Education as the backbone of sustainable nuclear build Croatian case study

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Some introduction

Why nuclear education in Croatia

Is Croatia nuclear country?
The Krško Nuclear Power Plant is located in Slovenia.
It was built as a joint venture of Slovenia and Croatia.

Construction
1975-1982
Commission date
January 1, 1983

Total Electricity Net Consumption 1984: 62,905 GWh

Federal system in which federal government and governments of six republics shared power and authority.

Yugoslav system had developed into a unique, highly decentralized, socially owned market economy.

- The second NPP was to be built in Croatia.
- Chernobyl cancel that.
History of Nuclear in Croatia

- Until 1991, Croatia was one of the former Yugoslavian republics.
- By the late 1960s, the federal commission was dismissed, and the development of a nuclear option for the energy sector was transferred to Slovenian and Croatian power utilities.
- The construction of the first nuclear reactor started in 1973 in Slovenia with at least one more nuclear power plant foreseen to be built in Croatia, with a number of potential locations being assessed and a possible site for the first build selected (Prevlaka near Zagreb).
- A number of reasons, the accident at the Chernobyl power plant, led to the ban of nuclear power plant in 1986 with no restrictions on nuclear research and scientific projects in Croatia and that plan was abandoned in 1987 by Slovenia due to a referendum held in 1986.
- Since the proclamation of Croatian independence in October 1991 until 1997 and the end of war for independence, any idea of nuclear build was put aside.
- However, nuclear research and efforts on the education of nuclear engineers continued.
History of the Krško Nuclear Power Plant

- The Krško Nuclear Power Plant is located in Krško, Slovenia.
- The plant was connected to the power grid on October 2, 1981 and went into commercial operation on January 15, 1983. It was built as a joint venture by Slovenia and Croatia which were at the time both part of Yugoslavia.
- The plant is a 2-loop Westinghouse pressurized water reactor, with a rated thermal capacity of 1,994 thermal megawatts (MWth) and 696 megawatts-electric (MWe), today more than 700 MW.
- Its sister power plant is Angra I in Brazil.
The Krško Nuclear Power Plant - Today

- The operating company Nuklearna Elektrarna Krško (NEK) is co-owned by the Slovenian state-owned company Gen-Energija, and the Croatian state-owned company Hrvatska elektroprivreda (HEP d.d.).

- The power plant provides 20% of Slovenia's and 16 percent of Croatia's power.

- In 1998, the Government of Slovenia nationalized NEK, stopped supplying power from Krško to HEP, and sued HEP for the unpaid bills.

- In 1999, HEP counter-sued for damages because of lack of supply.

- In January 2001, the leaders of the two countries agreed on equal ownership of the Krško plant, joint responsibility for the nuclear waste, and the compensation of mutual claims.
Joint ownership model of the Krško NPP

- **Dealing with the radioactive waste**, spent nuclear fuel and decommissioning issue
  - The **Governing Agreements did not expressly deal with financing of decommissioning** at the end of the Krško NPP useful life (2023)
  - Spent nuclear fuel and radioactive waste provisions:
    - *The Parties shall take all measures to provide, upon competition of construction of the Krško NPP, the security measures for prevention of possible adverse consequences for the human environment*
    - *The cost of performance of measures from the previous paragraph, together with the cost arising from disposal of nuclear fuel and radioactive waste shall be borne by the Parties from each Republic in proportion 50:50.*
2001 Agreement

Most significant features

**Governance of the Krško NPP**

The designated "Company bodies" would be the Shareholders' Assembly, the Supervisory Board, and the Management Board, "all of which are composed on a parity basis.

**50:50 Rights to Total Power Output of the Krško NPP**

The Krško NPP is required to deliver electricity produced at the Plant to the Shareholders in equal proportions.
Where we are now?

Regardless of the all political problems, the NPP worked smoothly all the time and supplied electricity

Both owners decided to extend life of NEK for next 20 years
2001 Agreement: employment

- One of the elements of this new contract was the employment of workers from Croatia.

- In AGREEMENT between the government of the Republic of Slovenia and the government of the Republic of Croatia on the regulation of the status and other legal relationships, connected with investments in the NPP Krško, d.o.o., its exploitation and decommissioning in Article 8 (Employment, Training) was stated:

  (1) Contracting Parties agree that an obligation of NEK, d.o.o. is defined in the Contract of Partnership that parity principle is observed at employment of members of Management Board and other employees granted authority as stipulated by the Contract of Partnership.

  (2) Company shall define the positions for which free employment shall be secured/granted, considering the principle of safety and optimal plant operation and proper representation of experts from both Contracting Parties.
History of nuclear education

- At the University of Zagreb Faculty of Electrical Engineering (ETF), the study program ETF4 was created in 1977 with the fields of: Energy; Electrical Engineering and Automation; Industrial Electronics; Telecommunications and Informatics; Automation; Computer Technology; Radio Communications and Professional Electronics; and **Nuclear Energy**.

- In 1977, the study program **Nuclear Energy** was introduced in order to educate electrical engineers in nuclear issues, which was needed due to the construction of the Krško Nuclear Power Plant.

- **Nuclear Energy program had in the first generation 11 students**

- The ETF 4 curriculum is carried out until the school year 1994/95, and it starts to be gradually extinguished, from the first year towards the end of the studies, and is replaced by the **new curriculum FER1**, which introduces studies in electrical engineering and computing.

- In 1995 the Faculty changes its name to the Faculty of Electrical Engineering and Computing (FER).
Today of nuclear education

- In the new study program, FER1, as a result of the accident in Chernobyl, the separate study program Nuclear Energy is cancelled and only some elective subjects related to nuclear engineering are retained.

- Today, the FER3 curriculum is in force, where the following are taught as elective subjects in the field of nuclear engineering:
  - Nuclear Engineering
  - Nuclear Fuel Cycle and Reactor Materials
  - Nuclear Safety
  - Fluid Dynamics and Heat Transfer
  - Computational Fluid Dynamics
  - Computational Heat Transfer.

- Today 2 professors, 2 assistants and 2 researchers work on education and projects as TSO with Krško Nuclear Power Plant
History of nuclear education

- Extensive research is currently ongoing aiming to identify all BSc, MSc, and PhD nuclear engineering related theses defended in the last two decades.

- Due to the limitations of databases’ search engines and Croatian language specifics the process is extremely slow but it already revealed some interesting facts and necessities.

- For example, search based on the keyword “nuklearna” (nuclear) identifies altogether 64 theses defended on all Croatian universities, majority on the University of Zagreb, 60%.

- Out of 64 theses, 39 were on BSc level, 22 on MSc level, and only 3 on PhD level.

- Particularly interesting is the distribution over the years with the oldest available records dating from 2001.
Distribution of thesis containing the word “nuklearna” (nuclear) over the last two decades on all Croatian higher education institutions

- The distribution over the years is depicted in Figure.
- It seems that the interest in nuclear is increasing in the last decade, and the data from the last two years collaborate that conclusion.
Nuclear Power Plant Krško – employment today

- Today, about 50 Croatian experts (out of a total of 640) work at NPP Krško.
- About half were students of the University of Zagreb Faculty of Electrical Engineering and Computing.
- New stipends for work at the NEK have also been announced.
A young woman from Zagreb controls the heart of the nuclear plant

- When she entered college, Lara thought for a long time about which path to take.
  - In the end, I chose FER (Faculty of Electrical Engineering and Computing) - says Lara.
  - There, after the first year, a new choice awaited her: computing or electrical engineering.
  - Computer science was very popular at that time, and at first it might have paid better.
  - However, I enrolled in computer science first.
  - And then over the summer I changed my mind and started studying electrical engineering.
  - Later, I chose energy, at the university quite by accident I "pinned" a small notice that the Krško Nuclear Power Plant offers scholarships, and here I am for the eighth year.
- From the first day I knew that I wanted to work in the control room - says Lara.
- Since then she has gone through all the steps.
- She trained as an operator, got to know every valve of the power plant, supervised the operation of the turbine and condenser, managed the reactor, and was the chief operator.
- And in the end, she got a license as a shift engineer at the Krško Nuclear Power Plant.
- Today, Lara is training the staff of the power plant.
Eleven EU countries launch alliance for nuclear power in Europe

2021

- Nine EU countries have signed a joint statement backing the future use of nuclear energy to fight against climate change effectively. According to the joint statement, nuclear energy represents a reliable energy source to secure a low-carbon future. The statement has been signed by a group of countries, including Czechia, Bulgaria, Croatia, Finland, Hungary, Poland, Romania, Slovakia and Slovenia.

2023

- Eleven European countries committed on Tuesday (28 February) to “cooperate more closely” across the entire nuclear supply chain, and promote “common industrial projects” in new generation capacity as well as new technologies like small reactors.
- The signatories signed a declaration in Stockholm, with the objective of “jointly reaffirming their desire to strengthen European cooperation in the field of nuclear energy,” Tuesday 28 February.
- The eleven signatories include Bulgaria, Croatia, Czech Republic, Finland, France, Hungary, the Netherlands, Poland, Romania, Slovakia, and Slovenia.
  - The EU Commissioner for Energy, Kadri Simson, also took part in the meeting, an EU official confirmed.
- The objectives of the cooperation is to promote research and innovation as well as helping to set “uniform safety rules in accordance with best international practice,” reads the joint declaration.
- Crucially, it also seeks “to reinforce industrial cooperation in the development of European nuclear capacity” and to explore “common industrial projects” for new reactors.
New alliance for nuclear power in Europe - experts

- A number of studies on public support for nuclear resulted in uniform conclusion that it is a **vital element for nuclear option to be accepted by policy makers as a part of energy development strategies**.
- The assessment is comprised of two aspects:
  - **technical competence and**
  - **social competence.**
- **Foundations for both rely on trained and competent experts supported by scientific community.**
- **The educational process is the backbone to secure required workforce for all stated tasks.**
- There are a number of questions that arouse from such reasoning:
  - what is the **critical mass of experts** required for a national sustainable nuclear buildup;
  - what areas of expertise should be covered;
  - what is the **optimum ratio of national vs. international experts** and scientists to secure public support;
  - when should targeted nuclear education of experts begin, at bachelor level or later on in the form of specialized workshops;
  - what are the **means of increasing the interest of possible candidates** for nuclear education, is it just the money;
  - if the **increase of public nuclear knowledge** has a low impact on pro-nuclear public opinion shift, can it be used to increase the interest of potential candidates for nuclear education?
New alliance for nuclear power in Europe - experts

- The categorization will be critical to identify available pool of experts for a potential sustainable nuclear build.

- To be more specific, in order to secure long-term safety and reliability of nuclear energy each nuclear stakeholder (administration, industry, and science) will have to be properly staffed.

- Although employees can be and most likely will have to be educated for specific nuclear oriented tasks, background nuclear affiliation would be useful.

- New nuclear build, especially for a country without active nuclear program is, among others, extremely qualified personnel demanding.

- It is the aim, at this stage of the research, to identify Croatian nuclear stakeholders, their current personnel capacity, and likely personnel demand if an active nuclear program is put into place.

- The first stakeholder group might broadly be referred to as administrative one. It consists of:
  - government ministries that are likely to be involved in a nuclear build,
  - Croatian Utility,
  - regulatory body, and
  - Fund for financing the decommissioning of the Krško Nuclear Power Plant and the disposal of Krško NPP radioactive waste and spent nuclear fuel (Fund for NEK).
Conclusions

▪ Recently observed shy shift of Croatian policy towards nuclear option provoked thinking about capabilities of nuclear stakeholders to respond to such a shift.

▪ It was soon realized that new nuclear build requires large number of new engineers with nuclear knowledge.

▪ The development of a new nuclear engineer implies a reliable educational structure that guarantees adoption of basic technical knowledge as well as specialized nuclear knowledge in different fields of engineering that would be necessary for a sustainable new nuclear build.
Conclusions

- In this preliminary stage of research current status of nuclear education in Croatia has been analysed.

- It was deduced that a *slight increase of students’ interest in nuclear engineering* on undergraduate and graduate level of university education exists.

- However, the analysis also indicates that these students lack basic nuclear knowledge, which implies that certain preconditions should be placed for students defending nuclear oriented theses and be considered as candidates for employment by nuclear stakeholders.

- Croatian case study also emphasized the need for *categorization of nuclear oriented topics in education* for further identification of available pool of experts for populating administration, industry, and science staff.

- It is important to emphasize that *even today NEK regularly publishes tenders for the employment of Croatian experts* and that it awards several scholarships to students of the Faculty of Electrical Engineering and Computing every year.