat content of the top 100 m of tropical oceans corresponds to 115 day of solar insolation. The heat content of the water vapor in the bottom 1 km of the atmosphere corresponds to 10 days of solar insolation.

Mechanical energy production potential

Assuming that 30% of the heat content of the world proven petroleum reserves could be converted to mechanical energy, the mechanical energy production potential of the world proven petroleum resources is 2.2×10^{21} J.

Assuming that 10% of the latent heat content of the air in the bottom kilometer of the atmosphere could be converted to mechanical energy when the heat is transported by convection from the bottom to the top of the troposphere, the mechanical energy production potential of the atmosphere's latent heat is 1.3×10^{21} TJ.

Assuming that 10% of the usable sensible heat content of the of water in the top 100 m of tropical ocean could be converted to mechanical energy when the heat is transported by convection from the bottom to the top of the troposphere, the mechanical energy production potential of the atmosphere's latent heat is 13×10^{21} TJ.

The heat content of the ocean and of the atmosphere is constantly renewed by solar radiation while petroleum resources are not being renewed.

Hurricane energy

According to the Hurricane FAQ web site the thermal energy released in an average hurricane is:

5.2×10^{19} Joules/day
or 6.0×10^{14} Watts.

This thermal energy was calculated from the rate of precipitation (2×10^{10} m^3/d) times water density (1000 kg/m^3) the latent heat of condensation of water (2.5×10^{6} J/kg).

Producing 5.2×10^{19} Joules of thermal energy would require cooling a strip of water 500 km long by 100 m deep and 86 km wide by 3°C. Hurricanes can travel 500 km/d and can cool a water strip 100 km wide by 100 m deep by up to 5°C.

The cooling effect of hurricane passage can easily be seen in infrared satellite photos. Surprisingly the sea cooling is often attributed to mixing of underlying cold water with surface water due to water agitation!

The thermal energy released by an average hurricane is equivalent to 300 times the world-wide electrical generating capacity - an incredible amount of energy is produced!

The only possible source for the thermal energy of hurricane is the cooling of sea water. The heat content of surface air is not much different before and after the passage of a hurricane but the heat content of the sea is much reduced by the passage of a hurricane.

If the heat transfer is considered to take place mainly under the eyewall in an annulus with an average diameter of 100 km and a width the 20 km, the heat flux from the sea surface to the air from must be 100,000 W/m^2. Heat flux in cooling towers can be as high as 300,000 W/m2 (per square meter of fill ground surface area). Hurricanes heat flux calculated based on surface to air heat transfer coefficient are usually considered to be around 2000 W/m^2. Heat transfer from spray is the reason for the discrepancy.

According to the hurricane FAQ's the mechanical energy produced in a hurricane is 1/400 of the thermal energy. The mechanical energy is estimated from the energy required to overcome friction. According to Kerry Emanuel the mechanical energy produced in a hurricane is 1/3 of the thermal energy. There is discrepancy by a factor of 133 between the two figures. The discrepancy is mainly due to the fact that the expansion is not constrained and that as a result the mechanical energy is not produced.

References:

Energy order of magnitude
http://en.wikipedia.org/wiki/Orders_of_magnitude_(energy)

Energy numbers
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Hurricane FAQ question D7
http://www.aoml.noaa.gov/hrd/tcfaq/D7.html

Microwave section 3.7 Sea surface Temperatures.
http://www.meted.ucar.edu/npoess/microwave_topics/overview/print.htm

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