

Repurposing sites of fossil plants with advanced nuclear reactors

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<https://www.iaea.org/topics/fast-reactors>

Background & Motivation of the Concept



- A coal-to-nuclear (C2N) transition means siting a nuclear reactor at the site of a (recently) retired coal power plant.
- Across the Globe, communities and the energy industry are working to decarbonize their energy generation and consumption and are implementing actions to achieve zero-carbon-emission goals.
- Environmental and climate change concerns place pressure on utility plant owners to retire Coal Power Plants.

Background & Motivation of the Concept

- Nuclear energy is key to achieving global net zero objectives, working in partnership with renewable energy sources and other low carbon options, as part of a sustainable energy system to decarbonize electricity and non-electric energy production.
- 550 GW of new nuclear capacity will be needed by 2050.

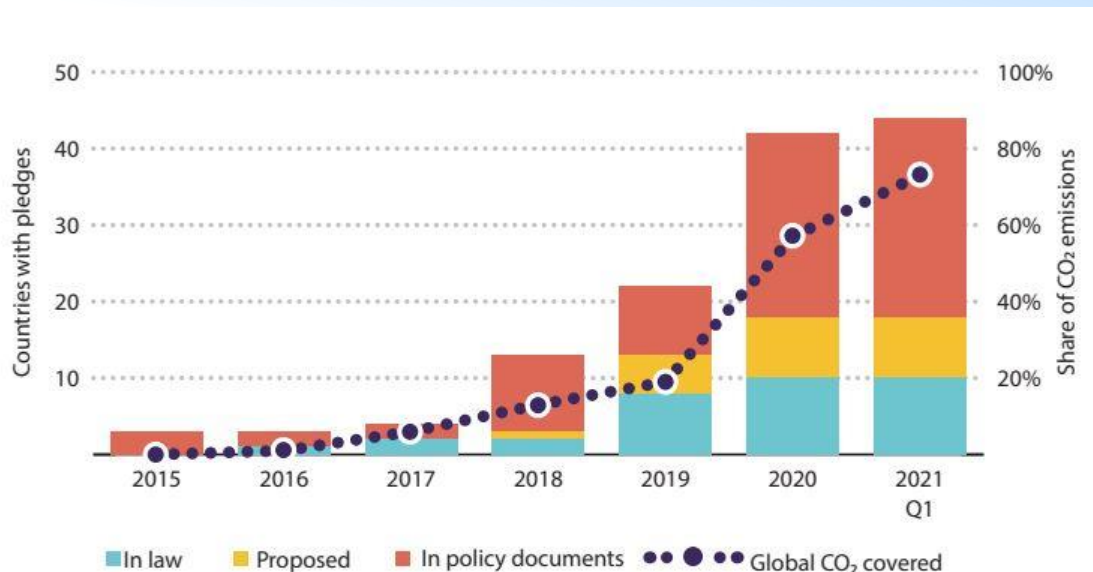
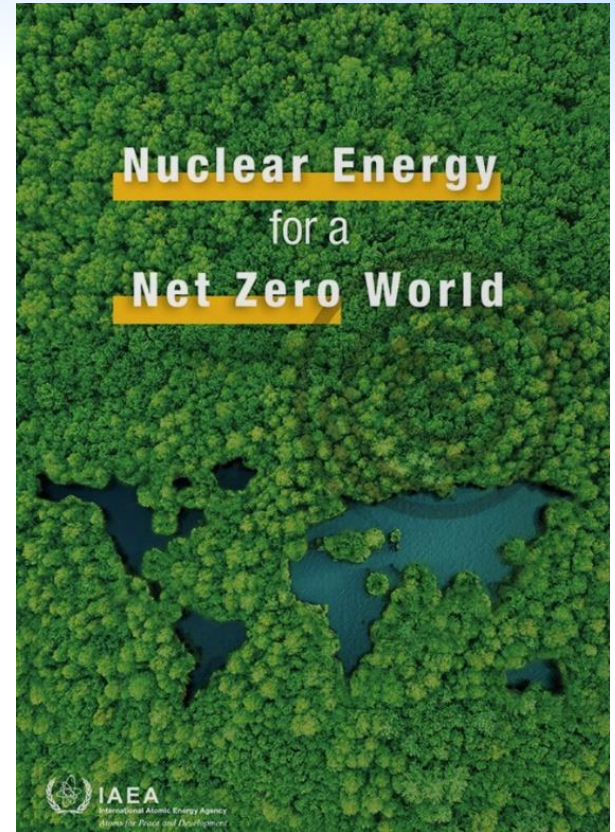


Figure 1. Number of countries with net zero commitments (incl. EU countries with national pledges) and share of global CO₂ emissions (incl. all EU countries) (based on data from [1, 9] as modified by IAEA).

Nuclear Energy for a Net Zero World by the Agency (COP26)

“... Decades of experience in many countries have demonstrated that these differences [between NPP and coal plants] can be easily managed. **Nuclear power plants can thus be envisaged as a cost effective solution for either entirely replacing or potentially “repowering” coal power plants on brownfield sites with the aim to maintain the generating capacity, ensure continued baseload and load following capabilities, and retain jobs on the site, while switching to low carbon electricity and heat production. While the most common form of repowering — i.e. re-utilization of coal power plant components, typically steam generation and heat rejection systems — is converting from coal to natural gas (in the U.S. between 2011 and 2019, 86 coal fired plants were converted), other options include adding a geothermal heat source, or equipping a plant with post-combustion carbon capture. In addition to repurposing the steam generation and heat rejection systems, repowering coal plants to nuclear power may also enable other elements of the existing infrastructure to be retained — such as transmission and cooling systems — resulting in significant savings and faster deployment, although this is likely to require significant modifications”.**



SMRs for C2N

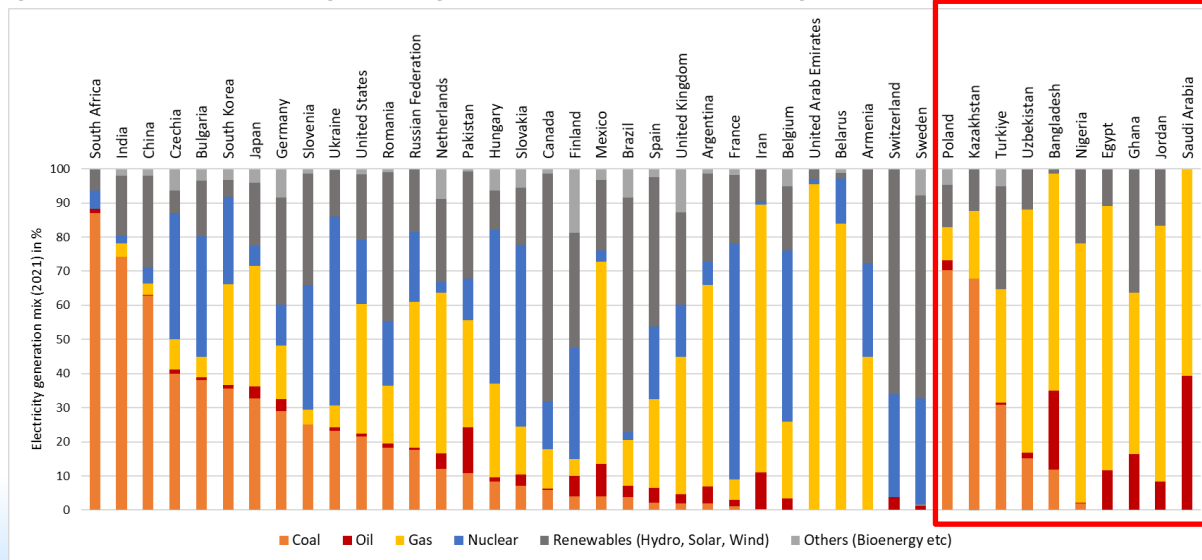
- SMR capacities are limited to 300 MWe, which is less than one-third the size of conventional NPP, but similar in output to many conventional coal boilers.
- Smaller physical size allows for factory assembly.
- Passive systems.
- Using multiple modular, small, and safe reactors allows the NPP to be scaled to meet local needs and support power generation for applications beyond electricity generation.
- Increased safety reduces the size of emergency-planning zones which allows easier siting.
- Low cost? & Safe operation.
- These attributes make SMRs and advanced reactors of particular interest for CPP to NPP conversion.

Benefits of C2N

- Nuclear power is a significant driver of economic growth, generating jobs in many economic sectors, and enabling a just transition away from coal.
- NPPs are well suited to replace coal fired power plants for low emissions electricity generation.
- NPPs can substitute coal fired boilers for district heating and industry.
- Reuse of infrastructure (roads, warehouses, administrative buildings).
- Reuse of transmission/ Grid.
- Job retention.
- Retain value of Assets.
- Lower construction costs and faster deployment of NPPs.

Who can benefit?

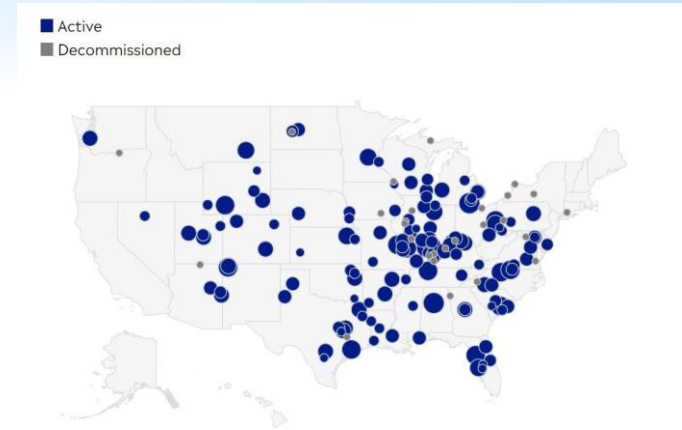
- As of 2022, the World has more than 2 TWe of coal-fired electric power plants, generating about 12 GT of CO₂ emissions per year, amounting to almost **one-third** of global total net annual emissions of approx. 40 GT/year.
- Repurposing coal with natural gas might eventually lead to gas to nuclear approach.



Electricity generation mix (2021) in countries with or planning nuclear power programmes

USA Case

- Currently **110 coal plants** operating in the U.S. that are planned for **retirement by 2040**.
- 120 GW of electricity capacity that could be replaced by advanced nuclear reactors.
- **1 billion tons of carbon dioxide per year eliminated**.
- 1.5 billion hours of construction employment, **35,000 power plant jobs** and **32,000 manufacturing jobs**.



Natrium Plant by TerraPower



- Natrium technology is a **345-MW** sodium fast reactor, with a molten salt-based integrated energy storage system
 - planned in Kemmerer, Wyoming (Naughton Power Plant). **Estimated completion by 2028**.
- U.S. DOE **Advanced Reactor Demonstration Program** committed nearly \$2 billion, TerraPower will match dollar-for-dollar
- Build the **supply chain for sodium fast reactors** in the U.S.
- Estimated jobs: **2,000 construction jobs** and **250 jobs at operational plant**

USA Case: Sodium Plant by Terrapower

ADVANTAGES

- Small / Flexible Footprint
 - Attractive size (345 MWe)
 - Thermal storage has the potential to boost the system's output to 500MWe of power for more than five and a half hours when needed
 - Flexibility to quickly load follow to accommodate the increased impact of solar and wind
 - Rapid Construction
 - Emergency Planning Zone at the Site Boundary
 - Non-Water Coolant
 - Inherent Safety
 - Grid Connection / Transmission Lines
- Able to tie into substation and grid ready for power level
- Workforce

Local community supportive and available for construction/operations



Naughton Power Plant

- Three-unit plant with total generating capacity of 700 MW
- Units 1 and 2 are coal fired ~450 MW
- Unit 3 was converted to natural gas in 2019
- The 2021 IRP reports the following retirement schedule: Units 1&2 2025.

Romania Case: Repurposing Doicești with NuScale

- In November 2021, Nuclearelectrica signed agreement with NuScale Power to **build 6-module VOYGR SMR with capacity of 462 MWe** at the site of the **former Doicești coal fired power plant**.
- Estimated cost of the SMR project including construction and installation is **\$1.6B, estimated competition by end of decade**.
- Small land footprint of around 10 hectares.
- Capital **cost savings could be on average approximately \$100M** depending on the site.
- Existing **hard infrastructure** supports project (**water, electrical grid, roads, railways, etc.**).
- In August 2022, Agency concluded **SEED mission to Romania**, where **first European SMR could be built**.



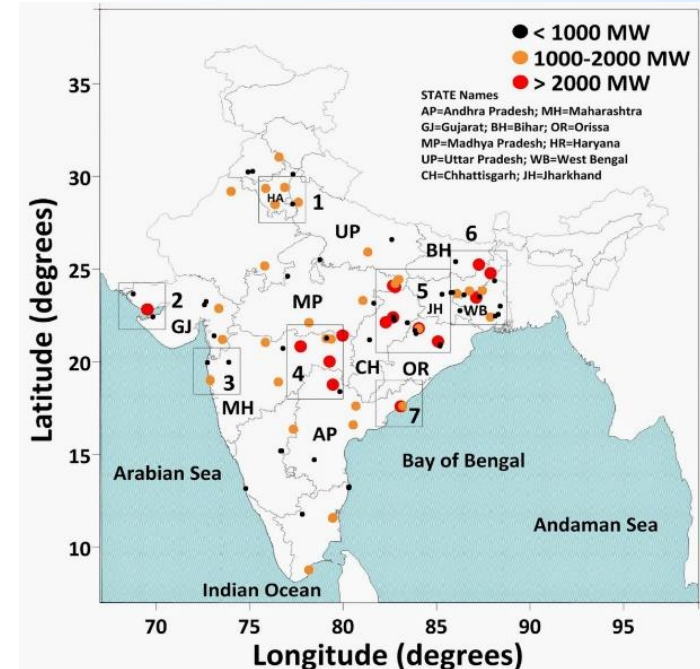
- Capacity building: Retaining the coal power plant workforce:
 - Many positions are directly transferable from coal to nuclear.
 - Other positions can move into SMR power plant jobs with cross training.
- Use of SMRs **avoids the costly natural gas interim step** of converting the coal plant to natural gas and then having to decommission the plant a decade later.

India Case: SMR project

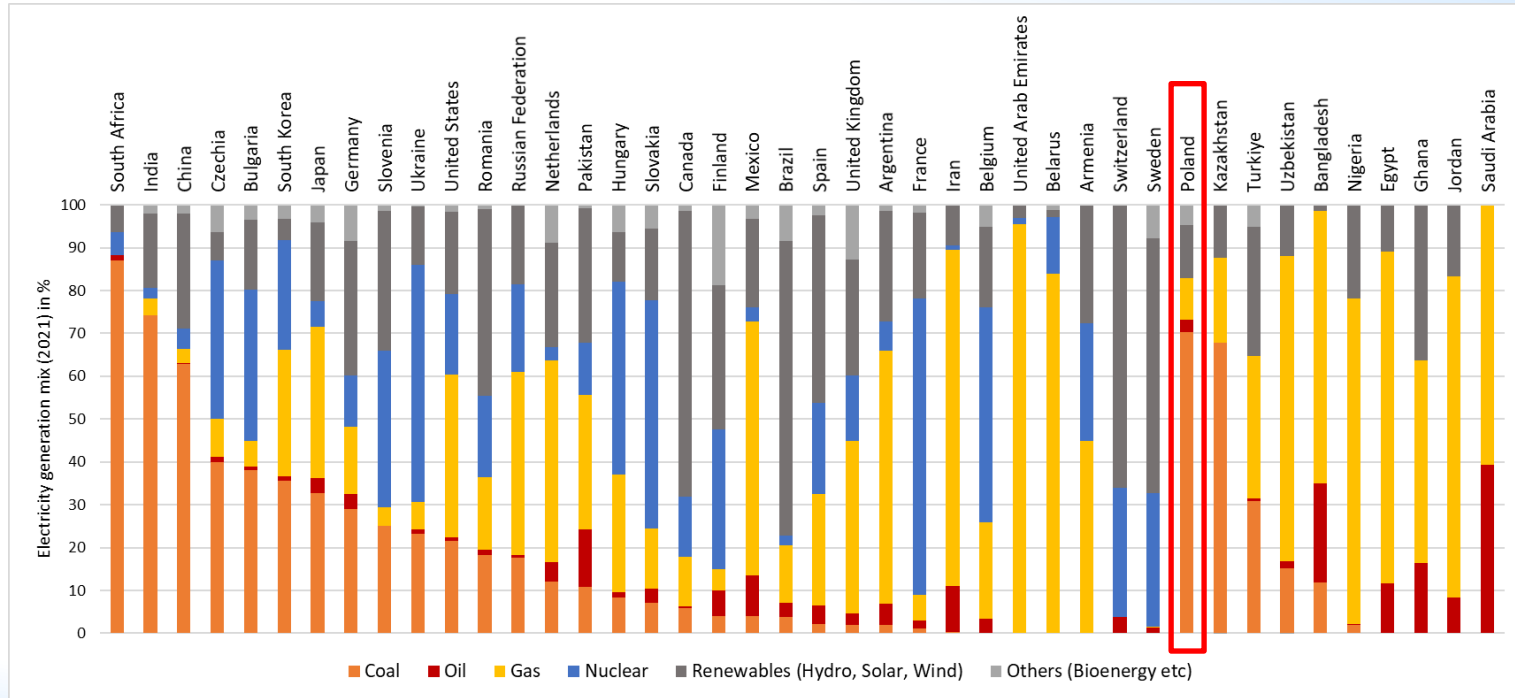
- Majority of the coal power plants are situated in zone with low seismic activity. Hence, they can be easily replaced by nuclear power plants.
- Technology for Water Cooled Reactors is matured – more than 6 decades old.
- These technologies could be easily adopted without further investment in research.

India by 2050 will be water stressed according to predictions of Government of India

- **SMRs benefit: Desalination for supplying clean drinking water:**
- India has 6100 km of coastline on the mainland.
 - **20 Coal fired plants, 5 Diesel power plants, 17 Natural Gas Power Plants by seaside.**
 - Typically, per MWe, 900 m³/d of clean water can be produced by SMRs.



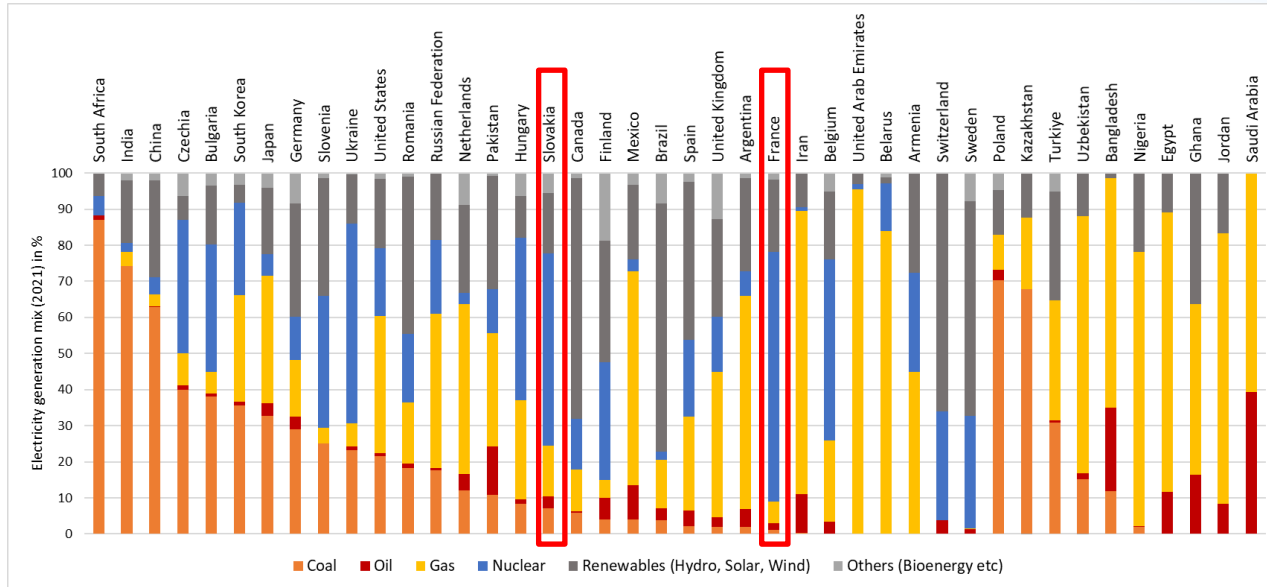
Poland



- The power system in Poland is currently dominated by coal-fired units.
- From 2033 onward, Poland intends to commission nuclear power plants, whose final installed capacity in 2043 is expected to be between 6 and 9 GW.
- A double effect of decarbonization can be achieved by investments in nuclear repowering of coal-fired units, replacing the coal boiler islands with nuclear reactor systems.
- These Repowered plants can operate flexibly via integration with TES systems using molten salt.
- In 2022, a Paper was published presenting Technoeconomic analysis for three cases of nuclear repowering of a 460MW supercritical coal-fired unit in Poland.
- Three cases of the structure of a nuclear unit
 - two assume the operation of the system without its integration with the TES system,
 - one case involves connecting two tanks for molten salt, constituting the heat storage system, between the nuclear island and the turbine island.
- The first case assumes the use of a system of three KP-FHR reactors, each with a thermal capacity of 320MW, whose total thermal power (960 MW) very closely approaches the nominal thermal power of the removed steam boiler (957.1 MW).
- The second case - number of reactors is reduced to two reactors.
- The third case uses two nuclear reactors equipped with a molten salt thermal energy storage system.
- Economic analysis was performed.
- Considering current market conditions, among the analysed cases, the most attractive investment is the one with two nuclear reactors and a TES system with a capacity of 800 MWh.

Alternative

- Replace Nuclear with Nuclear?



Webinar <https://www.iaea.org/newscenter/news/repurposing-fossil-fuel-power-plant-sites-with-smrs-to-ease-clean-energy-transition>



IAEA

International Atomic Energy Agency
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Thank you!

