Retrofitting Coal Power in the Philippines Using Korean SMR—Feasibility Evaluation

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Background

Climate Change

- Climate change and global warming are an existential threat, primarily caused by greenhouse gas (GHG) emissions
- Governments of the world have agreed to take action to reduce GHG emissions, including transitioning from fossil fuels to clean energy

Nuclear Energy

- Despite setbacks due to nuclear accidents, nuclear energy is increasingly being recognized as an important part of fighting global warming
- Nuclear energy does not release CO_2, unlike fossil fuels, and can provide base load power, unlike renewables

The Philippines

- One of the countries most vulnerable to climate change, the Philippines has pledged to reduce use of fossil fuels, such as coal
- 36 years since mothballing the Bataan Nuclear Power Plant, the government is again exploring nuclear energy to decarbonize and address the energy crisis

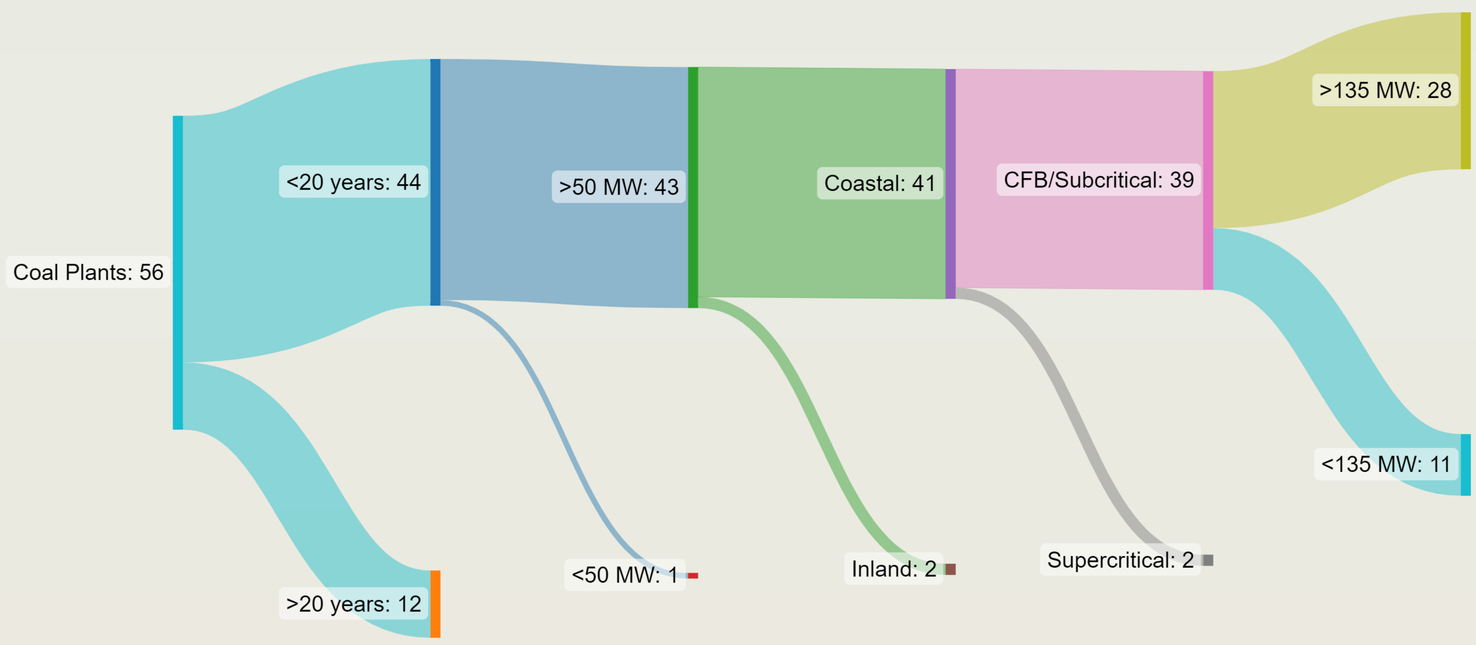
South Korea

- The South Korean government has also resolved to become a leader in clean energy
- It has begun exporting nuclear energy technology overseas
- The Philippines is also in talks with Korean government and private entities for cooperation in nuclear energy, including SMRs

Retrofit Decarbonization

- Proposals to retrofit existing coal power plants with SMRs are seen as one option to decarbonize, also known as nuclear repowering
- Such proposals have been studied in countries like China and Poland
- Repowering would take advantage of existing assets in coal to reduce the capital cost of nuclear power

Profile of Coal Power Plants in the Philippines



Initial Criteria for Candidates

Candidate coal-fired units for repowering must meet three criteria:

- ✓ Age: must be less than 20 years old for sufficient remaining service life of assets after retrofit
- ✓ Size: must have capacity greater than 50 MW since smaller units are more difficult and less practical to retrofit
- ✓ Location: must be located close to the sea for easier access to water as coolant

Only 41 out of the 56 coal units in the country met the three criteria and qualified as potential candidates for repowering.

Compatibility with SMR

Only those units that match the characteristics of the SMR design can be retrofitted. To match the PGSFR, two factors must be considered:

- ✓ Steam parameters: the PGSFR has a steam pressure of 17.8 MPa, which is too low for supercritical coal units, so only subcritical and circulating fluidized bed (CFB) units are suitable with the PGSFR
- ✓ Size: the PGSFR has a capacity of 150 MWe, so only coal units larger than 135 MW are considered suitable for PGSFR repowering

Out of 41 potential candidates, only 28 units match the PGSFR, comprising 6 MW out of a total 12 MW coal capacity.

Evaluation of Korean SMR Designs

SMR	Capacity	Temperature	Pressure
SMART	364 MWth/120 MWe	284 °C	3.5 MPa
BANDI-60S	200 MWth/60 MWe	270-290 °C	6.0 MPa
REX-10	10 MWth	198.3 °C	1.5 MPa
PGSFR	392 MWth/150 MWe	471.2 °C	17.8 MPa
i-SMR	540 MWth/180 MWe	284 °C	3.5 MPa

Selecting Suitable Korean SMR for Repowering

Five Korean-designed SMRs were considered. To select a suitable design among the five, two criteria were used:

- ✓ Steam parameters: most coal units are CFB, with steam typically at 540°C and 17 MPa. Subcritical units have steam below 550°C and 22 MPa, while supercritical units have steam at ~565°C and ~24 MPa
- ✓ Size: the SMR capacity must be small enough to allow retrofitting of units of different sizes but must be large enough to require only a minimal number of SMR units for each coal unit

The PGSFR has the steam parameters closest to that used in coal units, and its 150-MWe capacity allows for retrofitting most small coal units with one SMR and most medium and large units with two to four SMRs.

Map of the Philippines with locations of coal units (highlighted in red and yellow)

Formulating a Philippine Repowering Strategy

Phase I. Demonstration Project

Commencement of a repowering strategy is not expected until at least 2030, since a functional prototype of the PGSFR is not expected until 2028.

The first phase of the strategy will be to complete a demonstration project. Potential candidates for the initial demonstration units are TSI in Davao and PCDC in Iloilo (both highlighted in yellow) for their age, size, and location. This is expected to take 3-5 years.

This phase requires substantial participation and cooperation from Korean partners. This can be seen as part of Korea's commitment to be global leader in clean energy.

Phase II. Local Capacity-Building

After completing the demonstration project(s), the second phase will be to repower remaining units in Visayas and Mindanao (15 in total) and those in Luzon farther from the capital (5 in Quezon and Batangas).

The purpose of this phase is two-fold: to build local capacity to construct nuclear projects, and to increase public acceptance. Thus, it requires some Korean involvement but involves more local actors. Locations chosen are those away from the populous capital, which may be more acceptable to the public.

This phase is expected to take 8-10 years.

Phase III. Bataan & Coal Phaseout

The third and final phase involves the remaining 8 units in Bataan, around 100 km from Manila. These comprise 2.7 MW total capacity.

This phase will be done with maximal utilization of local capacity through relevant technology transfer. It is expected to take at least 5 years, making the expected completion of the strategy in 2050. Those coal units deemed unfit for repowering must also be decommissioned.

The strategy is expected to save up to USD 6 billion in upfront costs and 27,400 kilotons in CO_2 emissions.

Future

The results and proposals of this study could be used as a basis for a national plan to reduce Philippine carbon emissions, improve public acceptance of nuclear energy, and undergo capacity-building for a nuclear energy program.

The current study is by no means and complete and sufficiently comprehensive. There is need for further research on exploring the geologic, legal, and economic aspects of feasibility, more options for suitable SMR designs from Korea and abroad, and the challenges of nuclear waste management.

Acknowledgments

The authors would like to express gratitude to Ms. Carol Hornibrook, Mr. Andhika Yudha Prawira, and Cpt. Deukhyun Jo from the Nuclear Energy Environment and Nuclear Security (NENS) Laboratory at KAIST for their guidance, expertise, and contribution to the research.

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