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KOREA POWER EXCHANGE

# Challenges and Future Prospects for Power Systems Due to the Rapid Expansion of RE

2025. 9. 12

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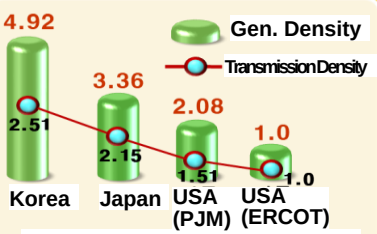
# Characteristics of Korea's Power System

**(Korea's Characteristics)** Isolated Power System, Highest Level of Equipment Density

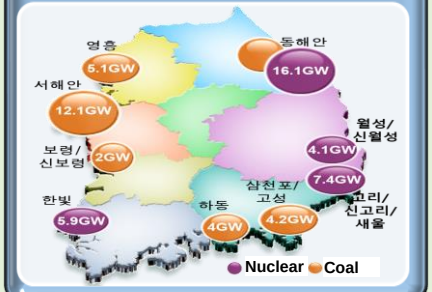
## General Feature

### ① Isolated System

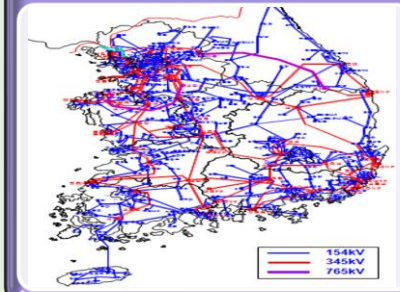
### ② Highest Level of Equipment Density




### ③ Large Scale Power Plant




### ④ High Density Transmission Network




**(RE Increase)** Korea is classified as Stage2 Under the IEA Framework, ❶Isolated System, ❷High Share of PV, ❸Concentrated deployment of RE(PV) in the Honam Region are causing issues seen in Stage 3-4

【IEA : Anticipated Issues By RE Integration Stage】

| Segment | Phase 1 | Phase 2 | Phase 3 | Phase 4 | Phase 5, 6 |
|---|---|---|---|---|---|
| RE Share | Less than 3% | 3~15% | 15~25% | Greater than 25% | Greater than 25%+ |
| Main Issue | None | Visibility<br>·Monitoring<br>·Data Acquisition | Flexibility<br>·Flexibility Resource<br>·Reserve Margin | Stability<br>·Voltage/Frequency<br>·Lack of Inertia | Surplus<br>· Supply-Demand Imbalance |
| Expected time | ~'14 | '15~'25 | '25~'34 | '34~ | '34+~ |

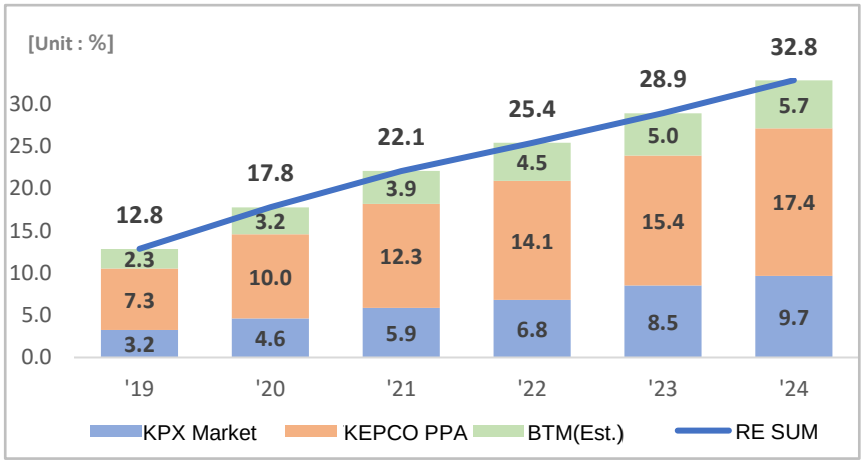
# Changes in Power System(RE as the Main Resource)

## Changes (RE Increase)

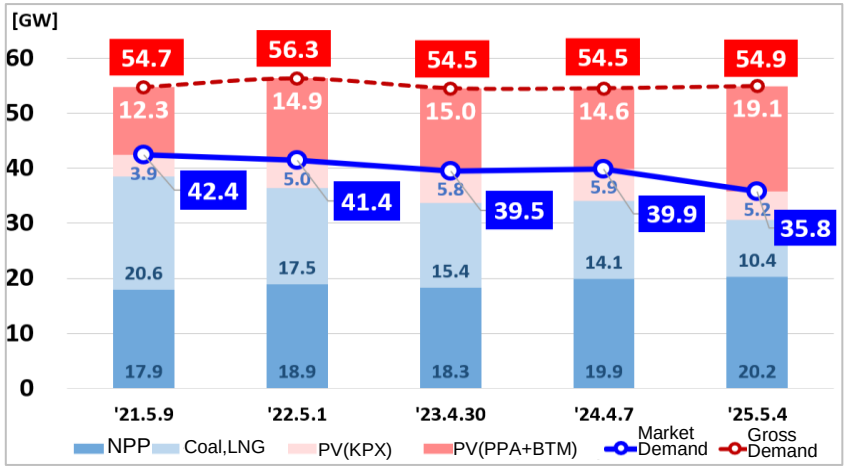
### ✔(Supply-Demand Management) Annual minimum demand decline

☞ (Minimum Demand) Long Holiday(New year, Chuseok) → Weekend in Spring and Fall(PV 高)

< Solar PV Capacity Trend>




< 5-year Minimum Demand>



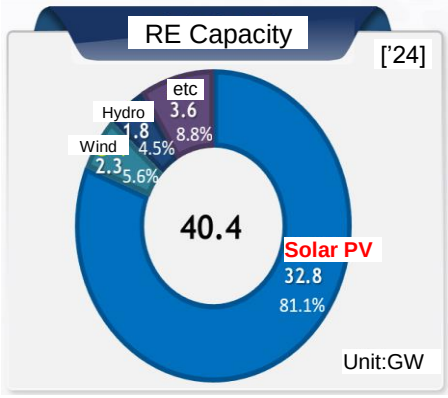

### ✔(Transmission Network Management)

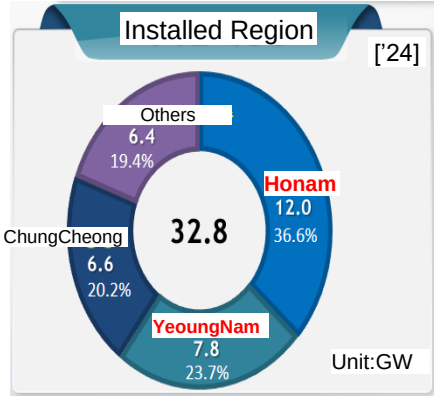
PV Concentration in Honam,Yeongnam

☞ Regional Gen. > Regional Demand

★ PV = 81.1% of Total RE

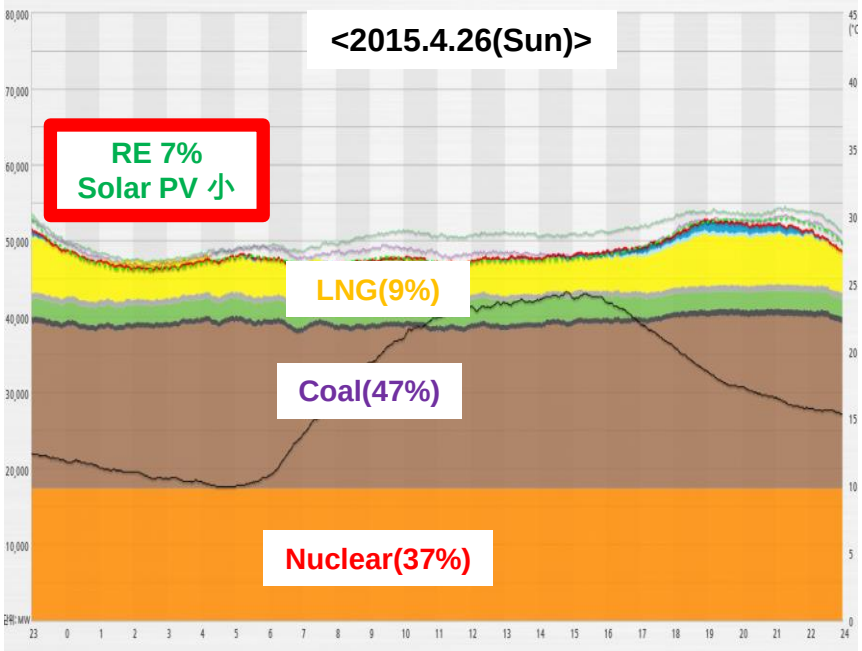
→ 60.3% of PV in Honam,Yeongnam

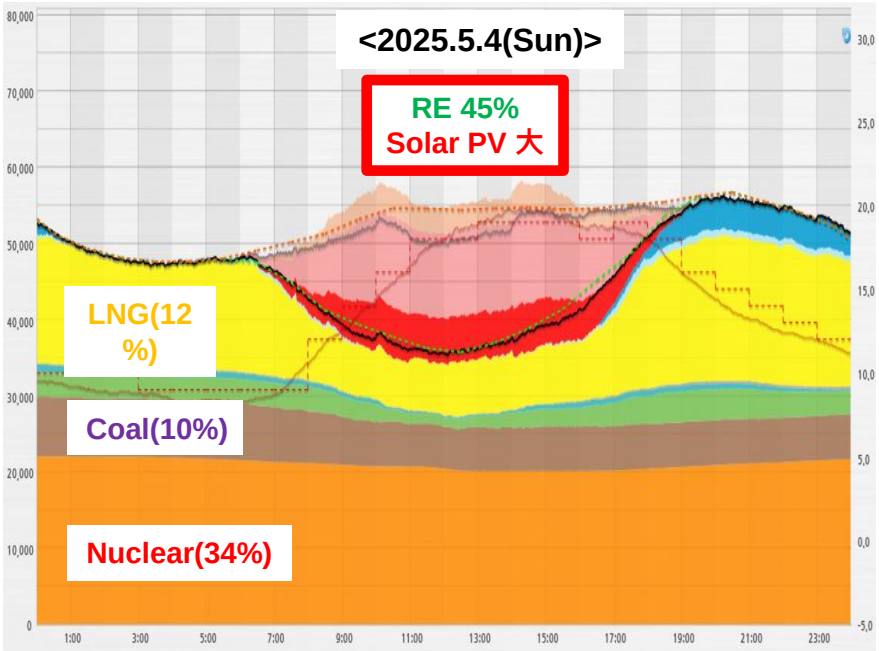


# Power Supply-Demand Operation(Flexibility Issues)

- PV daytime rise → Low coal & LNG utilization, deeper Duck curve
- Insufficient Network to Capital, High-cost LNG operation, Reduced downward Flexibility




**Market/Total Demand(1p.m.) : 47.0 / 48.2GW**

- Coal(20.8GW, 43%), Nuclear(17.3GW, 36%)
- Maximum Coal, Minimum LNG operation
- Demand variability 小, Min Demand at 4AM

**Market/Total Demand(1p.m.) : 35.8 / 54.6GW**

- PV(20.5GW, 37.5%), Nuclear(20.2GW, 37.0%)
- Coal&LNG Min operation(Only must-run Units online)
- Demand variability 大, Min Demand at 12PM

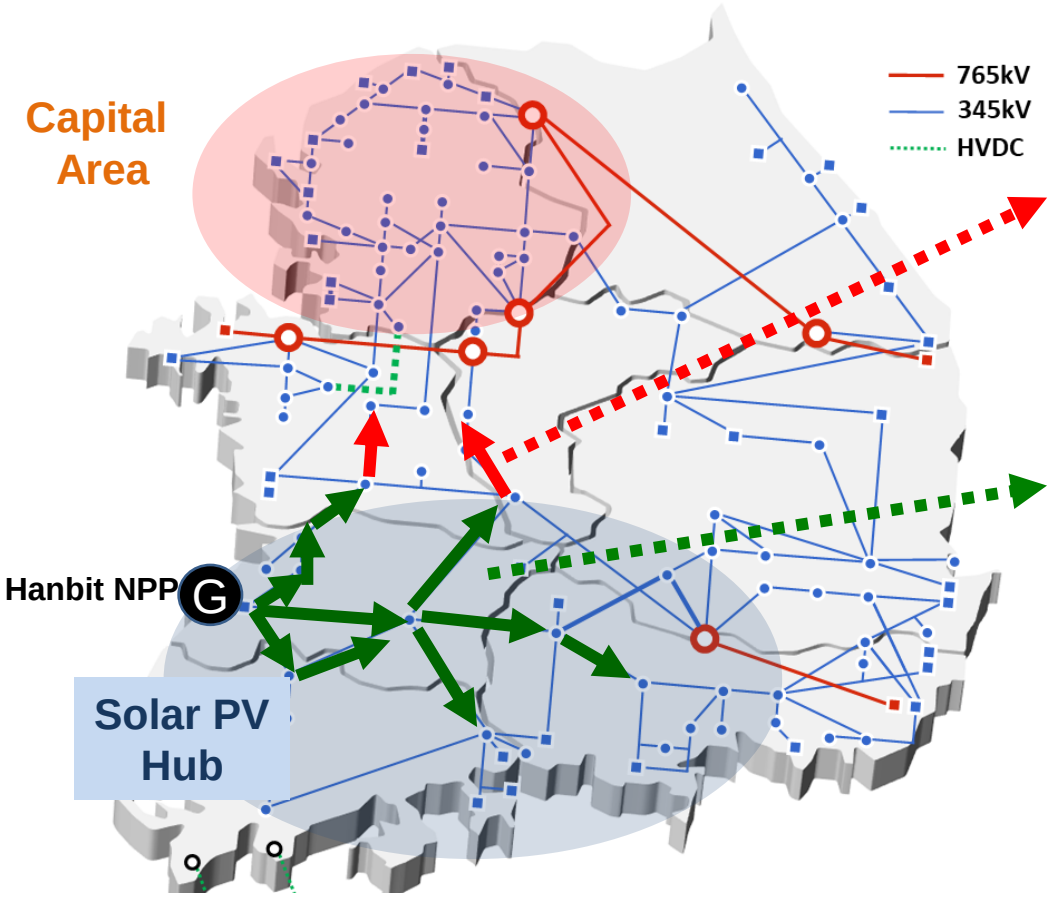
**Securing Upward & Downward Reserve Flexibility**

# Transmission Network Operation(Stability Issues)

**Stability Issue**

① (Voltage) Southern PV Surplus → Need to send power to ChungCheong
→ Tie-Transmission Line Saturated

② (Transient) Honam PV Surplus → Large scale generation Region
→ Hanbit NPP instability on Line fault




**① Honam-ChungCheong Tie-line Outage → Voltage instability**

- ✔ Honam-ChungCheong : Only 2 tie lines
  → Outage → Voltage not maintainable

→ Curtail NPP/RE Output

**② Line Fault near Hanbit NPP → Transient instability**

- ✔ Nearby Line fault → Hanbit NPP instability
  * SPS operation → Trip NPP on Line fault instantly
- ✔ Large Scale Gen. Region → Stability Deterioration

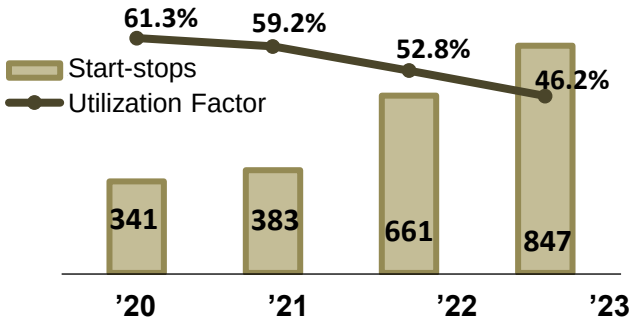
→ SPS Operation + Curtail NPP/RE Output

# Impact of RE Expansion on Conventional Generators

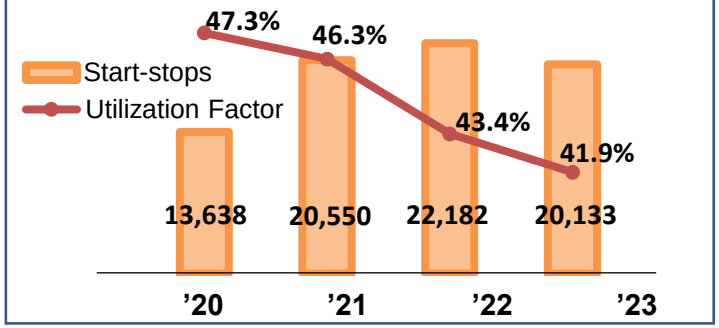
## Impact on Coal/LNG Generator

- (Utilization/Start-Stop) RE Growth → Low utilization, More start-stops

<Coal Unit Start-Stops & Capacity Factor >



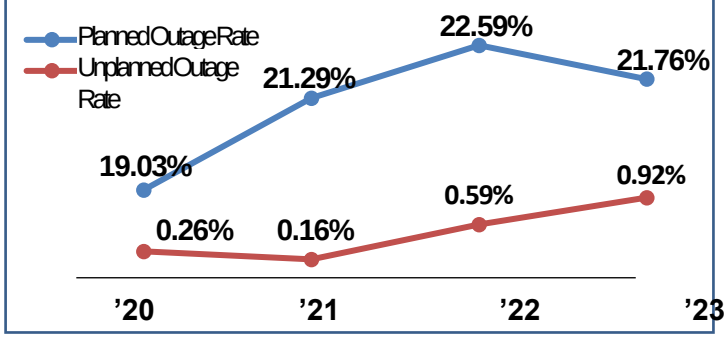

<LNG Unit Start-Stops & Capacity Factor >



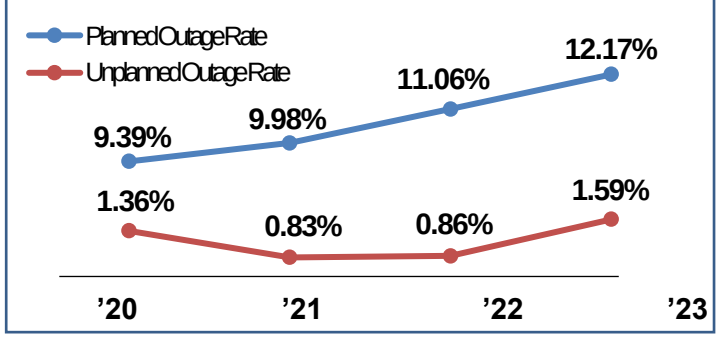

- (Maintenance Rate) Frequent start-stop → Higher planned/unplanned maintenance

  * (Coal) Higher unplanned outage rate
    (LNG) Shorter maintenance cycle → Higher unplanned outage rate

<Coal Unit Planned/Unplanned Outage Rate>




<LNG Unit Planned/Unplanned Outage Rate>




Power System Environmental Changes


**Past Efforts and Limitations**


Flexibility Enhancement Initiatives

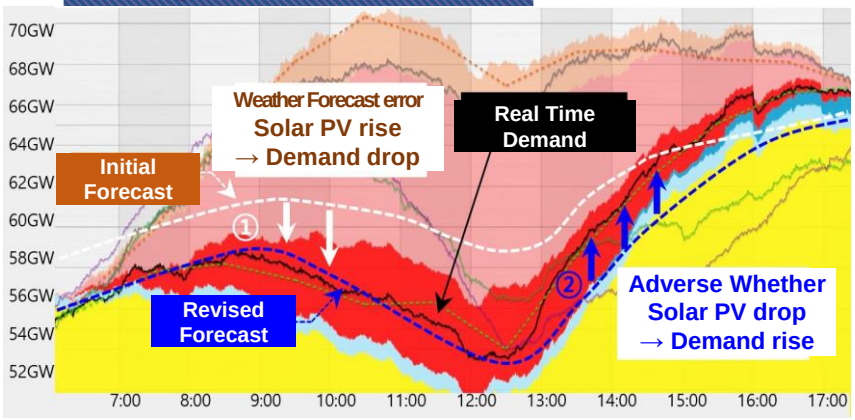
# Efforts for Stable Power System Operation

- **Min. Coal/LNG operation in a low demand period**
  - * All Coal/LNG units stopped except must-run units
- **NPP Flexibility (Curtailment day : 17days→27days)**
  - * First Nuclear power output curtailment in 2020
- **Mandatory online dispatch control for RE(market rule modification, April ’20)**
- **Quasi-Central generator dispatch implementation(’24 Fall~)**
  - * Dispatch to non-central generators during low demand period(with compensation)
- **New resources(ESS charge time shift, Plus DR, ’24 Spring~)**
  - * Solar PV linked ESS : charge start time 6AM → 10AM
  - * Plus DR : ESS, Vehicle Charger, pumping station

# Power balancing expected to be more challenging

**Despite various measures, Oversupply issue is expected to continue due to RE growth**

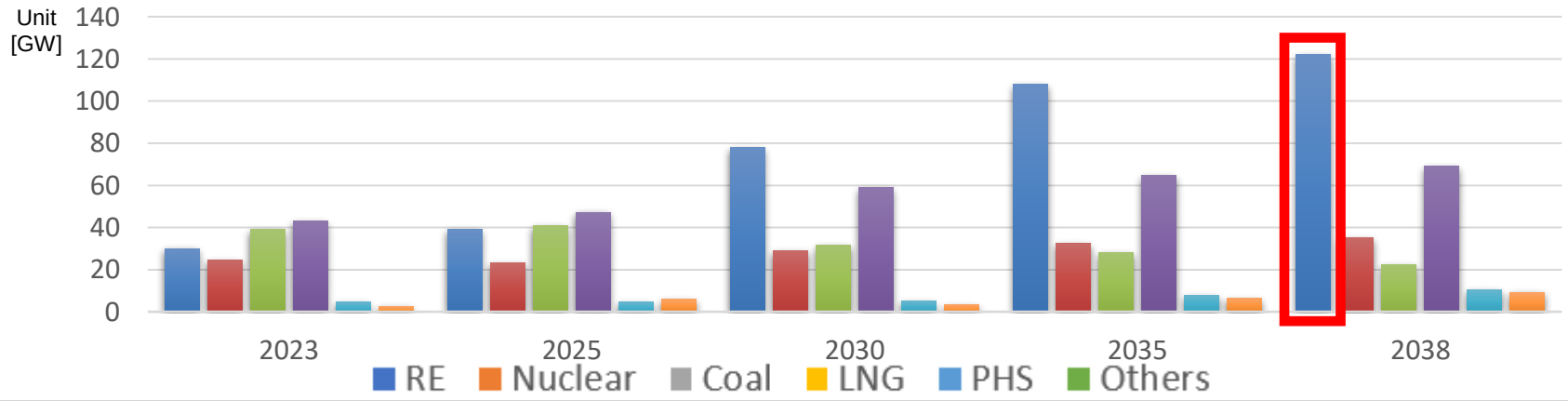
## Operation Data




- **Balancing difficulty due to RE growth**
  - √ (AM) PV rise → Sharp demand drop
  - √ (PM) PV drop → Demand rise
    → Reserve shortage
- **More non-central gen. Curtailment(Spring/Fall)**
  - √ (Occurrence) 2 times('23) → 27 times('24)

## RE Deployment Plan

- **('2038) 122GW (4 times vs. current) from 11th Power Supply-Demand Plan**

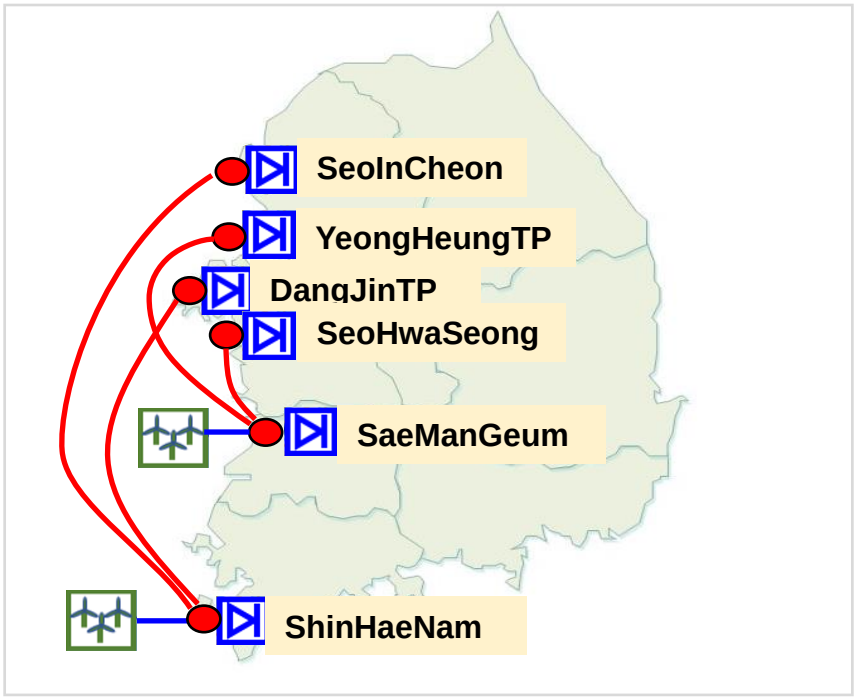


# East/West coast HVDC Network Reinforcement Plan

## (Overview) Reinforcement of Backbone Grid for Power System

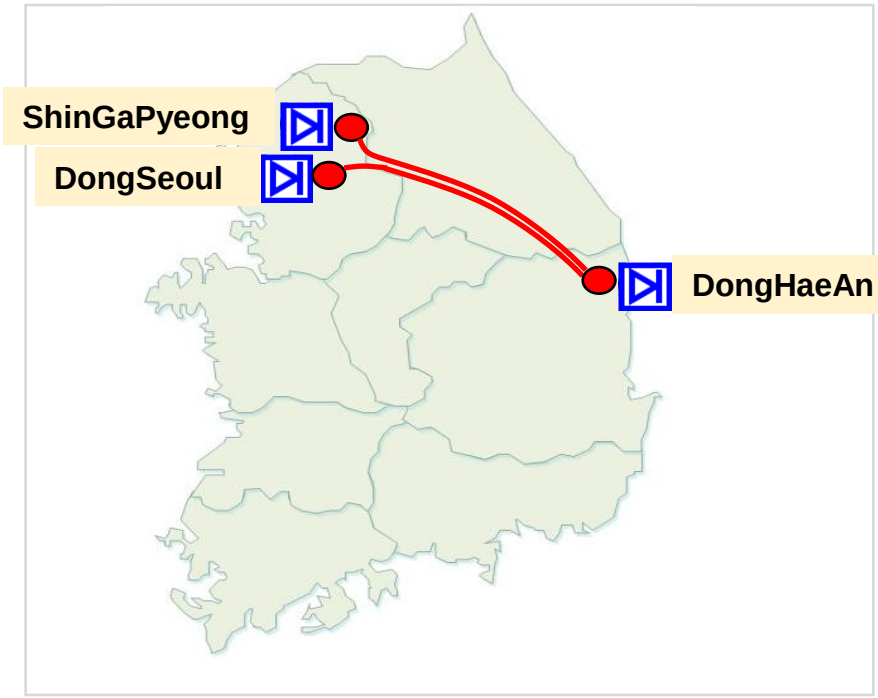
☞ Direct Supply from Honam NPP/RE & East coast NPP/Coal to Capital Area

< West Coast North-South HVDC Backbone>




- (Voltage) DC 500kV (VSC Type)
- (Capacity) 2GW × 4 (8GW)
- (Completion Date) '32~

< East Coast East-West HVDC Backbone>




- (Voltage) DC 500kV (LCC Type)
- (Capacity) 4GW × 2 (8GW)
- (Completion Date) 1st '26.10, 2nd '27.12

☞ East/West Line expansion → LNG(Capital area) shutdown possible → Greater grid flexibility


Power System Environmental Changes


Past Efforts and Limitations


**Flexibility Enhancement Initiatives**

# Flexibility Enhancement(Generator Flexibilization)

## Nuclear Power Plant

### Development of Flexible Nuclear Operation Technology(~2035)

| Category | | As-is (Planned Curtailment) | To-be (Continuous Flexible Operation) |
|---|---|---|---|
| Load Following operation | Operation range | 100-80-100% | 100-50-100% |
| | Operating Period | Within 40 days / year | Within 200 days / year |
| | Ramp Rate | 3%/hour | 25%/hour |
| Frequency Control(GF) | | N/A | ±3%(50~100% Range) |

### Small Modular Reactor(SMR) Technology Development

*** (High Performance) 100-20-100% Load following, 5%/min ramp, 20 min from 100→20%**

**√ Tech Development + Standard Design Approval → Construction permit early 2030s**
**→ Commercialization by 2035(175MW*4)**

### Flexibility and Constraint Relief through Rated Operation

*** Policy decision needed(equity& fairness)**

| As-is | To-be |
|---|---|
| Operate at 104~110% of rated capacity | Operate at 100%(Reduction of up to 1.0GW) |

☞ **Reduced output → Improve supply-demand flexibility, constraints, reduce start-stop(Coal)**

# Flexibility Enhancement(Generator Flexibilization)

## Coal

- **Flexibility Expansion via Equipment Upgrade**
  - ☞ (Min. output) SamcheockGreen#1,2 665 → 600MW(‘23)
    SamcheockTP#1,2 583 → 495MW (‘25)
- **Review min. operation tech(e.g. single mill operation)**

## LNG

- **Expand GT-only operations, smaller units in new builds**

  * e.g.) GT#1 + ST#1 → GT#2 + ST#1 (smaller units)

- **Securing Inertia by adding synchronous condenser to plants**

  ☞ Use stand-by plants as synchronous condensers

  - Need 15GWs by ’30. New CCGT with Sync-condenser + dedicated Units

# Flexibility Enhancement(New Flexibility Resource & Market Reform)

## New Flexibility Resources

### Long Duration BESS (Central Contract Market)

☞ **('23) 68MW, Jeju island ('25) 523MW for Mainland, 40MW for Jeju island (~'29) 2.22GW**

### Pumped-Hydro Storage

☞ 4.7GW in operation, 5.7GW in progress, (~'38) 11.7GW in total

Long duration BESS & Pumped-storage → Ease constraints, balance supply-demand

## Expand RE Flexibility

### Expand "Real-Time Online Controllable Resources"

☞ 530MW('24 Fall) → 1,076MW('25 Summer), further expansion planned

### RE-linked ESS (1.6GW PCS)

☞ **(Now) time-based charge/discharge (Future) based on irradiance & frequency**

RE-Linked ESS = Grid flexibility resources

### Strengthen RE performance verification process(Online Dispatch, Voltage control, etc)

- (Conventional) Full performance test before operation
- (RE) Same process but limited verification

# Flexibility Enhancement(New Flexibility Resource & Market Reform)

## Power Market Modernization Pilot Program(Jeju island, ’24.6~)

- **RE Bidding System**
  - ☞ RE Bidding → Merit Order Dispatch (provide incentives as CP)
    → Decrease in RE output curtailment, Enhance power system efficiency
- **Real-Time market**
  - ☞ (From) Day-ahead market (To)Real-time market with price signals(15min)
    → Improve demand and RE forecast accuracy
- **Reserve market**
  - ☞ Real-time based reserve procurement
    → only required reserves

## Ancillary Service Market

- **Enhance compensation for flexibility(control service, RE ancillary)**
  - ☞ Commercialize services(e.g. sync condenser, ESS frequency support)
    → Timely active stability resource deployment

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# Questions ?