Nuclear Illusion - Risks and False Myths

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1. The production of electricity

If we leave out hydroelectric, wind and photovoltaic plants – that at a planetary level produce less than 5% of all the electricity we consume – in order to make the electricity we use, we resort to the very same technology: the steam cycle, that is boiler, steam turbine, generator. Thus, the main element for producing electrical energy is water, under the form of high temperature and high pressure steam that set the turbines vortically as to obtain - at a constant level - an amount of direct current. This direct current will in its turn be transformed into alternating current that is going to enter the distribution nets.

Only recently, aeronautics derived gas turbines were added to the traditional steam cycles and this combination has allowed quite high performances. The Combined Cycle Gas Turbine (CCGT) technology was thus born, which nowadays is regarded as the most efficient system in the production of electric energy. The CCGT efficiency has by now reached 60%, and the costs of their implementation are by far the lowest in the market. It takes one or two years to build a medium power plant, i.e. between 400 and 600 MW.

In other words, the CCGT is the expression of a still prevailing ripe technology and there is nothing at the moment that can challenge their supremacy. The owners of such plants are going to hold them tightly for the next decades.

In order to obtain steam you have to burn fuel to warm water up. One can burn either wood or agricultural/forest by-products: in this case you have “biomass fuelled plants”. One can burn coal, oil or gas, as it happens with “traditional thermoelectric plants”. One can also warm water up by means of solar concentrators: one can speak here of “thermodynamic solar”. The basic technology is always the same: water, steam, turbine, transformer and then the distribution grids for the electric energy produced.

Nuclear plants too use this technology. What makes the difference is how you produce heat to warm the water up. The term “thermo-nuclear” points to the “neutron crucible” used, or better a balanced system in which a “core” packed with uranium pellets releases particles – i.e. neutrons – that, by hitting and disintegrating other uranium kernels, triggers off a chain reaction, producing as a result what heat is needed to warm water up. This is nuclear fission.

The whole massive machinery of combined steel, concrete, security systems etc serve to limit the collateral damages that the frightful flood of radiations can provoke and to confine the other radioactive elements that are generated in the “neutron crucible”.

Fission, at the end, consists in splitting the atomic kernels of uranium atoms, thus releasing a certain amount of energy. When a neutron is absorbed by a fissile isotope, such as ^{235}U, undergoes a nuclear fission and two or three other neutrons are ejected from the reaction. If near the split nucleus more fissile fuel is present, some may be absorbed and trigger further fission events. This is known as self-sustaining nuclear chain reaction.

The sum of the masses of the fragments and of the neutrons ejected, is slightly less than that of the original nucleus added to the neutron that is absorbed: the missing matter has been transformed in energy, according to the well-known Albert Einstein equation $E=mc^2$. The mass percentage transformed into energy amounts to about 0,1%, i.e. only one gram out of one kg of fissile isotopes is transformed into energy. Nevertheless this energy, exploitable as thermal energy, is 50 million times greater than the energy delivered by one fossil fuel carbon atom.

The chain reaction, though, in order to be able to generate energy in a controlled way, must be kept in conditions of balance. If there are not enough collisions taking place, the chain reaction will slow down and eventually dies; if too many collisions occur, the heat thereby generated is excessive and threatens a so called “meltdown”. The conditions of balance is guaranteed by a system of control rods, generally composed by metal alloys that can absorb neutrons; these bars are inserted in the core to the purpose of keeping under control – and, in case, to arrest a chain reaction. The fissionable uranium contained in the fuel continuously produces a given quantity of neutrons and the control rods are inserted and/or extracted in order to guarantee the equilibrium between the quantity of neutrons ejected and absorbed by the fissile isotopes. This balance is called the “critically point” of the reactor.

On the other hand it is precisely the delicate setting of the various motions needed to keep this balance that is responsible of the larger part of the accidents happened since the beginning of the nuclear age.

The neutrons ejected by the fissionable uranium must be slowed down, otherwise they keep moving straight on lowering their probabilities of hitting other nuclei; this is the reason why the whole core must be immersed in a so-called “moderator”, usually graphite or water, in any case an element containing a large quantity of hydrogen, in order to slow down the speed of neutrons so as to increase their probability of hitting other uranium nuclei. It is like shooting with a pistol through an airplane propeller: if the bullet is very fast its probability of hitting a blade is low, but if you slow somehow down its speed, you increase its probability of hitting a blade. Slowed down neutrons are known as “thermal neutrons”.

At last, for what concerns the thermodynamic output, we must remember that the efficiency of nuclear plants in terms of heat conversion in electric energy is rather low. Actually only 30-35% of the thermal power developed by the reactors is converted into electricity, which means that a 1.000 MW plant has in general a heat production of 2.000-3.000 MW. Let's add, just to make a comparison, that modern Combined Cycle Gas Turbine plants reach up to a brighter 60% efficiency. As a consequence, in the nuclear plants, there is the need of dissipating enormous quantities of heat, usually using nearby rivers or seas water.

Well, after all, it seems that the whole fuss amount of technology drives just to boil water to obtain the highly craved steam. All the rest is current technology; what's more, the downstream thermodynamic cycles, are subject to the Laws of thermodynamics. Which means, in plain words, reaching levels of efficiency on a par with those we had at the onset of the industrial revolution, when the power generated by the turbine was measured in terms of horsepower.

One suspects that the nuclear plants business is something akin to the potter's craft: an activity concerning pans, pots and – here – special boilers. Huge, beautiful, state-of-the-art pressure cookers, but after all, nothing but pots. Malignant people could be leaned to believe that a good deal of those supporting the nuclear option might make a living out of detaching fat coupons from steel, mechanic and concrete companies.

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