SEND Lab.
Smart Energy Network Design Laboratory

Grid Innovation for Long-term Electricity Security

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Speaker

- **Career**
  - Associate Professor, Dept. of Electrical Engineering (2022.9 ~ present)
  - Assistant Professor, Dept. of Electrical Engineering (2018.9 ~ 2022.8)

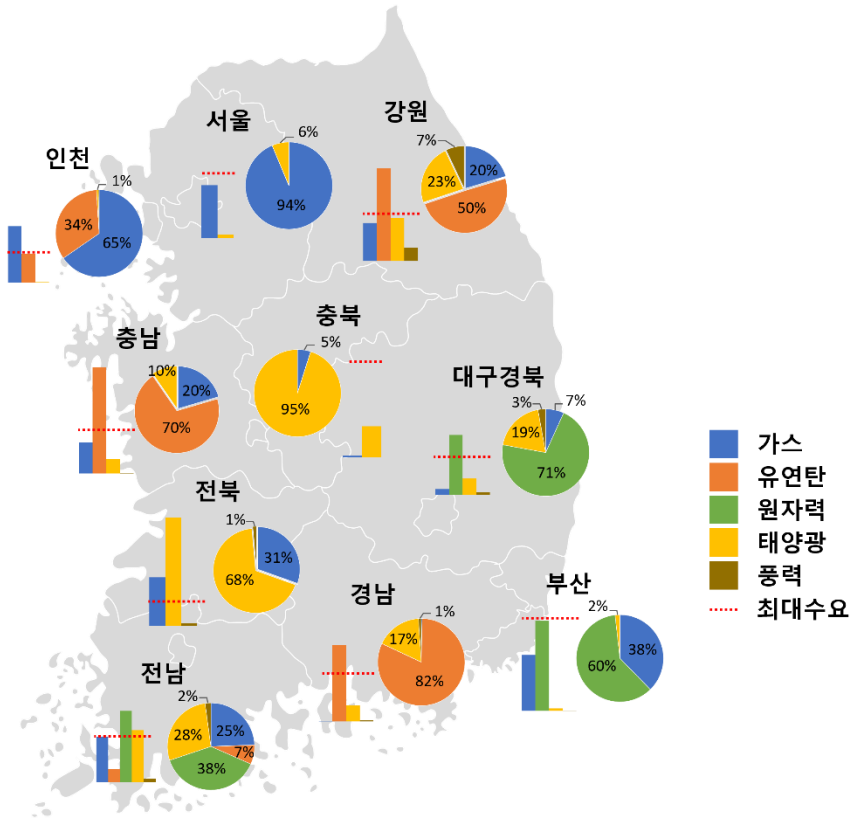
- **Activities**
  - Commission Member, **2050 Carbon Neutrality Commission** ('21.5 ~ '22.5)
  - Board Member, **Korea Energy Agency** ('20.11 ~ '22.10)
  - Council Member, **Hydrogen Economy Council** ('20.7 ~ '22.7)

Key Takeaways of Today's presentation

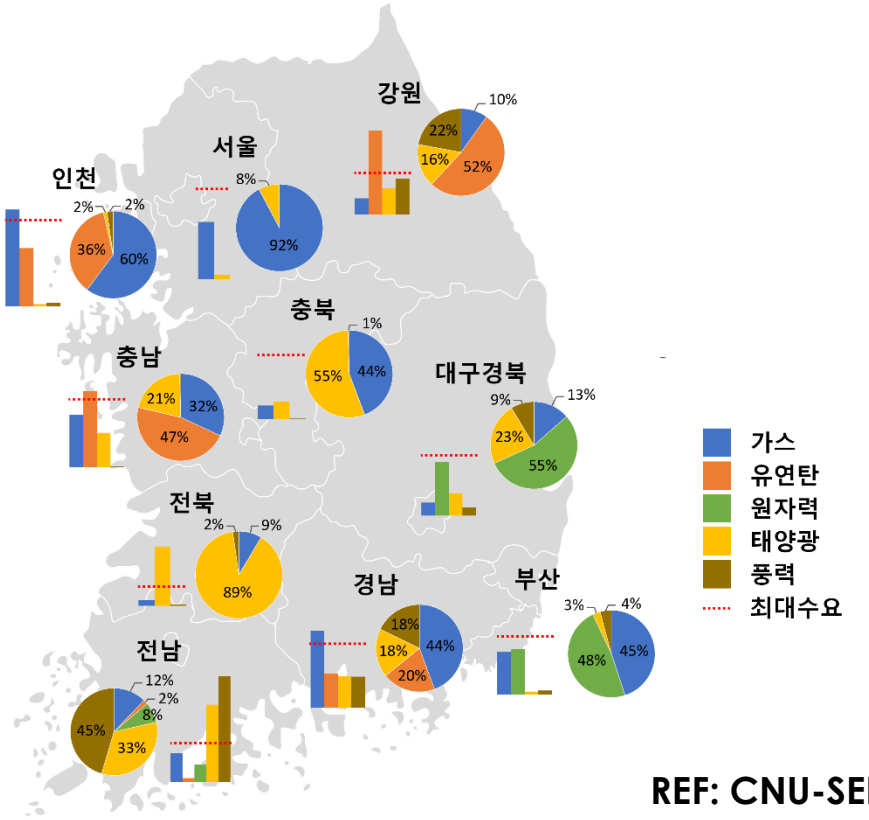
- Grid is the crucial component of ensuring long-term electricity security
- Solely generation expansion planning does not guarantee the supply and demand balance
- It is common problem for every generation, not only for renewable
- We need to utilize all innovative solutions for grid reinforcement

Current Status of Korean Power System

- **Uneven distribution of generation – Mismatch of gen. area and load area**



<2022 Gen / Load Map of Korea>



REF: CNU-SEND Lab.

<2034 Gen / Load Map of Korea>

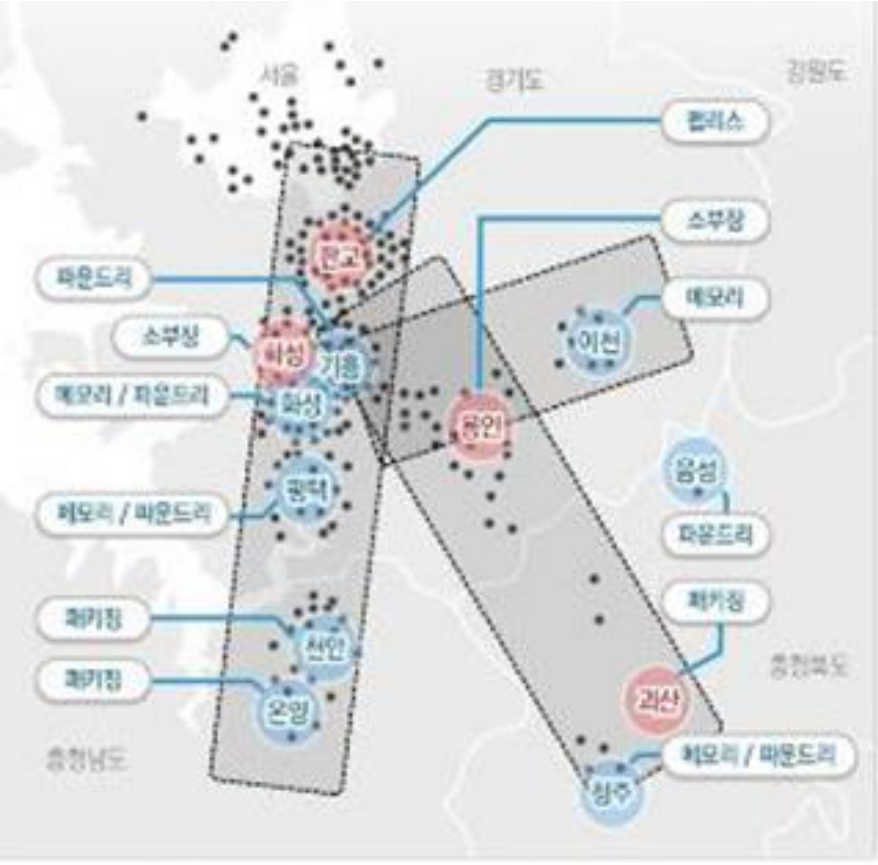
Current Status of Korean Power System

- **Uneven distribution of generation – Concentration of bulk-generation in the coastal area**
  - Technical constraints on transmission capacity in the east-coast area
    - ✓ Transient instability
    - ✓ Frequency instability
  - Same problem in the west-coast area in the Chungnam province
  - **Not rational to build new generation on these areas before grid reinforcement**

<Constraints in the east-coast area>

Current Status of Korean Power System

- **Uneven distribution of demand – Continuously growing demand in the metropolitan area**
  - K-Semiconductor belt (left) / Data-center (right)

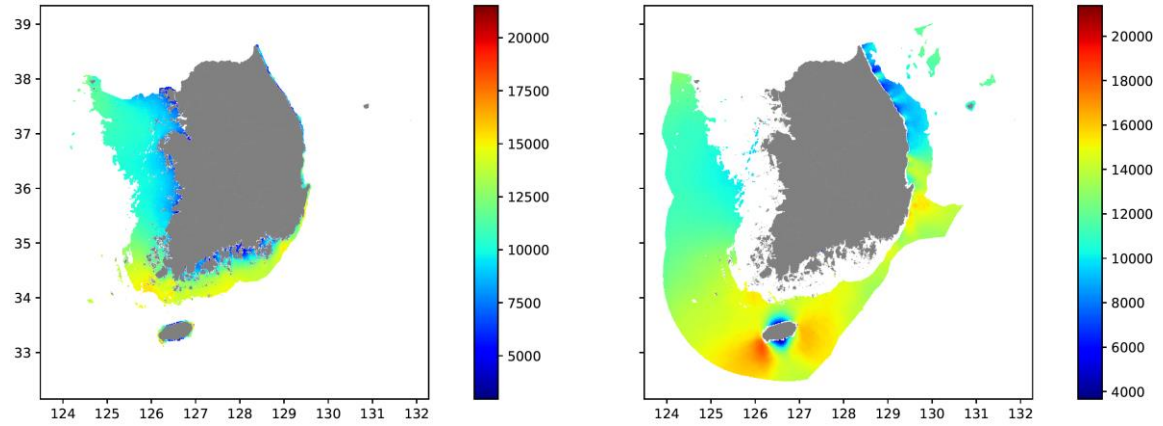


Grid Planning based on Optimal Expansion Planning

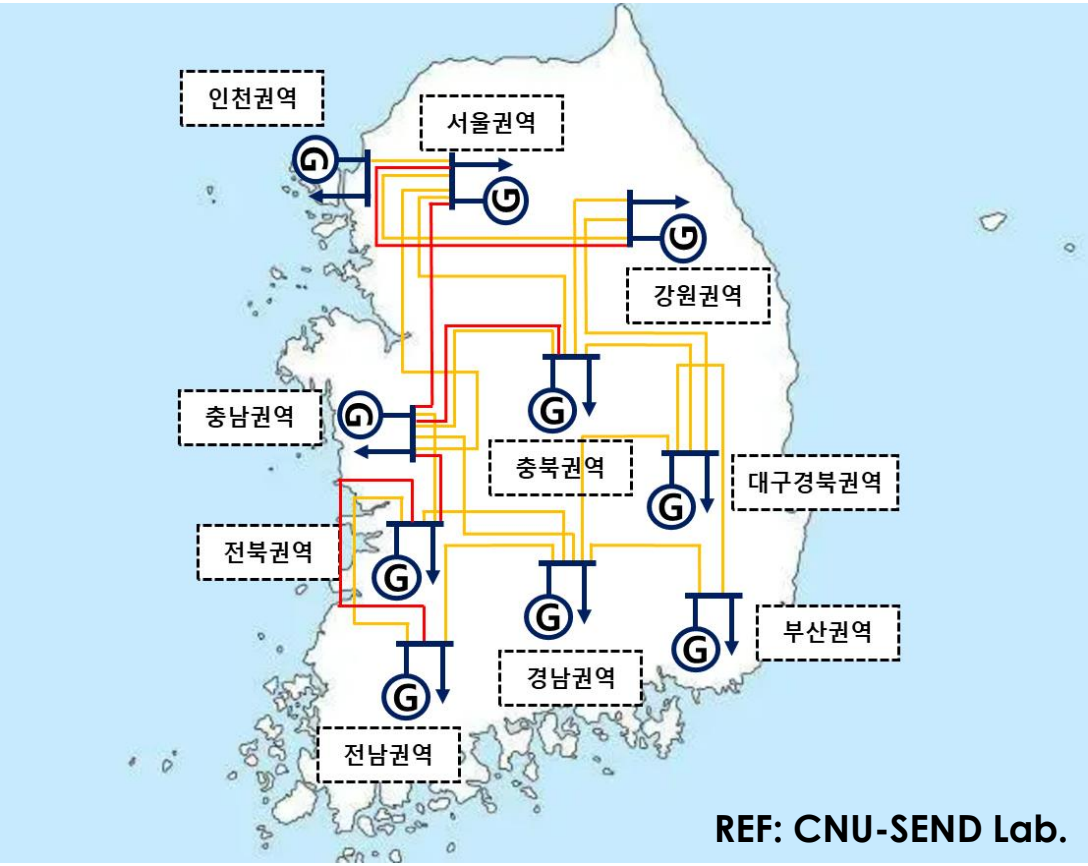
- **2034 result based on optimal planning**
  - **Corridors** from the south area to the metropolitan area appear
    - ✓ Continuous increase in the demand of metropolitan area
    - ✓ Concentration of solar and wind gen. in the south-west and the south area

REF: NEXT Group

< Technical potential of Offshore wind >



Offshore wind(fixed-bottom) Offshore wind(floating)



REF: CNU-SEND Lab.

Feasibility of Current Grid Plan

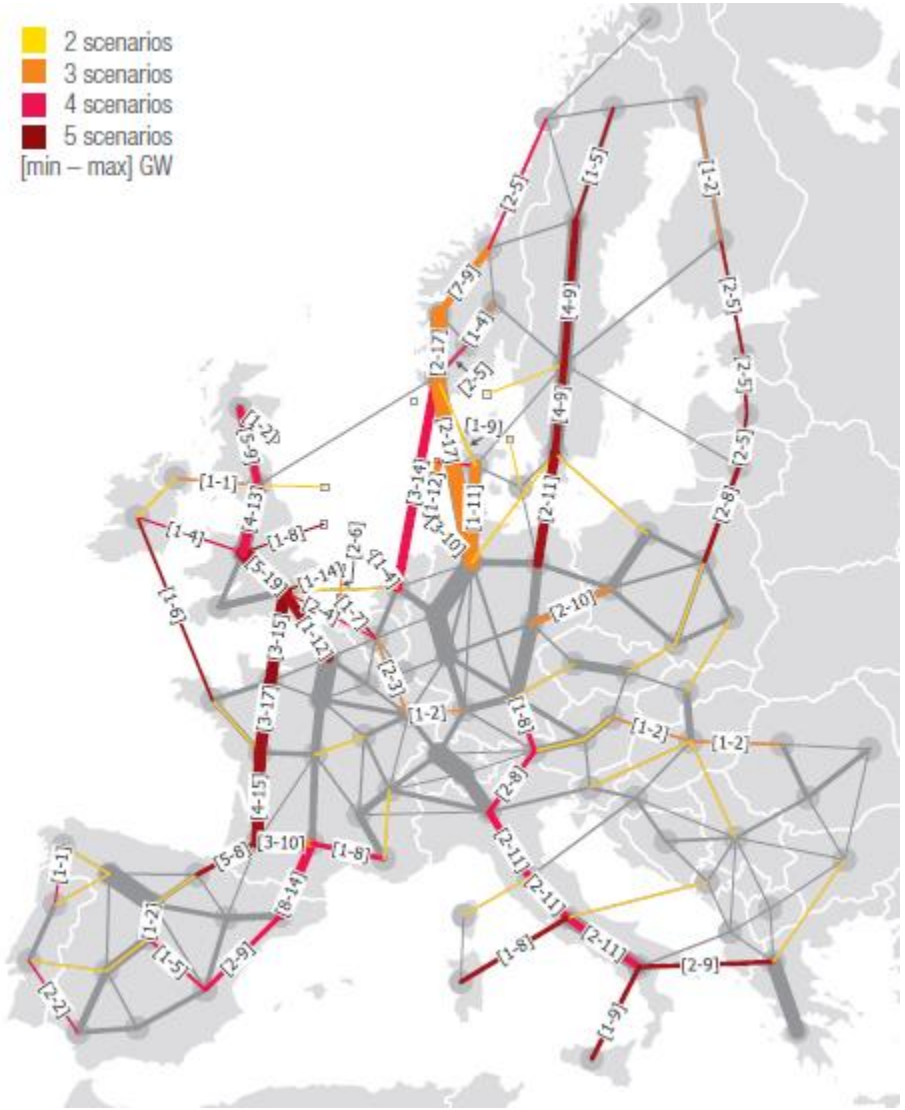
- **It is not the problem of technologies or economics**
  - ➢ It is the social acceptance problem ! Needs alternative ways !

<Survey results on opinions of residents about transmission lines>

Questions	Strongly disagree	Almost disagree	Normal	Almost agree	Strongly agree
• Transmission line construction is a social problem	0.5%	1.9%	14.6%	44.2%	38.7%
• It is the problem of local community when the transmission lines pass our region	1.6%	6.0%	31.0%	46.4%	14.8%
• It would be severe problem when the transmission lines pass our region	1.1%	11.0%	32.7%	39.6%	15.7%
• Transmission lines are very dangerous facilities which can affect health of residents	1.4%	10.7%	33.2%	41.8%	12.9%
• Transmission lines would affect the price of house and land	1.1%	4.7%	29.4%	45.9%	19.0%
• I willingly pay an additional tariff for undergrounding transmission facilities in our region	22.0%	28.8%	33.0%	12.9%	3.3%

Alternative Solutions?

- **Grid reinforcement before gen. construction**
  - Probabilistic approach for load-and-gen growth
  - Model-based optimal transmission expansion planning
  - Choose **common corridors** among several scenarios
  - Use potential map of renewable generation
    - ✓ **We can easily forecast sites where renewable gen. want to be located in**



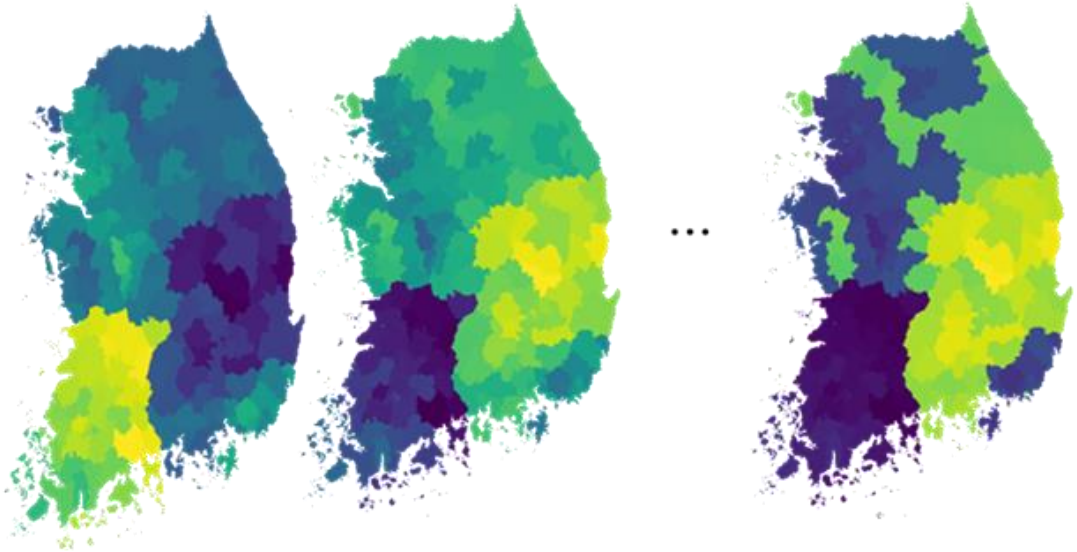
<Common reinforcement of corridors based on optimal transmission capacity expansion planning>

REF: EU e-highway 2050 project

Alternative Solutions?

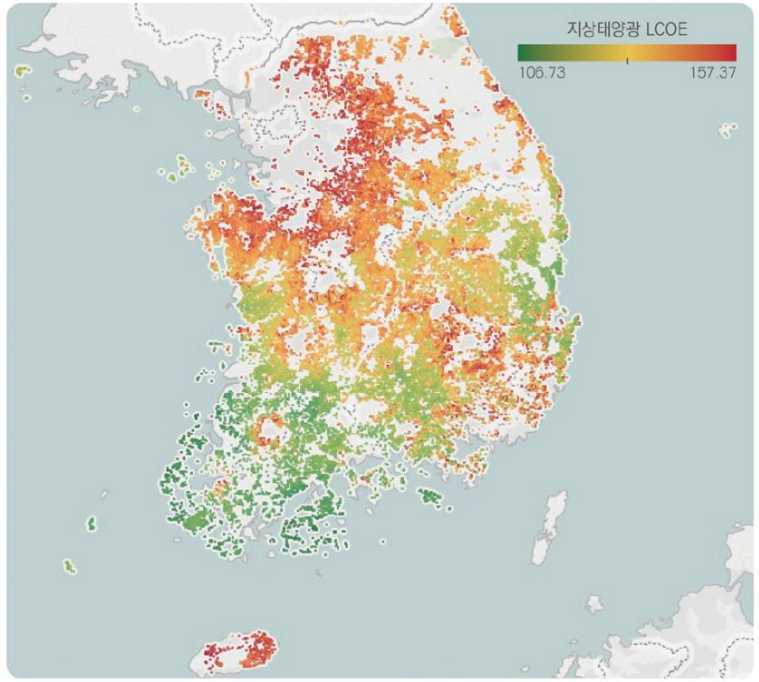
- **Decentralization of generation and load**
  - ➢ There must be a better distribution of generation and load in terms of total cost (grid investment + losses + congestion), compared to the current forecast in the long-term grid plan of KEPCO
  - ➢ But, it needs government intervention

REF: KEEI



<Various distribution of generation and load in Korean power system>

REF: CNU-SEND Lab.

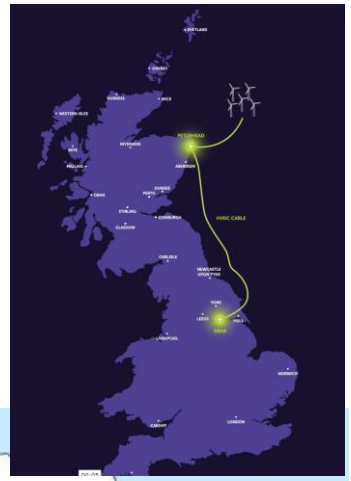


순위	지상태양광 [LCOE]	
1	전라남도	124
2	전라북도	135
3	경상북도	138
4	강원도	143
5	경상남도	144
6	충청북도	144
7	충청남도	148
8	제주특별자치도	172
9	세종특별자치시	188
10	울산광역시	198
11	광주광역시	222
12	경기도	244
13	대전광역시	249
14	대구광역시	260
15	인천광역시	268
16	부산광역시	375
17	서울특별시	2,127

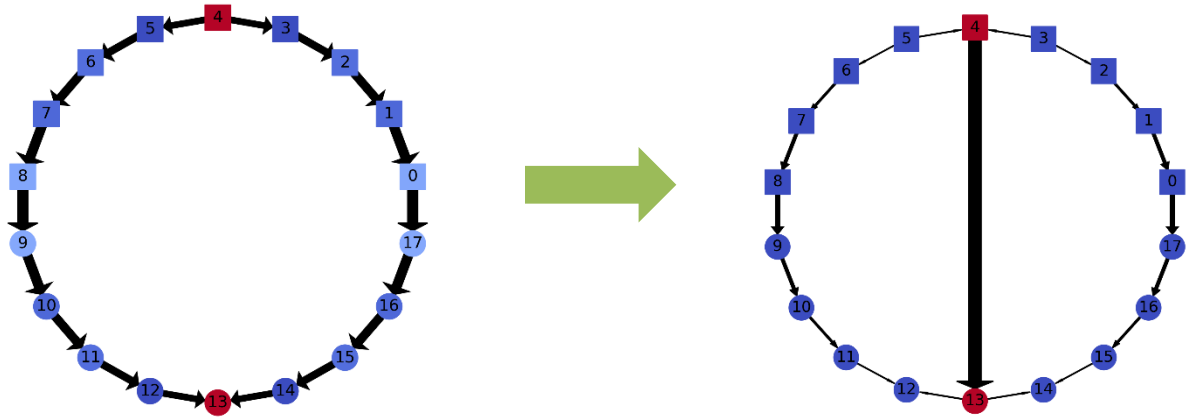
<Varying LCOE of solar PV by region>

Alternative Solutions?

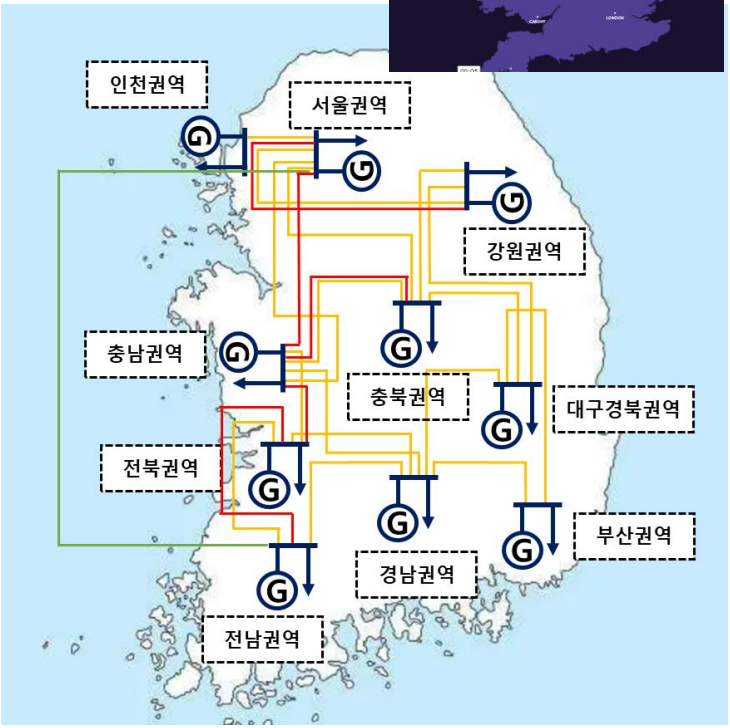
- **Innovative long-distance DC highway**
  - Directly linking the generation area and demand area using undersea cable (Ex. UK Eastern Green Link 2 project !!)
  - More feasible way in terms of the social acceptance
  - It can solve the system strength problem
  - Also, based on the complex system theory, the grid short-cut can improve the total system stability



<UK Eastern Green Link 2>
REF: UK SSEN



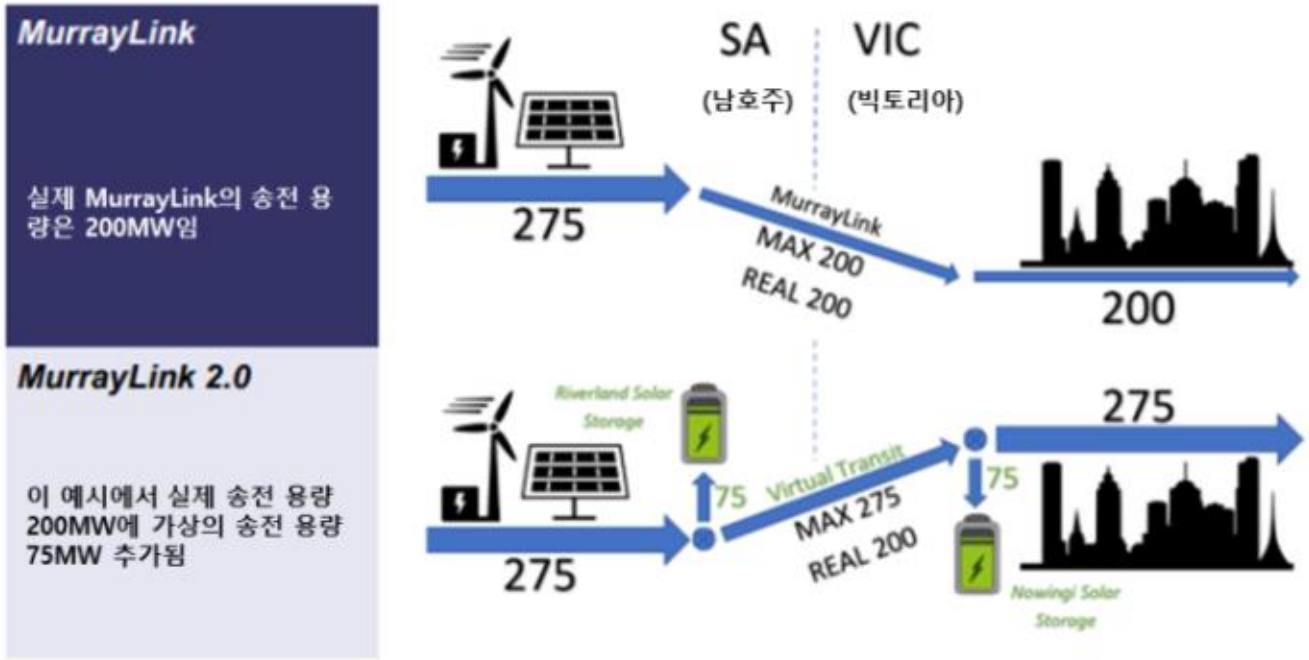
<Concept of grid short-cut for stability enhancement>
REF: KENTECH Prof. Heetae Kim



<Concept of west-coast DC highway>
REF: CNU-SEND Lab.

Alternative Solutions?

- **Non-wire Alternative with Energy Storage System**
  - Storage can virtually enhance the transmission capacity without physical reinforcement (Ex. South Australian MurrayLink 2.0 project)
  - The problem was the cost of storage, but it can be overcome soon



<Concept of MurrayLink 2.0 based on non-wire alternative solution>

REF: South Australian Transformation PADR feedback, 2018.

Key Takeaways of Today's presentation (again)

- **Grid is the crucial component of ensuring long-term electricity security**
- **Solely generation expansion planning does not guarantee the supply and demand balance**
- **It is common problem for every generation, not only for renewable**
- **We need to utilize all innovative solutions for grid reinforcement in order to ensure long-term electricity security**