Energy sources

What is energy

All organisms need energy to live. Energy is connected to all human activities: whenever we think or move, we use the energy that is stored in our body and all the objects that we use or that surround us need energy to work or needed energy when they were built. Energy illuminates us and warms our houses, allows us to move, feeds the tools we use to produce food, and so on.
All that produces energy is “an energy source”. The Sun is the main source of energy for the Earth.
The Earth receives from the Sun an uninterrupted flow of energy that, as well as supplying all vital processes (both vegetal and animal), melts the ice and supplies the water cycle between the sea and the atmosphere; it produces the wind, favours the growth of those plants that during millions of years have transformed, together with animal remains, into fossil fuels, coal and natural gas.
In general, all the energy available on our planet derives, directly or indirectly, from the Sun: water energy, wind energy, chemical energy of fossil fuels (coal, oil and natural gas) and biomass (i.e. wood); even waves energy.
Tides energy derives from the gravitational fields of the Sun, Moon and Earth.
Geothermal and nuclear energy do not derive from the subsequent transformations of solar energy, but are related to the Earth formation.

Primary and secondary sources

The numerous existing energy sources can be classified in different ways. Primary sources can be used directly, as they appear in the natural environment: coal, oil, natural gas and wood, nuclear fuels (uranium), the sun, the wind, tides, mountain lakes, the rivers (from which hydroelectric energy can be obtained) and the Earth heat that supplies geothermal energy.
Secondary sources derive from the transformation of primary energy sources: for example petrol, that derives from the treatment of crude oil and electric energy, obtained from the conversion of mechanical energy (hydroelectric plants, Aeolian plants), chemical plants (thermoelectric), or nuclear (nuclear plants). Electric energy is produced by electric plants, i.e. suitable installations that can transform primary energy (non-transformed) into electric energy.

Renewable and non-renewable

Some sources are renewable, i.e. they provide energy, which is constantly regenerated by means of chemical transformations (e.g. biomass) or physical transformations (e.g. water power, solar, wind power, etc.). In particular the sun, the wind, the water cycle, the tides, the heat of the Earth are non-exhaustible sources, which are always available and will never end. Biomass, instead, can re-generate within times that are similar to man’s life. With reference to wood, for example, it is always possible to have some combustible available, even though sometimes it is necessary to consume a small quantity of it and reforest in those areas where trees have been cut down.
Non-renewable sources, instead, are characterised by long regeneration times, so long (millions of years) that after they have been exploited they are considered depleted. They are those energy sources that took millions of years to form, like fossil fuels (oil, coal, natural gas) or when our planet was formed, such as uranium. These sources, although there is still plenty of them, are limited and represent a sort of energy warehouse on the Earth.
In 2013, only 13.5% of the energy consumed in the world derives from renewable sources. All the rest derives from non-renewable sources, mainly from fossil fuels (81.7%) and 4.8% from nuclear plants (*International Energy Agency (IEA) – Key World Energy Statistics 2015*).

Energy measurement

The units of measurement used by human beings to express the quantity of energy sources are numerous. There are measures for physical quantities and measures for the energy or heat content.
The official measurement unit for energy is the Joule (J).

Among the most common units measuring energy mention should be made of the kilowatt/hour (kWh), used especially for electric energy (in fact it is used to calculate electricity bills). In order to measure the production of large electricity plants or the national consumption, the Terawatt/hour (TWh) is used, which corresponds to a billion kW/h.
The most common units measuring heat include the BTU (British Thermal Unit) and the kilogram calorie (kg-cal) and especially the Tonne of Oil Equivalent.
The Tonne of oil equivalent is the most common at international level because it is connected to one of the most important and widely used fuels: oil. By measuring the different energy sources in terms of Tonne of oil equivalent, a comparison becomes possible and they can be aggregated, a vital operation to calculate how much energy a country consumes in a year or how much energy is still available under the surface (oil and natural gas fields and coal mines).
But what is Tonne of oil equivalent? Basically, one Tonne of oil equivalent represents the quantity of heat which can be obtained from a tonne of oil. In practice, if we measure coal in terms of Tonne of oil equivalent, it means we are considering the quantity of coal capable of producing as much heat as a tonne of oil.
(Let's remember that: 1 Kcal = 4.186 J = 1,16 x 10^{-3} kWh = 1x10^{-7} TOE).
How can we calculate the physical quantities corresponding to one Tonne of oil equivalent of coal or natural gas? In other words, how many kilograms of coal are needed to reach one Tonne of oil equivalent of coal and how many cubic metres of natural gas to produce one Tonne of oil equivalent of gas?
To calculate that equivalence and use the units measuring physical quantities (kilograms, litres, cubic metres) of the different energy sources, we resort to calories.
We know that one tonne of oil contains 10 million kilogram calories (kg-cal), whereas one tonne of pit coal contains 7 million kg-cal. Therefore one Tonne of oil equivalent of coal, since it measures the quantity of coal containing as many kilogram calories as one tonne of oil, is equal to approximately 1.43 tonnes (measure of the physical quantity) of coal.
Calculations are easier if we take, for example, vegetable fuels, containing 2.5 million kilogram calories per tonne of material. In this case, to obtain 10 million kg-cal (the calorific content of a tonne of petrol) we need 4 tonnes of vegetable fuels; therefore one Tonne of oil equivalent of vegetable fuels correspond to 4 tonnes of vegetable fuels.
If we know the contents, in terms of calories, of the physical units measuring the different energy sources we can calculate all the Tonne of oil equivalent equivalents. The following table reports the "Net Heat Value", i.e. estimates based on international average values leading to the conversion of the content of calories into the various units measuring the physical quantities of some of the most common fossil energy sources.