

# Powering the Future of RMI:

# Integrating Electric Vehicles into the Grid

(Korean Experiences and suggestions for RMI's energy transition)

World bank E-Mobility Workshop (RMI)

2026-3-13 / Majuro, Marshall Islands

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**I** The Korean EV trajectory

**II** The PV-EV Synergy and Grid Flexibility

**III** Technical Resilience for Future Grid

**IV** Summary and Suggestions (FYI)

# National Plan for EV and Charging-infra

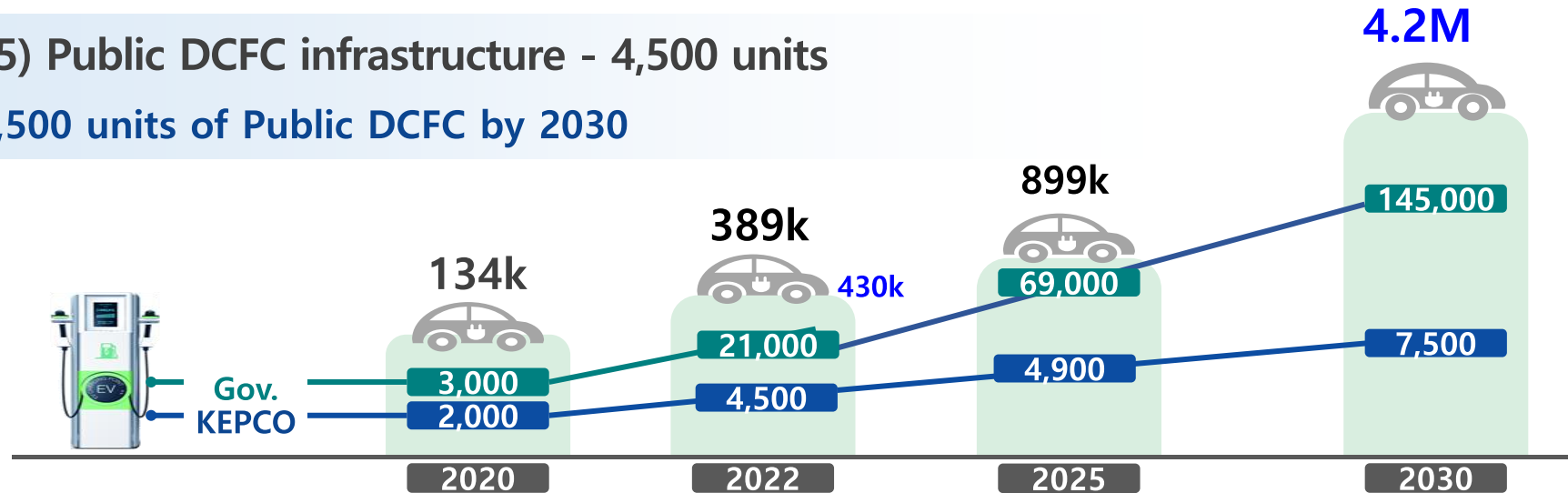
## □ EV and EV Charging infra Plans



**4.2 Million EVs in 2030** (1<sup>st</sup> NDC Basic Plan, April 2023)  
(145,000 units of Public DCFC)



(2025) Public DCFC infrastructure - 4,500 units  
➔ 7,500 units of Public DCFC by 2030

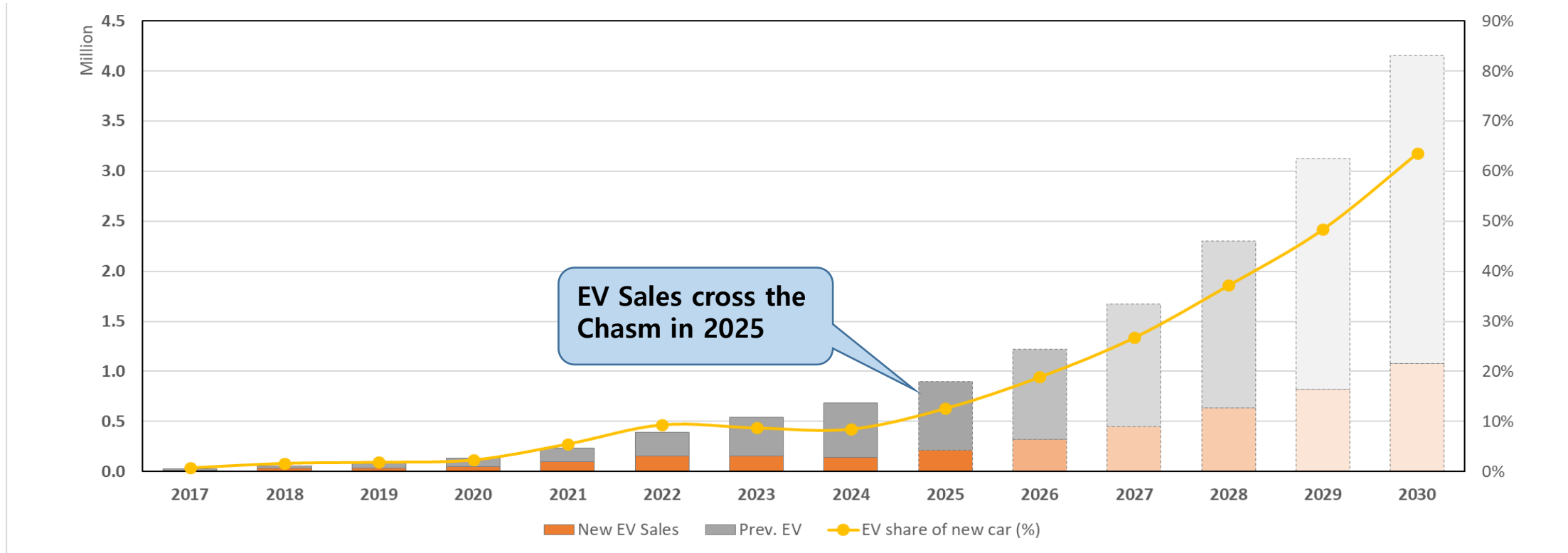


## □ The 4<sup>th</sup> Environmental Vehicle Basic Plan (2021~2025) (23 Feb 2021)

- (EV) Car (Taxi) (930k) + Bus (11k)+ Truck (193k) ➔ 1.13 M
- (EVSE) AC L2 at Workplace and Residential (500k), DCFC at Highway center (17k)  
➔ Mandatory Charging infra for APT homes (5%) and public parking (2%)

## □ Electric Vehicle Sales Forecast: 2026~2030 (Korea)

- EVs : 10,855 (2016) → 389,855 (2022) → 899,101 (2025) → **4.2M(2030)** → **>10M (2040)**
- 2x in 31 months (450k → 899k), CAGR: ~50% (5 years)



서울	부산	대구	인천	광주	대전	울산	세종	경기	강원	충북	충남	전북	전남	경북	경남	제주	계
101,331	60,687	42,592	79,860	19,115	25,432	13,340	7,330	207,075	25,679	32,901	39,839	30,511	41,322	45,090	65,934	61,063	899,101

Source: MoLIT, MoE, KEPRI (Light Truck: 169,744대, 5x Energy ~ 848,720 → 1,578,077)

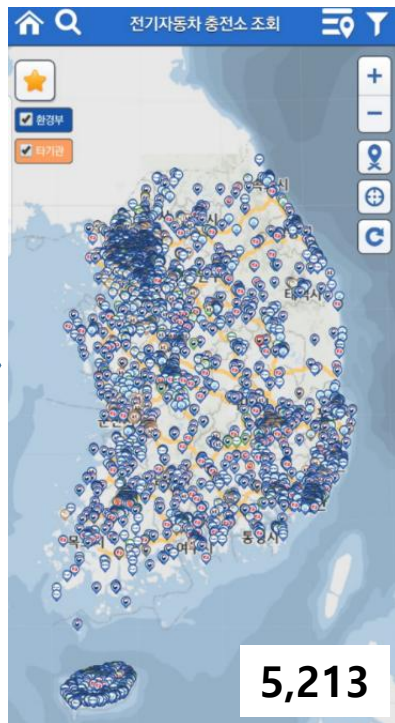
# Landscape of Public Chargers in Korea

## □ EV Charger Growth

- EVSEs: 486,964 (Public DC Fast: 65,557; AC L2: 421,407 as of Dec. 2025)
- 13.7 EVs/DCFC, 2.1 EVs/L2 (*World Best, IEA*)
- KEPCO share: 9,412 (DCFC: 4,911; Slow: 4,501) at 4,600 stations



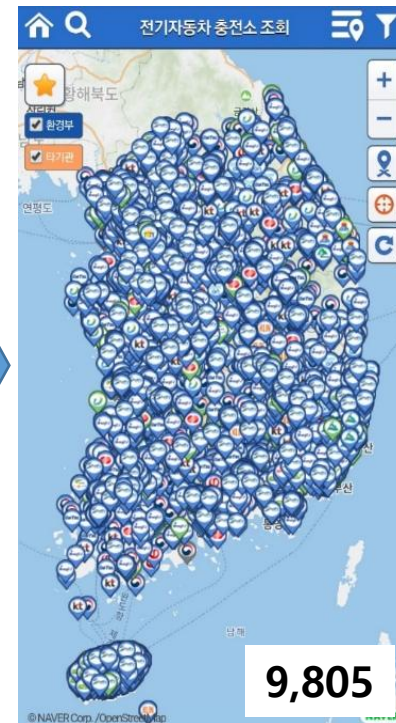
(Mar. 2017)



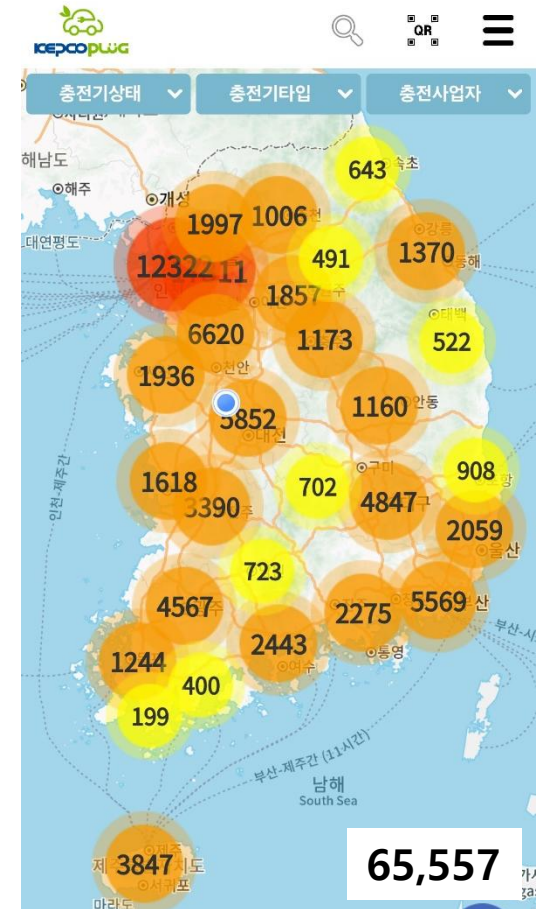
(Mar. 2018)



(Oct. 2019)



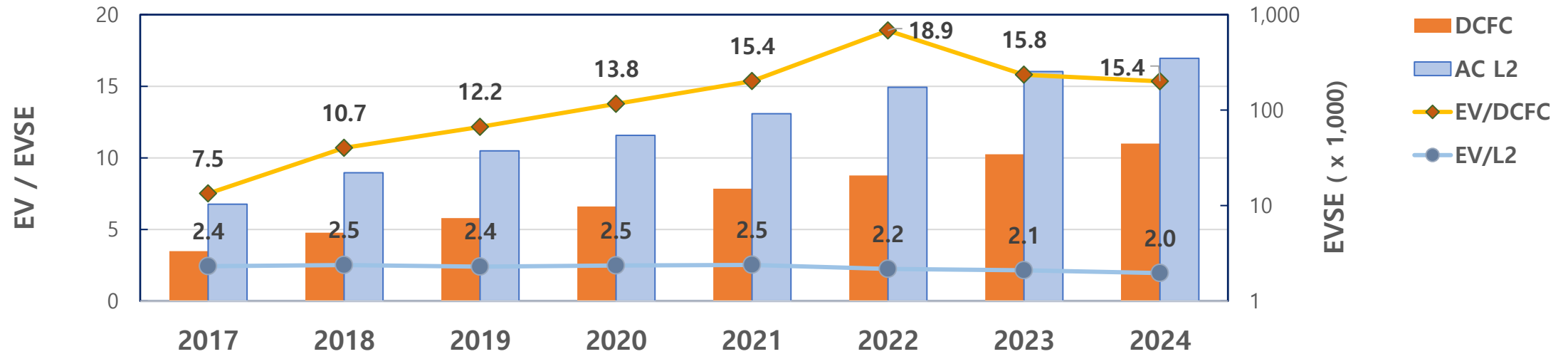
(Aug. 2020)



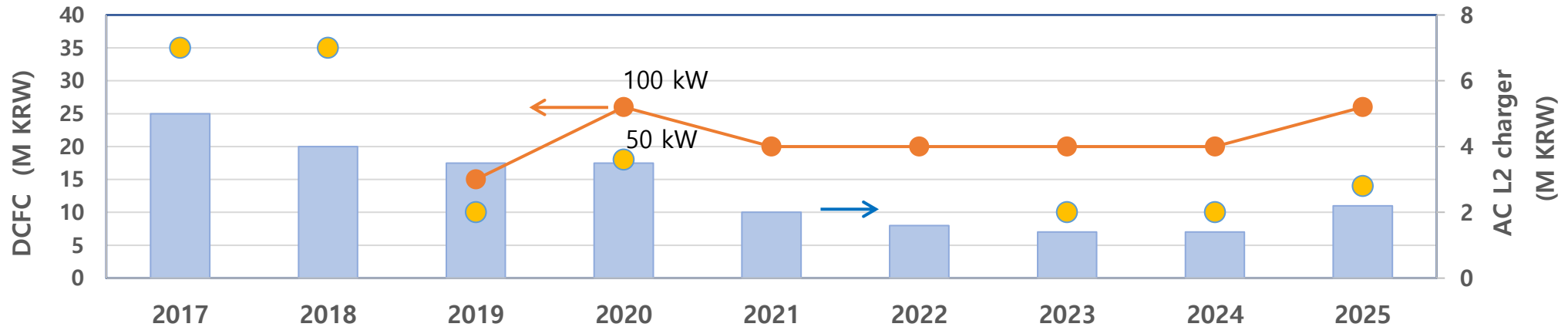
(Dec. 2025)

# Public Charger Growth and subsidies

## World Best EV/Charger ratio



## Charging infra subsidies (M KRW per charger)



# Changes in support policies and EV charging rates

## ❑ EV charge Electricity rate discount

Period		Jan 2017~	July 2020~	July 2021~	July 2022~
Discount rate	Demand Charge	100%	50%	25%	None
	Energy Charge	50%	30%	10%	

## ❑ EV charging ToU rates (KEPCO)

Season/Hour	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Max/Min
Spring (MAR~MAY)	85.4							97.2		102	97.2	102.1					97.2			85.4	1.20				
Summer (JUN~AUG)	84.3							172		259	172	259.2					172			84.3	3.07				
Fall (SEP, OCT)	85.4							97.2		102	97.2	102.1					97.2			85.4	1.20				
Winter (NOV~FEB)	107.4							155	217.5		154.9			217.5		154.9			107.4	2.03					

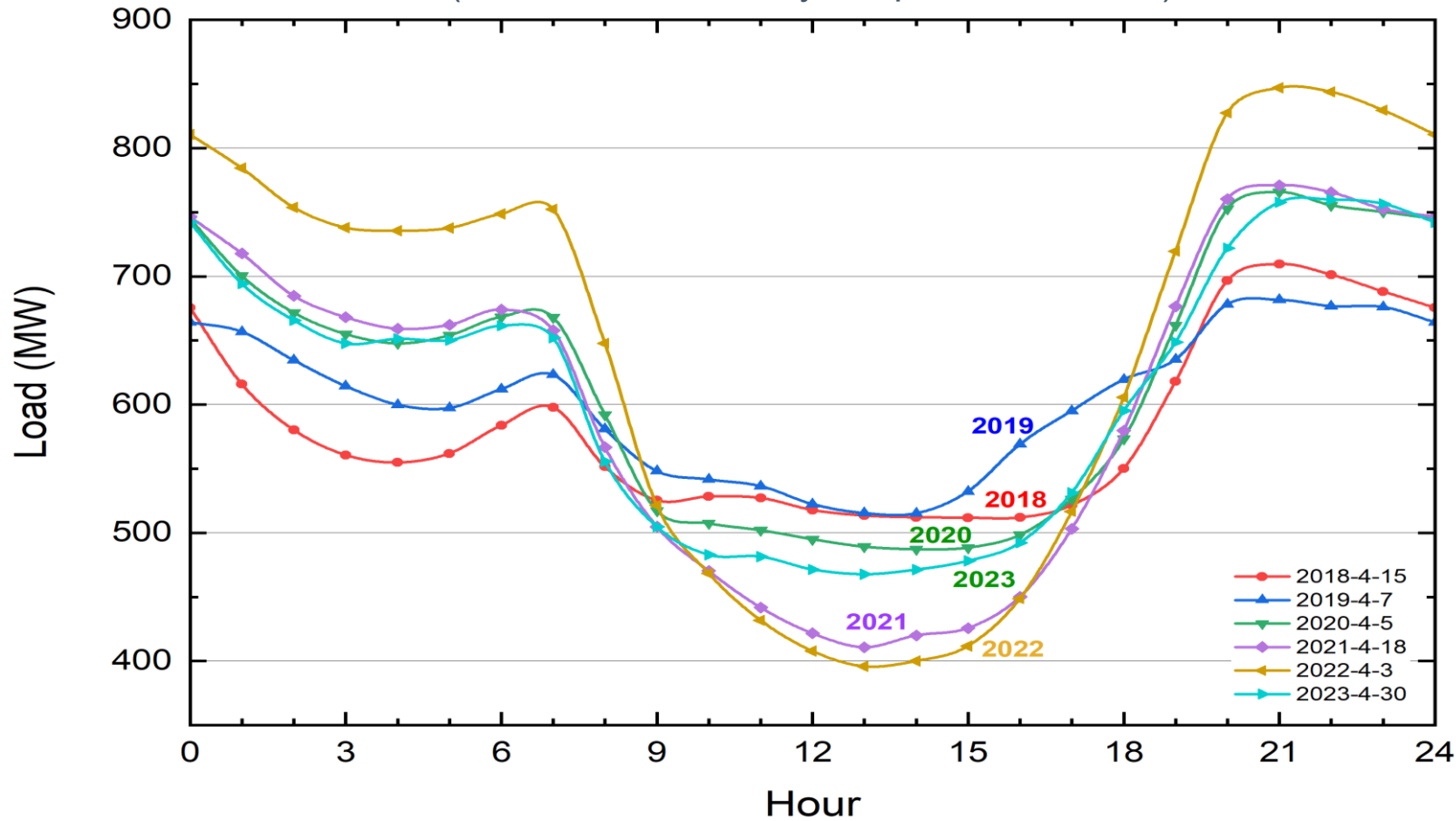
## ❑ Other policies and regulations

- Mandatory Charging infra for new APT-homes and public parking (5%) and old facilities (2%) for a lot size >100 and >50, respectively.
- Occupancy or Idle fine: 1-hr for DCFC and 14-hr for AC L2 chargers
- Smart controlled, V2G ready chargers for new installations (2025~)

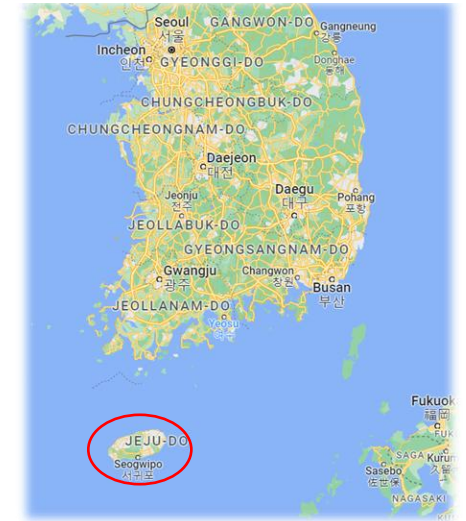
# Power Grid, ESS, Flexibility

□ The *Duck curve* turning into a “*Canyon curve*”

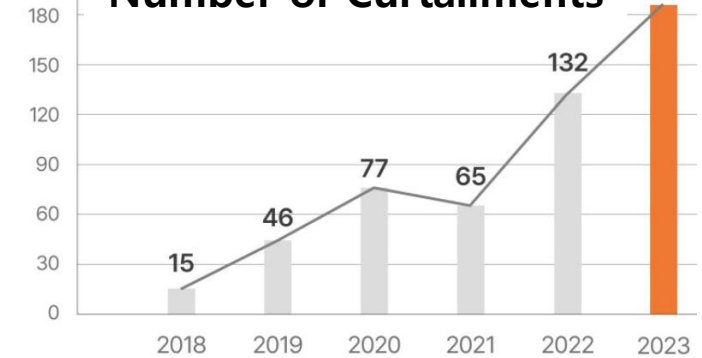
(The Lowest load day in April, 2018~2023)



**Jeju** 제주특별자치도  
Jeju Special Self-Governing Province



Number of Curtailments

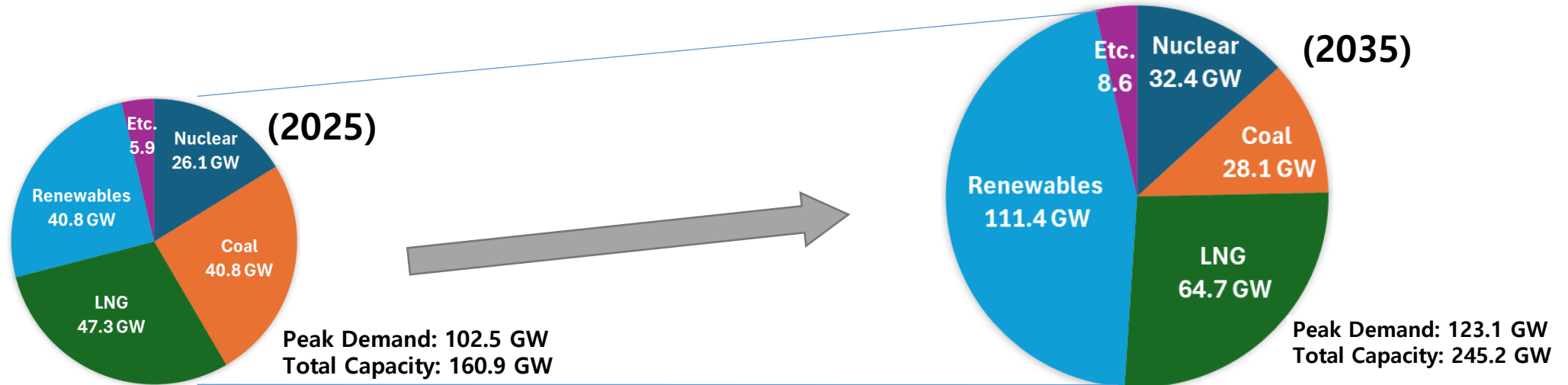
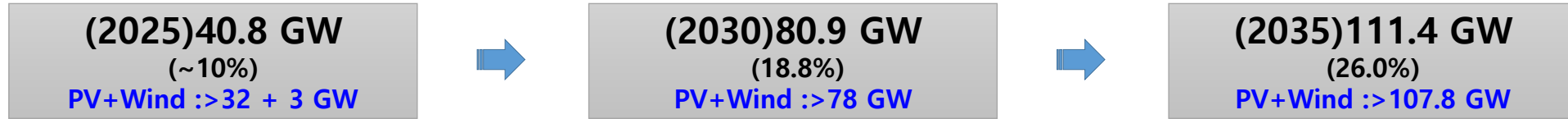


Source: KPX, ETNEWS (<https://www.etnews.com/20230609000179> )

# Power Grid, ESS, Flexibility



- The 11<sup>th</sup> Basic Plan for Electricity Supply and demand (21 Feb. 2025)
    - 2030, Renewables (PV, Wind) Capacity will Exceed 50% of Peak demand
      - ➔ Curtailment for coping with output variability in renewable power generation (~3%)
      - ➔ Pumped Hydro Power (5.7 GW), Secure Long/Short duration ESS (23 GW) ➔ \$20B ~ \$31B
- (Flexibility Resources) V2G EV 1.5 GW, DR Market 4.7 GW (2038)



# Power Grid, ESS, Flexibility

□ PV increase, Grid reinforcement delay → **More Ancillary service**

- ESS for Grid stability support → 978 MW (889 MWh, ~\$600M USD)

## KEPCO completes 978 MW battery storage project

The project is billed as Asia's largest battery energy storage system for grid stabilization purposes.



By Marija Maisch  
Sep 27, 2024



Grid-scale

Projects & Applications



(북부변전소 ESS 336 MW)

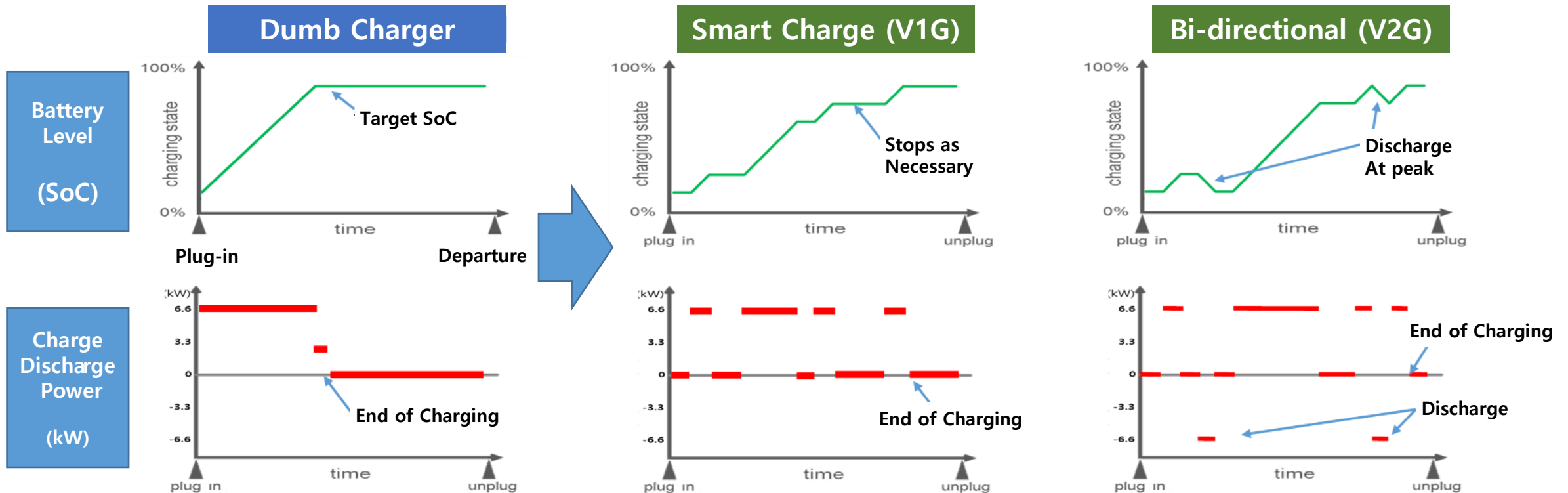
출처: KEPCO, 산업부, <https://www.ess-news.com/2024/09/27/kepc-completes-978-mw-battery-storage-project/>

# VGI-V2G for Grid Flexibility

## □ EV Charging method

- AC/L2 Chargers of current deployment : Dumb supply of electricity and transaction function

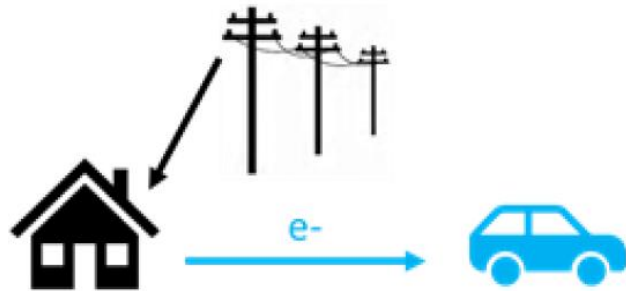
➔ Add Communication & control: Smart Charging (V1G) ➔ bi-directional power transfer (V2G)



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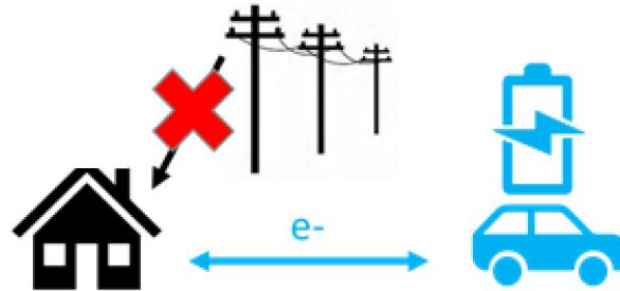
## □ eVehicle-Grid Integration (VGI) – V1G and V2G Use Cases

### Managed charging (V1G)



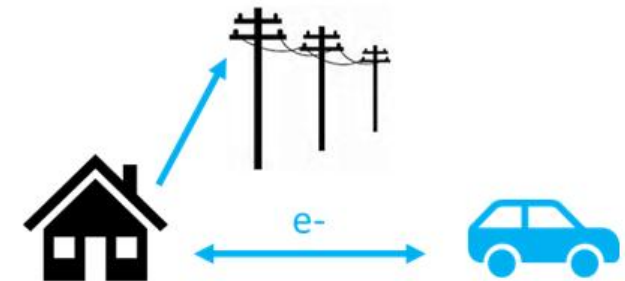
- Econo-Charge (ToU rate)
- Demand Response
- Peak Shaving, Load Shift
- Demand Flexibility

### Resiliency (V2X)



- Resiliency: Vehicle to X (Home, Building, etc.)
- Vehicle to Micro Grid
- EV as a Backup Resource

### Export (V2G)



- EV Energy export
- Energy Arbitrage (Flex rate)
- Peak Support
- Flexible Grid Resource

- Using only 6-hours a week (~3.6%)

TECH • TRANSPORTATION

## Today's Cars Are Parked 95% of the Time

BY DAVID Z. MORRIS

March 14, 2016 6:06 AM GMT+9



An aerial picture shows new Chevrolet cars at a General Motors' parking lot in Shenyang, Liaoning province, China, June 28, 2015.

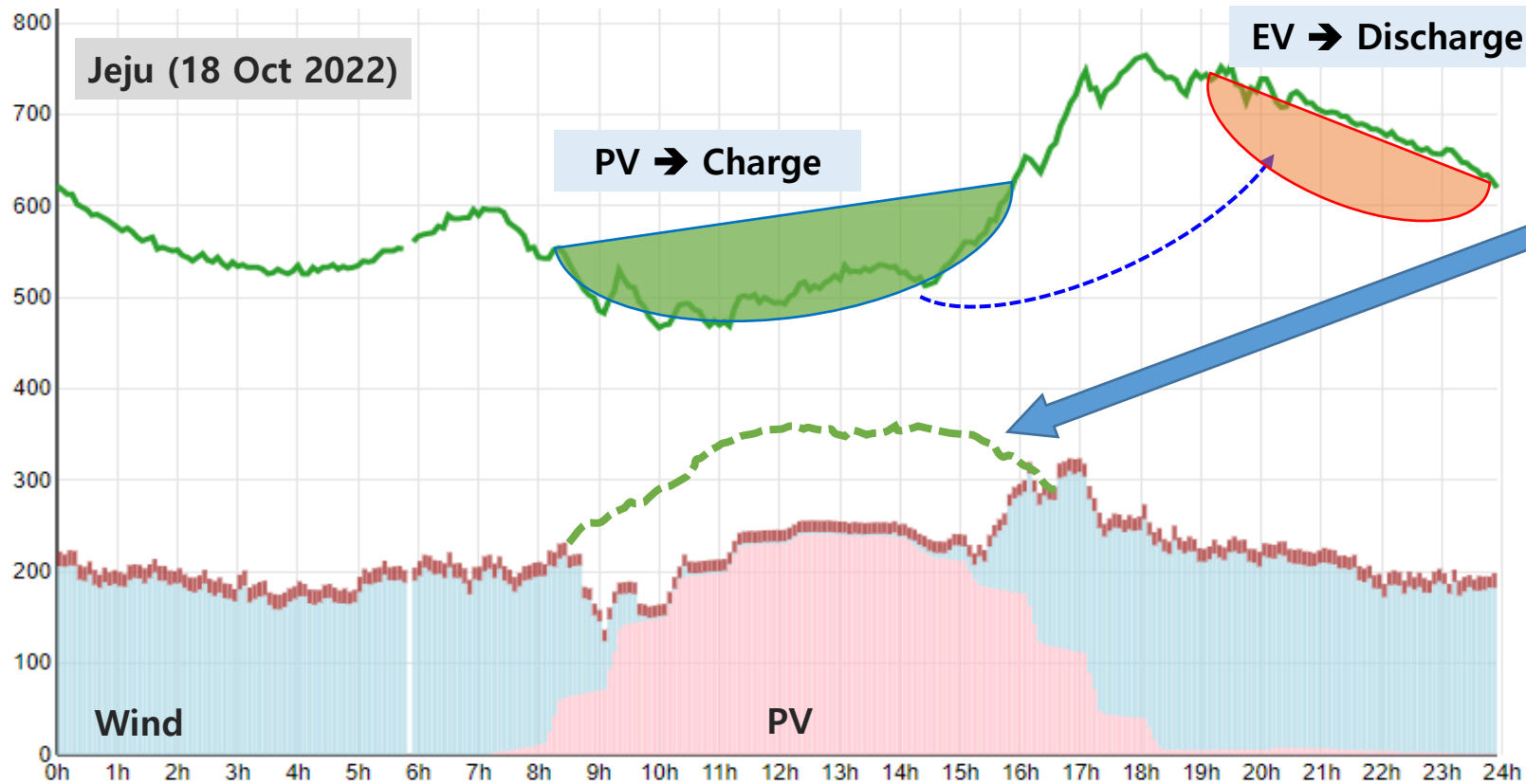
PHOTOGRAPH BY SHENG LI — REUTERS

*"....this suggests an average of just under 18 trips per car every week. Since the duration of the average car trip is about 20 minutes, the typical car is only on the move for 6 hours in the week:  
for the remaining 162 hours it is stationary – parked."*

# VGI-V2G for Grid Flexibility

□ Utilize EV as Virtual ESS → Easing Curtailment (Charge) and demand Support (Discharge)

● V2G EV of 10 kW x 1,000 → Equivalent to 10 MW ESS



PV and Wind curtailment relief  
(~100 MW)

EV V2G → Flexibility Resource  
(10 kW x 10,000 = 100 MW)



Stable grid operation  
Increased utilization of  
Renewables (PV)

출처: KPX, 제주도 (제주도 등록차량 (2023.9.): 700,830 대)

# VGI-V2G for Grid Flexibility

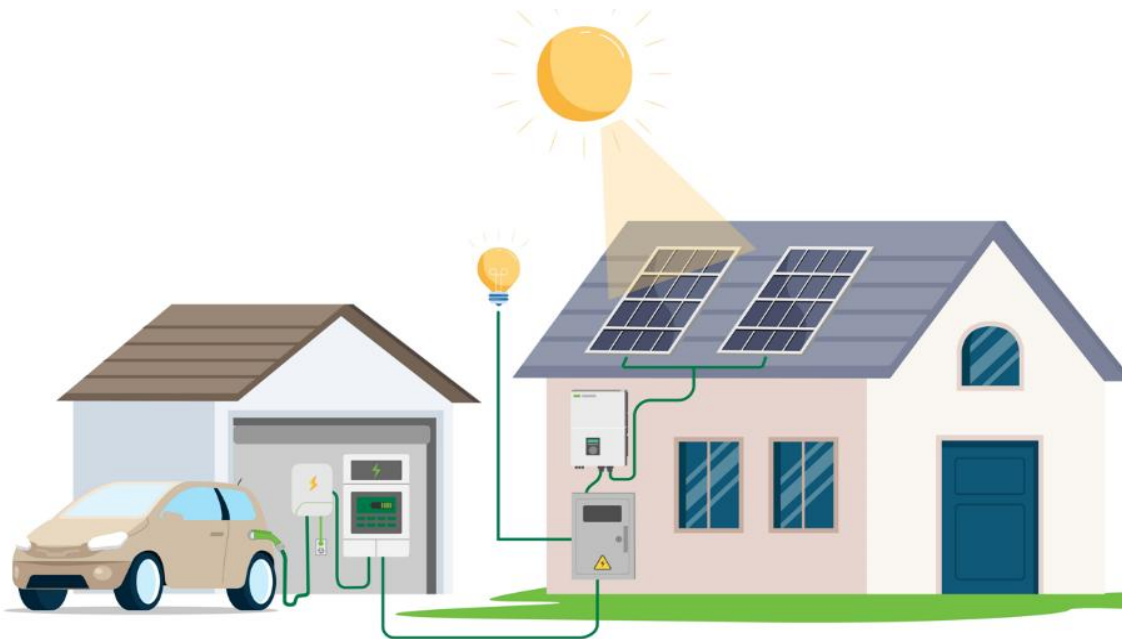
## □ V2L - The "Power Bank on Wheels" (May 2021~)

- HYUNDAI IONIQ 5, IONIQ 6: 3.6 kW (220 V, 16 A)
- KIA EV6, EV3, EV5, EV9: 3.6 kW (220 V, 16 A)
- GENESIS eG80, GV60, GV70: 3.6 kW (220 V, 16 A)
- FORD F-150 Lightning: 9.6 kW (120/240 V, 80 A)
- Chevy Silverado; BYD Atto, Seal; Polestar 4 (2.2~3.3 kW)



# The Math of Self-Sufficiency: Roof-top PVs

- ❑ A modest roof-top PV system can fully fuel an EV
    - Annual Energy need (10,000 km driving)
      - 10,000 km / 5 km/kWh  $\approx$  2,000 kWh/year
    - Roof-top PV requirement
      - 2,000 kWh / (365 days / 24 hours / 18% capacity factor)  $\approx$  1.3 kW  $\rightarrow$  (380 W/panel x 4 = 1.5 kW (8 m<sup>2</sup>))
- $\rightarrow$  A roof-top PV of 3~4 kW will cool your home and fully charge the EV**



# High PV penetration: Challenges and Solutions

## □ The PV Uptake and challenges

- **Rapid solar fluctuations (from cloud cover) can cause many Problems**
  - Voltage Increases at the end of lines, Frequency Fluctuations, Fault Propagation, etc.
- **Various challenges:**
  - Grid capacity limit → Grid reinforcements, Large Scale ESS, DERMS
  - Large number of Curtailments



## □ The Grid code revision

- **RMI must implement a "Tight Grid Code" for all rooftop PV to prevent blackouts.**
- **Key Requirements:**
  - ✓ Voltage Control: Inverters must adjust reactive power locally.
  - ✓ Frequency Response: Automatic power reduction when frequency rises.
  - ✓ Fault Ride-Through: Inverters must stay connected during minor grid glitches rather than tripping and causing a cascade failure.
  - ✓ Grid-forming Functions: Inverters can regulate voltage and frequency, support inertia

## □ The KEPCO Advanced Distribution Management System (ADMS)

- Fault Location Isolation and Service Restoration
- Distributed energy resource management system
- Distribution Network Reconfiguration
- Outage management system

Distribution Control Center



Communication Network

Switch



FRTU



Network Modem



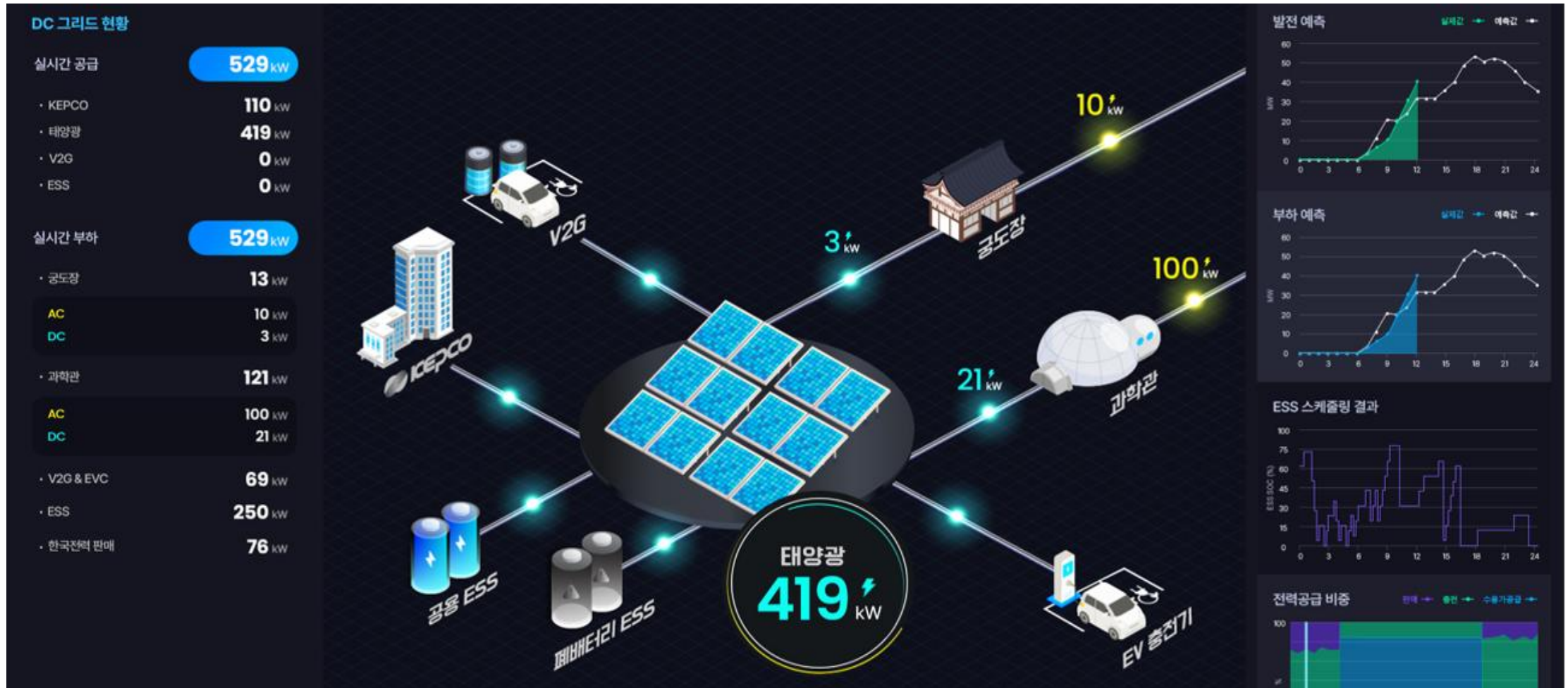
Field Distribution Network

FRTU : Feeder Remote Terminal Unit

# KEPCO Micro-Grid Solutions

## □ Integrated control of Power generation resources and consumptions

### ● The Microgrid Platform: Microgrid EMS, SCADA, Applications



- Electric Vehicles can be utilized as a virtual large-scale ESS that can stabilize fluctuations of renewables and shift demand
- Short Term (~2 years): Repair existing chargers, implement "Tight Grid Codes" for new solar power, and launch an EV taxi pilot with public charging stations.  
Make a master plan for Grid upgrades and EV adoption
- Medium Term (~5 years): Standardize and build V2G-compatible chargers and introduce ToU tariffs to encourage daytime charging
- Long Term (2030+): Full integration where EVs act as the primary balancing resource for RMI's 100% renewable energy goal

# 감사합니다 Thank you

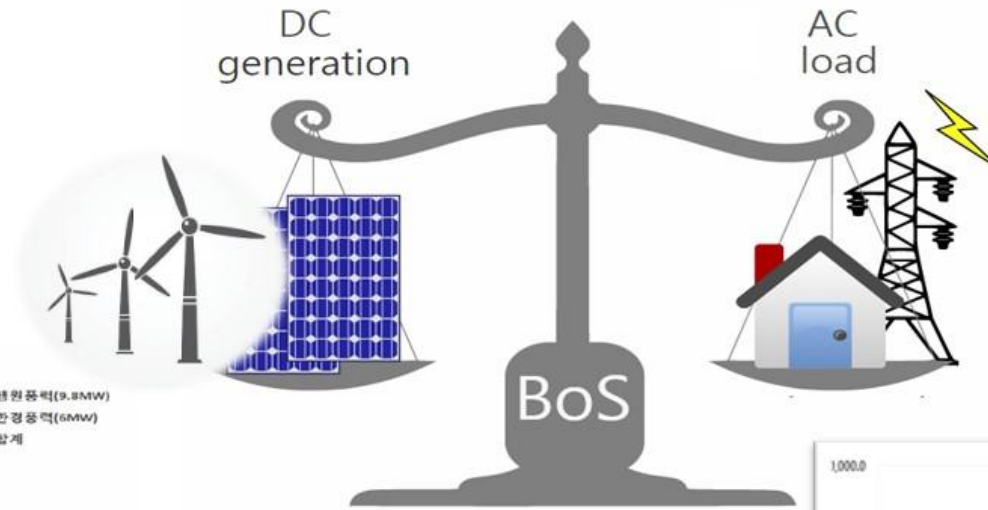


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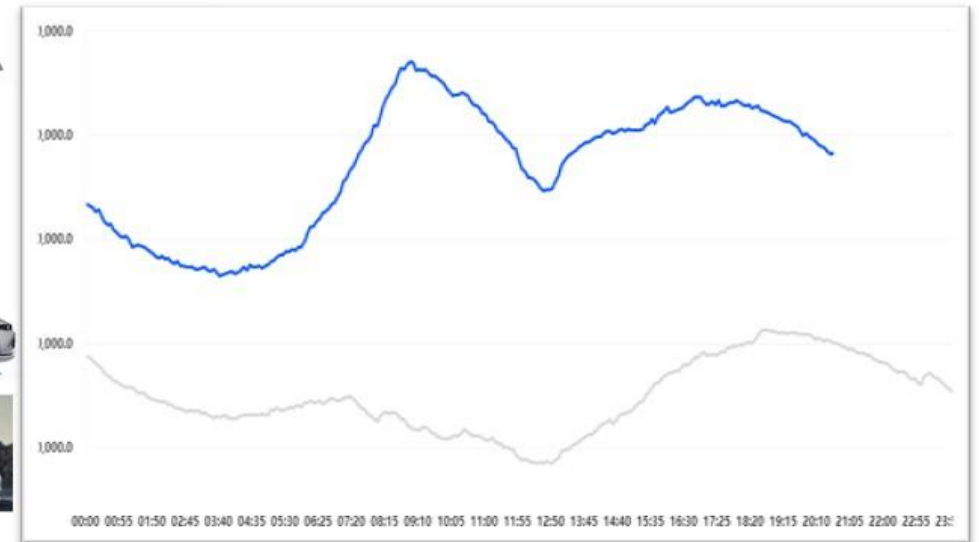
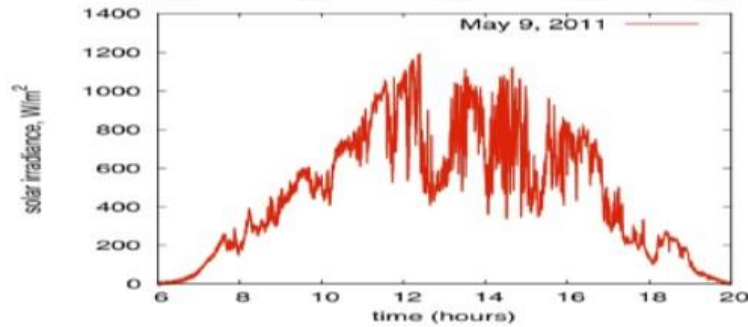
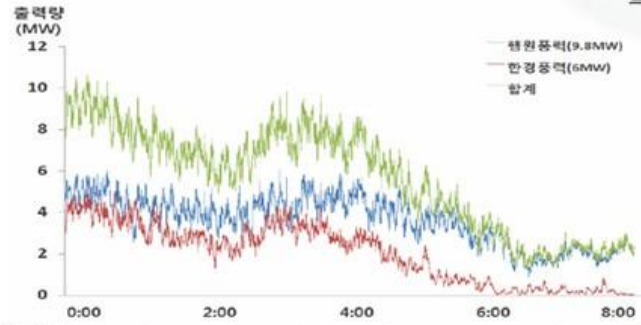


# Back-up Slides

## □ Grid-friendly EV Charging infrastructure



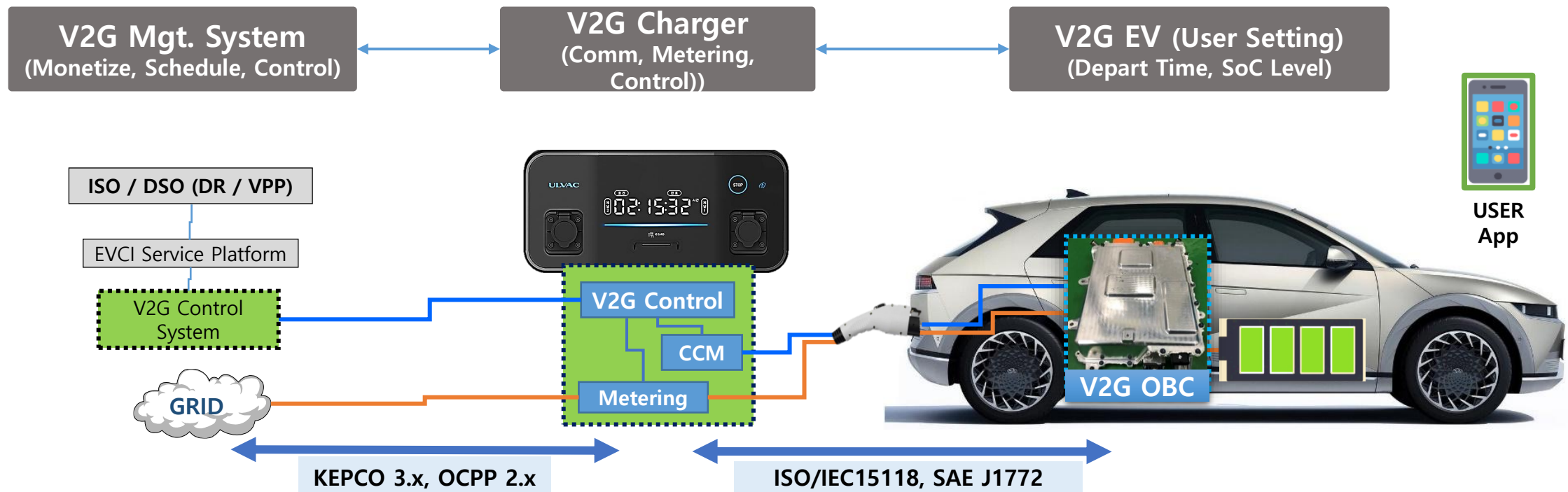
태양광발전(9.8MW)  
 풍력발전(5MW)  
 합계



# KEPCO V2G System

## □ VGI - V2G system Components

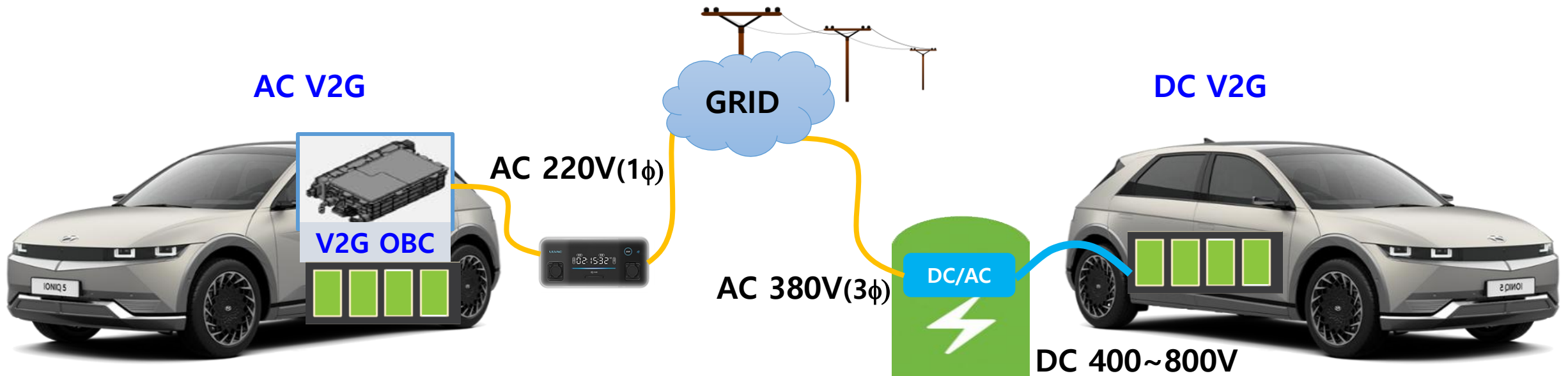
- User Friendly: Meeting Target Level (SoC, %) and Departure time. Cost Minimization
  - Grid Flexibility: DSO (DR / VPP) needs, Select Right Charging Sessions and Reschedule charge profile
- ➔ As a virtual ESS by Simultaneous control of Multiple Chargers. (BESS or PH equivalent)



Source: KEPCO, Hyundai Motor, ULVAC

## □ V2G Method

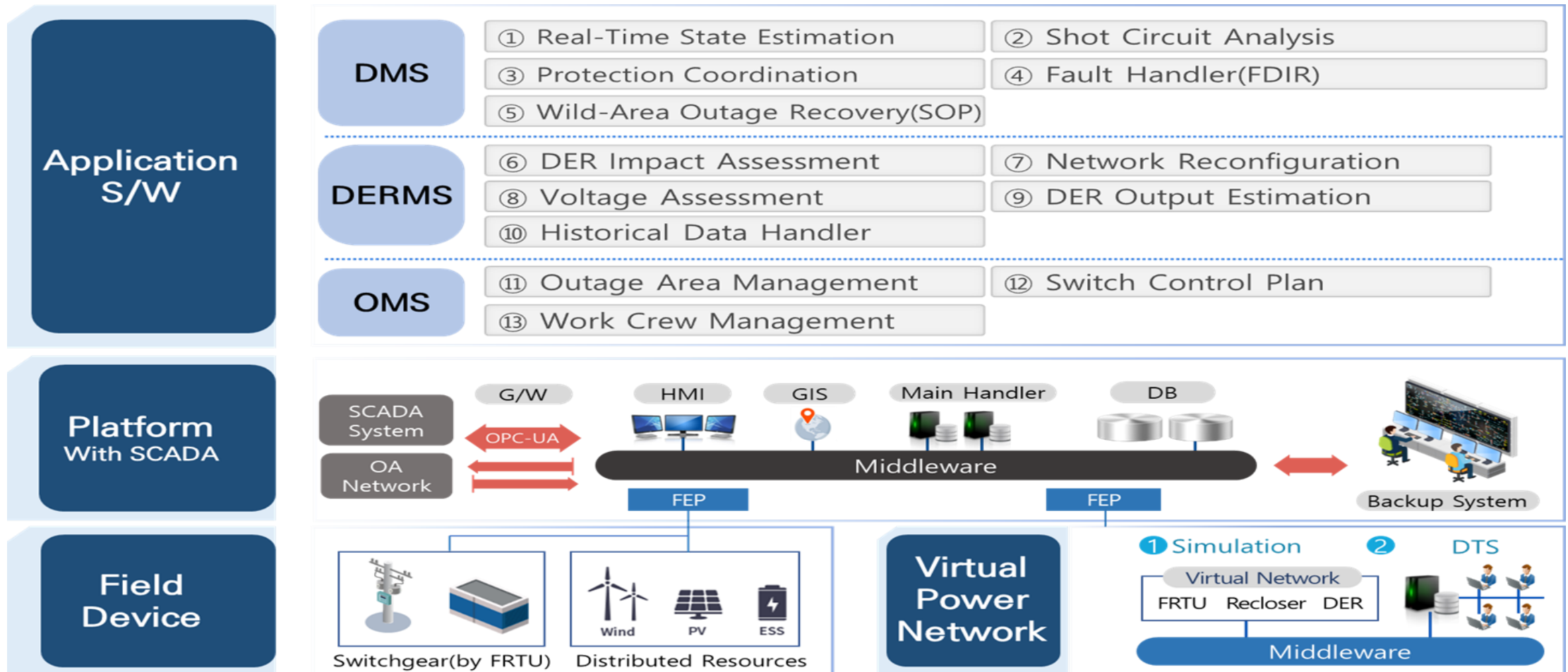
- (AC type) On-board Charger(OBC) converts DC output of battery to AC 220V → Low Cost!
  - EV (DC 800V) ⇒ OBC (DC ↔ AC 220V) ⇒ EVSE ⇒ Distribution line (220V, 1-phase)
- (DC type) External EVSE converts the DC output of battery to AC
  - EV (DC400~800V) ⇒ EVSE (DC ↔ AC ) ⇒ Distribution line (380V, 3-phase)



Source: KEPRI

# ADMS – Software Configuration

The ADMS is composed of application software that supports DMS, DERMS, and OMS functions, built on a D-SCADA-based platform responsible for monitoring and controlling distribution network equipment.



# Micro Grid - Energy Cloud Platform Architecture

