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KOREA INSTITUE OF ENERGY TECHNOLOGY

Current Status and Future Plans of MVDC Projects in Korea

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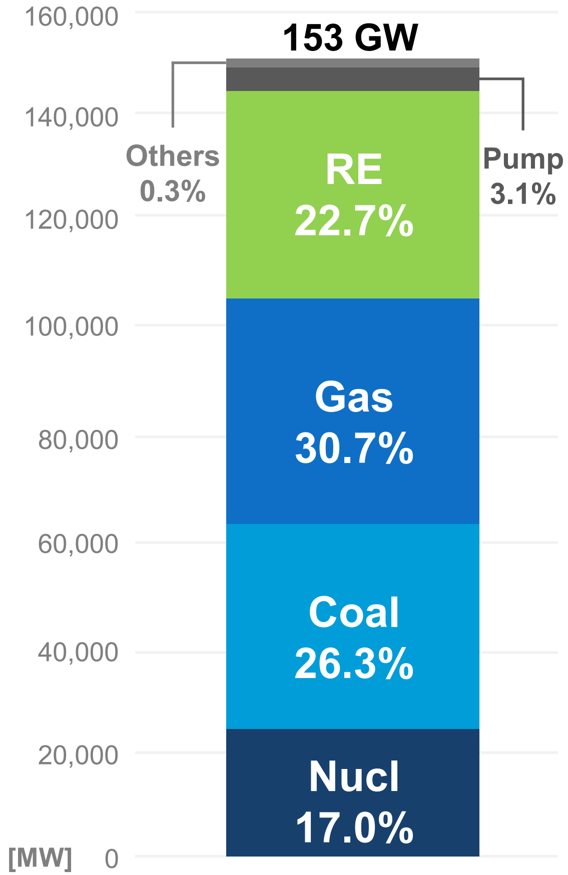
2025.11.12

I. Overview of power systems in Korea

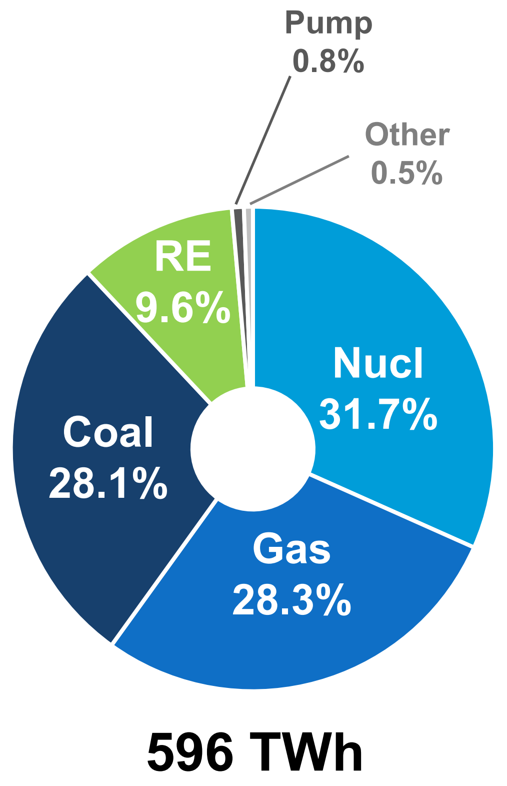
Development of Korea Power System

Key Electric Power Index

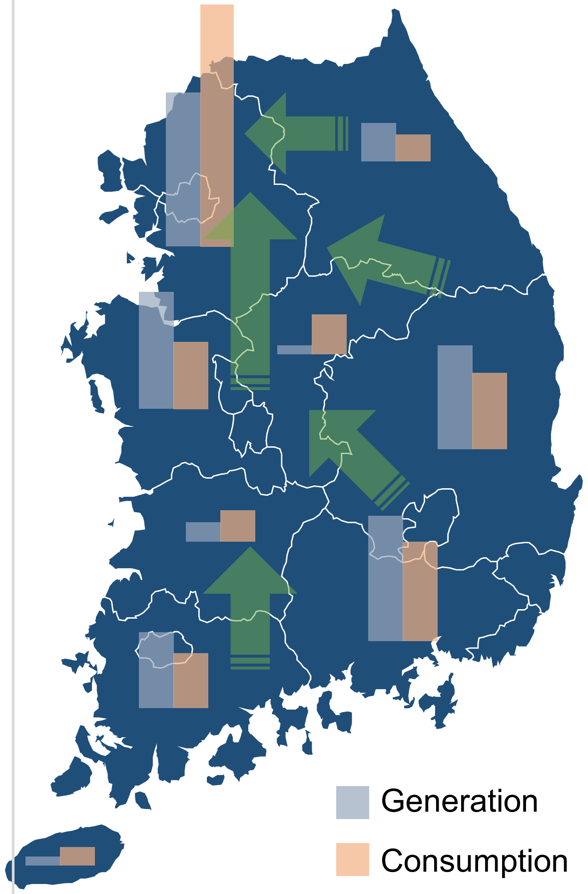
Generation Capacity (2024)



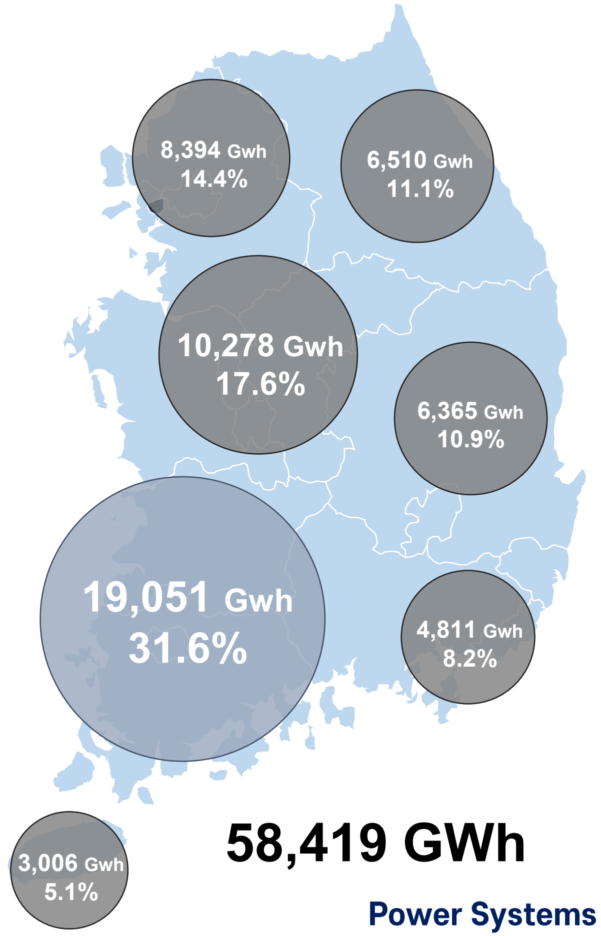
Annual Generation (2024)



Regional Balance (2024)



Regional RE Generation (2023)

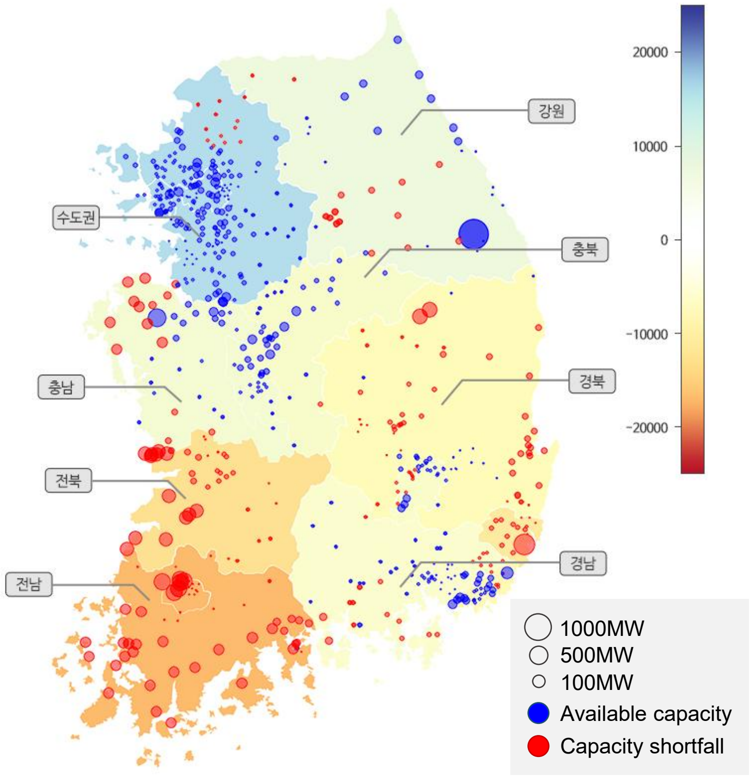


Power Supply Margins by Region

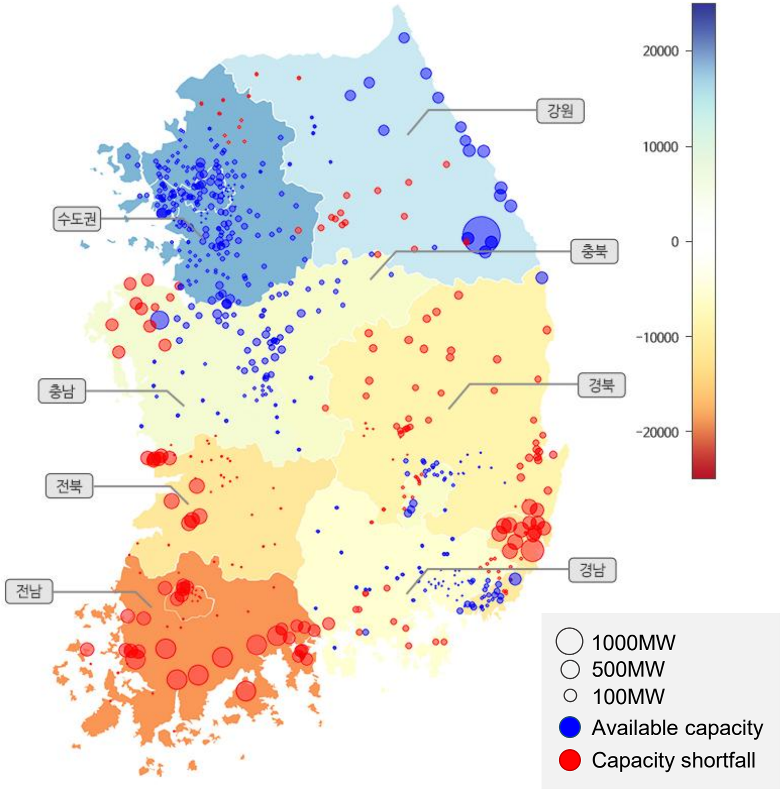
Availability of RES Installation in South Korea

➡ Significant regional differences in hosting capacity → no spare capacity for RESs in Jeonnam !

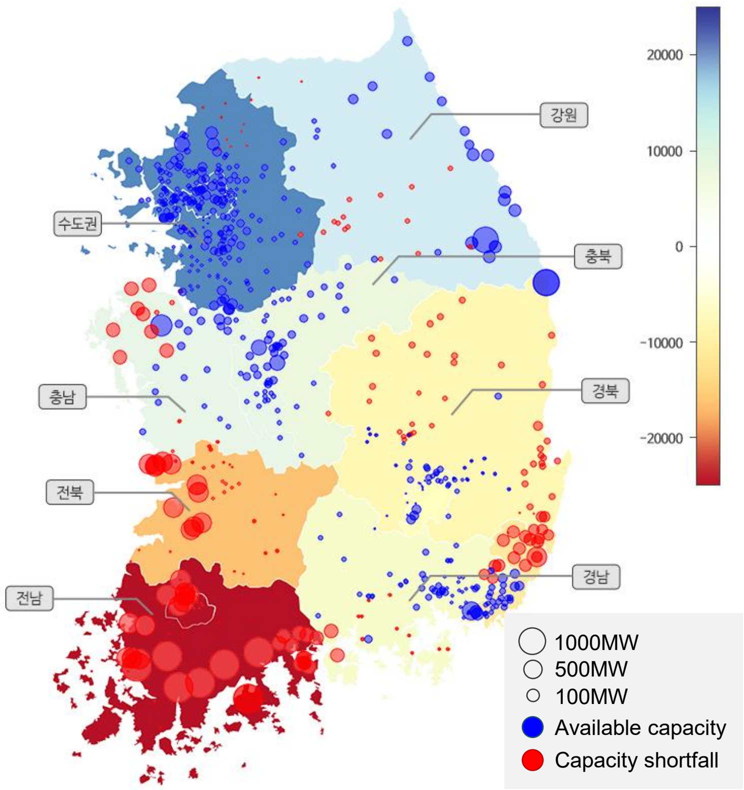
2026 ~ 2030



2031 ~ 2035



2036 ~



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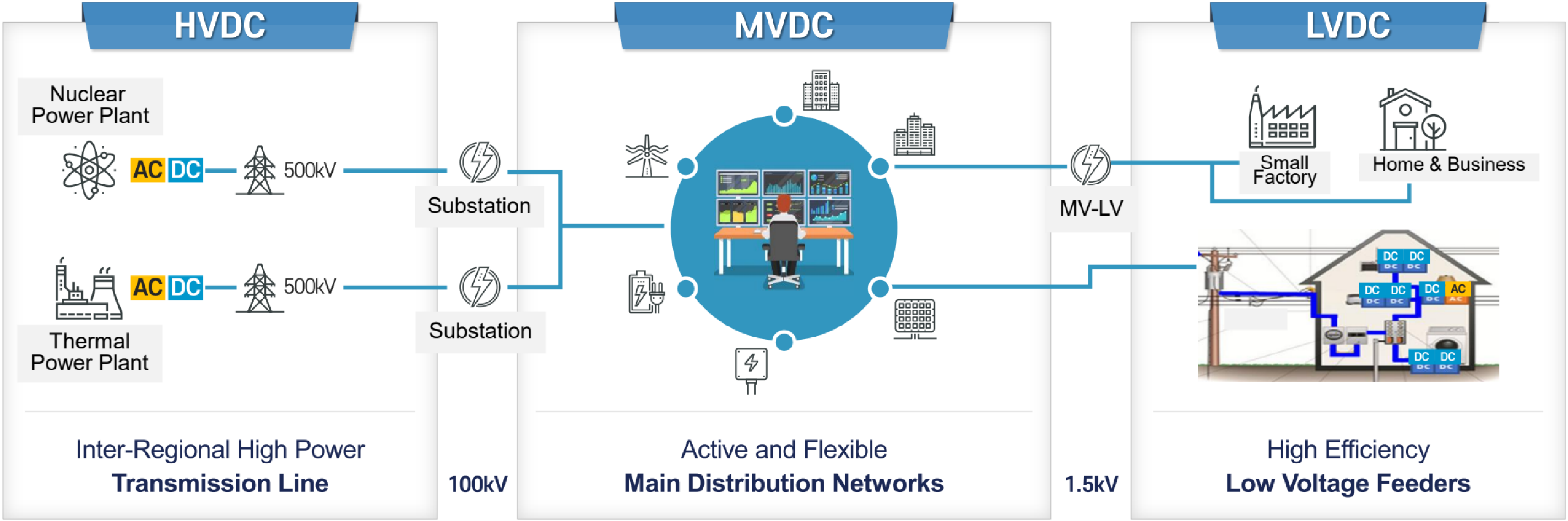
Power Systems Lab

DC Network Characteristic – HV vs MV vs LV

MVDC : Linchpin Technology

➡ Hub linking transmission grid with customer, integrating distributed energy resources (DERs), and energy storage system

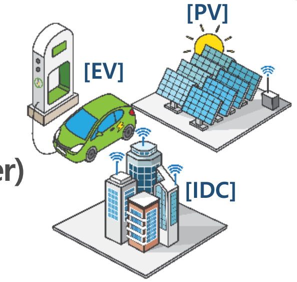


[Ref: "Medium voltage DC (MVDC) grids for an all-electric society, IEC White Paper, 2025.09]

Medium-Voltage DC (MVDC) Grids

MVDC operation to overcome the excessive facilities and saturation of RES connection

High voltage DC load & source



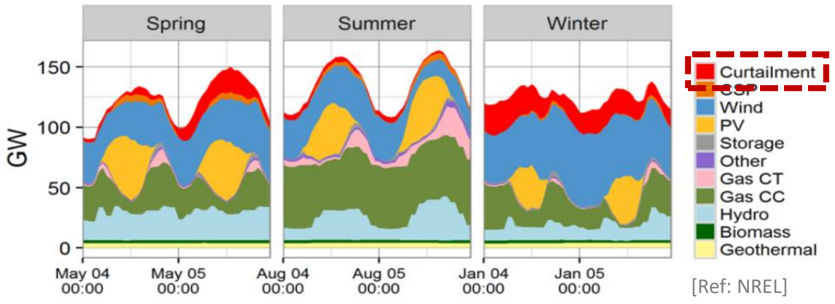
- Fast charger with EV
  DC load in urban (e.g., Data Center)

※ DC (Data Center)

- Expansion of RES & DC-based DGs

Complexity of distribution network operation

- Expansion of intermittent DGs increases the complexity of distribution network operation



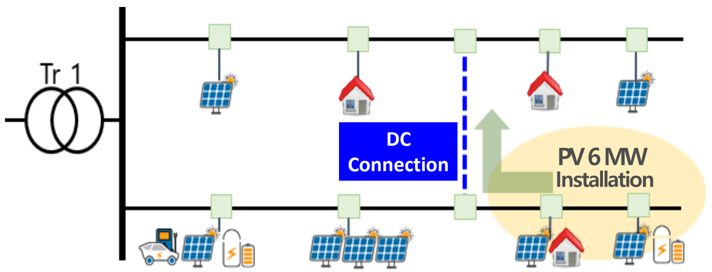
[Ref: NREL]

* Generation scheduling including curtailment of RES

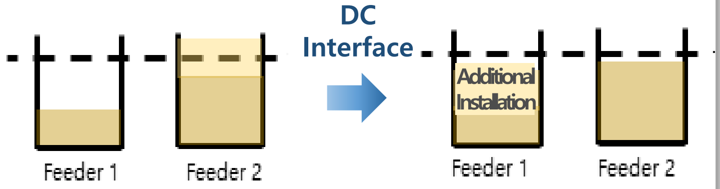
Increasing RES capacity & line rating

- DC power flow control → efficiency & Dx facilities deferral
- Increase hosting capacity by maximizing existing facilities

Feeder 1 (Unsaturated) : PV 6MW (Max. Cap. 12MW)

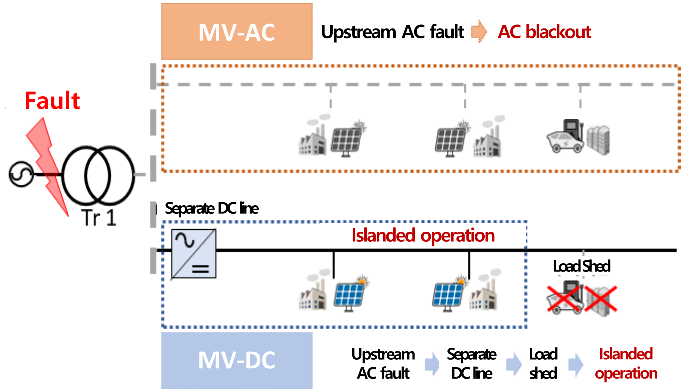


Feeder 2 (Saturated) : PV 12MW + 6MW (Max. Cap. 12MW)



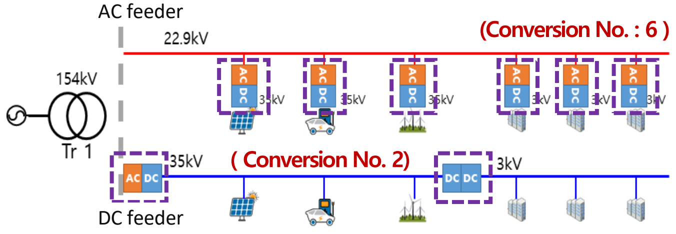
Uninterruptible power supply during fault

- DC voltage forming + Multi-terminal topology for bypass power supply



Reduction in AC/DC conversion loss

- Inefficiency & cost for AC/DC conversion



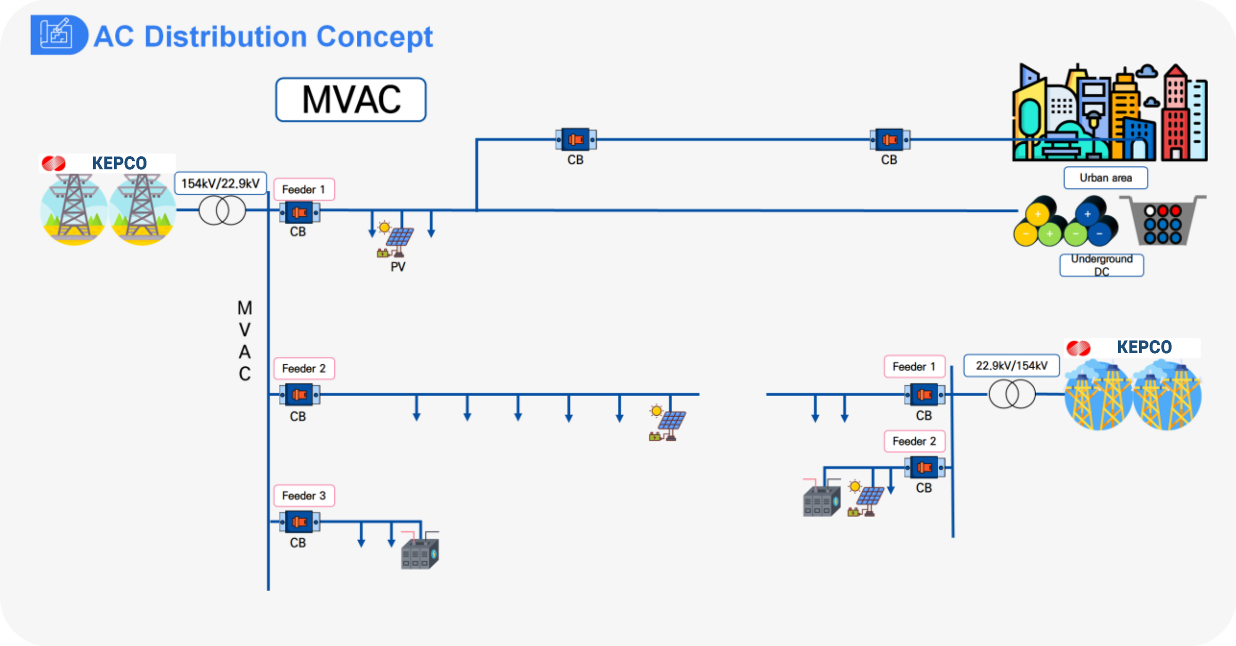
MVDC Feasibility Study in Korea

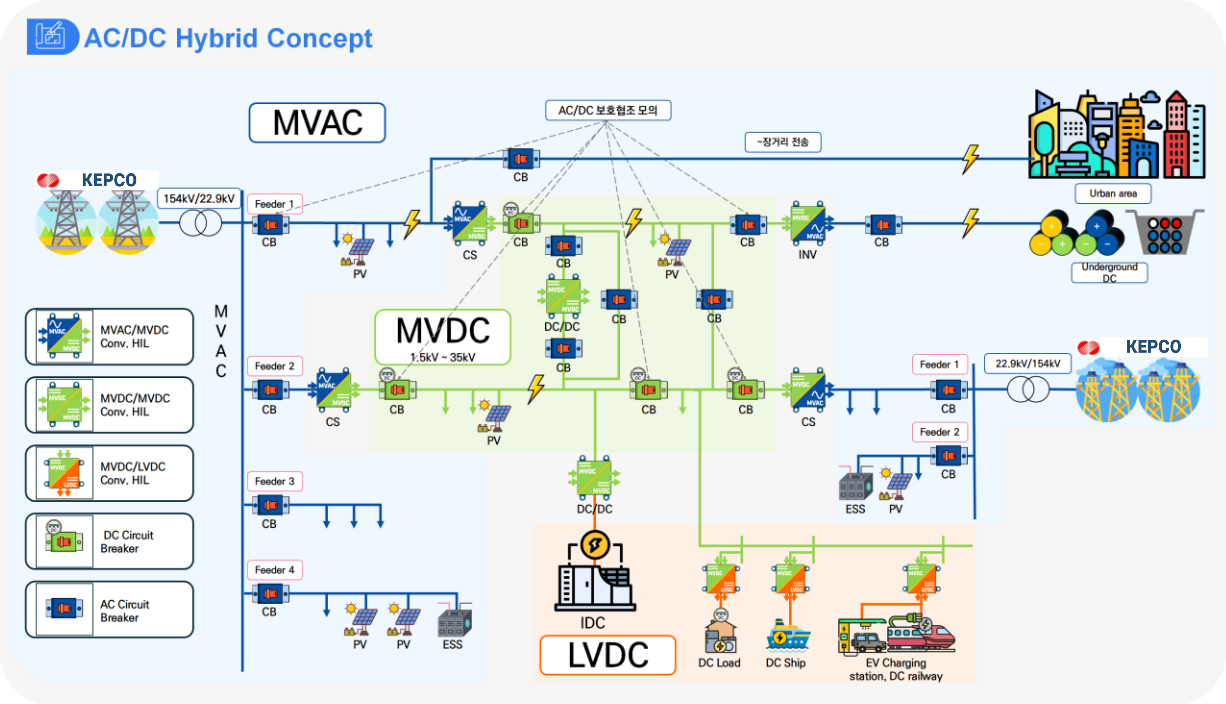
Direction of Change

➡ From radial AC to multiterminal AC/DC hybrid networks → higher structural complexity

➡ IBRs and DC integration → large computational burden for system analysis

As-is	To-be
✓ Pros : Easy planning, operation, and management ✓ Cons : Low reliability, uneven line utilization, voltage drop and high loss	✓ Pros : High reliability, high transfer capacity, flexible operation ✓ Cons : High structural and operational complexity, protection challenges



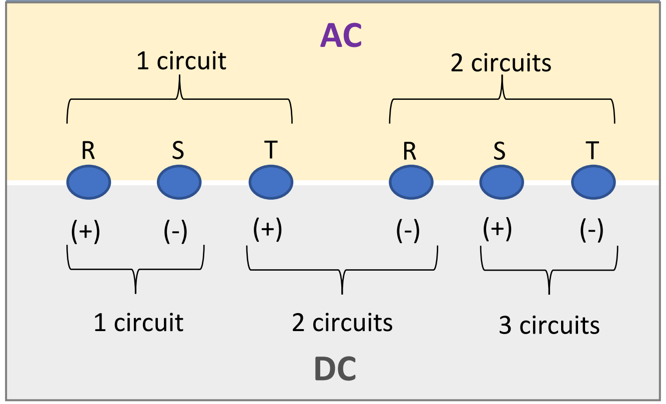


MVDC Feasibility Study in Korea

Expected Benefits

- DC delivers up to 4x the transfer capacity of AC under the same conditions
- 20MW (normal condition) x 2 AC feeder can reach ~80MW when converted to DC

AC 2 circuits ▶ DC 3 circuits



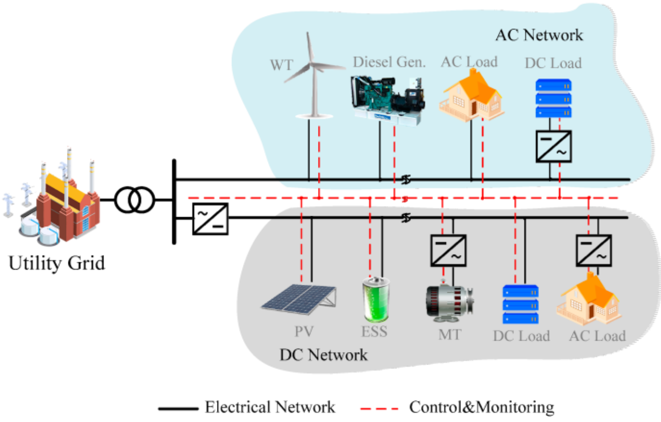
MVDC application range

DC (kV)	DC range (kV)	
	VSC	Insulation
3	＞ 4.8(±2.4)	＜ 9.2(±4.6)
6	＞ 9.6(±4.8)	＜ 18.3(±9.2)
10	＞ 16(±8)	＜ 30.5(±15.3)
20	＞ 32(±16)	＜ 61(±30.5)
22.9	＞ 36.6(±18.3)	＜ 69.8(±34.9)
35	＞ 56(±28)	＜ 106.8(±53.4)

(1.6 ~ 3.05) x V_{ACL} = V_{DC}

(In Korea) 3.05 x 22.9kV$_{ACL}$ = 70kV$_{DC}$ = ±35kV$_{DC}$

※ Ref : MVDC Grid Feasibility Study, CIGRE, 2020.2



Power Transfer Capacity with DC conversion

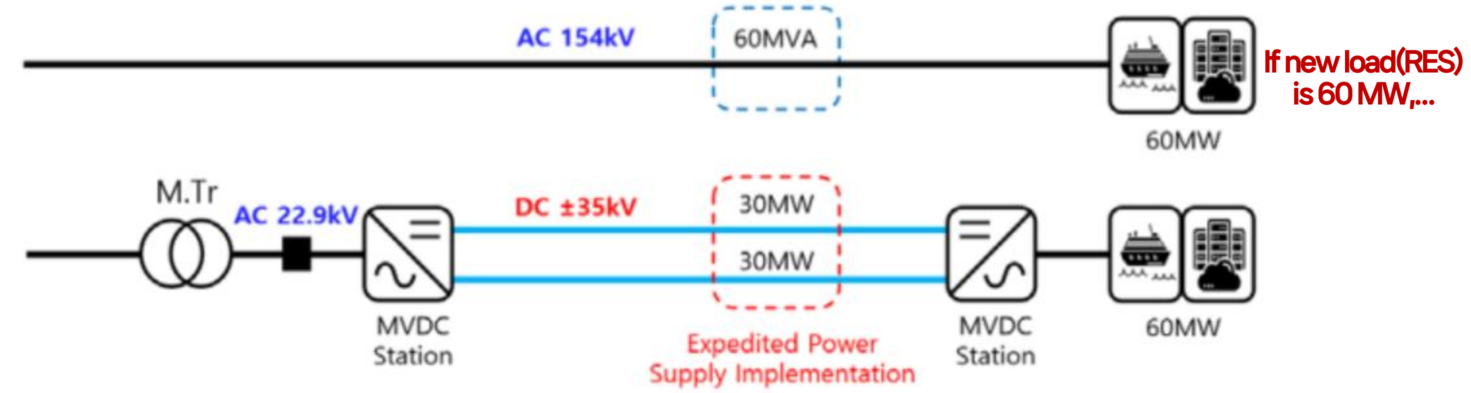
Category	MVAC	MVDC	Effect
Configuration	3Φ, 2 circuits (6-core), 13.2 kV RMS	2-pole, 3 circuits (6-core), ±35 kV	1.42 x
Voltage	3Φ, 13.2 kV RMS	2-pole, ±35 kV	1.88 x
Current	Allowable current: 525 A (XLPE 325 mm² Cable)	Allowable current: 715 A (XLPE 325 mm² Cable)	1.36 x
Total Capacity	Transfer capacity: **37.4 MW** 2 Circuits × 3Φ × 13.2 kV × PF × 525 A	Transfer capacity: **150.2 MW (≈4× AC)** 3 Circuits × 2-Pole × 35 kV × 715 A	4 x

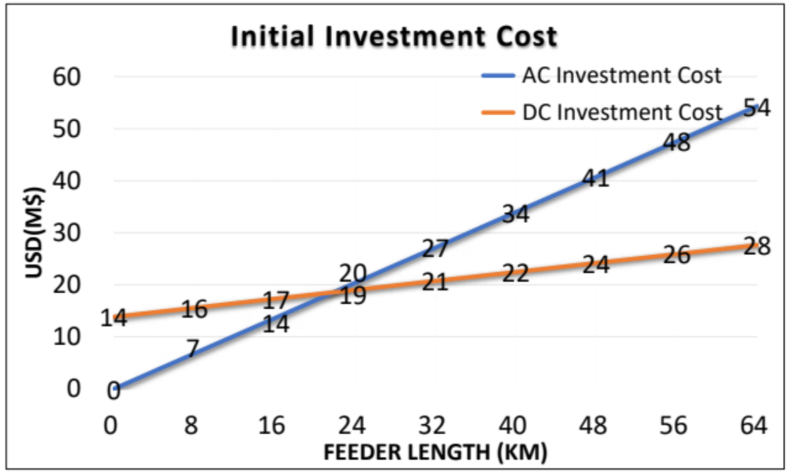
MVDC Feasibility Study in Korea

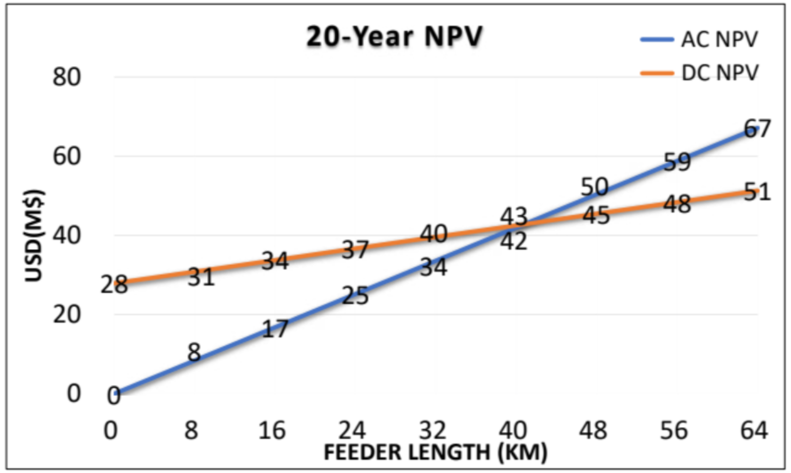
Long-distance supply using MVDC

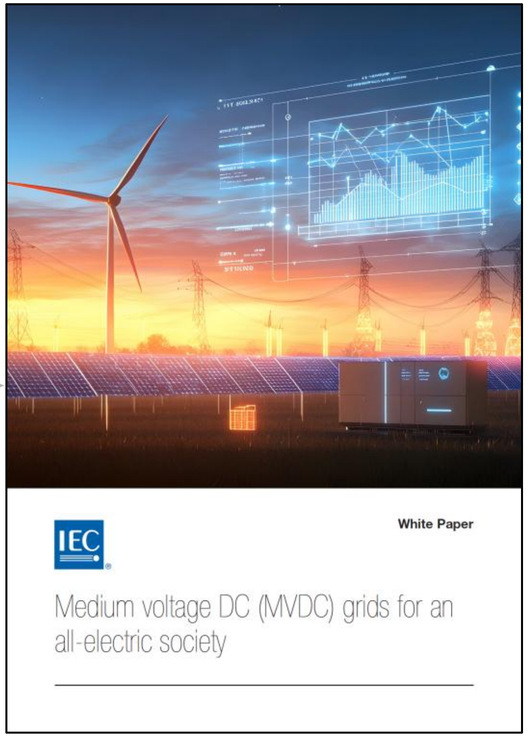
➡ In Korea, loads greater than 40MVA or lengths exceeding 30km, power should be supplied using a 154kV Tx instead of the 22.9 kV Dx

MVDC replacement of a long-distance line scenario







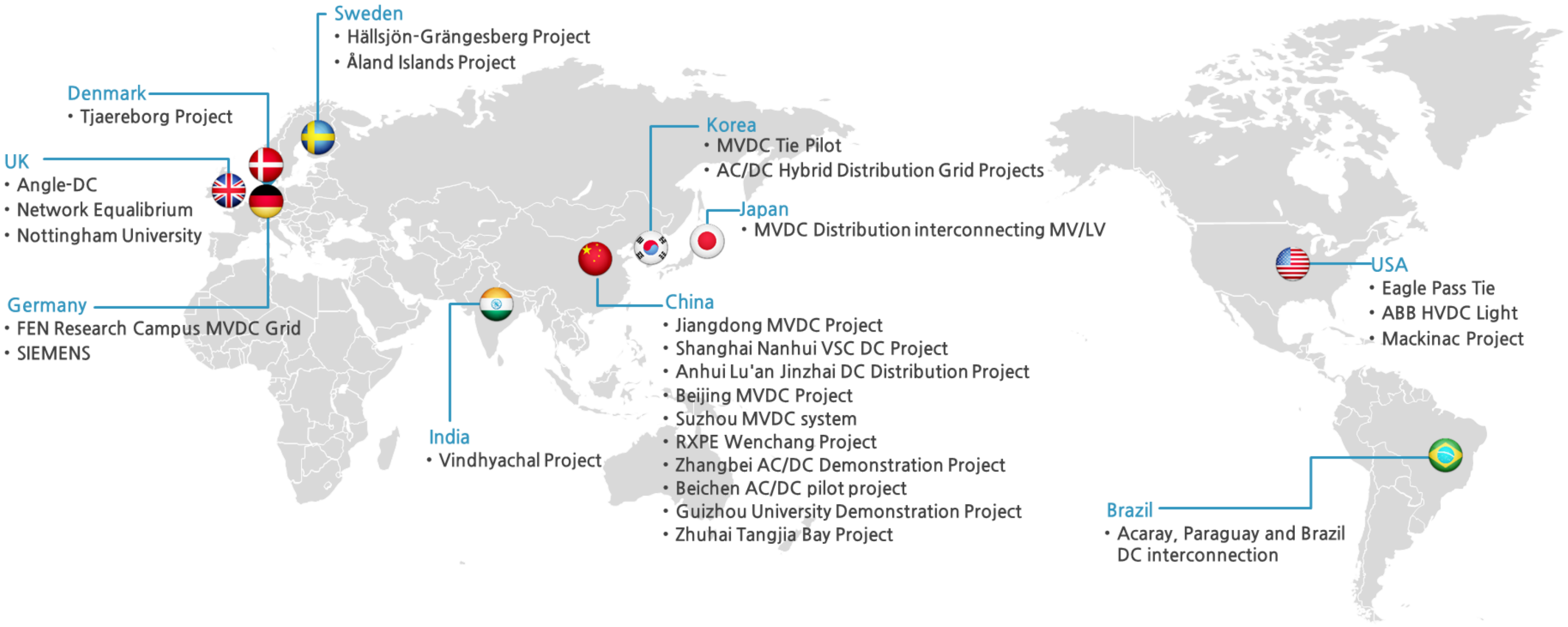


[IEC White Paper regarding MVDC grids]

[Ref: "Medium voltage DC (MVDC) grids for an all-electric society, IEC White Paper, 2025.09]

Medium-Voltage DC (MVDC) Projects in Worldwide

MVDC Projects are increasing world-wide in a variety of contexts



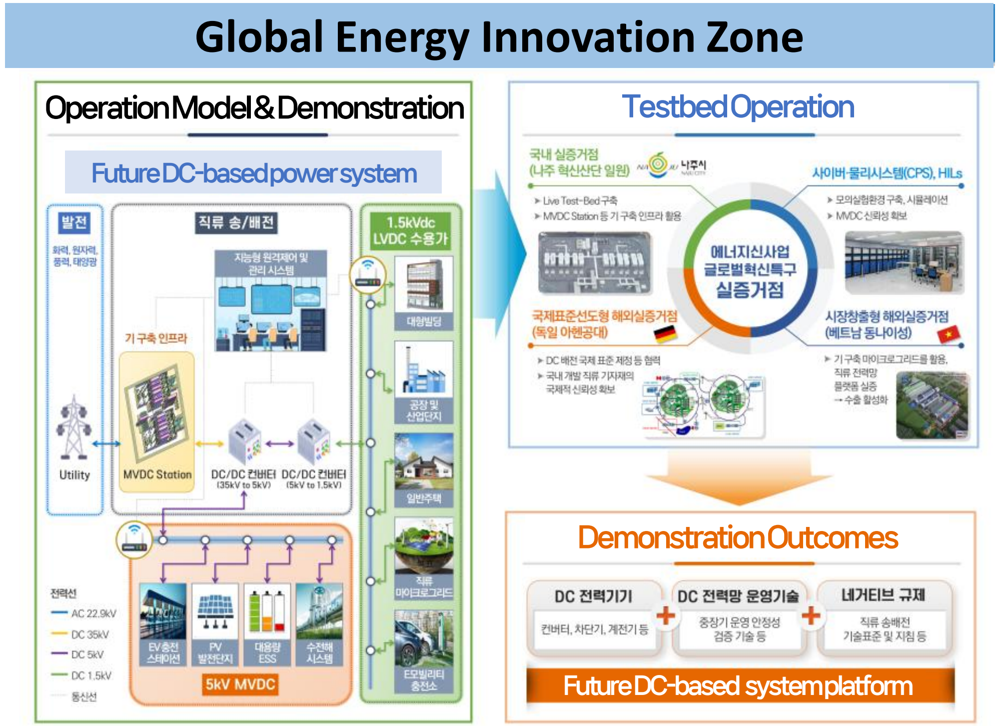
II. MVDC projects in Korea

MVDC Project #1 : ±35kV Converter Station

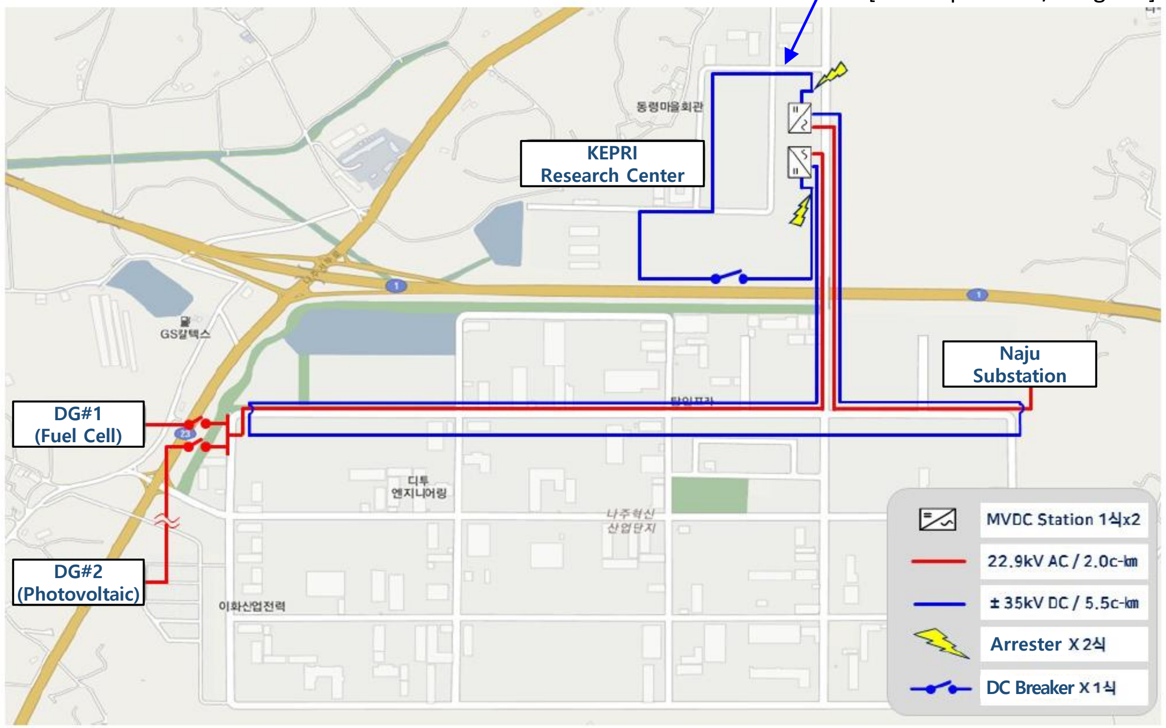
MVDC Device Testbed (Regulatory Sandbox)

- ±35kV MVDC Converter Station & Protection Devices with long MVDC lines
- Plan to expand to the ‘future DC grid platform’ (based on two consecutive regulatory sandboxes)

[Ref: kepri.re.kr / rfz.go.kr]

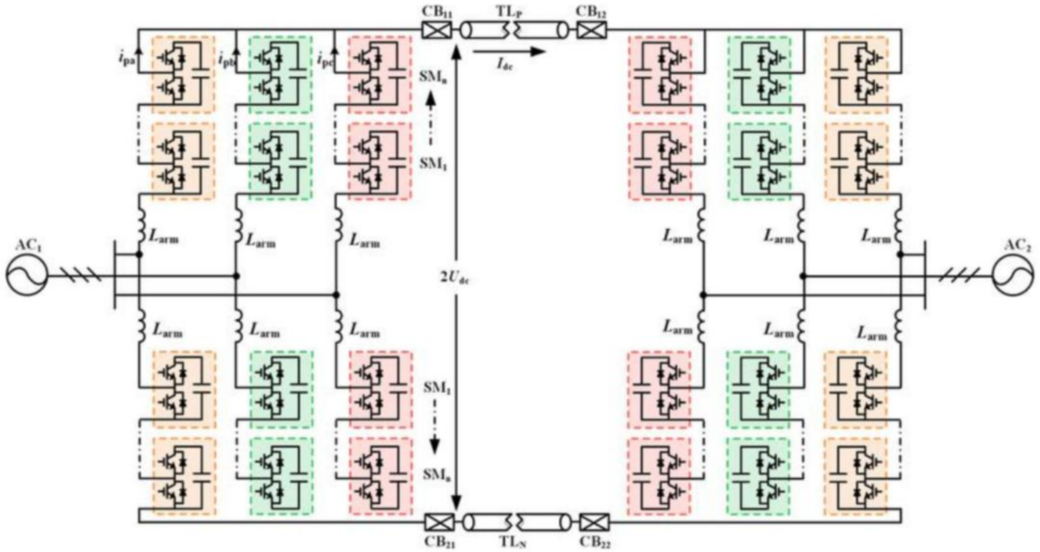


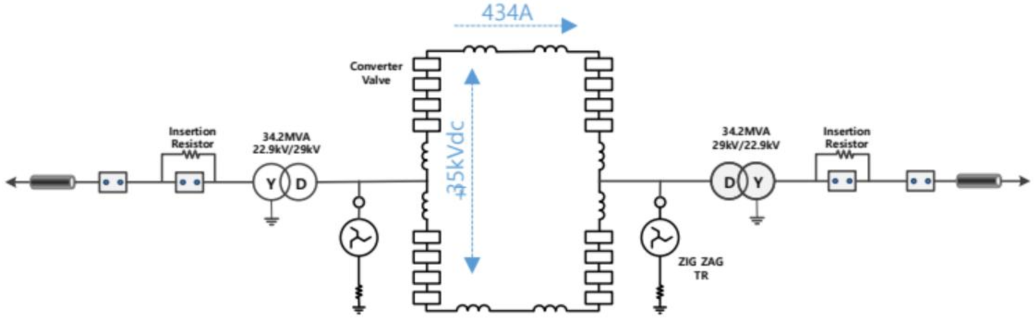
[DC Global Innovative Sandbox in Naju]



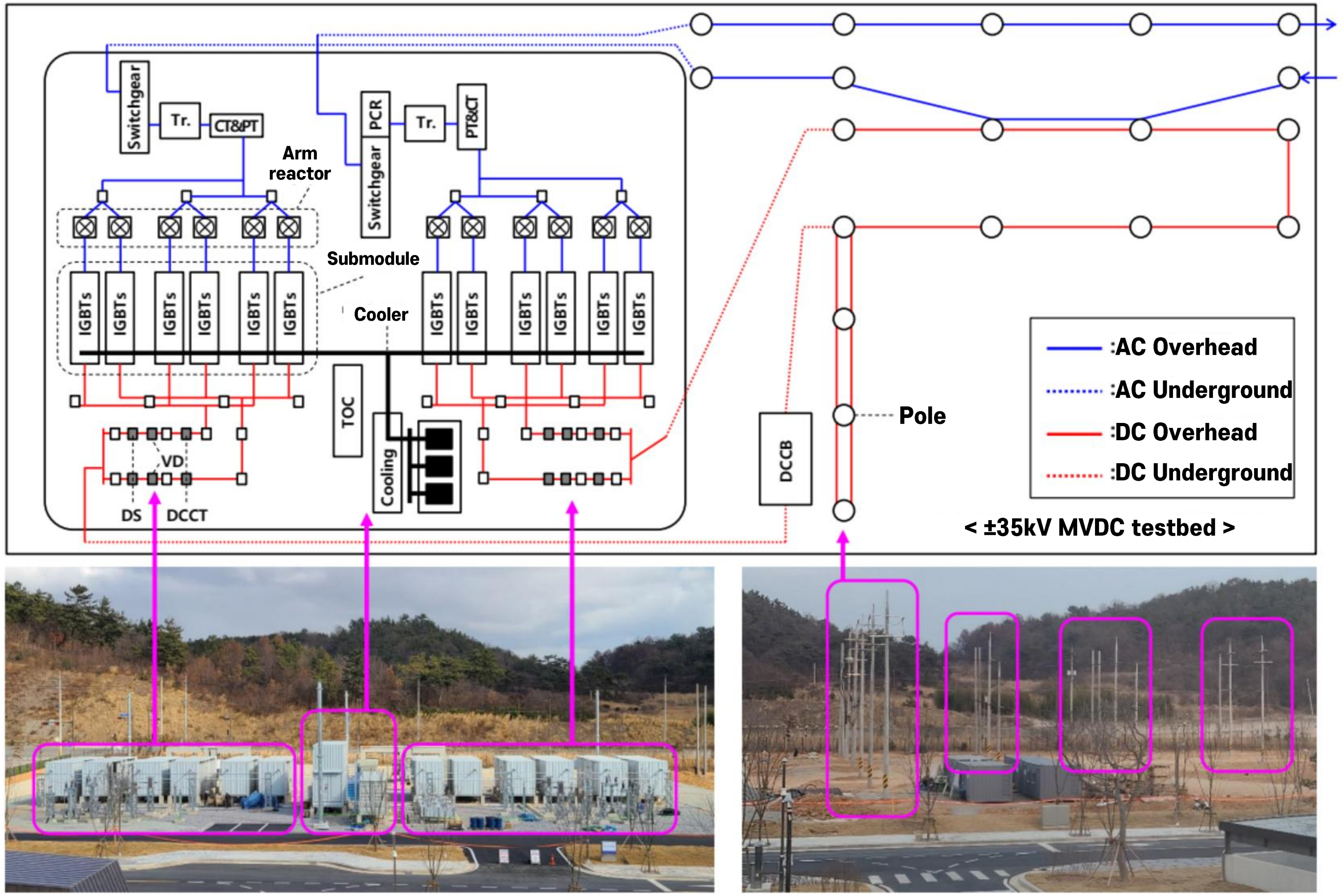
[MVDC Testbed at KEPRI]

±35kV MVDC testbed



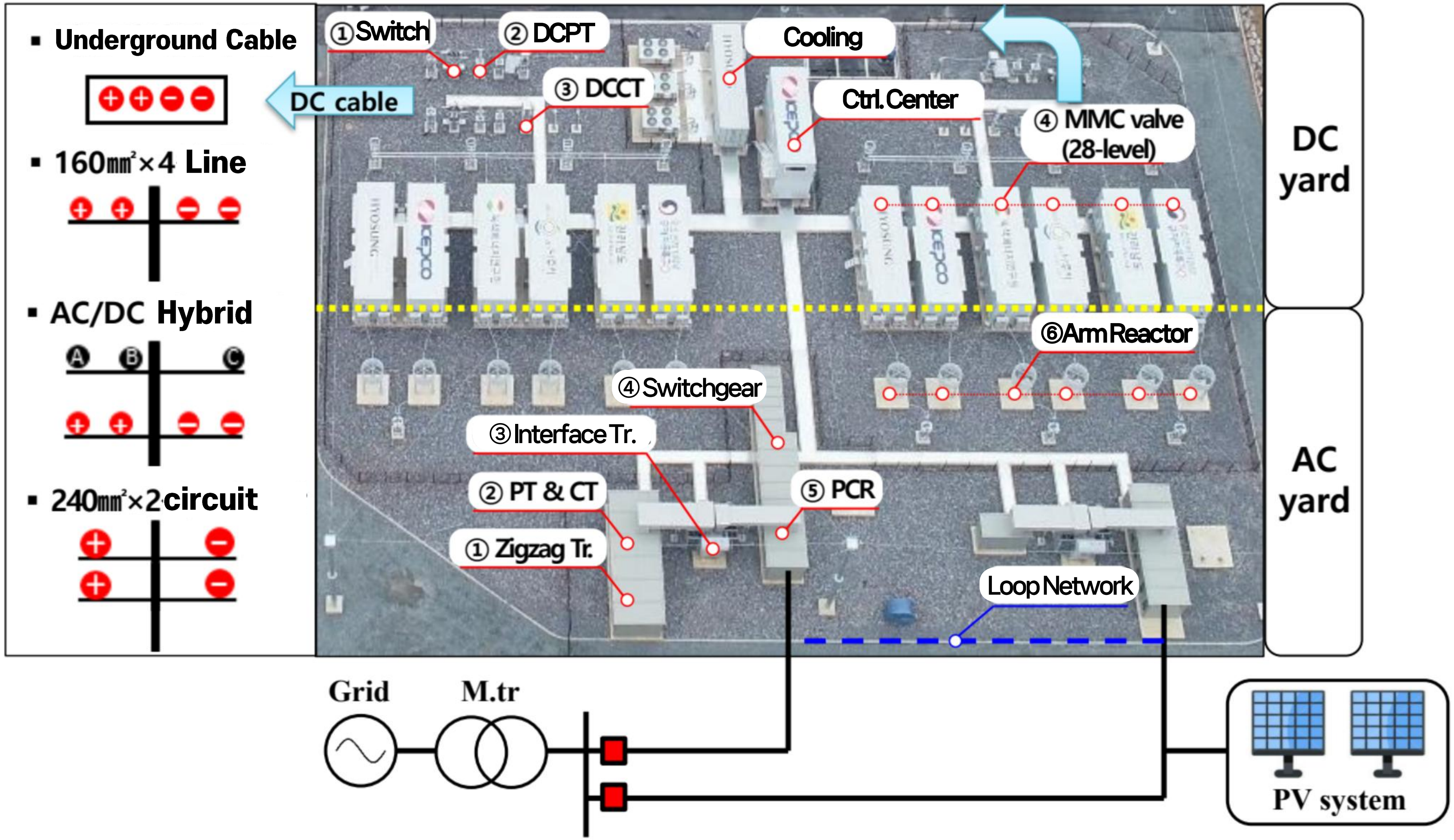


Sub-module: 28 level + 2 redundancy
(30MW & 15 MVAr)



MVDC Project #1 : ±35kV Converter Station

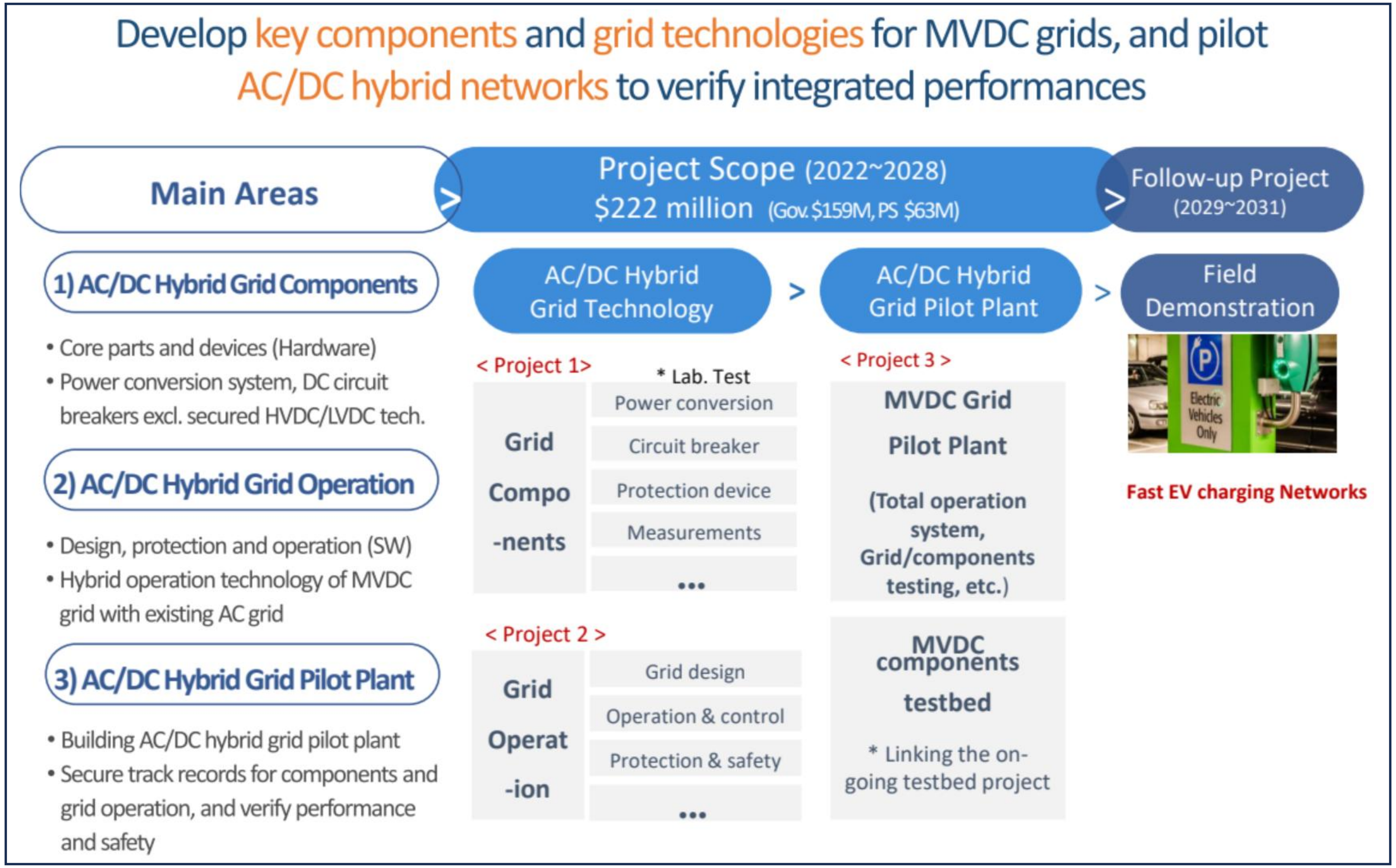
±35kV MVDC testbed

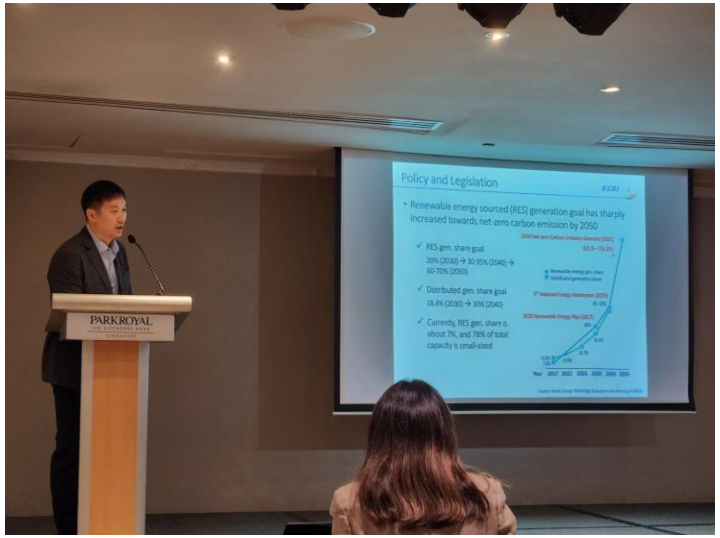


MVDC Project #2 : ±20kV DC Distribution Network

MVDC 'Grids'

➡ **Goal: Development and demonstration of core DC technologies for 2030 AC/DC hybrid grid operation**





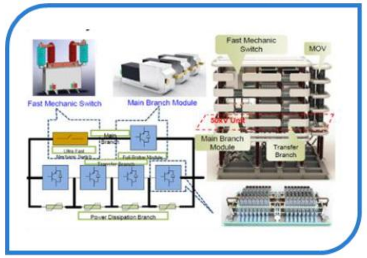
[Introduction to the MVDC Project in Korea]
(Singapore 2022 symposium)

MVDC Project #2 : ±20kV DC Distribution Network

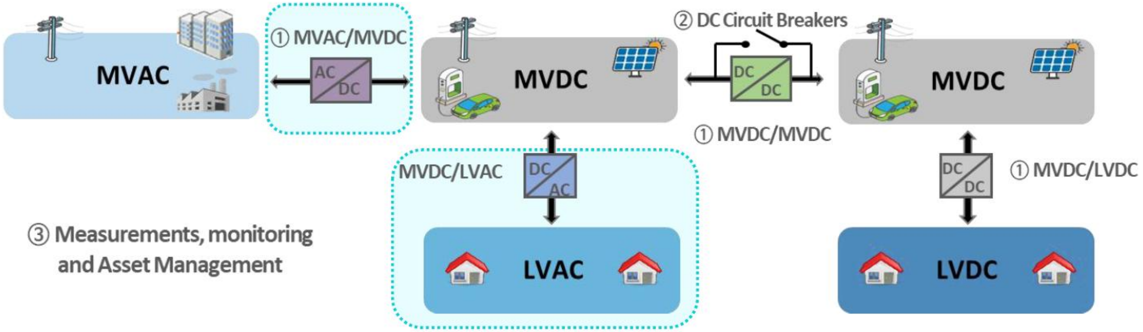
Components

① Power Conversion Systems

② Protection Devices(CBs)



③ Instruments(DC measurements, etc.)

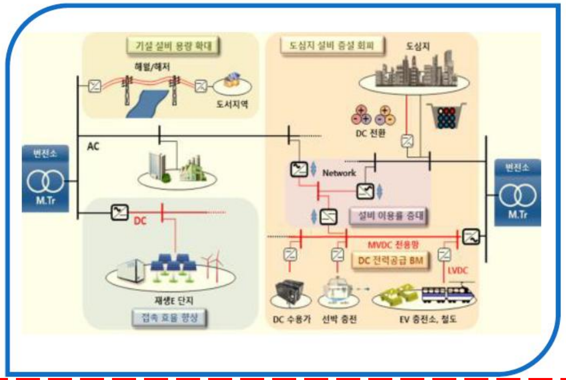


③ Measurements, monitoring and Asset Management

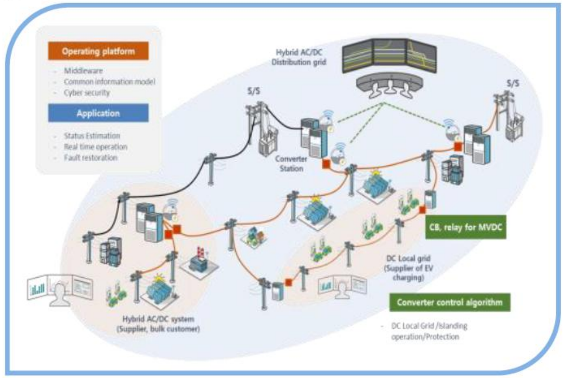
Developed in HVDC & LVDC Initiatives

Grid Technology

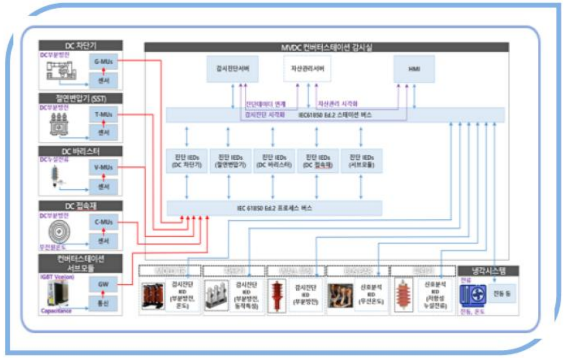
Planning, Design & Analysis



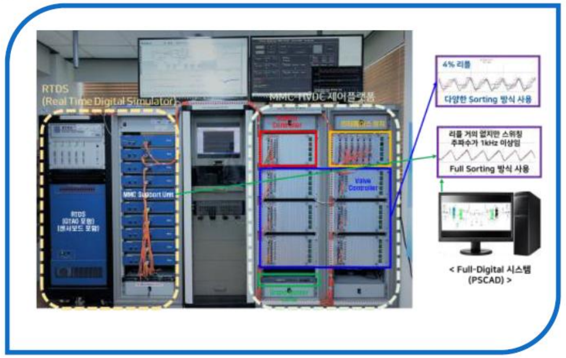
Operating Systems



Digital Safety Management



Testing & Evaluation



AC/DC hybrid Grid Testbed

- Close-to-real environment
- Full Load & Network Integration test
- Evaluation of Fundamentals and System Integrations

Test bed

MVDC Project #2 : ±20kV DC Distribution Network

Verification of MVDC Operation System

Step 1 – Operation platform and application

Step 2 – Testbed implementation

Operation platform

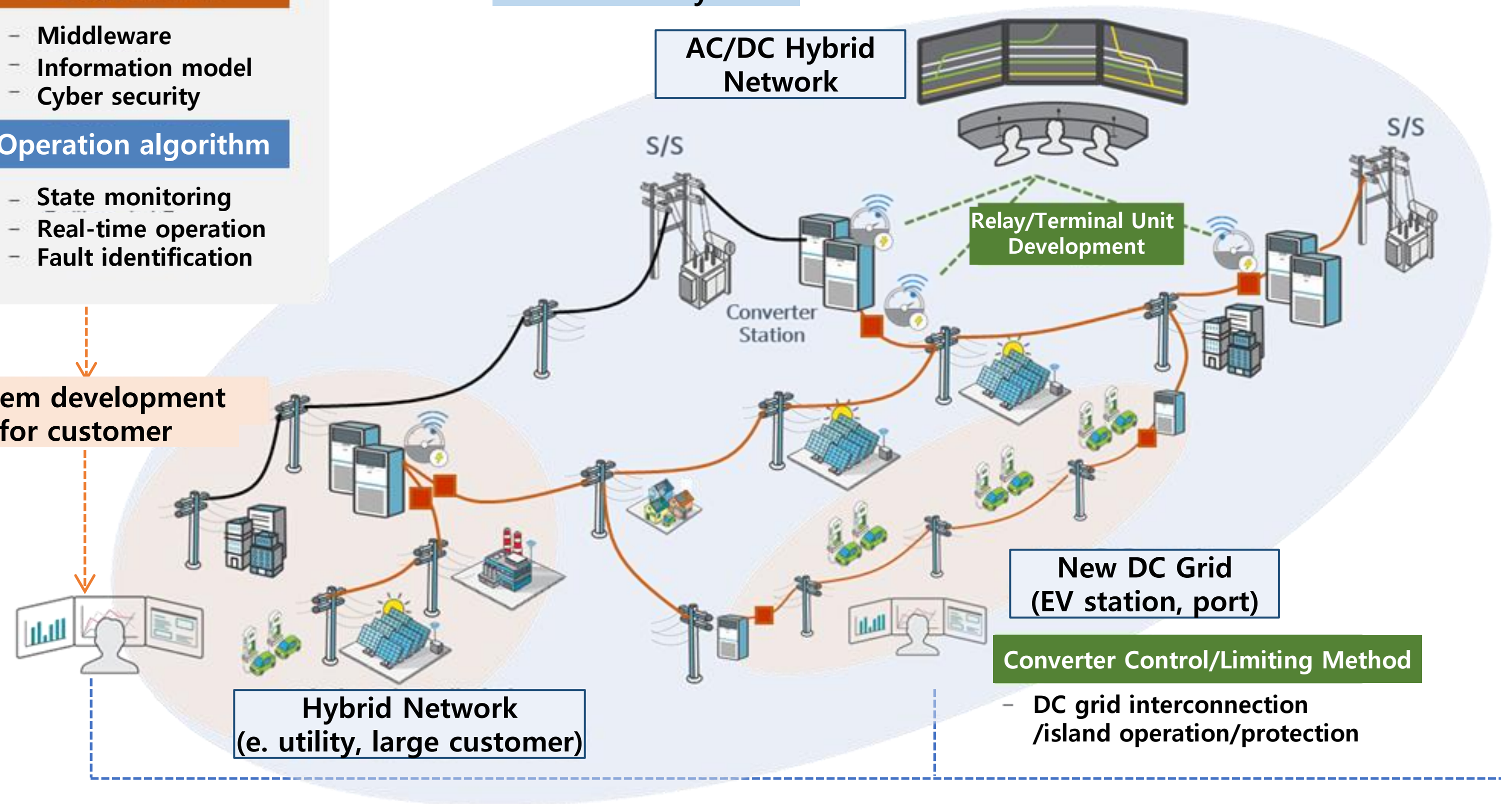
- Middleware
- Information model
- Cyber security

Operation algorithm

- State monitoring
- Real-time operation
- Fault identification

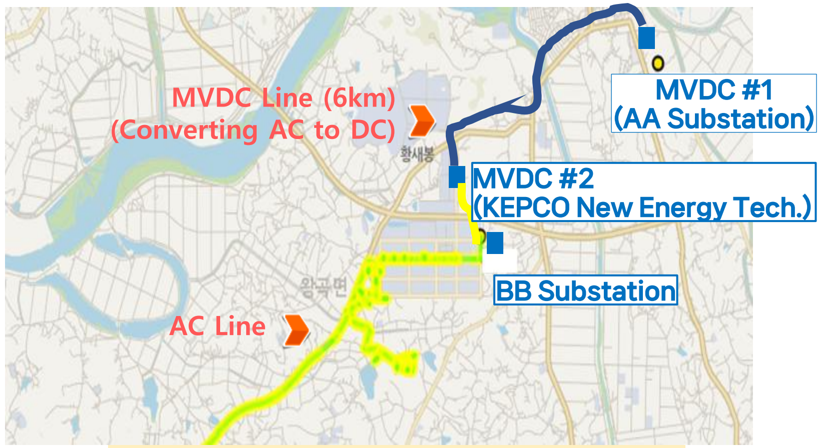
System development for utility

System development for customer



Overview of Operation System for Hybrid AC/DC Network

Testbed #1: Operation system verification



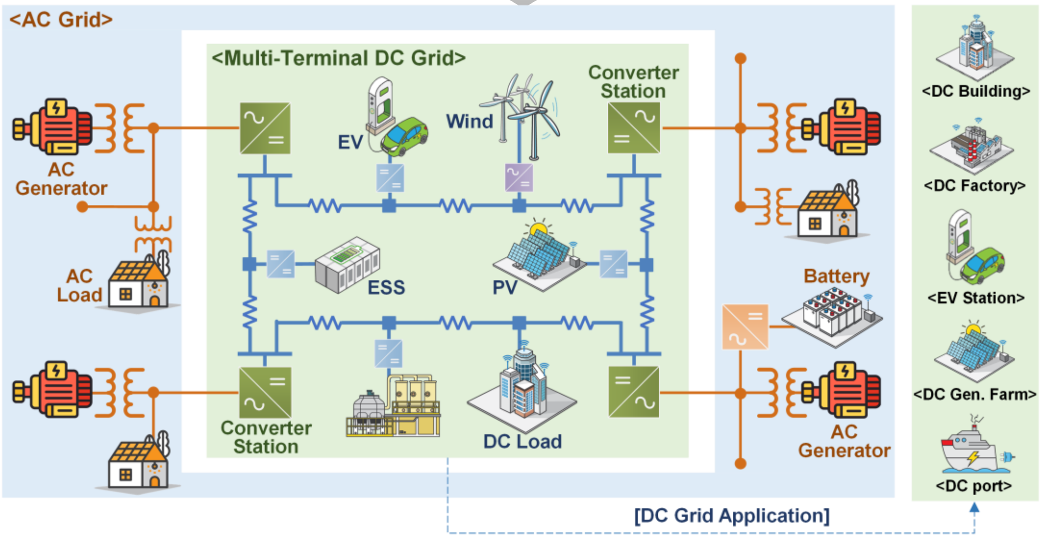
Testbed #2: P2P for RES connection

MVDC Project #2 : ±20kV DC Distribution Network

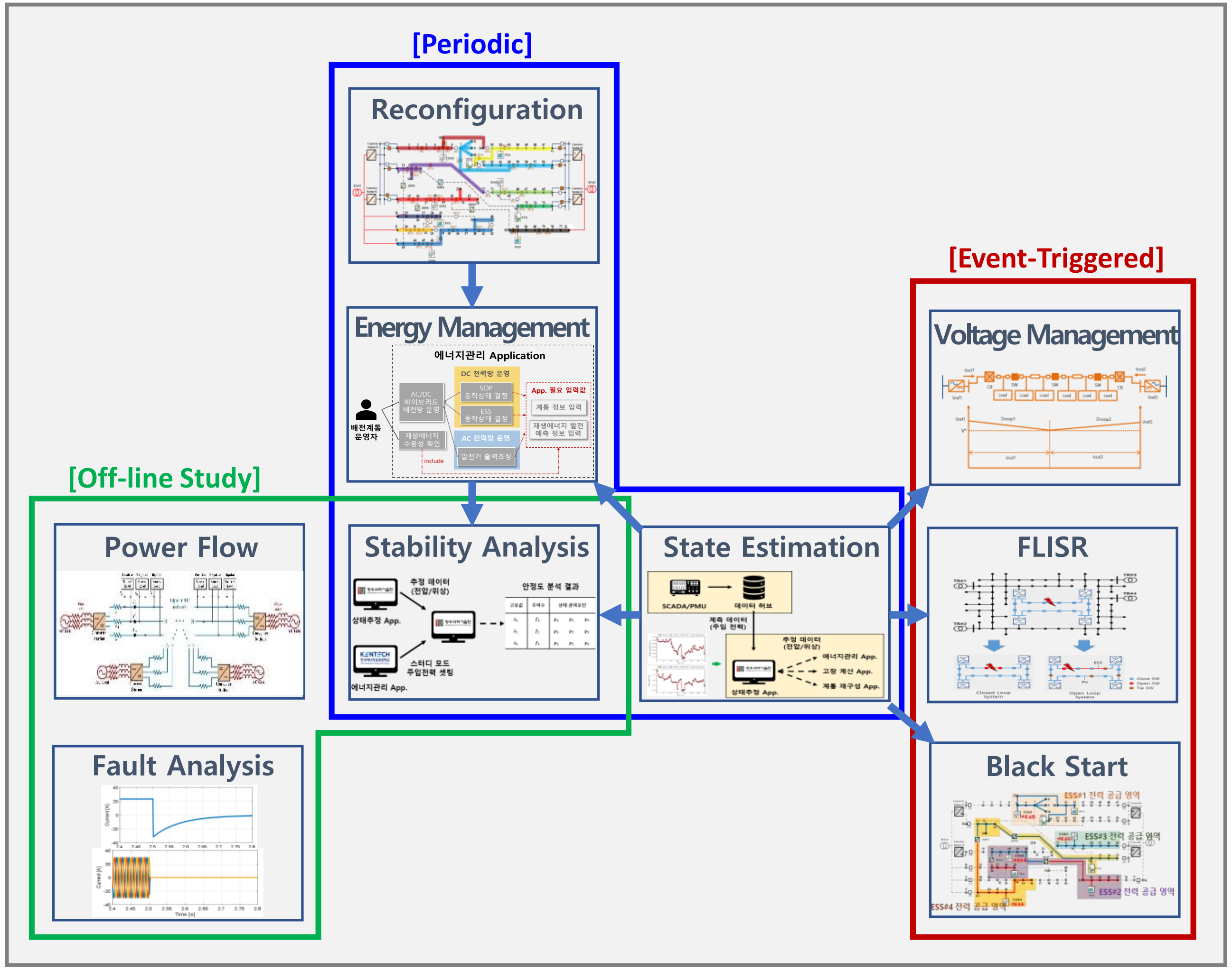
Development of New Operation System

Type	AC	Hybrid AC/DC
Objective	V, P, Q, Stable/Reliable	DC V, DC Power, Stable/Reliable
Asset	OLTC, Breaker, Switch, FRTU, DER-AVM	Converter station, DC terminal devices
Analysis	Pure AC	AC/DC Hybrid
Fault	Fault current based on impedance	Depending on topology and control of converter station
Control	Switch on/off area, Relay adjustment, Power factor etc	Voltage & power set-point of converter station

New operation system for hybrid AC/DC Dx grid



<MVDC Dx Network Application>



[Ref: 'Operation System for AC/DC Hybrid Distribution Network, MOTIE, 2022]

II. Future plan for MVDC

MVDC Project #2 : ±20kV DC Distribution Network

「Comprehensive Testbed」 Utilizing Completed Research Outputs & Operating a Testbed

Team 1 – Components

Converter Technology

LS ELECTRIC	20MW MV/MV Converter	MV/MV DC converter
HD현대일렉트릭	2MW MV/LV Converter	MV/LV DC converter
KERI 한국전기연구원	Converter Control Method	MMC control

DC High-Voltage Protection Device

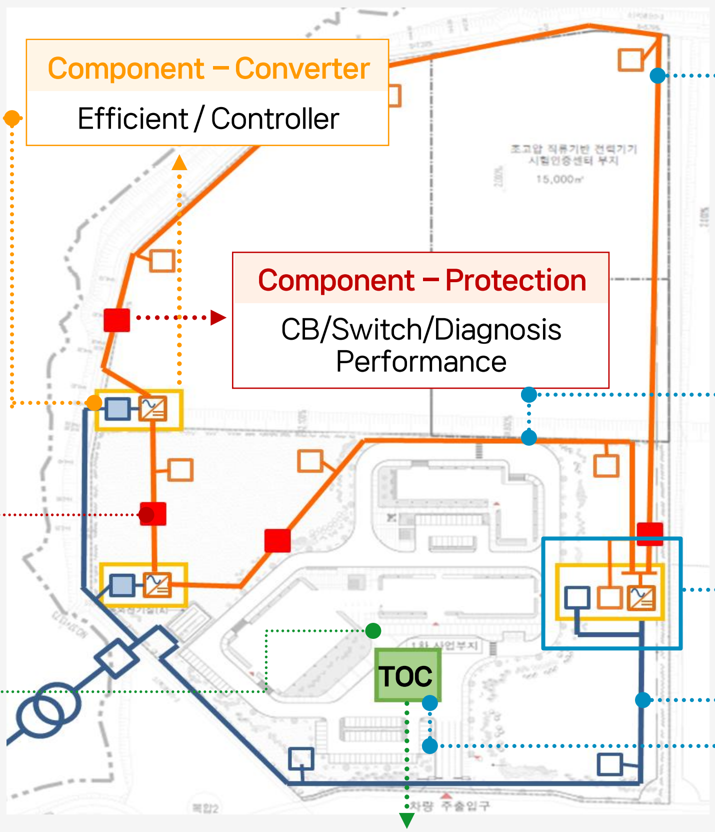
ENTEC 인텍전기전자주식회사 ENTEC ELECTRIC & ELECTRONIC CO., LTD	42kV DC Hybrid Circuit Breaker	DC CB (Hybrid Type)
VITZRO EM	Protection Devices	Switchgear, Surge Arrester
KERI 한국전기연구원	Measure, Monitor, Evaluation	Diagnostic System

Team 2 – Grid Technology

Design, Operation Tech, Safety & Performance

KEPCO 전력연구원	Dx network design and analysis	Design & analysis
KERI 한국전기연구원	Operating & Protection system	Hybrid Dx. Operation
ETRI	Environment (Safety)	Advanced Environment
KERI 한국전기연구원	Performance Evaluation	Real-time Performance

AC/DC Hybrid Dx Network Testbed(안)



Grid – Operation System

Operation system evaluation for Comprehensive testbed

MVDC #1 · MVDC #2 · SOP · MVAC · TOC

Evaluation #1 – RES Hosting Capacity
- Measure Max Transfer Capacity: AC vs DC
- Saturation temperature under same load

Evaluation #2 – Allowable Load Demand
- Max load comparison using Soft Open Point

Evaluation #3 – Voltage Fluctuation
- Voltage fluctuation (for nominal voltage)
- Compliance points / total measured points

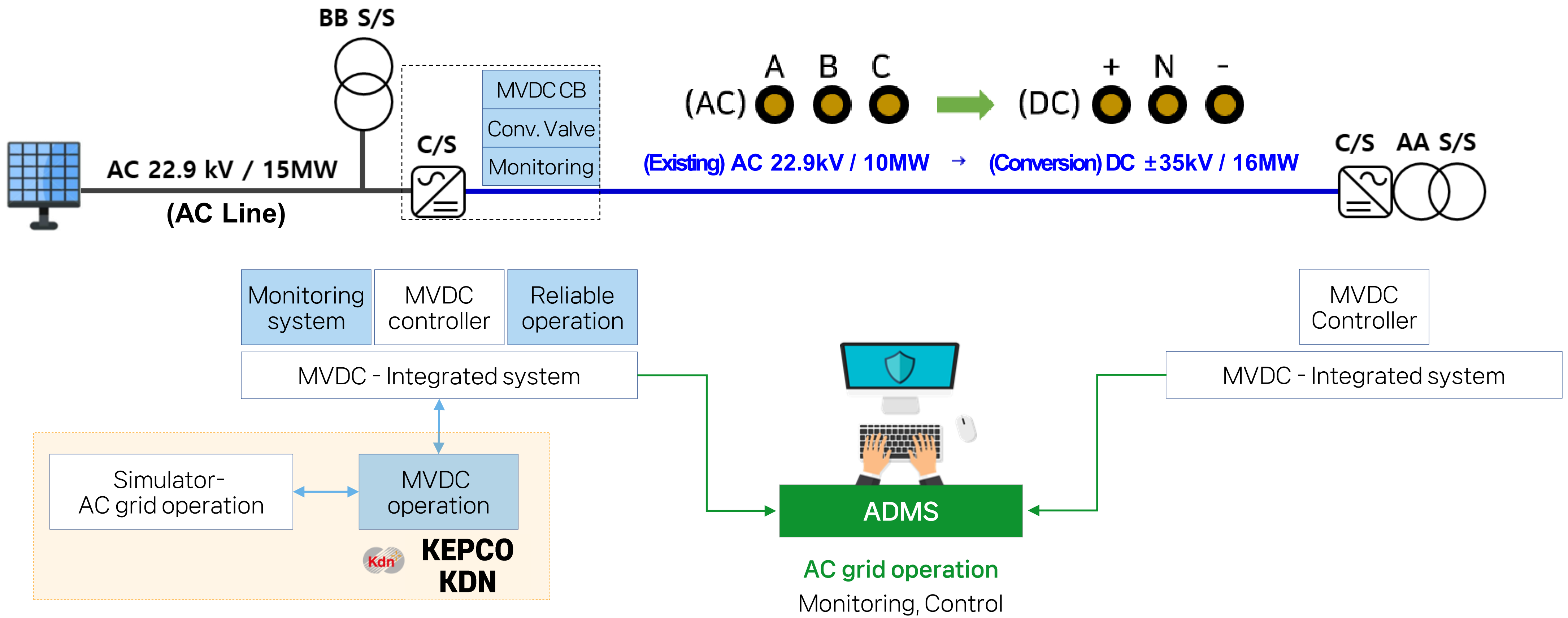
Evaluation #4 – Dx Algorithm Accuracy
- Operation module calculation accuracy

Evaluation #5 – Human safety
- EMF human safety compliance check

MVDC Project #2 : ±20kV DC Distribution Network

AC/DC Hybrid Dx Network(22.9kV/±35kV) Field Operation

On-site operation of the testbed incorporating MVDC technology

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Thank you