



Green Hydrogen

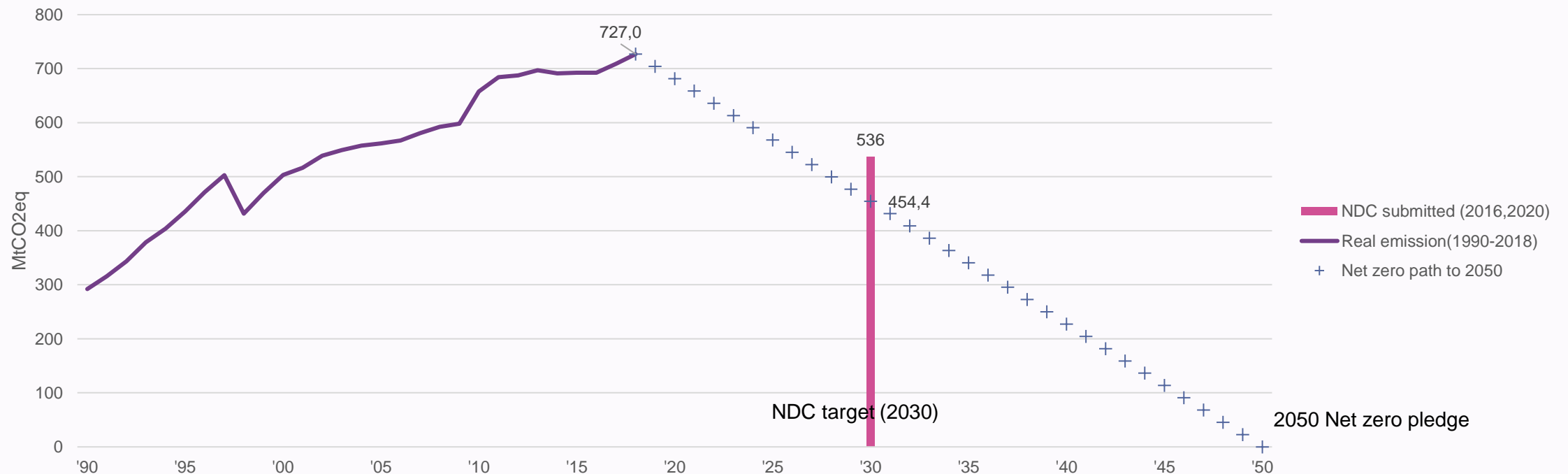
GESI

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A brief overview of climate policy in Korea

- ▶ 2016, NDC submitted – 536 MtCO₂eq as a target (37.4% reduction from BAU)
- ▶ 2020. Oct. Net zero pledge by 2050
- ▶ 2020. Dec. NDC submitted – identical target as previous one (24.4% reduction from 2017 emission level)



Hydrogen boom in Korea

Gov's hydrogen plan

Gov's hydrogen roadmap by 2040

- ✓ hydrogen production amount : 5.26 Mton of hydrogen
- ✓ Building sector : 2.1GW of fuel cell installed in buildings
- ✓ Transportation sector : 3.05 million vehicles
- ✓ Power sector : 8GW of fuel cell for electricity generation

Hydrogen promotion policies

HPS (Hydrogen Economy Portfolio Standard)

- ✓ Similar to RPS, electricity generators have obligations to buy electricity generated from hydrogen
- ✓ Green hydrogen promoted but start with blue or even gray hydrogen

For Fuel cell generation, natural gas is provided at discount price

Responses from private sector

40billion USD investment from private sector

- ✓ Fuel cell, FCEV, Liquefied plants, hydrogen charging stations and etc.
- ✓ Focusing on hydrogen infrastructure rather than producing green hydrogen
- ✓ Start with Blue Hydrogen and increasing share of Green hydrogen in the future

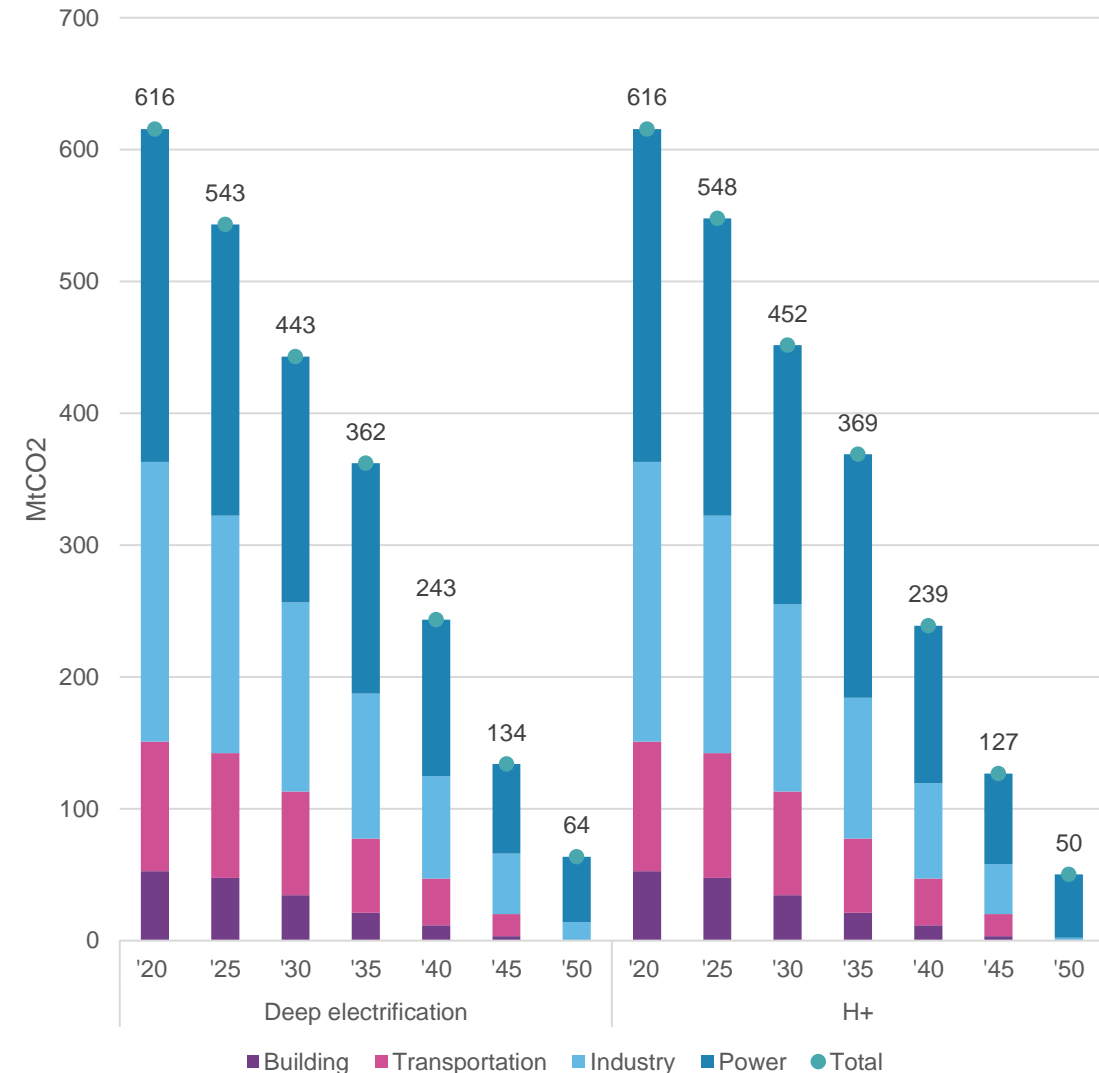
The ambition level of hydrogen is high but it does not match with RE plan

- Basic energy plan targets 35-40% of RE generation by 2040
 - The RE generation amount is 240-260TWh
 - This amount is less than 263 TWh, the necessary electricity for hydrogen production in the hydrogen roadmap
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Hydrogen vision of GESI in 2050 by sector

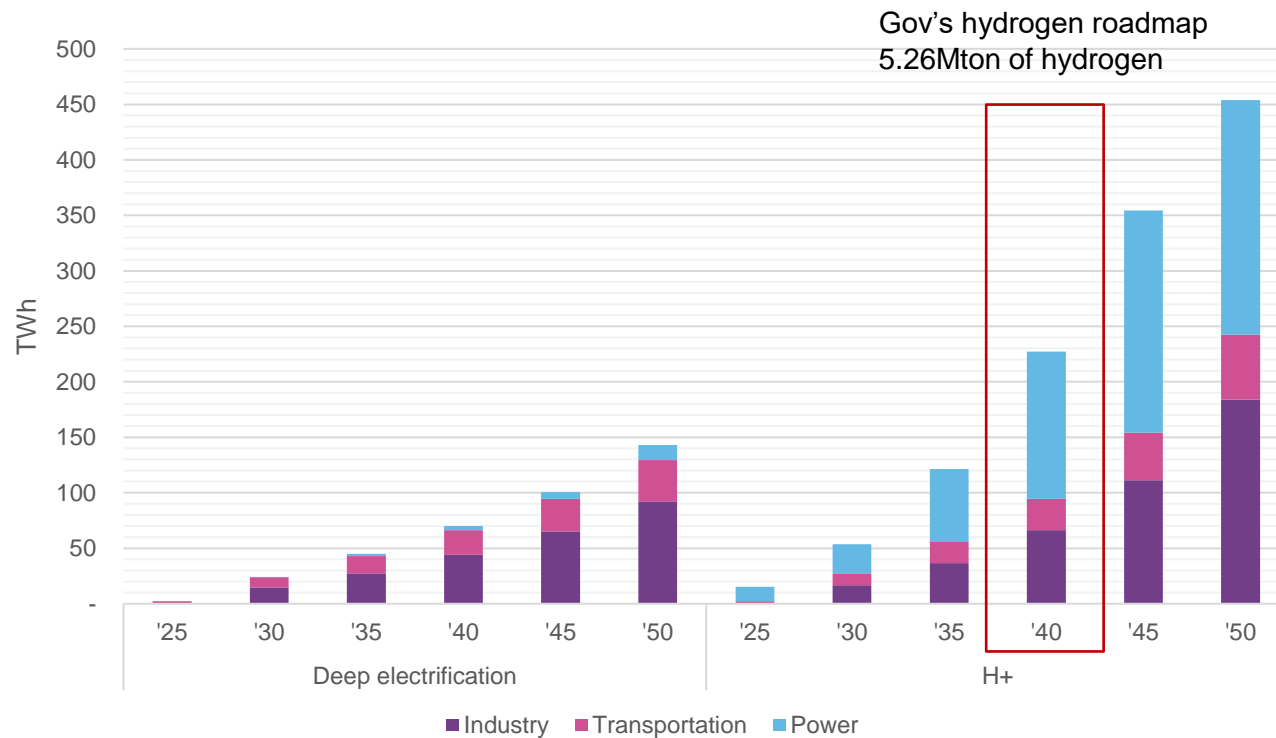
O refers to the same assumption as CO2 pricing scenario

scenario	Deep electrification	H+ scenario
CO2 pricing	Increase to 150 euro/tCO2eq by 2050	O
CO2 emission restriction	None	O
Technology cost	Cost reduction by technology development	O
Annual RE expansion limit	PV (12GW), Onshore Wind(4GW), Offshore Wind(8GW)	O
Coal power plants	Phase out by 2040	O
Nuclear power plants	Following gov. plan (8GW in 2050)	O
Hydrogen Demand	For demand hard to electrify	Following Gov's hydrogen roadmap
Electricity demand	Electricity demand increase due to electrification	O
Heating demand	Increase of building efficiency Expansion of district heating Electrification of individual heating Heat storage for flexibility 100% electrification by 2045	Fuel cell installed for building
Transportation demand	Increase BEVs and FCEVs No sales of ICEVs from 2040	Higher share of FCEVs relative to CO2 pricing scenario

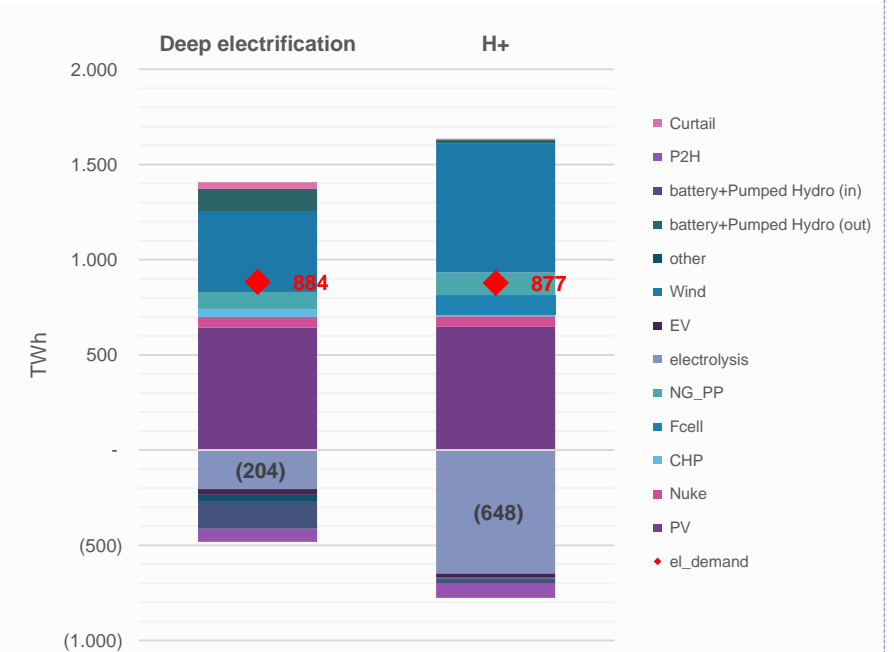


Hydrogen vision by GESI

- ▶ Role of hydrogen for the decarbonization
 - CO2 pricing scenario prioritize electrification to hydrogen
 - Hydrogen is used in hard to electrify sectors (heavy duty vehicle, high-temperature process)
- ▶ System inefficiency from too large deployment of hydrogen consuming technologies (Fuel cell and FCEV)



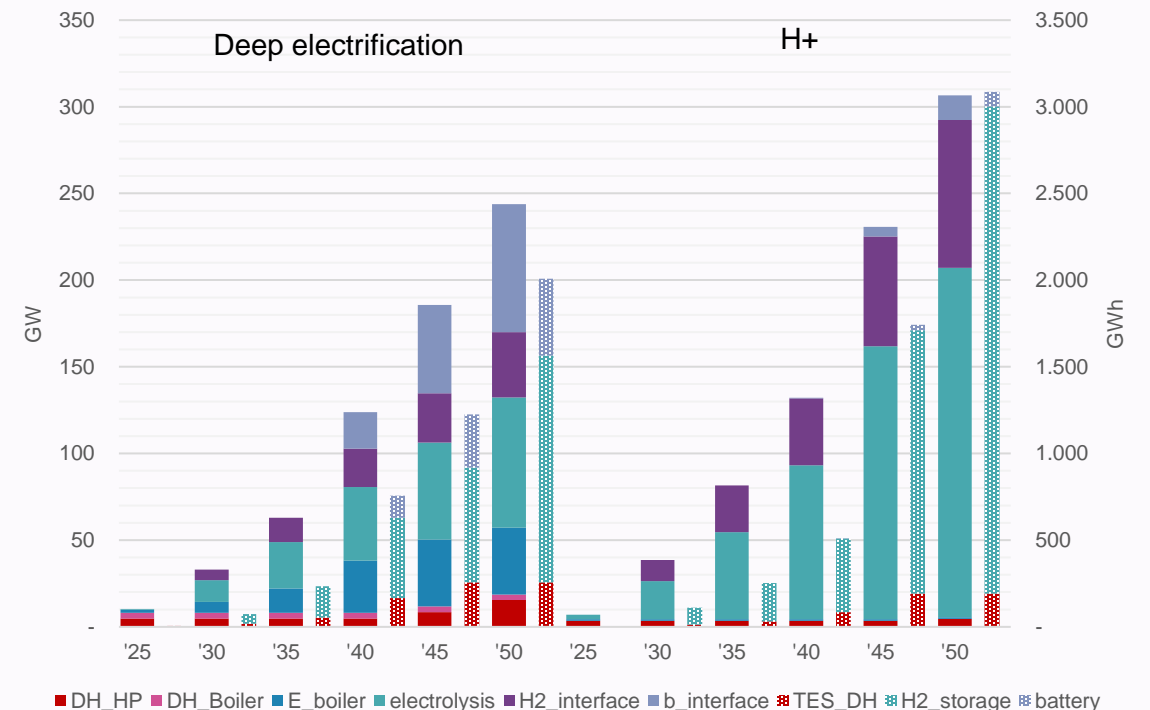
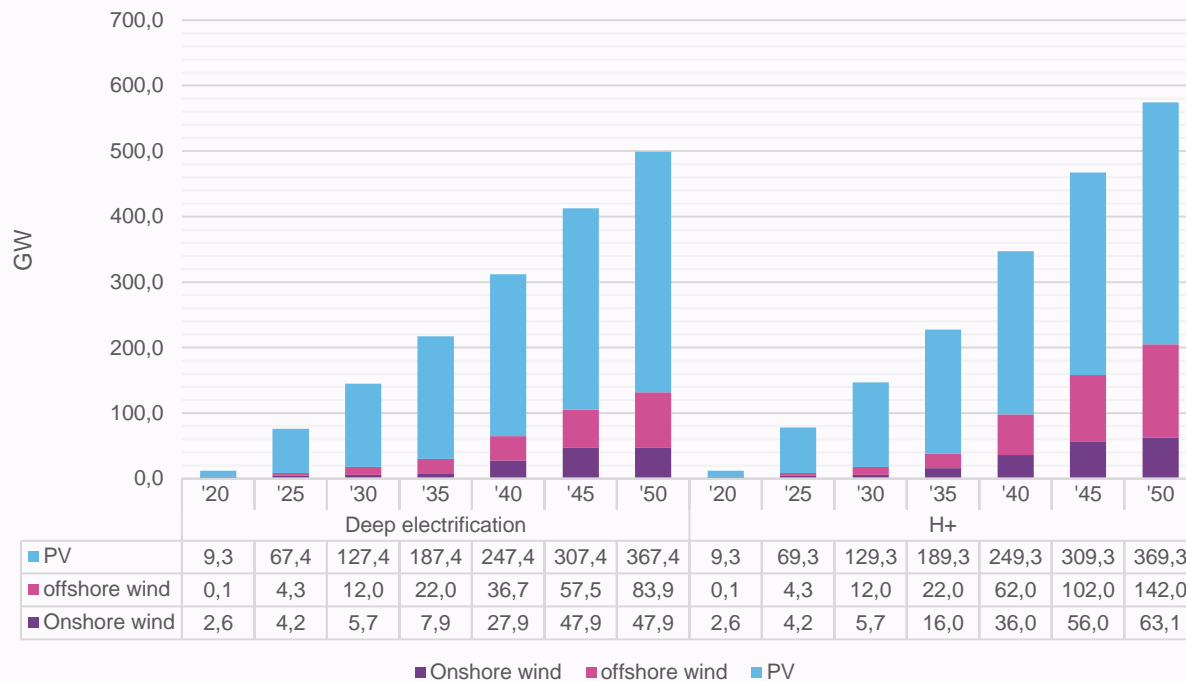
- ▶ H+ scenario results show:
 - More energy is produced and consumed in H+ scenario
 - It is necessary to minimize less efficient process (power → hydrogen → power)



Hydrogen vision by GESI

- ▶ For CO2 pricing scenario, RE 500 GW (PV 367GW, Wind 130GW) is necessary
- ▶ In H+ scenario, more RE and flexible capacity are needed (+15%)
 - ▶ RE 574GW is necessary

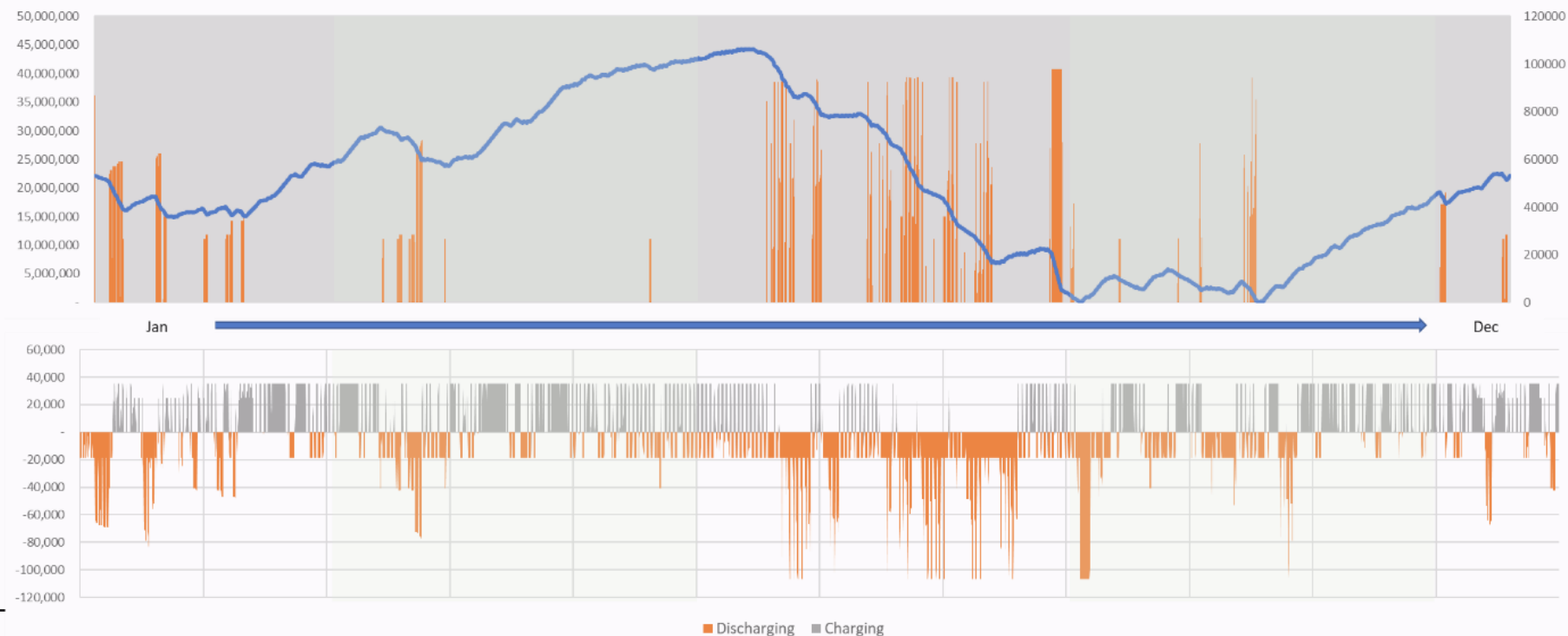
	CO2 Pricing	H+
Storage Capacity (GWh)	2,008	3,085
Production Capacity (GW)	606.0	674.8
Flexible Capacity (GW)	243.8	306.6
Flexible Capacity ratio (%)	27.7	31.2



Role of hydrogen in deep decarbonization

- ▶ Even with low efficiency of hydrogen, hydrogen is an essential component for the decarbonization of energy system
 - ▶ Industrial processes, heavy duty vehicle, material for chemical products
- ▶ Another important role for hydrogen is to overcome seasonality of RE production
 - ▶ In Korea, summer season (late June to Aug), there is lack of RE production. Hydrogen can be saved for this period.

<Hydrogen storage status in 2050 >



Toward Green Hydrogen market

- ▶ For the international hydrogen market,
 - Need an international authority to monitor GHG emission while producing hydrogen and certify “GHG impact free hydrogen”
 - Develop long range and international hydrogen transportation means at affordable cost
 - Each country needs some extent of self sufficiency of energy for energy security reasons
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