[Commentary] Fallacy of Abundant Cheap Nuclear Energy

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Abstract

Scientists, scientific literature, and popular science literature project fusion and fission as the future energy solutions to the energy problem of the world. In this article, it has been shown that neither fusion nor fission could solve the energy problem of the world in the future.

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"Real fuel" and "false fuel"

To know whether a fuel is real fuel or not is to determine whether the fuel has a positive net energy yield (energy-return) i.e., the fuel produces greater amounts of energy when it is used than the energy investment in extracting the fuel from basic raw materials and making, processing, transporting as well as disposing of residues of the fuel. A huge amount of energy is obtained when Hydrogen, Aluminium, or thermite (a mixture of powdered aluminium and oxides of iron) are burned. But energy obtained from the combustion of those fuels is not greater than the energy spent to make them from natural resources. Therefore, hydrogen and thermite cannot be treated as real fuels. Electricity could be readily generated from combustion of those fuels but electricity made from those fuels will be more energy-expensive than electricity made from coal or petroleum. Hydrogen and Aluminium, although seemingly prospective as fuels are false or energy-negative fuels.

Fusion Energy

On December 5, 2022, an array of lasers at the National Ignition Facility (NIF), part of the Lawrence Livermore National Laboratory in California, fired 2.05 megajoules of energy at a tiny cylinder holding a pellet of frozen deuterium and tritium, heavier forms of hydrogen. The pellet compressed and generated temperatures and pressures intense enough to cause the hydrogen inside it to fuse. In a tiny blaze lasting less than a billionth of a second, the fusing atomic nuclei released

3.15 megajoules of energy—about 50 percent more than had been used to heat the pellet" [1].

Those scientists of NIF have expended 2.05 megajoules of energy to get 3.15 megajoules in exchange. Good news indeed! However, they have not given energy to manufacture the deuterium and tritium pellets used for their so-called fusion.

In the absence of these data, it could not be said that the fusion process discovered by the NIF scientists could be a breakthrough to solve the energy problem of the UK.

Fission Energy of Plutonium

Similarly, it is said by nuclear technologists that one thermal MW day energy is required to produce 0.9 gram of Plutonium.

Calculation 1:

0.9 gram of Plutonium is made by using 1000×1000× 60×60×24/4.2 Cals [1Feiveson 2004].

1 gram of Plutonium is made by using 1000×1000× 60×60×24/(4.2×0.9) Cals =23×10^{6} kcals.

1 kilogram of Plutonium is made by using 1000×1000× 60×60×24/(4.2×0.9) $\times10^{3}$ Cals =23×10^{9} kcals.

Calculation 2:

The fission of 1 kilogram of plutonium-239 can produce an explosion equivalent to 21,000tons of TNT [2].

1 kilogram of Plutonium 239=21, 000 ton TNT=21000, 000,000 kcals=21×10^{9} kcals.) [1gram of TNT≡ 1 kilocal]

Therefore, 23×10^{9} kcals of energy (3 times more) are required to make one kilogram of plutonium but, that amount of plutonium yields kcals of heat by way of fission as per [3] and kcals of heat by way of fission as per Encyclopedia Britannica [4].

Hence, plutonium just like hydrogen and Aluminium is a false fuel. False fuels may serve as real fuel only when they are available as formerly useless by-products and benefit from 'upstream energy subsidies'.

Fission Energy of Uranium

As per Albert Einstein I kg of any material (especially Uranium) through full reaction could burnt to give 2×10^{13} kcals energy ($E= mc^2= 1\times(3\times10^8)^2$ joules = 2×10^{13} kcals). If that were so, all the countries of this world would not compete with each other to get petroleum from the petrol-producing countries. If some very little parts of the little boy had undergone a so-called fission reaction then the whole of Japan would have been burnt in the twinkling of an eye, not to speak of the destruction of 1.7 square miles of Hiroshima by the bomb that got its energy from the Sun [5].

Many countries use Uranium to solve their energy problem. Natural Uranium, i.e., Uranium 238 could not be used as nuclear fuel. Uranium 238 contains a very small amount of Uranium 235 which as per the experts acts as nuclear fuel. It is also said that 6 kgs of natural Uranium are gone through the Uranium enrichment process to get 1 kg of reactor-quality enriched Uranium that contains approximately 4% of Uranium 235.

European Nuclear Society [6] says that 1 kg of reactor-quality Uranium (4% Uranium 235) burns off to give 82.3×10^{7} kilocals.

(Energy expenditure to construct the reactors, to prepare ancillary materials like heavy water, coolers, etc, and energy used for waste disposal, after Fukushima surveillance work and decommissioning have not been deducted from the figure.)

But the question is: what amount of energy is expended to generate 1 kg of reactor-quality Uranium?

It has already been mentioned that to get 1 kg of reactor-quality Uranium, 6 kilograms of Uranium 238 is required. Now to extract 6 kilograms of ordinary Uranium how much energy is required?

Status of Uranium as fuel, real or false?

Uranium is not available in nature in a free state. It is available in ores. As of 2013, Olympic Dam was the second-largest uranium-producing mine in the world. The uranium ore of this mine contained 0.05 % Uranium 238 [7].

To produce 6 kgs of natural Uranium 12000 kgs of the Olympic Dam-like ores are required.

This ore is treated with various chemicals to separate Uranium from other ingredients[8]. To produce those chemicals, heat energy is abundantly required. Now, the heat required for chemical processes comes generally from the combustion of fossil fuels. Therefore, to prepare Uranium fuel, fossil fuels are required in the long run. But the essential question is: how much fossil fuel is required to get 6 kgs of Uranium from its now available ores?

We give a simple study to elucidate this problem below.

After preliminary concentration to remove sand and clay, the ore is leached with sulphuric acid and treated with an excess of the acid and then with hydrogen sulphide to precipitate all metallic radicals other than Uranium. The filtrate is then treated with an excess of ammonium hydroxide to precipitate Uranium as ammonium diurate which is ignited to prepare U_3O_8. This U_3O_8 is reduced to UO_2 by hydrogen. The dioxide is converted into Uranium fluoride by heating it strongly in gaseous hydrogen fluoride. The fluoride is then reduced to the metal using pure metallic calcium. However, nowadays selective tertiary amines are used to separate Uranium from the leached solution of the ore.

Sulphuric Acid, Hydrochloric Acid, Hydrogen Sulphide, Sodium Carbonate, Ammonium Hydroxide, Hydrogen, and Calcium are not available in nature. In the ultimate analysis, fossil fuels and other chemicals are required to prepare those elements and compounds.

The energy required to extract a metal from its ore depends on the quality of purity of the metal required and the percentage of the metal in the ore. To extract iron from 80% iron ore, the same amount of coal by weight is required. Therefore, it is likely that to extract extremely pure natural Uranium (used to extract Uranium 235 from it) from its abundantly available 0.05% ore, coal is required ten times the weight of the ore.

Therefore 1, 20, 000 kgs of coal [1 kg coal ≡ 7000 kilocals] or its equivalent energy is required to extract 6 kilograms of natural Uranium. The heat energy of that coal is 84×10^7 kilocals.

Now to make 1 kg reactor quality Uranium from that 6 kg natural Uranium further 2.33×10^7 kilocals energy is required for enrichment [8].

Therefore, to prepare 1 kilogram of reactor-quality Uranium some 86.33×10^7 kilocals energy is required if 0.05% ore (the most abundant ore) is used. But 1-kilogram reactor-quality Uranium burns off to produce 82.3×10^7 kilocals of heat energy [6]. (We have not deduced energy expenditure for the ancillary arrangements for the entire system of producing nuclear energy including waste disposal, after-Fukushima surveillance work, and decommissioning.)

France uses 0.3% Uranium ores for its nuclear energy. However, the Cour des Comptes study shows that France has not much benefited in the energy sector from its nuclear fuel/ nuclear electricity as the country professes [9].

Therefore, from simple college physics calculations, it stands that the propaganda of abundant cheap nuclear energy is fallacious.

Notes

[6] With a complete combustion or fission, approx. 8 kWh of heat can be generated from 1 kg of coal, approx. 12 kWh from 1 kg of mineral oil and around 24,000,000 kWh from 1 kg of uranium-235.

1 gram of coal≡8watt hour ≡8 ×60×60 / (4.2) cals =7 kilocals.

1 kg of coal ≡8 000 ×60×60 / (4.2) cals ≡ 7000 kilocals.

1 kg of U235 ≡24,000,000, 000 ×60×60 /(4.2) cals ≡ 205.7×10^{11} cals.

4 % of 1 kg of U235≡1 kg of U235×4 /100 ≡ [24,000,000,000 ×60×60 ×4 /(100× 4.2)] cals ≡ 823×10^9 cals =82.3×10^{10} cals.

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