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COMMON MISCONCEPTIONS ABOUT NUCLEAR ENERGY - CASE STUDY FROM INTERACTIONS IN VISITORS CENTER

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ABSTRACT

Paper presents a case study based on more than ten years of experience and interactions with visitors in GEN Interactive visitor center Svet energije (the World of Energy) in Krško / Slovenia. Misconceptions or myths about nuclear energy, such as: "Nuclear powerplants have cooling towers which are giant chimneys that emit smoke" or "Serious possibility of nuclear (bomb-like) explosion of NPP," are some of the common ideas that average visitors express during their visit. We developed optimized responses to such situations during multiple interactions with visitors and numerous public discussions where such misleading statements were expressed. It is crucial to handle an explanation of a misconception in a gentle, non-dismissive tone and try to debunk a nuclear myth with particular attention to prevent possible embarrassment or ridicule of a person that expressed this misconception.

1 INTRODUCTION

The basis for a case study of common misconceptions or myths about nuclear are based on 11 years of interactions of nuclear communicators with more than 73,000 visitors in the visitor center Svet energije (the World of Energy) in Krško / Slovenia. After an initial presentation, the basics of various energy technologies are presented, and visitors can physically experiment with interactive exhibits (using buttons, levers, and digital displays). In the second part of the interaction with visitors, an explanation of nuclear technology is

demonstrated with miniaturized scale models of the complete primary loop of the actual nuclear power plant, fuel rods, and a miniaturized model of the entire NPP Krško with all its buildings. Public discussions with visitors are encouraged with open-end questions and during short pauses, when visitors can roam freely around energy presenting exhibits. With this approach, presentor gives chance, to be approached and even more encourage shy visitors they can ask for face-to-face questions, without public exposure in front of the whole group.

At these stages of communication, most misunderstandings about nuclear are expressed and later debunked.

2 SEVEN COMMON MISCONCEPTIONS ABOUT NUCLEAR ENERGY

We collected a list of most common misconceptions about nuclear technology from our interactions with visitors during their interaction with nuclear communicators. Most of those misconceptions indicate fear of unknown and fear or distrust towards complex aspects nuclear technology.

2.1 Myth #1: "A nuclear power plant will explode like an atomic bomb"

Fuel of nuclear power plant is produced from natural isotope of Uranium 235, which is chemically separated from other ore and later enriched with centrifuges to 4-5% U-235 concentration levels. Enriched U-235 is sintered into ceramic pallets, which are encapsuled into multiple fuel rods that comprise nuclear fuel assembly.

To produce material for the atomic bomb, U-235 needs to be enriched to 90% enrichment level, which is much more complex and is never done for commercial fuel for nuclear reactors.

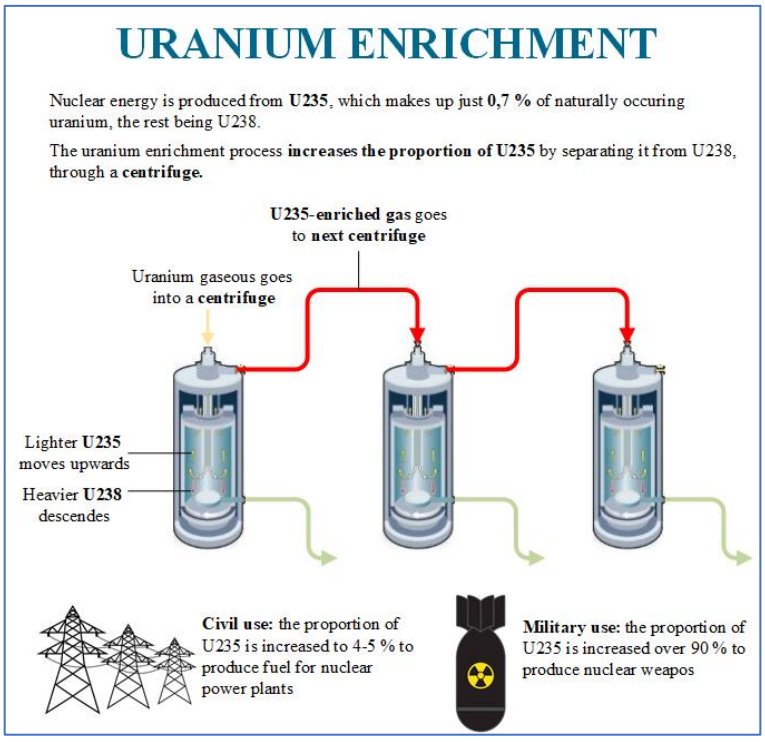

Figure 1: Uranium enrichment stages and use cases

In the nuclear reactor, enrichment of fissile U235 is lower than 5% and every single core design must prove to have negative reactivity coefficient after every refueling. PWR reactors have numerous basic design features that prevent uncontrollable nuclear chain reaction (supercriticality) with physical mechanisms that decrease thermal utilization factor:

- Boron acid in primary coolant
- Control rods can stop chain reaction 2 seconds after drop signal
- Higher moderator and fuel temperatures shut down the chain reaction

2.2 Myth #2: "Cooling towers emit dirty smoke"

Cooling towers in NPPs only emit clean water vapor, produced during the cooling process of steam turbine. It contains no pollutants (like smoke from burning) and it is not radioactive.

With animation of NPP start up simulation, developed in GEN energija, 3 cooling loops of NPP are explained. It is distinctly presented, that no burning of material and consequential smoke is emitted during the process of heat production with nuclear fission.

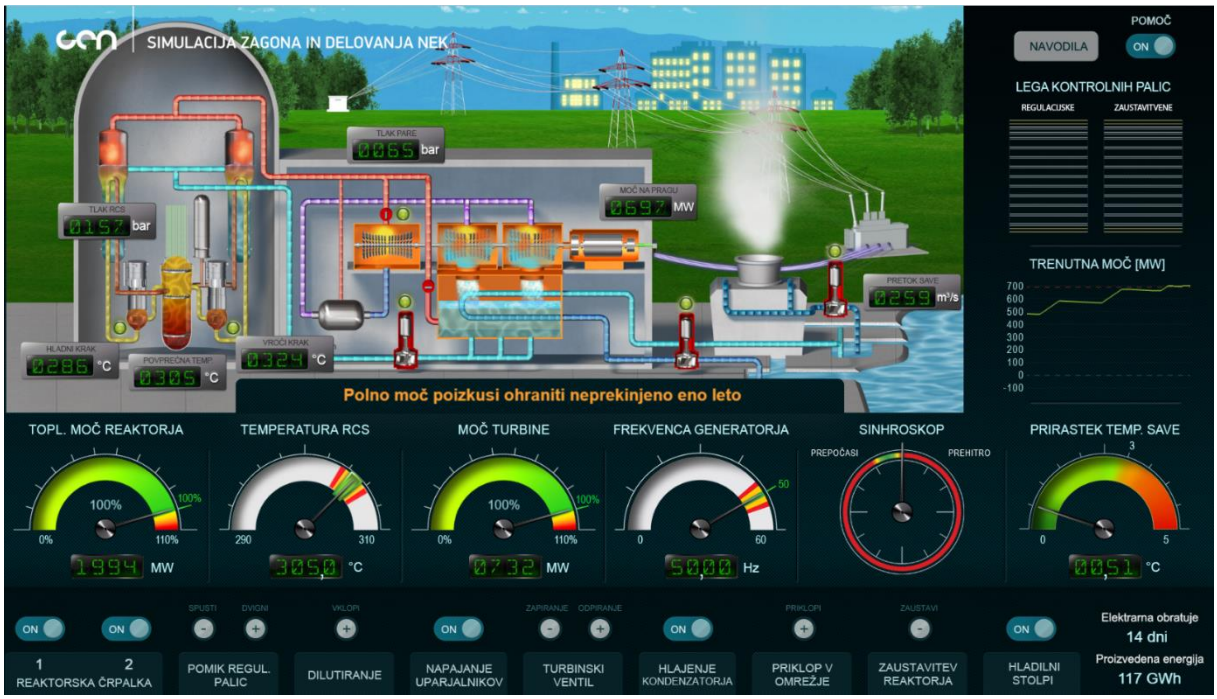

Figure 2: Interactive simulation of NPP start-up and operation developed by GEN energija

Nuclear reaction produces heat, transferred to primary loop coolant, which than transfears heat to the steam generator (SG), there massive amounts of steam is produced in the secondary side. Steam expands and gives energy to large Turbine.

Unused heat from the turbine is transferred to condenser located below turbine, which is cooled with Sava river or cooling towers, emitting only clean water vapor / steam to the atmosphere.

2.3 Myth #3: "Nuclear waste pollute the environment and effect people"

The Nuclear waste is minimal and safely stored. A typical 1,000 MW NPP each year generate about 50 cubic meters of low and medium level waste, and 9 cubic meters of spent nuclear fuel, that can be more than 90% recycled.

Nuclear waste from NPPs and other activities such as medicine does not pollute the environment because it is controlled. Every single piece of radioactive material is measured, weighted, dried out, packed in marked steel drum / container and stored in safe place.

There are two containers in exhibition room, one is cross-cut with visible presentation of Low level nuclear waste, comprised of used rubber gloves, foils and cleaning towels. This presentation usually calms down visitors and terminates their fear of nuclear waste.

2.4 Myth #4: "Nuclear will be destroyed by a large earthquake"

Nuclear power plants are designed to withstand also the largest possible earthquake at the location of a plant. Earthquakes haven't seriously damaged any NPP in the last 60 years.

Human civilization has proved that can build large object such as Roman colosseum and aqueducts, churches that stand for thousands of years. With modern engineering methods of construction, using reinforced steel, and concrete, NPPS are one of the safest buildings on this planet. Probability of large, devastating earthquake (more than 7 on Richter scale) in the vicinity of NPP, that will structurally damage powerplant is slim to none. All systems, structures, and component, needed for the safe operation and shutdown in cases of emergencies are engineered in such a way, that ensures safe outcome. Level 7 earthquake on Richter scale (maximal predicted for Krško region) has 100 times less energy than level 9 on Richter scale that happened in Fukushima / Japan.

2.5 Myth #5: "Nuclear is "old" Technology"

It is true, that majority of NPPs were built in 70s and 80s and are now 30 or 40 years old. However the technology of utilizing the atom is new and less than 70 years old. (solar power plants are older than NPPs, first solar photovoltaic power plant was built more than 100 yeast ago – before the first NPP). [3]

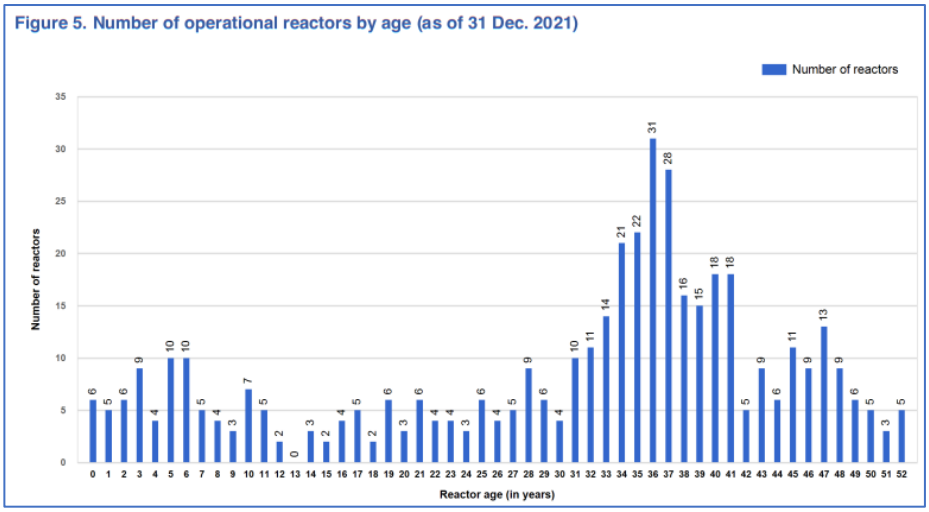

Figure 3: Number of operational reactors by age (as of 31 dec. 2021) [3]

In this time, technology of nuclear equipment and replaced components experienced significant advancement in material science and gained experiences. Slovenian NPP is completely renewed with additional, cutting-edge safe systems, that ensure safe response even in most unpredictable cases, such as potential fall of airplane or large earthquake.

We explain to the visitors and show the exhibit, which shows all inspections, maintenance, and modernization for safe, stable and high-availability operation of NPP NEK in Krško. Most of the upgrades and uprates are performed during scheduled maintenance outages, which take place every 18 months and take approximately 30 days to complete.

Some of the largest upgrades of NEK NPP in the past:

- Replacement of the electric generator rotor
- Replacement of the reactor vessel head
- Installation of a third diesel generator
- Construction of flood protection embankment

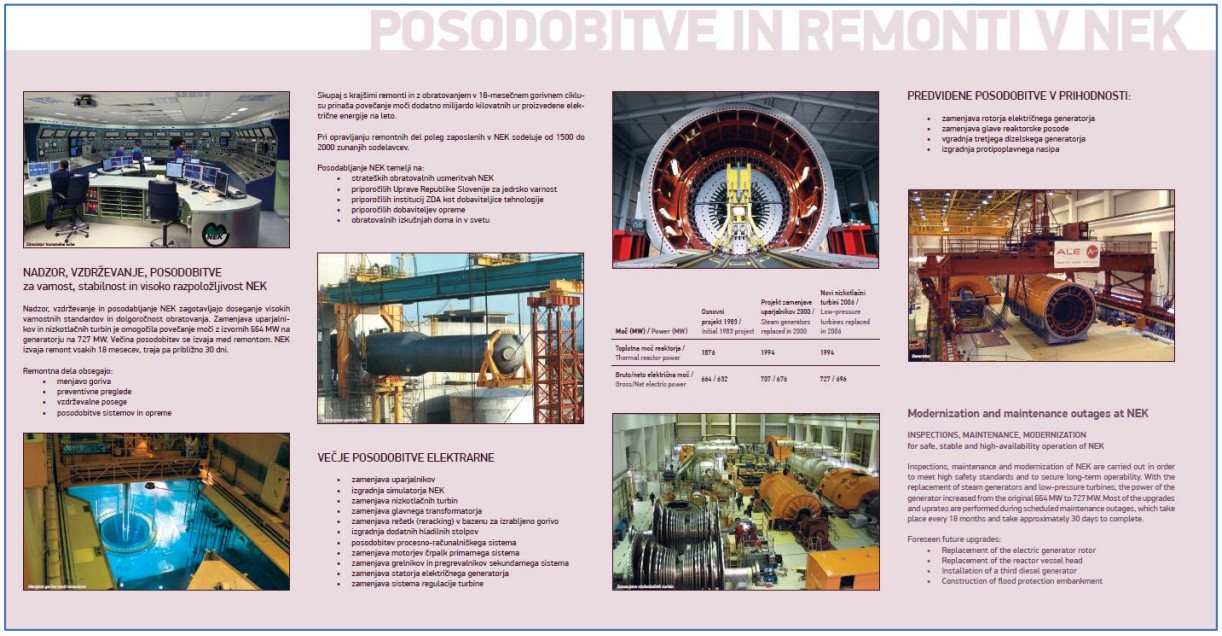

Figure 4: Picture and explanation of NEK NPP upgrades and refuelling process in the visitor center: Svet energije

2.6 Myth #6: "Nuclear waste cannot be safely stored"

Truth: Used nuclear fuel can be recycled to make new fuel and byproducts [5]. Most of the waste from this process will require a storage time of less than 300 years. A facility for final disposal of spent nuclear fuel is designed so that the barriers, after closure of the repository, provide the requisite safety without monitoring and maintenance.

Finally, less than 1% of total waste volume is radioactive for 10,000 years. This portion is not much more toxic than some things found in nature and can be tehnically shielded to protect humans and wildlife.

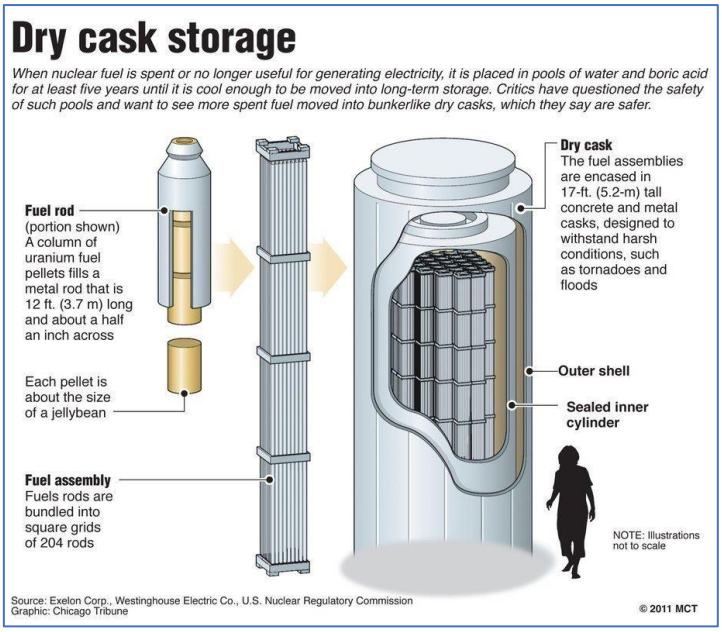

Figure 5: Dry cask storage of spent nuclear fuel [6]

2.7 Myth #7: "Nuclear is EXPENSIVE"

Nuclear powerplants are extremely large and complex objects, with large involvement of personnel and capital. Once build, value of energy of NPPs, with their availability factor usually higher of 90% ensures grid stability regardless of weather or environmental impacts.

In the levelised cost of electricity (LCOE) calculations, which are based on a levelised average lifetime cost approach, nuclear has lowest cost of electric energy. Costs are calculated at the plant level (busbar), and therefore do not include transmission and distribution costs, which are much higher for variable renewables such as wind and solar. [4]

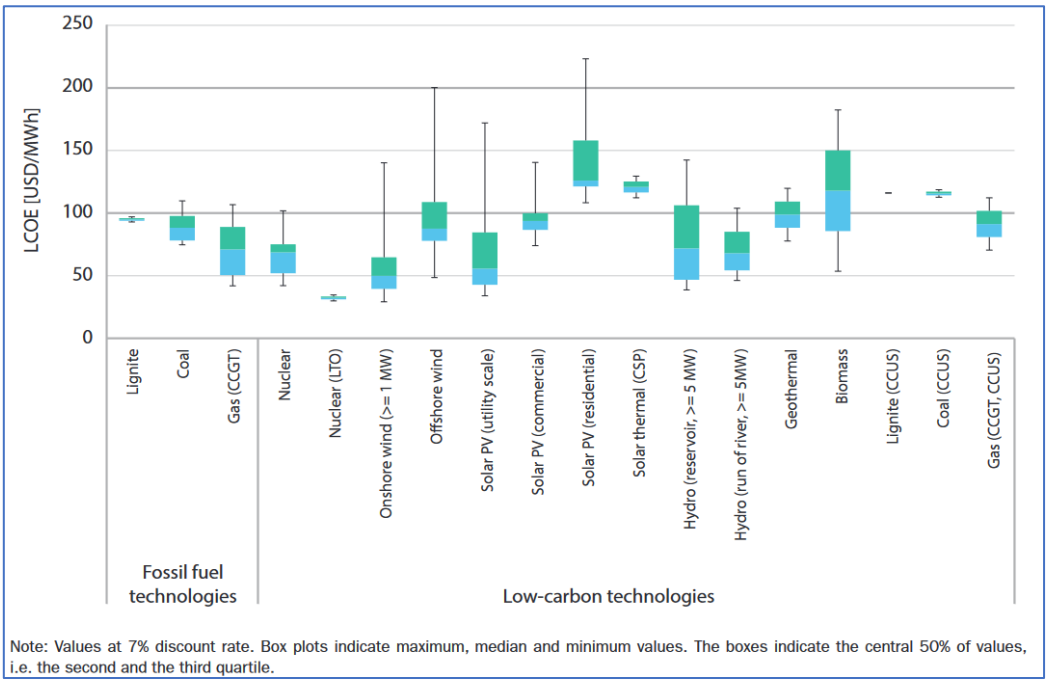

Figure 6: Levelised cost of electricity by technology [4]

3 DEBUNKING MYTHS AND OVERCOMING FEAR OF NUCLEAR

When it comes to a discussion about nuclear energy, often fear, doubt and do not understanding can be present among people. The usual approach of educating people is to present most general facts about the operating of nuclear power plants. By doing that more stress is put on scientific facts that seem inevitable, then what is important and understandable for the general public.

The public's concern over the environmental impact of the nuclear energy is a deterrent to the relaunch of nuclear power programs. The worry is not so much about normal plant operations but rather with abnormal situations. Every human and especially every industrial activity has its effects on and implications for the environment.

Our experience that the right approach is to answer questions, doubts, and misconceptions instead of bombarding people with an extensive amount of scientific information. We usually try to explain the facts through real life situations that people can connect with. Simplicity and humor make the greatest impression on listeners and make them feel more encouraged to ask questions about the topic.

Computer simulations are an effective tool for changing visitors' mindsets because they are based on personal experiential learning in combination with a lecturer who has highly developed lecturing skills and sensitivity to listeners is a "winning" combination.

Most common thing about typical older visitor is deeply rooted fear of nuclear disaster like Chernobyl nuclear accident in 1986. Younger visitors remember Fukushima accident with vivid image of hydrogen explosion of reactor building roof.

Some of the visitors remembers images from cartoons (like The Simpsons) or other TV shows, where nuclear is depicted in several misleading ways (waste is liquid, operators are not educated, safety is not priority no.1, …).

Figure 7: The Simpsons falsely present nuclear waste as green glowing liquid [7]

There are several crucial steps in process of debunking myth about nuclear energy:

- Try to listen and understand origin of fear or misconception about nuclear
- Talk with understanding tone and try to build rapport with visitor
- Use data, simulation, or data visualization to present reality
- Ask "WHY" questions, about uncommon heretical beliefs
- Finish debunking with in-depth interpretation of complex topics
- Try to achieve "AHA" moment, when myth becomes debunked and misbelieve replaced with real knowledge
- Try to be playful and "not too-serious" about serious topics 😊

REFERENCES

[1] IEA, Nuclear Power and Secure Energy Transitions (From today's challenges to tomorrow's clean energy systems), June 2022, 95 pages

[2] https://www.energy.gov/ne/articles/7-things-simpsons-got-wrong-about-nuclear

[3] IAEA, Nuclear Power Reactors in the World, 2022 Edition, Vienna 2022

[4] IEA - NEA, Projected Costs of Generating Electricity, 2020 Edition

[5] K.S. Krane, Introductory Nuclear Physics, John Wiley and Sons, 1988

[6] IAEA, Technical Meeting on the Phenomenology, Simulation and Modelling of Accidents in Spent Fuel Pools, IAEA Headquarters, Vienna, 2-5 September 2019. (https://nucleus.iaea.org/sites/connect/SFMpublic/TM%20on%20Phenomenology%20Simulation%20%20Modelling%20of%20Accid/EGY-Mahmoud-Presentation.pdf)

[7] Homer Eats Nuclear Waste - The Simpsons (https://www.youtube.com/watch?v=kNgIVXrQOC8)