Nuclear Waste Transmutation by Fast Systems

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With regard to typical predictions of a doubling of world's primary energy need for 2050, sustained growth critically depends on the long-term availability of energy resources and their environmental consequences. Therefore, in order to be based on scientific reasoning, the prime condition for real effectiveness, energy policies have to rely, for each energy-producing system, on a thorough life-cycle analysis ("cradle-to-grave") of the integral environmental impact.

Ranges between 10 – 130 g/kWh_{elec} are quoted for nuclear power in various life-cycle studies, substantially lower than that of any fossil-fuelled power technology for electricity production, and also in (often rather favourable) competition with other "renewable" technologies.

Indeed, for Europe, the amount of CO_2 yearly avoided by the use of nuclear power has been estimated by the European Commission to about 900 million tonnes, i.e. roughly equivalent to the transport sector. Such (and other) facts underline that it seems rather unlikely to reach a 2020 EU CO_2 reduction target of 20% without a continued reliance on a significant nuclear share in the mix of the energy-generating systems.

For the horizon of, say 2040, for an industrial deployment, a large international effort is presently made on the "generation-4" nuclear reactors that aim to comply in an ideal way to the criteria of sustainability[1], safety, reliability, and proliferation resistance. However, the use of nuclear energy is heavily debated in many European countries because of the long-term environmental burden of nuclear waste from the present-"generation-2" (and immediate-future "generation-3") LWR reactors[2]. The significance of this subject for Europe may be highlighted by the fact that about 2500 tons of spent fuel are produced every year by the 135 reactors of the European Union.

It is this context, as well for phasing definitely out nuclear power, as well as continuing it, that the prospect of "Partitioning and Transmutation", or "P&T", may well play an important role. P&T of nuclear waste implements the principle of sustainable development in a rather general way: *separating out* of the spent fuel (partitioning) the radiotoxic components for *recycling* them (transmutation) in fast reactors in a way to minimize their toxicity and recover their contained energy in a useful way, in other words, minimizing potential health hazards while optimizing benefit for society.

In contrast to ("waste-self-burning") critical fast reactors, waste-transmuting reactors containing large amounts of minor actinides (MA) accumulated from earlier reactors require subcritical operation with an external neutron source, hence the name Accelerator Driven Systems (ADS). MYRRHA, a project on the European ESFRI-list is aimed a demonstration of ADS technology. MYRRHA, that would also serve other important applications, is to be built in Belgium on the site of the research center in Mol. Many important R&D contributions towards MYRRHA have been made (or are in progress) by a large European collaborative effort within EURATOM-projects.

The present seminar will present and discuss all the issues outlined above. While an effort will be made for making these somewhat arduous subjects accessible to a broad audience, indulgence is also requested by the presenter for succeeding only partially and, further, simplifying certain aspects for the sake of understandability (however back-up transparencies exist for required precisions in the discussion part).

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[1] Sustainability means here in particular that the energy content of the (natural) Uranium and of the "breaded" heavier elements is fully exploited, and thus also the production of high-level long-lived minor actinide (MA) waste avoided. This requires so-called "fast" (i.e. not moderated) *"generation-IV"* reactors, since the fission of MA is essentially induced by the fast part of the neutron spectrum.

[2] LWR, *light water reactor*, using pressurized "natural" water for cooling and moderation is the most often used technology at present.