FNR FUEL SUPPLY   April 4, 2023

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THE FNR FUEL SUPPLY PROBLEM:
Sustainable prevention of further CO_2 driven climate change requires large scale deployment of Fast Neutron Reactors (FNRs).

At present industrialized countries need about one 1 GWt of fuel sustainable FNR capacity per 100,000 people to displace fossil fuels. It is anticipated that full deployment of battery electric vehicles may eventually reduce this load to about 1 GWt per 200,000 people. However, at present any and all deployment of FNRs in both Canada and the USA is prevented by absence of dependable sources of FNR initial core fuel.

The FNR initial core and blanket fuels, that are required for sustainable reduction of CO_2 emissions, can be obtained by reprocessing of used nuclear fuel from water moderated power reactors. In this respect CANDU reactors are the most fuel efficient, typically producing 4 grams to 6 grams of trans uranic elements (TRU) per kg of natural uranium input. About 2 / 3 of this TRU is plutonium. During FNR core fuel production the TRU is concentrated to about 199 grams / kg.

Both Canadian and US governmental agencies have failed to enable reprocessing of existing used nuclear fuel. This failure is now the main obstacle to near term deployment of FNRs. In Canada this problem is mainly due to policy and leadership failures at the NWMO (Nuclear Waste Management Organization), CNL (Canadian Nuclear Laboratories), OPG (Ontario Power Generation) and NRCAN.

In North America development of nuclear fuel reprocessing has been delayed by an array of both regulatory and irrational political constraints on transportation, storage and reprocessing of used nuclear reactor fuel and on interim storage / disposal of related waste. There is little recognition of the reality that there is no substitute for breeding and fission of TRU in a sustainable nuclear fuel cycle.

In recent years many US nuclear power plants (NPPs) have relied on Russia for supply of reactor fuel, but the 2022 invasion of Ukraine by Russia has made future dependence on Russia for nuclear fuel supply non-viable.

Any party financing a nuclear power plant, such as an electricity utility, requires a dependable supply of suitable nuclear fuel at an acceptable price. Without certainty of fuel supply, financing of new NPP capacity is impossible to arrange.

Reprocessing of used nuclear fuel to make FNR fuel and safe interim storage of nuclear waste should be the responsibility of each national government.

ROLE OF THE FUEL SUPPLIER:
The fuel supplier should provide fully assembled nuclear fuel bundles to reactor owners and should

take back and recycle the used fuel bundles. The fuel supplier should try to isolate the reactor owner, which is typically an electricity utility, from the complexity of nuclear fuel supply, fuel recycling and interim uranium and fission product storage.

FNR nuclear fuel bundles are mainly formed from HT-9 steel, fissile fuel rods, fertile fuel rods, internal sodium, fuel tube end caps, and seal welding.

Fissile core fuel source material is obtained by electrolysis of a molten salt solution containing TRU, depleted U, and fission products. The appropriate source materials are alloyed with Zr and then cast into core fuel rods.

Fertile blanket fuel rods are realized by a combination of blanket rod mechanical sorting and by recycling involving electrolytic molten salt purification of uranium followed by alloying with Zr and casting.

The fuel materials are both chemically active and radioactive, so all operations involving fuel materials, fuel rods or fully assembled fuel bundles should be done in an argon atmosphere with appropriate bio-safety shielding.

The isotopic composition of the fuel rods should be carefully monitored and controlled.

The fuel handling process must be designed such that there is no possibility of an assembly of fuel material, fuel rods or fuel bundles accidentally becoming critical.

Generally the used reactor fuel must be obtained from a quasi-governmental body. The used fuel transport, storage, processing, waste management and new fuel transport are all subject to regulation by various parties. The ratio of Pu-240 to Pu-239 should always be kept over 10% so that the Pu is unsuitable for making fission bombs. Overseeing the entire process is a nuclear safety regulatory authority such as the CNSC (Canadian Nuclear Safety Commission) which licenses the required facilities, processes, transportation and storage methodologies.

In general the fuel material analysis, fabrication and recycling require expertise not normally possessed by an electricity utility. Isolation of fuel materials, controlled alloying and casting of fuel rods, fabrication of fuel bundles and subsequent material recycling require highly specialized equipment and personnel skills. Interim products and waste require careful management. It usually does not make economic sense for an electricity utility to engage in fuel supply, fabrication and recycling. Instead a fuel supply, fabrication and recycling facility should be a national asset that is shared by multiple electricity/heat supply utilities. The utilities should only handle fully assembled fuel bundles that are transported in purpose designed shielded containers.

In summary, a precondition for obtaining FNR NPP project financing is the existence of a dependable source of FNR fuel. At this time, absence of a dependable FNR fuel supply and recycling facility is preventing deployment of FNRs in North America.

FUNDING A FUEL PROCESSING AND REPROCESSING FACILITY:
At this time there is no practical mechanism for private sector financing of the required facility for FNR fuel supply and recycling. Without both an assured source of used CANDU fuel and a developed market for FNR fuel the private sector cannot function.

Part of the problem of funding a nuclear fuel processing and recycling facility is the existence of irrational political parties and other organizations, with vested interests in maintaining the status quo, that lobby against recycling of nuclear fuel. Due to the time required for development and commissioning of a nuclear fuel processing facility and then subsequent buildup of a FNR fuel inventory and deployment of FNRs it will not be possible for FNRs to significantly impact CO_2 emissions until at least two decades after the fuel processing facility is fully funded.