THE PROCESS OF DECARBONIZATION OF THE DOMESTIC POWER INDUSTRY IN POLAND USING SMR REACTORS

ISSUES RELATED TO SPENT FUEL AS ONE OF THE PARAMETERS DETERMINING THE CHOICE OF TECHNOLOGY

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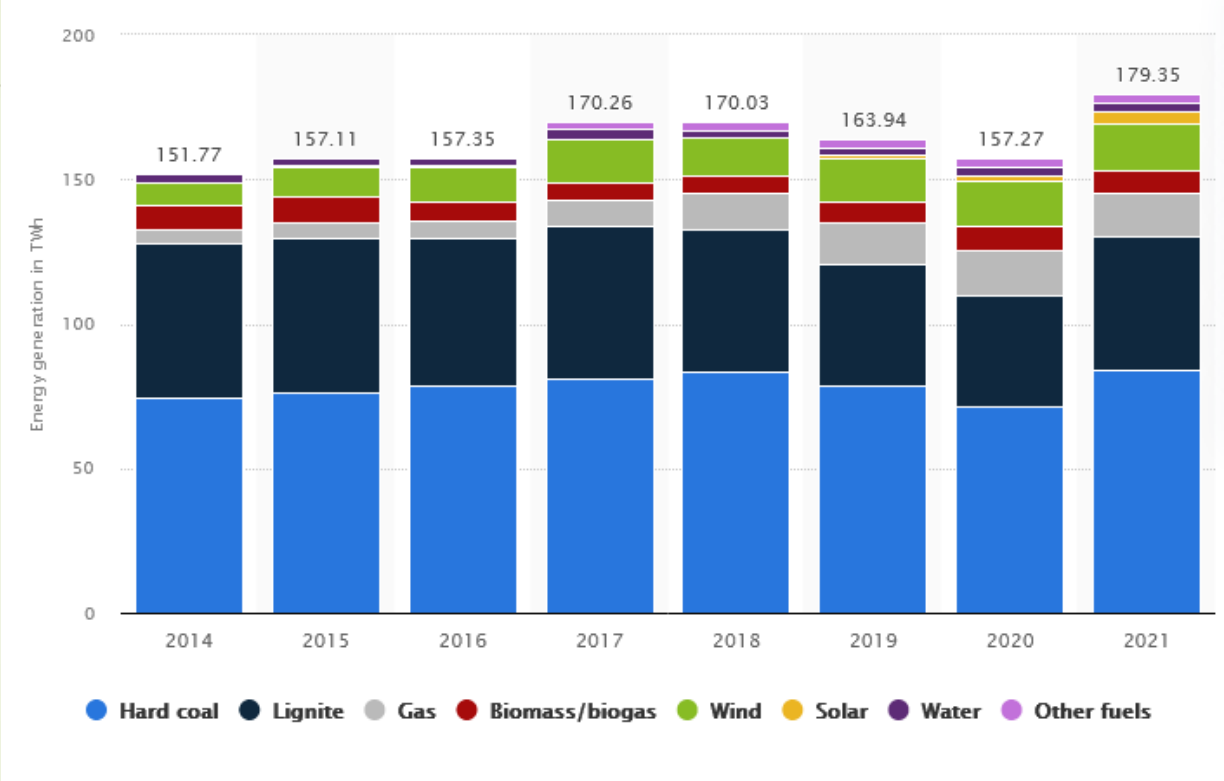
Outline

- Energy sector in Poland;
- Plan of decarbonization of the power industry;
- Selection of the nuclear technology;
- SF and RW management consideration.

Energy sector in Poland



https://www.statista.com/statistics/1308147/poland-energy-generation-by-technology/

- Poland's power sector is tightly coupled with the domestic coal sector.
- Coal power makes up nearly 80% of annual electricity generation and 70% of the available generating capacity.
- In addition, a quarter of Polish heating is provided through district heating networks by combined heat and power (CHP) and heat-only stations that are fueled by coal.

Implementation of nuclear energy

Energy Policy of Poland until 2040 (PEP2040) sets the framework for the energy transition in Poland.

STRATEGIC PROJECT 5. - Polish Nuclear Power Programme

SPECIFIC OBJECTIVE 5. - Implementation of nuclear power

In **2033**, the first power unit of a nuclear power plant will be launched, with a **capacity of approx. 1-1.6 GW.**

Subsequent units will be implemented **every 2-3 years**, and the entire nuclear programme involves the construction **of 6 units.**

Polish Nuclear Power Programme (2020)

Construction and commissioning in Poland nuclear power plants with a total installed nuclear capacity from approx. **6 to approx. 9 GWe** based on proven, large-scale, Generation III (+) **pressurised water reactors**.

There is also the potential to use **high-temperature reactors (HTRs),** which not being an alternative to large-scale light-water nuclear power units, could be used in the future mainly as a source of **process heat for industry.**

Not only large-scale nuclear energy?

- High-temperature reactors

The Polish government plans to build a cogeneration HTR of 200-350 MWt for process heat, and before this a 10 MWt experimental HTR at Swierk.

- Small modular reactors

Poland has a number of energy-intensive industrial companies, among them, Synthos, KGHM, and PKN Orlen, planning modernization plants to include new small reactors.

Repowering of existing coal power plants with SMRs

- The current Polish power and heat sector consists of 303 larger coal units with a combined installed capacity of 33.3 GWe.
- 17,500 MWe of capacity that was either constructed in the last 20 years (since the year 2000) or has undergone significant modernization and renovation in that time period.
- The remaining 16,900 MWe of capacity is older than 20 years and have not undergone any major recent modernizations and can thus be expected to instead be decommissioned and replaced by greenfield low-carbon energy.
- A half of the existing capacity (16,900 MWe across 55 units) are applicable for analysis of retrofit options.

QVIST, S., GŁADYSZ, P., BARTELA, Ł., SOWIŻDŻAŁ, A., Retrofit Decarbonization of Coal Power Plants—A Case Study for Poland. Energies 2021, 14, 120

Project DEsire

“Plan of decarbonisation of the domestic power industry through modernization with the use of nuclear reactors of III+ and IV generation” (Desire)

- This project is financially supported by the National Centre for Research and Development (NCBiR) of Poland as part of the project under the Polish Strategic Program "Social and economic development of Poland in the conditions of globalizing markets" – GOSPOSTRATEG.
- The main goal of the project is to develop **a plan for the decarbonization** of the domestic commercial power industry through modernization with the **use of generations III and IV nuclear reactors**, which is to constitute a road map for the organization of investment processes leading to the transformation of centralized generation systems.
- An important goal of the Desire project is to create and pilot the Conventional Power Generation Transformation Cluster (KTEZ). KTEZ is to provide organizational support for activities aimed at increasing the effectiveness of various stakeholder groups in the process of transformation of domestic power plants and combined heat and power plants.

https://projektdesire.pl

Ministerstwo Klimatu i Środowiska

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A ranking of nuclear reactor technologies - an approach implemented in the DEsire project

Formal requirements and recommendations imposed by international and national organizations on the process of designing and operating nuclear power systems.

The applied solutions of the security systems of the reactor itself, the heat cycle of the steam turbine and the auxiliary infrastructure.

Potential nuclear threats to the personnel of the nuclear reactor unit and local population.

Management of spent nuclear fuel and radioactive waste.

- When choosing a nuclear technology, technical issues are very important, e.g. be considered is the amount of spent fuel produces and the method of its management.
- The issues of managing SMR spent fuel during storage, transportation, possible reprocessing and recycling, or final disposal are obviously connected with the nuclear safety of the whole process but also with its economy.

SMR designs as possible retrofit of coal-fired plants for the Polish energy system

- The nuclear reactor technology most suitable for replacing coal units is based on high temperature reactors, most of which are classified as SMRs (small modular reactors).
- In addition to Generation III reactors, the group of Generation IV reactors is also considered as a potential nuclear technology of future.

Design	Fuel type	Fuel enrichment %	Coolant	Power	Temperature
High-Temperature Gas-cooled Reactor (HTR-PM)	TRISO fuel	<19,75%	Helium	250 MWth	750°C Helium 566°C steam
Xe-100 — X-Energy (HTGR)	Triso X UCO, UO_2	5-20%	Helium	200 MWth	750°C Helium 565°C steam
ThorCon molten salt fission reactor	U and 9.0 kg of Th per day	19.75%	Salts	557 MWth	550 °C
Kairos Power FHR (KP-FHR)	Uranium oxide (UO2)	19,75%	Salts	320 MWth	585 °C
Terrestrial Energy Integral Molten Salt Reactor (iMSR)	Molten UF_4	<19,75%	Salts	400 MWth	~ 585 °C
Westinghouse Lead Fast Reactor (LFR)	Oxide (UO_2 or MOX prototype); Advanced, high-density fuel (commercial)	Fast reactor	Lead	950 MWth	~ 595 °C
NuScale (SMR-PWR)	Uranium oxide (UO_2)	8-9%	Water	250 MWt/unit	288°C
BWRX-300 GE Hitachi	Uranium oxide (UO_2)	3-5%	Water	870 MWth	345°C

Factors influencing the selection of nuclear reactor technology

PARAMETER	CRITERION
The applied solutions of the security systems of the reactor itself, the heat cycle of the steam turbine and the auxiliary infrastructure.	Number of security systems
	Cooling systems redundancy
	Consequences of a serious reactor accident with damage to containment
	The degree of technology advancement
Management of spent nuclear fuel and radioactive waste.	Availability of RW management technology
	Availability of SF management technology
	Nuclear fuel enrichment
	Quantity of SF and RW
	RW from decommissioning

- Available technologies of: reprocessing, interim storage and final disposal of SF/RW;
- Available technologies of: reprocessing and interim storage of SF/RW;
- Available technology of interim storage of SF/RW;
- No concept of SF/RW management;
- Typical construction waste ("single large blocks") and light water;
- Typical construction waste (a few "small blocks") and light water;
- Additional non-standard/ problematic waste, e.g. graphite, waste from cleaning molten salts, lead, heavy water or gaseous coolant;
- The degree of nuclear fuel enrichment within the range: 10-20%; 5-10% or <5%

Summary

- There is consensus that Poland must gradually move away from the use of fossil fuels in favor of the exploitation of low-emission sources.
- A perspective direction of decarbonization of power industry in Poland ca be its modernization towards the use of nuclear reactors.
- The nuclear reactor technology most suitable for replacing coal units can be based on high temperature reactors, most of which are classified as SMRs (small modular reactors).
- These aspects related to SF and RW should be carefully taken into account when choosing nuclear technology. Consideration on all stages of SF and RW management (storage, transportation, possible reprocessing and recycling, or final disposal) are obviously connected with the nuclear safety of the whole process but also with its economy.
- The amount of spent fuel, its chemical and radiochemical form, total activity, as well as the type of radioactive waste generated during the operation of different types of reactors are evaluated and will be the basis for assessing the technology in the framework of works carried out, among others in the Desire project.

Thank You for Your kind attention!

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