ENERGETICS

MUR DM 117/ENI - Decommissioning of radioactive components from advanced fusion and fission nuclear reactors

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Context of the research activity	Most radioactive waste generated from decommissioning of nuclear power reactor operation is activated solid metallic material from the main machine components. Some components from future fusion reactors will also have surface contamination including tritium. Radioactive nuclides in fusion waste are mainly solid metallic activation products, not so different from fission decom waste. The options for handling fusion waste must therefore be derived from those for fission decommissiong waste. Progetto finanziato nell'ambito del PNRR - DM 117/2023 - CUP E14D23001950004
	Activated materials, generated by neutron interactions with plant structure, will be the main source of radioactive components from a fusion reactor: they will be removed from the plant during routine blanket and divertor replacements, and then in decommissioning at end-of-life. One of the main goals for fusion is the minimisation of radioactive waste originating from a power plant, with a waste management strategy including the maximum reasonably possible use of materials recycling – within the nuclear industry – and materials clearance (i.e., declassification to non-radioactive material). Concerning fission reactors, most of the radioactive inventory is coming instead from spent nuclear ful: however, if volumes of waste are considered only, decommissioning low-activity waste originating from the decommissiong phase is the most massive source for fission too. Italy is facing a difficult pathway leading to the siting of the Deposito Nazionale, the Italian radioactive waste repository site, where just low and

Objectives	intermediate radioactive waste from the decommissiong phases of the former italian fission plants are to the disposed of. Public acceptance and localization of low- and intermediate waste components turns out to be a delicate question in our nation: so it is worthile studying solutions that minimse the volume and masses of such materials too. This research concentrates on the low and intermediate radioactive waste issue for both fission and fusion, proposing an approach (the “minimum-waste” option), which could be quite convenient for nuclear reactors, in view of their ultimate safety and public acceptance. it is appropriate to explore solutions that minimise the use of final repositories. For this purpose, a new waste management strategy must be developed. It was based upon two main concepts: 1. Recycling of moderately radioactive materials within the nuclear industry. 2. Declassification of the lowest activated materials to non-active material (Clearance). This recycling and clearance strategy appears to have a great potential interest, since its application could reduce the amount of permanent disposal waste (PDW) - excluding fission spent fuel - to minimal levels: previous studies from fusion power plants indicate that about 70% of the total could be recycled and 30% cleared to non-active material. In particular, recycling – after a long interim decay period (up to 100 year) – is the main way for avoiding the production of permanent disposal waste. In fact, the direct reuse or recycling of materials within the nuclear industry, usually after a decay period of up to 50 years, keeps the material out of the waste stream. For example, recycled materials may be used to fabricate further components for nuclear power plants of any type. The feasibility of recycling low-level radioactive materials has been the subject of studies for some years. It is generally assumed that the radiological criterion, which determines the possibility of recycling, is based on the gamma dose rate at the surface of the material (“contact” dose rate). However, recycling is a question dealing not only with radiation protection, but also with metallurgy, materials science, shielding and remote handling techniques. A wide experience in these fields is available from fission research. Not all the “recyclable” material, from a merely radioactive concentration viewpoint, is effectively worth recycling: it must be assessed whether and when recycling of such materials is feasible or convenient. Economical assessment of waste recycling must be considered too. Recycling processes and long-time storage of fusion waste should raise the price of waste more than market prices of industrial waste, but the actual price, in our Nation, could be different than other ones. Economically viable strategies must be envisaged for recycling and clearance, however taking into account - due to the peculiar Italian situation - other parameters too, in order to assess when the "minimum waste option" may be actually convenient, from an economical, sociological and political viewpoint.

Skills and competencies for the development of the activity	Nuclear engineering, nuclear physiscs, particle physics, radiation protection, materials science, use of neutronics and neutron-induced radioactivity codes, radioactive waste management, localisation of nuclear devices, italian and international legislation.