Topic: Nuclear Energy

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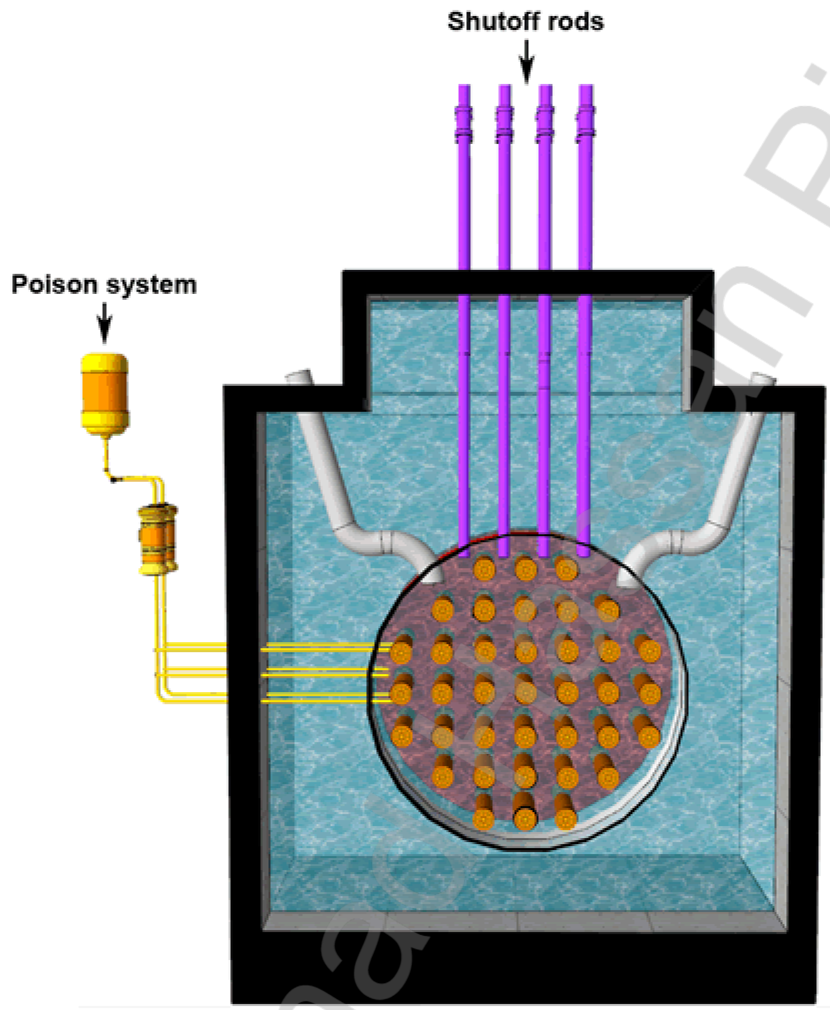
1. When looking at nuclear energy you quickly come to realize that a lot of the information regarding it is shrouded in myths such as the facts regarding the handling of its waste this includes the fact that according to an estimate in 2008 between 2004 and 2020 1772300 m³ of radioactive waste would be produced out of which 25% would've been low-level waste and 0.1% would be a high-level waste.[Hassan 1]with high-level waste arising from the burning of uranium fuel in nuclear reactors and requires shielding and storage as it produces a decay heat of (>2kW/m3) and is thus the major concern when regarding nuclear waste[Hassan 2] whereas low-level waste consists of waste which has a radioactivity of 12GBq/T and thus does not require shielding and ranges across a wide variety of material with usually short half-life and always has low radiation[1][2][Hassan]
2. Furthermore, when looking at the management of HLW we see that out of the 390000 metric tonnes of heavy metals produced since the advent of civil nuclear power 127000 metric tons of heavy metals have been reprocessed meaning turned back into useful nuclear fuel whereas the rest is put under deep geological disposal with engineered barrels[3] [Hassan]
3. When looking at the matter of nuclear accidents we see that it too is shrouded in myths to the point where nuclear power plants are believed to be nuclear bombs just waiting to go off whereas this cannot be further from the truth as nuclear power plants have countless safety precautions in place to prevent nuclear accidents but first things first It should be emphasized that a commercial-type power reactor simply cannot under any circumstances explode like a nuclear bomb – the fuel is not enriched beyond about 5%, and much higher enrichment is needed for explosives.[5]
4. Every country which operates nuclear power plants has a nuclear safety inspectorate and all of these work closely with the IAEA.[5]
5. There are five levels of defence:
6. (1) The purpose of the first level of defence is to prevent deviations from normal operation and the failure of items important to safety. This leads to requirements that the plant be soundly and conservatively sited, designed, constructed, maintained and operated in accordance with quality management and appropriate and proven engineering practices. To meet these objectives, careful attention is paid to the selection of appropriate design codes and materials, and to the quality control of the manufacture of components and construction of the plant, as well as to its commissioning. Design options that reduce the potential for internal hazards contribute to the prevention of accidents at this level of defence. Attention is also paid to the processes and procedures involved in design, manufacture, construction, and in-service inspection, maintenance and testing, to the ease of access for these activities, and to the way the plant is operated and to how operating experience is utilized. This process is supported by a

detailed analysis that determines the requirements for operation and maintenance of the plant and the requirements for quality management for operational and maintenance practices.

7. (2) The purpose of the second level of defence is to detect and control deviations from normal operational states in order to prevent anticipated operational occurrences at the plant from escalating to accident conditions. This is in recognition of the fact that postulated initiating events are likely to occur over the operating lifetime of a nuclear power plant, despite the care taken to prevent them. This second level of defence necessitates the provision of specific systems and features in the design, the confirmation of their effectiveness through safety analysis, and the establishment of operating procedures to prevent such initiating events, or otherwise to minimize their consequences, and to return the plant to a safe state.
8. (3) For the third level of defence, it is assumed that, although very unlikely, the escalation of certain anticipated operational occurrences or postulated initiating events might not be controlled at a preceding level and that an accident could develop. In the design of the plant, such accidents are postulated to occur. This leads to the requirement that inherent and/or engineered safety features, safety systems and procedures be capable of preventing damage to the reactor core or preventing radioactive releases requiring off-site protective actions and returning the plant to a safe state.
9. (4) The purpose of the fourth level of defence is to mitigate the consequences of accidents that result from the failure of the third level of defence in depth. This is achieved by preventing the progression of such accidents and mitigating the consequences of a severe accident. The safety objective in the case of a severe accident is that only protective actions that are limited in terms of lengths of time and areas of application would be necessary and that off-site contamination would be avoided or minimized. Event sequences that would lead to an early radioactive release or a large radioactive release3 are required to be practically eliminated.
10. (5) The purpose of the fifth and final level of defence is to mitigate the radiological consequences of radioactive releases that could potentially result from accidents. This requires the provision of adequately equipped emergency response facilities and emergency plans and emergency procedures for on-site and off-site emergency response.[6]
11. The barriers in a typical plant are: the fuel is in the form of solid ceramic (UO_2) pellets, and radioactive fission products remain largely bound inside these pellets as the fuel is burned. The pellets are packed inside sealed zirconium alloy tubes to form fuel rods. These are confined inside a large steel pressure vessel with walls up to 30 cm thick – the associated primary water cooling pipework is also substantial. All this, in turn, is enclosed inside a robust reinforced concrete containment structure with walls at least one meter thick. This amounts to three significant barriers around the fuel, which itself is stable up to very high temperatures. These barriers are monitored continually. The fuel cladding is monitored by measuring the amount of radioactivity in the cooling water. The high-pressure cooling system is monitored by the leak rate of water, and the containment structure by periodically measuring the leak rate of air at about five times atmospheric pressure.[5]

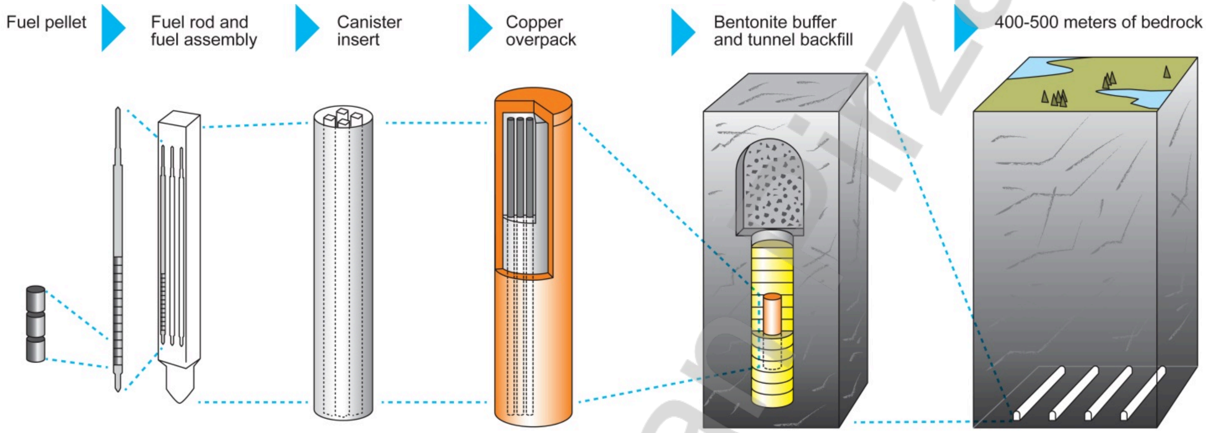
12. In case of irregularities many power plants also have independent, fast acting and effective shutdown systems such as a shutdown system made up of rods that drop automatically and stop the chain reaction if something irregular is detected or a second system injects a liquid, or poison, inside the reactor to immediately stop the chain reaction. [7]



13.
14. Ok so far all the talk has been of hypotheticals but even when looking at the accidents that did take place it is still clear that nuclear energy is better than every other fossil fuel out there when we look at the history of nuclear energy there have been a total of 3 major accidents (Chernobyl (50 confirmed death[8]), Fukushima Daiichi(1 confirmed death[9]) and three mile island(no confirmed deaths)) which have combined claimed a total of 51 lives (confirmed) and 1 waste disposal accident (Kyshtym disaster), taking more extreme death counts such as 60000 for chernobyl[10] and 9000 for Kyshtym (disputed sources) compared to 8.7 million deaths due to the outdoor air pollution caused by burning fossil fuels in 2018 [11]
15. Finally, we come to the comparison of the efficiency of other energy sources as One kilogram of uranium-235 can theoretically produce about 20 terajoules of energy

(2×1013 joules), assuming complete fission; as much energy as 1.5 million kilograms (1,500 tonnes) of coal.[12]

16. Image of storage barrels from [4]



The material of the barrels may vary based on the type of waste

1. Addressing the matters of the Fukushima disaster which is one of the first points raised by anti-nuclear preachers, you may be surprised to learn that the disaster was not in any way due to flaws in the plant or nuclear energy but was in fact due to a freak incident as the power plant was hit firstly by the fourth strongest earthquake in recorded history and a 50-foot tsunami wave and though the plant was prepared for both these individual occurrences no man-made structure was and is prepared for both these occurrences simultaneously. Units 1~3 were operating at the time but shut down automatically when the quake hit. The shutdown reactors need to be continuously cooled, because the fuel rods, though out of fission reaction, release great heat due to the nuclear decaying process of radioactive fission products. [13] TEPCO officials reported that tsunami waves generated by the main shock of the Japan earthquake on March 11, 2011, damaged the backup generators at the Fukushima Daiichi plant. Although all three of the reactors that were operating were successfully shut down, the loss of power caused cooling systems to fail in each of them within the first few days of the disaster. Rising residual heat within each reactor's core caused the fuel rods in reactors 1, 2, and 3 to overheat and partially melt down, leading at times to the release of radiation. Melted material fell to the bottom of the containment vessels in reactors 1 and 2 and bored sizable holes in the floor of each vessel—a fact that emerged in late May. Those holes partially exposed the nuclear material in the cores. Explosions resulting from the buildup of pressurized hydrogen gas occurred in the outer containment buildings enclosing reactors 1 and 3 on March 12 and March 14, respectively. A third explosion occurred on March 15 in the building surrounding reactor 2.[14]
2. After the explosions, the Japanese government created an evacuation zone of 20km which was later expanded to 30 km while workers pumped sea water and boric acid into the reactor cores in an attempt to cool them down, On April 12 nuclear regulators elevated the severity level of the nuclear emergency from 5 to 7—the

highest level on the scale created by the International Atomic Energy Agency—placing it in the same category as the Chernobyl accident, which had occurred in the Soviet Union in 1986. It was not until the middle of December 2011 that Japanese Prime Minister Noda Yoshihiko declared the facility stable after the cold shutdown of the reactors was completed.[14] but this is all misleading as this incident was not nearly as devastating as the Chernobyl accident. [15]

3. Chernobyl released 5300 PBqa of radiation while Fukushima released 520PBqa thus Fukushima accounted for approximately 10% of the releases of Chernobyl. If one takes into account that about 80% of the atmospheric releases were blown offshore, the amount Fukushima's releases effectively affecting the Japanese mainland decreases to about 2% of the releases from Chernobyl [17]
4. When looking at the deaths we see that Fukushima again pales in comparison to Chernobyl as Chernobyl o had around a maximum of 60000 deaths [10] whereas Fukushima only has one total death[8](meaning the second worst accident in nuclear energy history took fewer lives than most fossil power plant accidents)
5. Then we come to the contaminated areas The areas with deposition of more than 100 kBq·m−2 137Cs were 56,000 km2 for Chernobyl and approx. 3000 km2 in the case of Fukushima [18]
6. In the the end, the greatest amount of damage Fukushima ended up causing was a cultural one as this incident caused a further distrust in nuclear power plants which continues to this day

sources

[1]:https://www.ensreg.eu/safe-management-spent-fuel-and-radioactive-waste/categorisation-radioactive-waste
[2]:https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-wastes/radioactive-waste-management.aspx
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