EGU21-11085, updated on 27 Jan 2022
https://doi.org/10.5194/egusphere-egu21-11085
EGU General Assembly 2021

Replacing Coal with Wind and Solar in South Korea's electricity system

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South Korea's current energy system heavily relies on fossil fuels in particular coal-fired generation followed by nuclear. Currently, the country is defining its long-term energy strategy and latest Basic Electric Power Supply and Demand Plan proposes to increase the share of renewable energies to 26% by 2034, while converting most of their older half of coal plants to LNG. However, to be consistent with Paris Agreement compatible pathways, more ambitious coal phase out schedules to retire the entire coal fleet until 2030 are also discussed. We consolidate such a schedule with an expansion plan for wind and solar capacities derived from open-source renewable resource and energy system models.

For the analysis of integrating renewable energies into South Korea's future energy system, we perform a detailed assessment of the technical potential of renewable energy sources by applying a temporally and spatially resolved modelling. A comprehensive set of geographical constraints and land exclusion factors are applied to derive the suitable area for placement of wind onshore and offshore turbines as well as PV installations. The land eligibility analysis is followed by the simulation of generation profiles from wind turbines and PV units from ERA-5 weather data, deriving the hourly capacity factors and the corresponding levelized cost of electricity for each location.

We optimize the expansion and operation of renewable energies and storage in South Korea's electricity system for a Paris Agreement compatible coal phase out until 2030. The model chooses from the renewable expansion potentials and their cost characteristics derived in the resource assessment to balance an hourly-resolved demand scenario for each year. Flexibility needs are met with an optimized dispatch of the existing gas power plants and additional short-term and long-term storage capacities. The detailed modelling approach at a high temporal and spatial resolution allows to have a realistic assessment of the power system integration impacts of varying renewable sources and to evaluate the system adaptation needs in terms of required storage capacities.