WORLD BANK GROUP | KOREA GREEN GROWTH TRUST FUND | Ministry of Economy and Finance

KOREA GREEN INNOVATION DAYS

The KEPCO AC* V2G** Pilot using IONIQ 5 EVs

*AC-Alternating Current, **Vehicle to Grid

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KEPCO Research Institute

KEPCO

KGID CAIRO

Introduction

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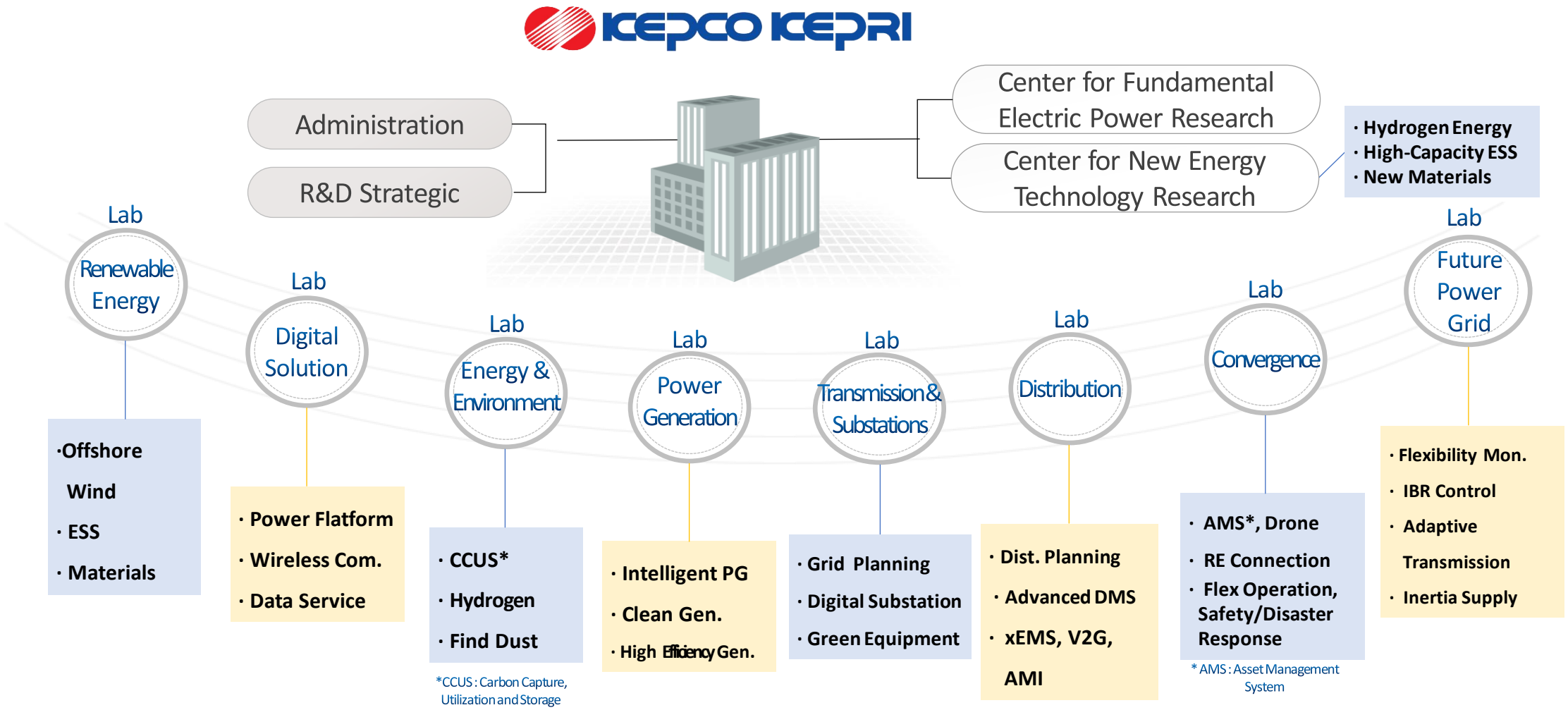
❑ The KEPCO Research Institute



Status of EV and Charging infrastructure

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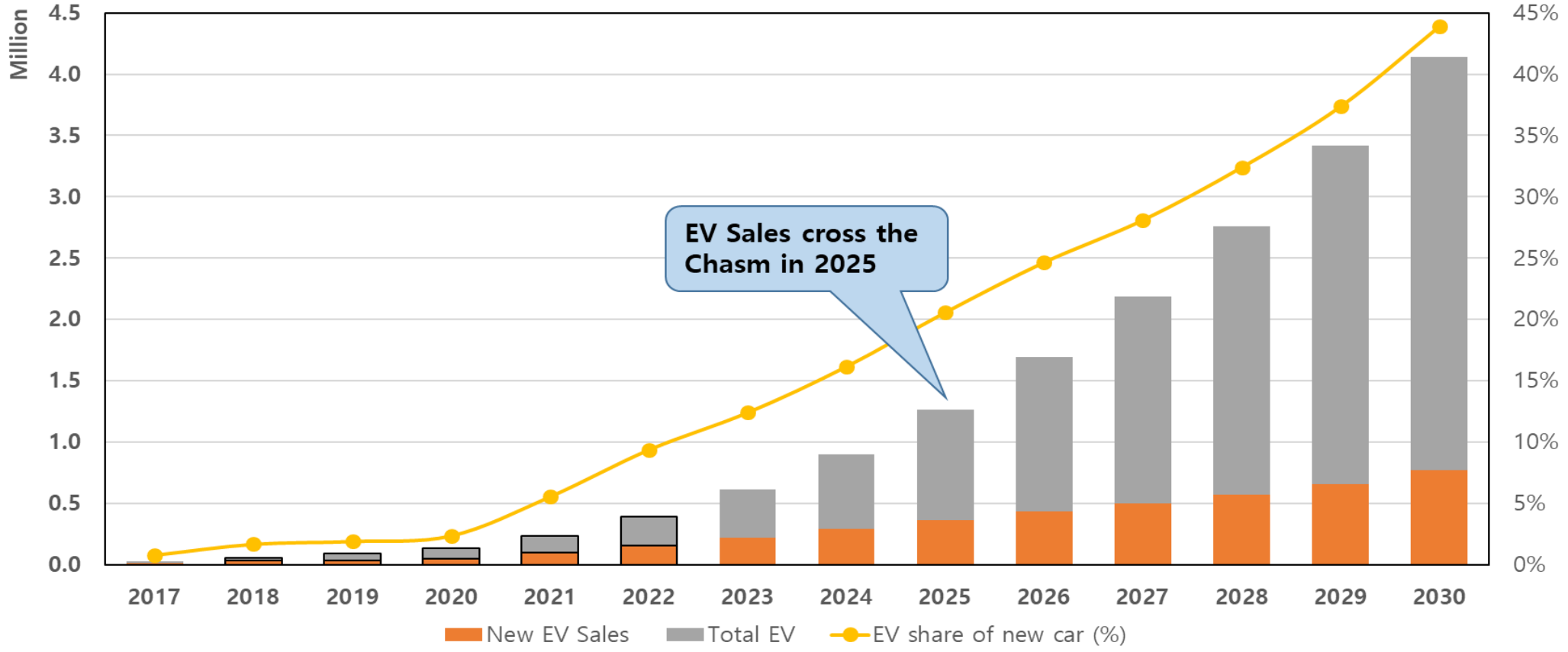
❑ Electric Vehicle Sales Forecast : 2023~2030

- EVs : 10,855 (2016) ➔ 389,855 (2022) ➔ 505,971 (Aug. 2023) ➔ 4.2M (2030) ➔ >15M (2040)
- 2x in 17 months (191k ➔ 389k), CAGR: >73% (5 years)



Source: MoLIT, MoE, KEPRI (LDT = 115,342)

Status of EV and Charging infrastructure

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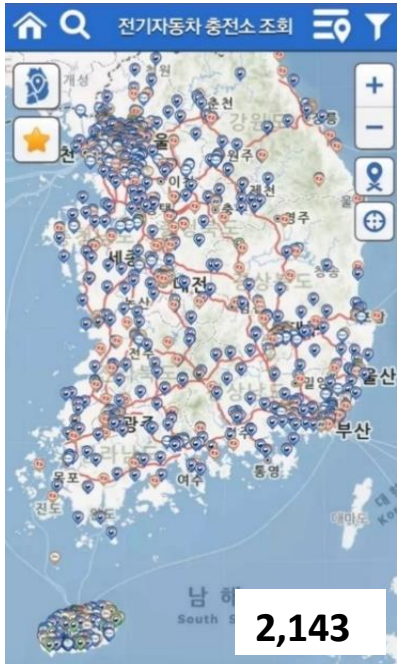
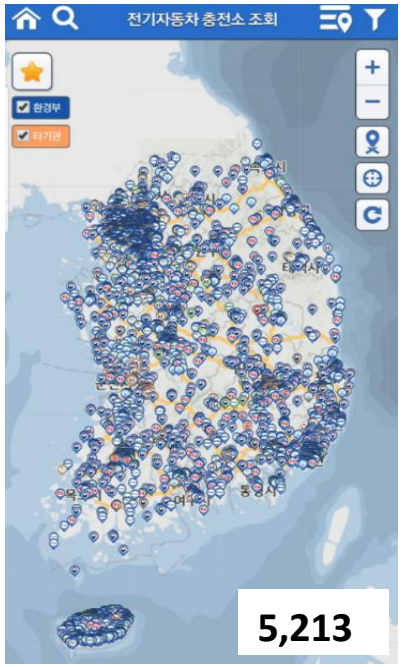
❑ Charging Landscape: Public Chargers

- EVSEs: 240,695 (Public Fast: 25,548; Public Slow: 215,147 as of May 2023)
- 18.9 EVs/DC Fast, 2.1 EVs/Public Slow, 7 kW/EV *(IEA, World Best!)*

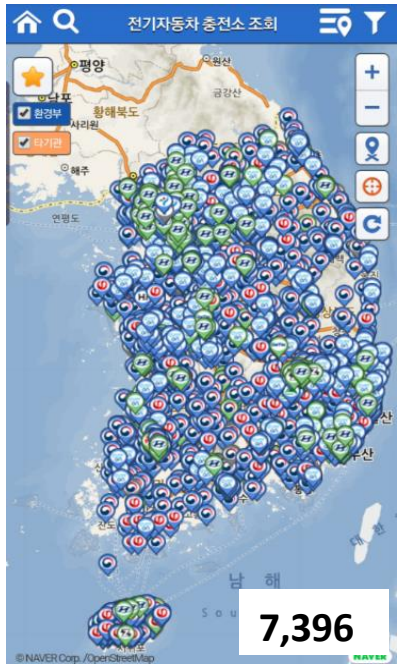
  - KEPCO share : 10,852 (Fast: 5,072; Slow: 5,780) at 4,755 stations



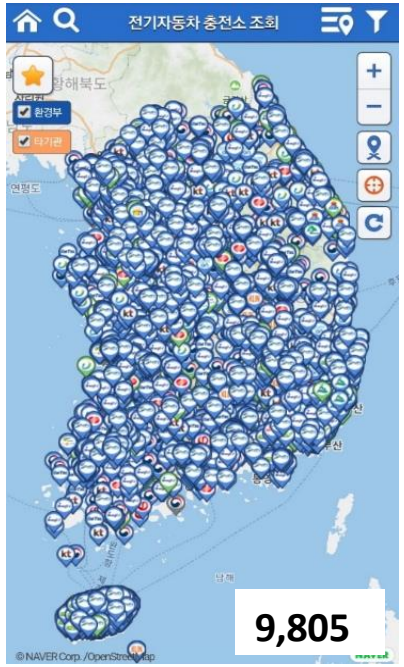
(Mar. 2017)



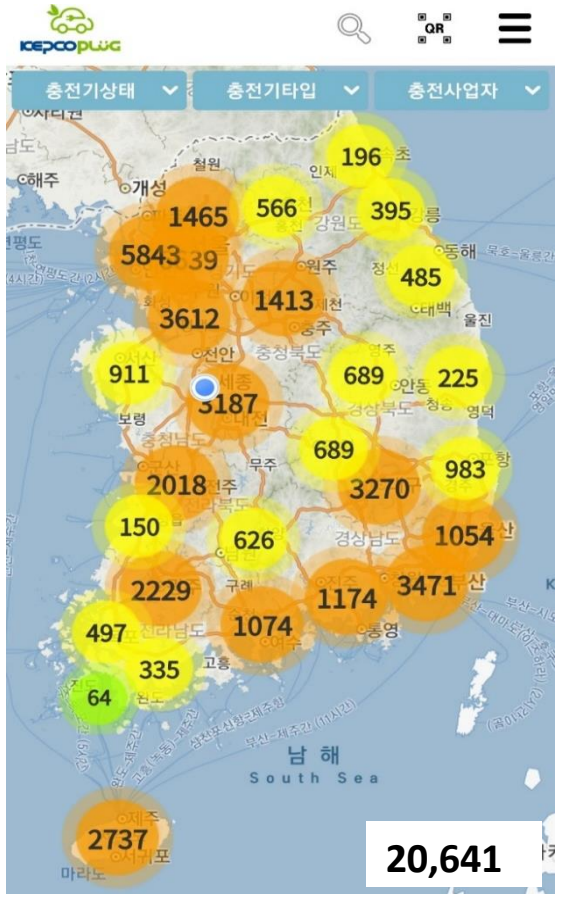
(Mar. 2018)



(Oct. 2019)



(Aug. 2020)



(Dec. 2022)

Source: https://ev.or.kr, https://evc.kepco.co.kr (KEPCO-Plug), http://keco.or.kr, IEA EV Outlook

VGI*- V2G for Grid Flexibility

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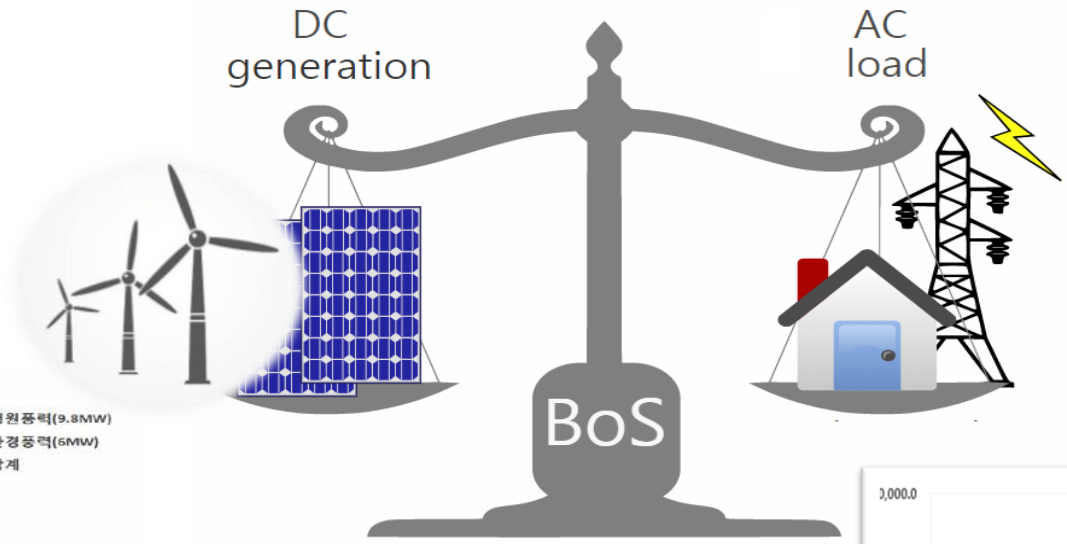
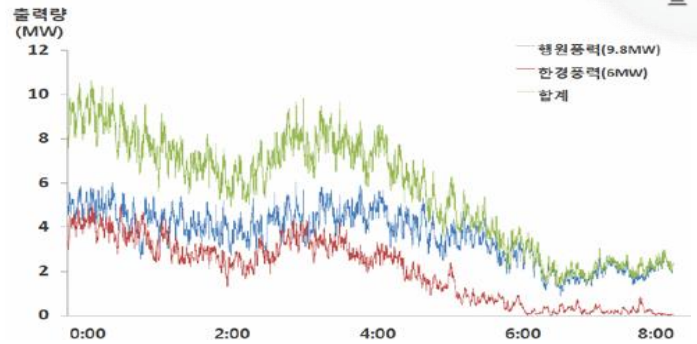
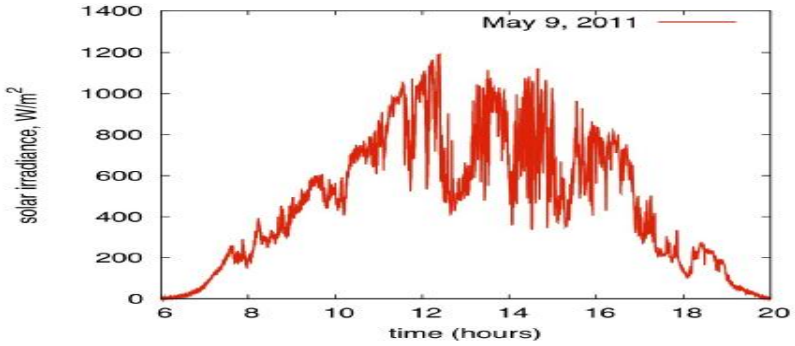
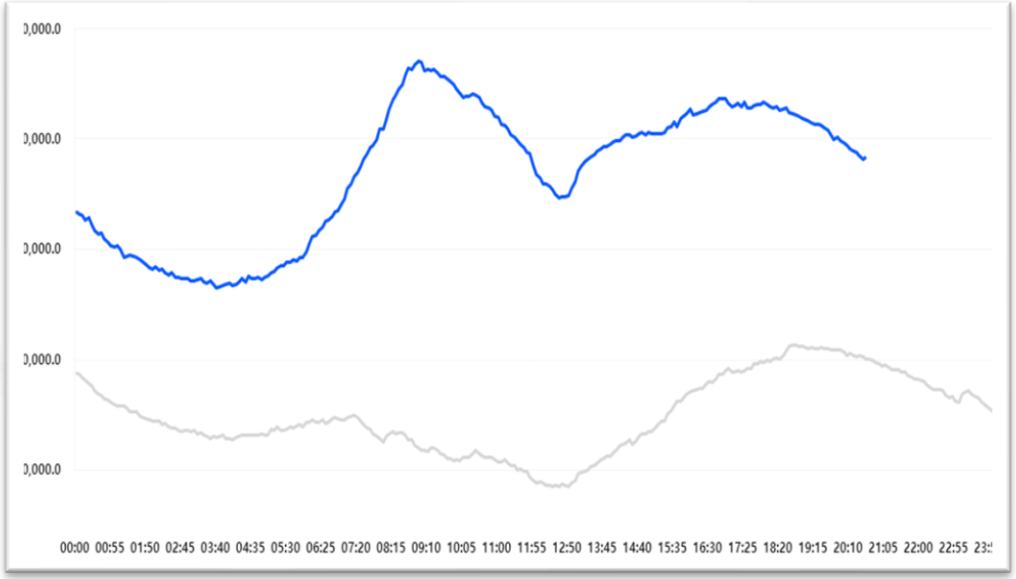
❑ Balancing of Fluctuating Renewables with EV (V2G)

*VGI: Electric Vehicle-Grid Integration









VGI - V2G for Grid Flexibility

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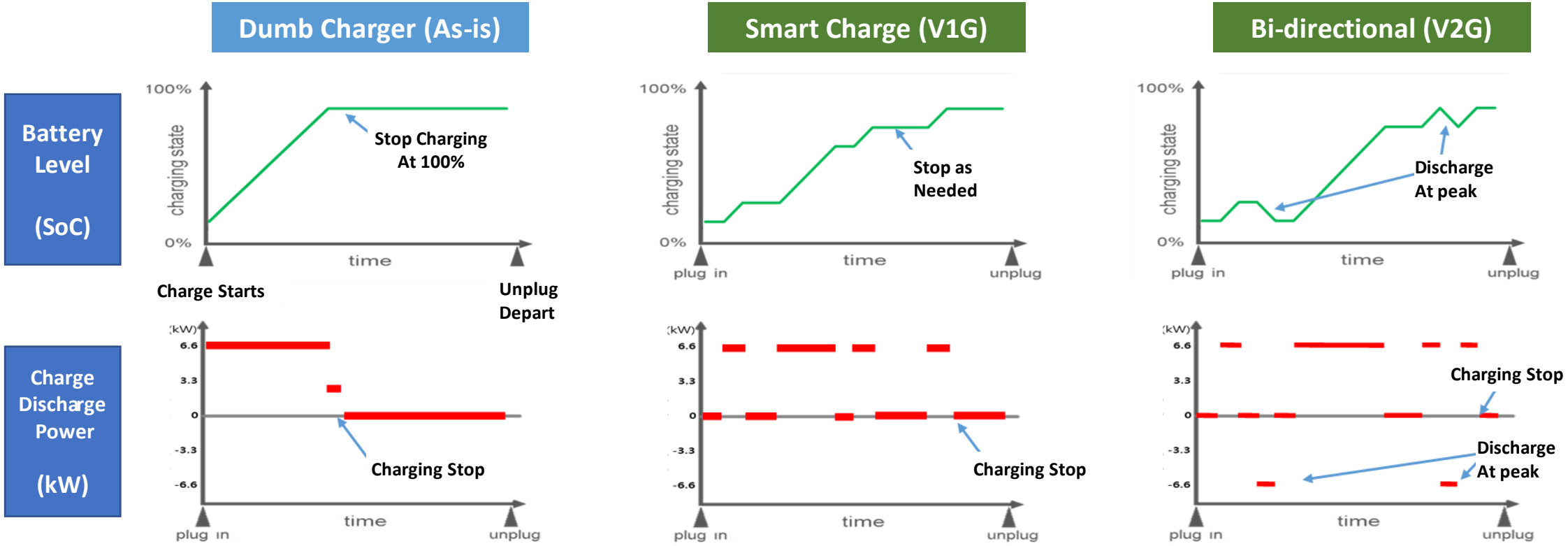
❑ EV Charging method

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

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



FYI: VGI - V2G for Grid Flexibility

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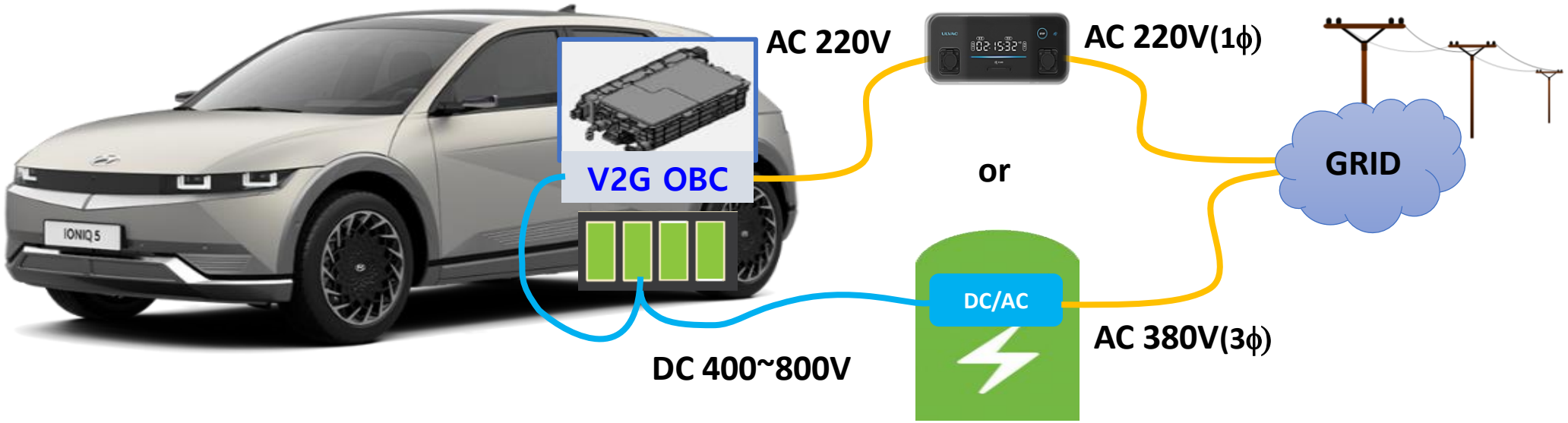
❑ V2G Method

- (AC type) On-board Charger(OBC) converts DC output of battery to AC 220V
  - EV (DC 800V) ➞ OBC (DC ⇔ AC 220V) ⇨ EVSE ⇨ Distribution line (220V, 1-phase)
- (DC type) External EVSE converts thevDC output of battery to AC
  - EV (DC400~800V) ⇨ EVSE (DC ⇔ AC) ⇨ Distribution line (380V, 3-phase)



Source: KEPCO

FYI: VGI - V2G for Grid Flexibility

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❑ V2G Approach: CHADEMO (DC) vs. CCS Type-1 (AC)

Type	CHADEMO (DC)	CCS Type 1 (AC)
Output Voltage	DC 350 ~ 500 V	AC 220~240 V
Power	3.3 ~ 30 kW (3-Phase)	3.3 ~ 11 kW (1-Phase)
Power conversion	EVSE	OBC
Cost (6.6 kW)	> €5,991	< $1000 (~$500)
EVSE Mfgs.	ABB, Delta, Denso, Nichicon, Fermata	ULVAC, etc.
EV OEMs	Nissan, Mitsubishi, Toyota, Honda, Peugeot	Hyundai, KIA, Genesis, Audi, BMW, Mercedes-Benz, Volkswagen, Ford, GM, Peugeot, Porsche, Polestar
Countries	Japan, EU, NA	Korea, NA, EU (type 2)

*OBC – Onboard Charger

FYI: VGI - V2G for Grid Flexibility

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❑ Economics of Flexibility Resources (FYI)

Category	Pumped Hydro	BESS (Li)	VGI (V2G)
Unit Capacity	200~400 MW	0.1~4 MW	7~10 kW
Geo. Location	☹☹☹	☺	☺☺
Occupied Area (m^2/MW)	1,109	25	1,785 (Parking lot for 100)
Environmental	☹☹	☺	☺☺
Construction Time	>7 years	>6 Mo.	<1 Mo.
Const. Cost* (1 GW) (billion KRW)	934 (~7-hr)	870 (1-hr)	130 (~6-hr)
T&D Class	345kV	22.9kV / 154 kV	220V, 380V
Ramp rate	100~200 MW/min	>MW/ms	~ kW/sec. (per EV)
RT Efficiency	72~81%	>81%	>85%
Source	YECHEON P.H.	KEPCO	KEPCO

* Excluding T&D and LNG terminal investment, US$1 ~ KRW 1,300

The KEPCO V2G Project

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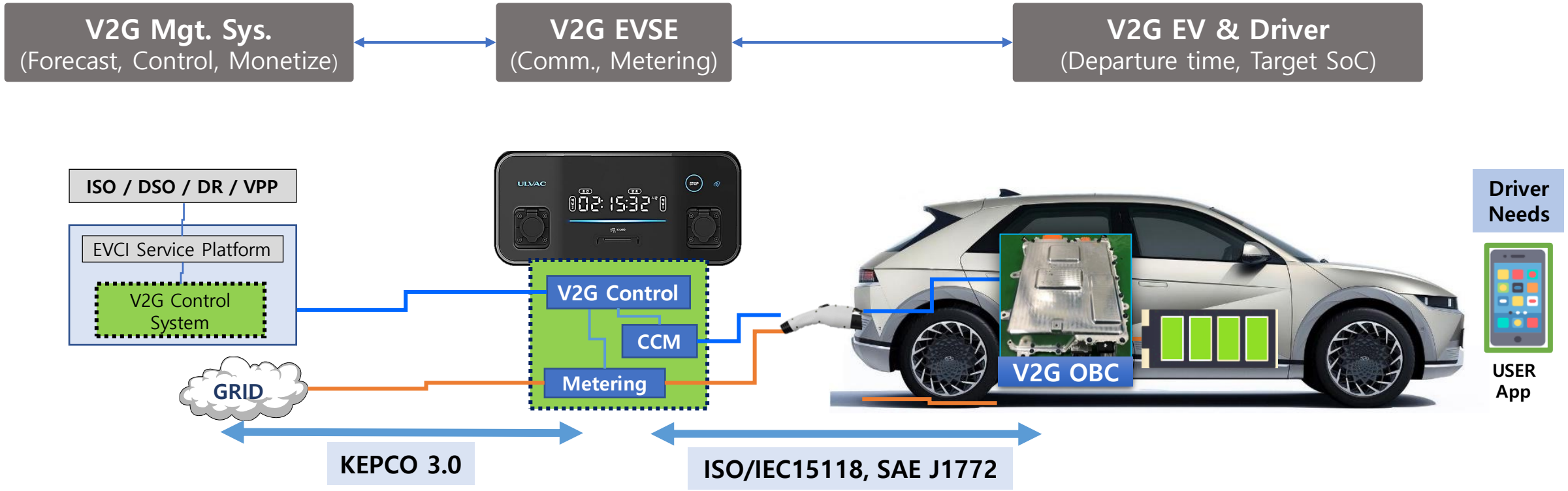
❑ KEPCO VGI - V2G system

- **Driver's Charging Needs: Departure time & Charge Level (SoC, %) ➔ Charging Schedule (ToU optimized)**
- **Power System Needs: DR or VPP power needs ➔ Select Right Charging Session & Reschedule**



Source: KEPCO, Hyundai Motor, ULVAC

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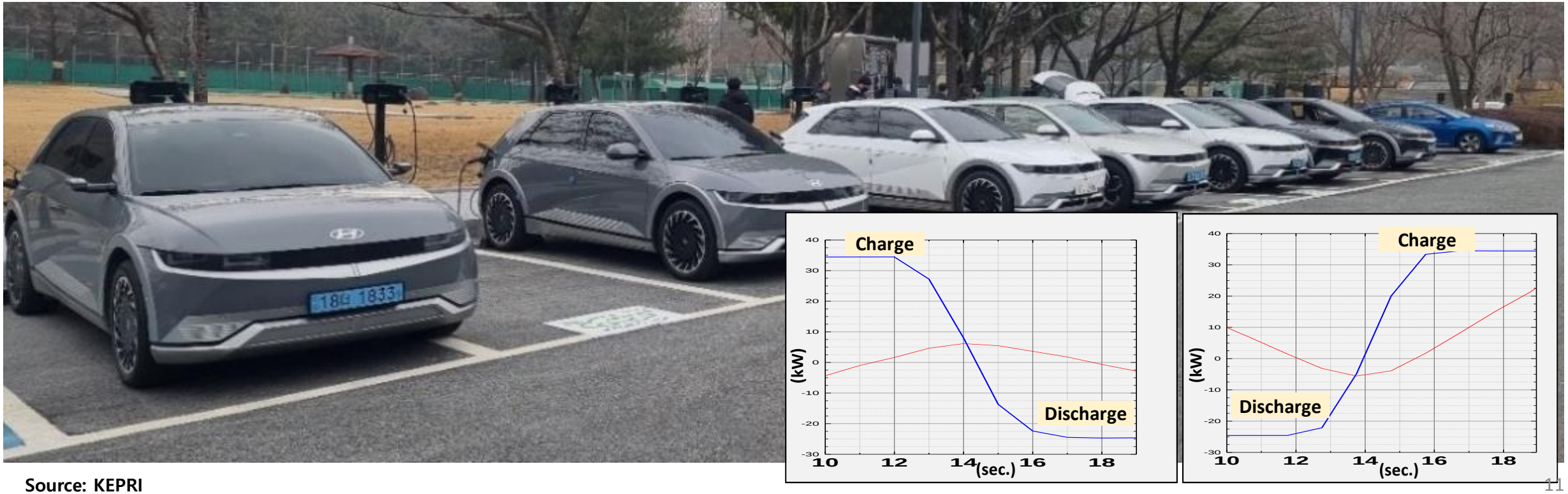
❑ V2G Charge control performance for multiple EVs

- Multi-channel power analyzer with real-time recording
- Simultaneous control of many EV's Charge/Discharge/Wait by Scheduling
- Response time of aggregated EVSEs: < 20 sec.



Source: KEPRI

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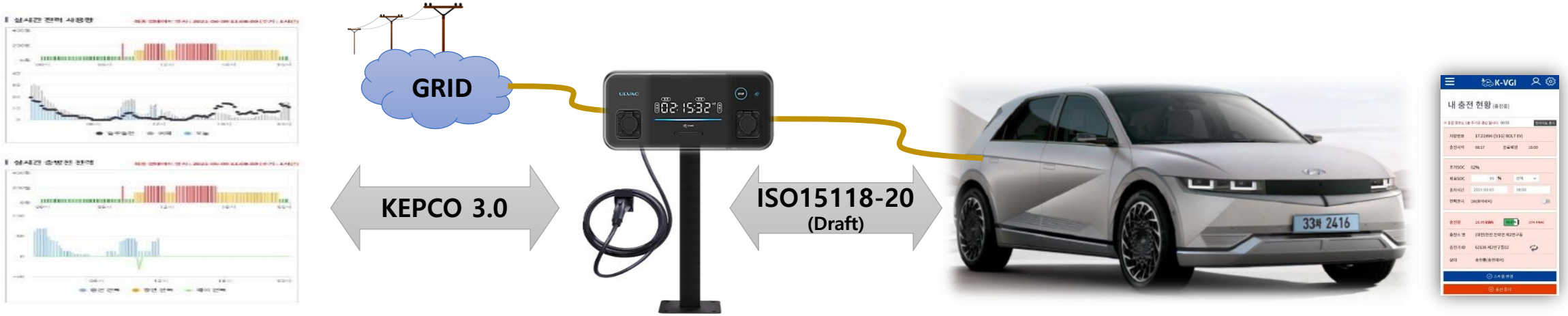
❑ V2G demonstration for fleet and personal IONIQ5 owners

- Period: November 2021 ~ August 2023 (12+ months)
- EV : Hyundai IONIQ 5, >100 units (V2G Firmware Modification, August 2021~)
- EVSE : ULVAC AC V2G EVSE, 100 Units (Charge 7 kW / Discharge 5 kW, AC 220V)
- Participants: Private users (50), Participating organizations (30), KEPCO Fleet (10), SK Rental car (12)
- V2G MS: K-VGI System (KEPCO 3.0 & ISO15118-20 draft protocol)



VGI management sys. | AC V2G EVSE | Hyundai IONIQ 5 (updated) | User App

Source: KEPRI, Hyundai Motor, ULVAC

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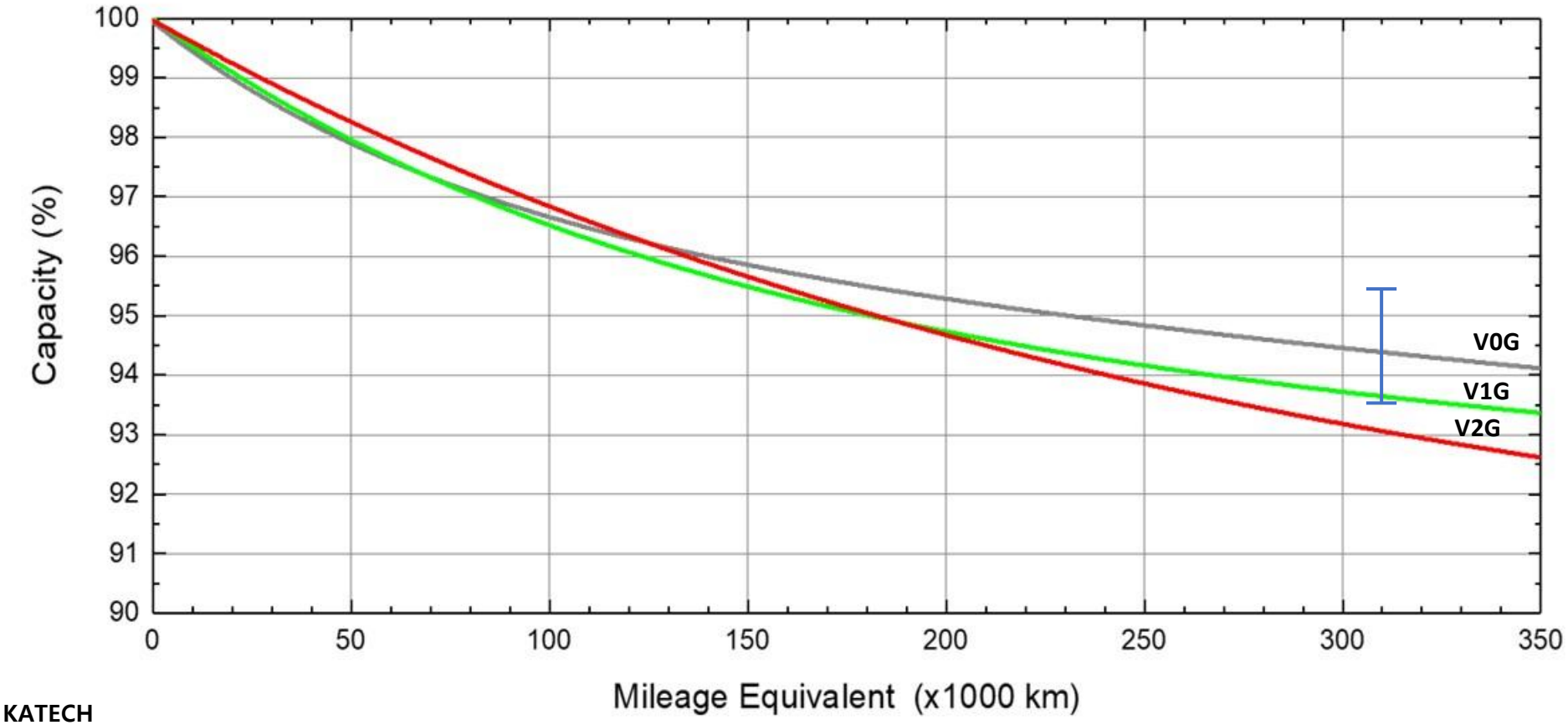
❑ Studies of battery life effect of V2G and V1G (KATECH, KEPRI)

- **Charge-Discharge cycles: >1,300 (Equivalent to >350,000 km of Driving)**
- **Difference: < 2%p**



Source: KEPRI, KATECH

Future Collaboration

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❑ EV infrastructures and V2G pilot program for EV fleets

- Charging infrastructure planning and development
- V2G pilot program design, deployment and support
- Charging infrastructure Specification and Standardization
- R&D program for Grid Flexibility, Distribution Management, AMI, xEMS

Source: Hyundai, KIA, KEPCO

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