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Maximizing Nuclear Power for 2050 Carbon Neutral Energy Mix in Korea

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Introduction

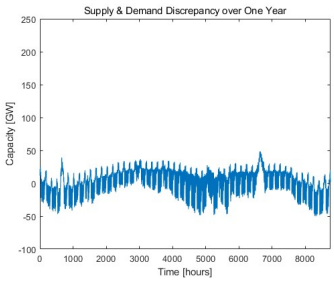
- The IPCC(Intergovernmental Panel on Climate Change) proposed that the world should reach carbon neutrality by the year 2050 in order to keep global warming under 1.5℃
- To reach the goal, the South Korean Presidential Committee on Carbon Neutrality presented three road maps on Aug. 5th 2021
- However, the report has received criticism for many reasons. The biggest reason is that the plan is based on many technologies that are not commercially available today or the near future. Another reason is that it does not address how much ESS(Energy Storage System) is required to reach such goal.
- In order to mitigate the instability, large scale Energy Storage Systems must be introduced to the grid. Although large scale batteries are still very costly, there is very limited options when it comes to large scale implementations.
- **This paper presents 3 different carbon neutral scenarios of energy mix in South Korea for year 2050.** It will be based on energy technologies currently available in the market today or in the near future. Also, ESS requirements will also be taken into consideration.

Methods

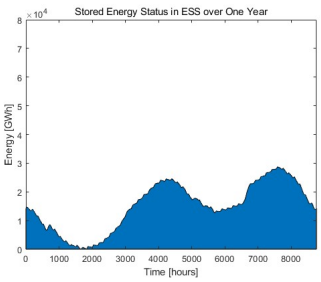
- The total electricity generation required for 2050 was predicted to be 1207.7 to 1259.4TWh according to the Committee's reports.
- The hourly electricity demand profile of year 2017 was used assuming that the profile remains the same and a multiplication factor was multiplied to make the **total electricity generated as 1259.4TWh**.
- Nuclear power plants are very good baseload energy sources, especially in Korea since the nuclear plants supply the most cost-effective electricity in the grid. However, it is less advantageous to reduce the power following the load because of the big capital costs.
- Solar and wind power plants do not require fuel to run so once installed, they can continuously generate power for their engineered lifetime with minimum maintenance. However, the same reason makes them heavily dependent on weather conditions, which makes power generation inflexible.
- **Supply curve for renewable energy was derived from actual electricity generation data from solar and wind farms.** Data from KOSPO (Korea Southern Power) and Korea Rural Community Corporation was used. Totally, data from 41MW of wind power generation and 6.3MW of solar photovoltaic power generation was used. The supply curve of actual plant generation data was scaled up to meet our target generation capacity.
- The hourly demand curve was compared to the generation curve of the scenario. **Excess electricity was stored in ESS and when demand was higher than supply, the energy stored in ESS was used.** Charge/Discharge efficiency of 90% was used. Although current nuclear reactor technology can provide load-following, load-following was not implemented in this study.

Results

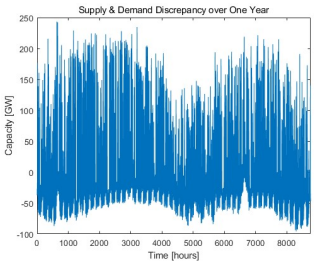
- The **first scenario is nuclear 100%(1259.4TWh)** with ESS. Assuming electricity demand profile remains the same with 2017, nuclear can provide 66%(831.2TWh) of demand without power reduction. To power more than 66%, , ESS storage strategy was selected.
- The **second scenario uses nuclear for 66% as baseload with 34% from solar** along with ESS to store excessive energy.
- The **third** is similar with the second but with wind power plants instead of solar. So, **nuclear plants take care of baseload and supply 66% of the total generation with 34% of generation supplied by wind** with ESS to supply flexibility.



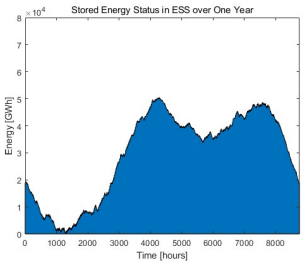
Supply & Demand Discrepancy over One Year for Scenario 1



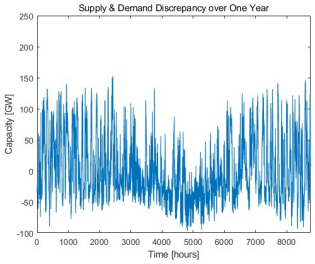
Stored Energy Status in ESS over One Year for Scenario 1



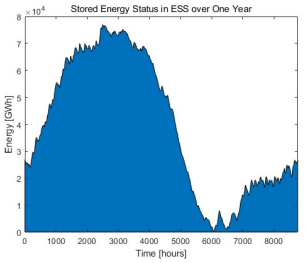
Supply & Demand Discrepancy over One Year for Scenario 2



Stored Energy Status in ESS over One Year for Scenario 2



Supply & Demand Discrepancy over One Year for Scenario 3



Stored Energy Status in ESS over One Year for Scenario 3

ESS Requirement Comparison for 3 Scenarios

	Scenario1: N100	Scenario2 N66+S34	Scenario3 N66+W34
Max. Storage	48.5GW	243.4GW	152.8GW
Max. Discharge	50.0GW	95.7GW	97.0GW
Max. Energy Stored	28,795GWh	50,552GWh	76,988GWh

- With the absence of flexible power sources, all three scenarios have very challenging requirements for ESS. The ESS requirements are compared in the table above.
- Out of the three, **scenario1 has the least demanding ESS requirement**.
- **Scenario2 has the biggest storage power requirement** since solar energy is only available for a few hours during the day. Comparing with scenario1, scenario2 needs five times the storage capacity.
- **Scenario3 needs to store the most energy** among the three. More than 2.6 times of that of scenario 1 is required.

Conclusion

- Three scenarios of energy mix for South Korea is reviewed to reach carbon neutrality in 2050. Different combinations of nuclear, solar, and wind power is used for the scenarios. Without load-following power sources, ESS requirements are demanding. However, the nuclear 100% scenario has least challenging ESS requirements compared to the other scenarios with renewable sources.