Microgrids for a just energy transition

APEC Workshop on Driving Trade and Investment for DC Power Systems and Microgrid Frameworks Through Public Policy Alignment

Christian Roatta, Senior Trade and Multilateral Affairs Specialist
UL Solutions
Feb. 24, 2025

Safety. Science. Transformation.™

What goals are we trying to achieve?

Two policy goals

Power supply

- Reliability
- Security
- Quality

Regulatory ecosystem

Standards/technical requirements, conformity assessment, accreditation, surveillance

Sustainable growth of renewable energy

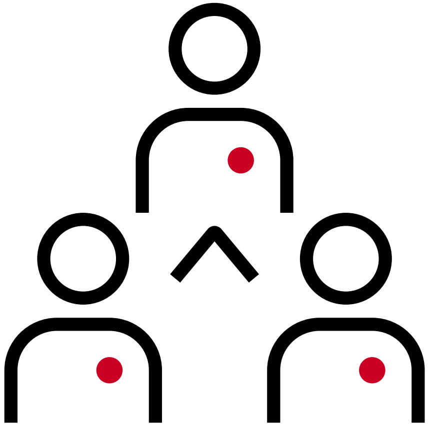
Enhance the power supply for the general public

Increase the share of renewables in the power system

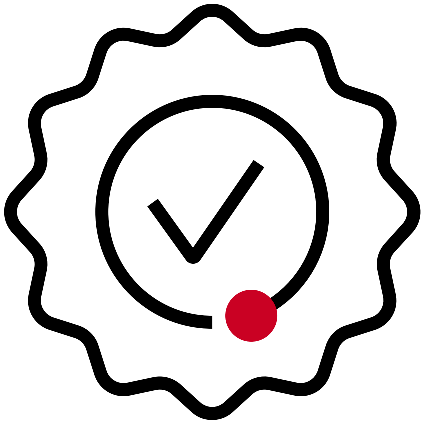
Two objectives reconciled

UL Solutions, empowering trust through:

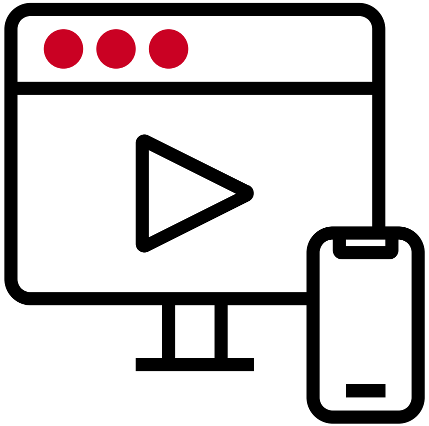
Technical advisory



Testing, inspection and certification



Digital tools



Industries we serve

CLO25EVCS2324650

Automotive and mobility

Buildings and construction

Energy and utilities

Financial and investment services

Government services

Healthcare and life sciences

Industrial products and systems

Life safety and security

Chemicals and materials

Products and components

Retail

Technology and electronics

The five pillars of microgrid risk mitigation

Microgrid system and component designers must prioritize five foundational areas in addressing risk: safety, security, performance, sustainability and cost efficiency.

UL Solutions

https://www.UL.com/resources/navigating-risks-and-advancing-mitigation-strategies-microgrid-systems

The five pillars of microgrid risk mitigation (continued)

Safety is paramount to achieve secure power delivery to users and safe working conditions for operators, installers and technicians.

Security increases protection from natural disasters, intentional destruction, accidental scenarios and cyberattacks.

Performance refers to the microgrid's ability to deliver necessary power during normal operating parameters and in the case of outlier events. Performance support strives to provide as much power as possible, even during critical events.

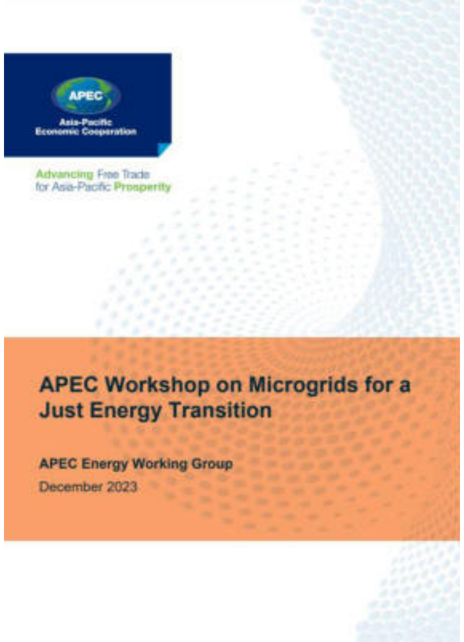
Sustainability is about designing and deploying systems that will work long term and establishing a preference for renewable energy sourcing wherever possible. Sustainable design enables reliable operation from reliable energy sources.

Cost-effectiveness is a significant consideration in microgrid installations. Cost-efficiency metrics strive to create the best possible energy production and consumption scenario from a financial standpoint.

https://www.UL.com/resources/navigating-risks-and-advancing-mitigation-strategies-microgrid-systems

APEC Workshop on Microgrids for a Just Energy Transition (EWG 04 2023S)

- Oct. 16, 2023, in Manila, The Philippines
- The workshop convened **43 stakeholders from six economies**, comprising government officials, senior private-sector leaders and nonprofit experts.
- Twenty-seven of the participants were private-sector, while 14 were public-sector.



Report can be found here: [APEC Workshop on Microgrids for a Just Energy Transition | APEC]

Workshop: Challenges and recommendations

The workshop's expert panelists identified the following challenges and recommendations.

Challenges

- High degrees of regulatory complexity
- Varied and inconsistent regulatory requirements between and within economies
- Frequent changes in leadership at regulatory agencies
- High barriers to market entry and exit
- For some developing economies, short time horizons for investments can be a major barrier to incentivizing long-term financing.

Recommendations

- Streamline regulations and permitting approval processes.
- Periodically review technical regulations and conformity assessment procedures with the aim of increasingly aligning them with international, risk-based best practices.
- Use international standards, where applicable, for microgrid technologies.
- Strengthen public–private partnerships to stabilize financial investments in microgrids.
- Leverage additional opportunities for multilateral cooperation.

Additional takeaways

- Whether or not an energy system is part of a large grid or microgrid, all persons deserve safety and security. It is especially important to take steps to support underserved communities. Microgrid technologies and deployed systems are not sustainable assets if they are not safe and secure.

- Microgrids provide opportunities to increase the reliability and resiliency of energy access in both urban and remote settings, especially for underserved communities.

- Investment in further research and innovation is essential to expanding energy access. This includes research in business frameworks and models, effective public policy, peer-to-peer technologies, and more.

Building on the project

How do we build capacity in Asia-Pacific Economic Cooperation (APEC) economies while facilitating trade and investment?

Driving trade and investment for DC power systems and microgrid frameworks through public policy alignment

- Survey of APEC economies to identify preliminary challenges/recommendations (March-July 2024)
- Hands-on workshop of cross-cutting stakeholders to expand and develop policy recommendations and best practices (February 2025)
- Publish a project report to serve as a resource for public- and private-sector stakeholders (2025)
- Post-workshop monitoring and follow-up with APEC economies (2025-2026)

Framing questions to take forward into this workshop

Framing questions

- How does my economy’s (or company’s) experience with these investments differ from others’ experiences? What is similar?
- How do safety, security and sustainability considerations for DC power and microgrid investments change across various contexts, e.g., in cities vs. remote settings? How should that effect our approach?
- How can public–private partnerships operationalize investments and reduce cost-associated risks?
- What lessons can be drawn from the successes and failures of investments in these technologies?
- What’s on the horizon? What challenges are just beginning to arise but are not prevalent? How do we head them off?
- How can we leverage the results of this workshop in publications?

Thank you

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DC Microgrid for Communities in Thailand

Asst. Prof. Dr. Worajit Setthapun

Asian Development College for Community Economy and Technology (adiCET)

Chiang Mai Rajabhat University, Thailand

Session 2 – Panel: Microgrids and DC Power Innovation

The APEC Workshop on Driving Trade & Investment for DC Power Systems and Microgrid Frameworks Through Public Policy Alignment

Feb 24-25, 2025

**Asia-Pacific Economic Cooperation (APEC)
The First Senior Officials' Meeting (SOM1) and Related Meetings**

**Hwabaek Convention Center (HICO)
Gyeongju, Republic of Korea**

Thailand Smart Grid Development Master Plan (2015 – 2036)

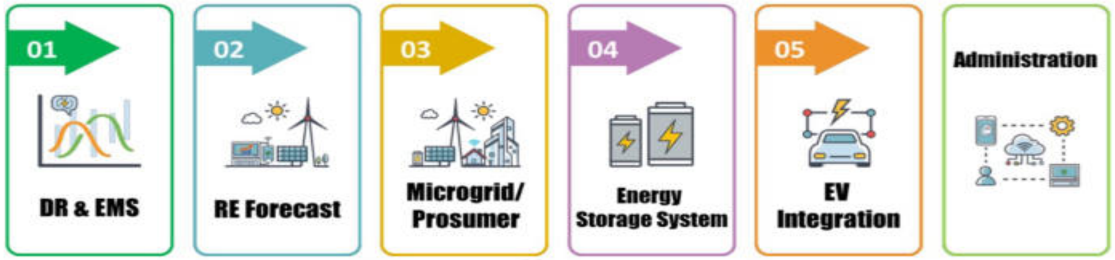
APEC 2025 KOREA

Vision: "Promote sufficient, efficient, sustainable electricity supply as well as high quality services and maximization of benefits to the Country"

Thailand Smart Grid Development Work Plan

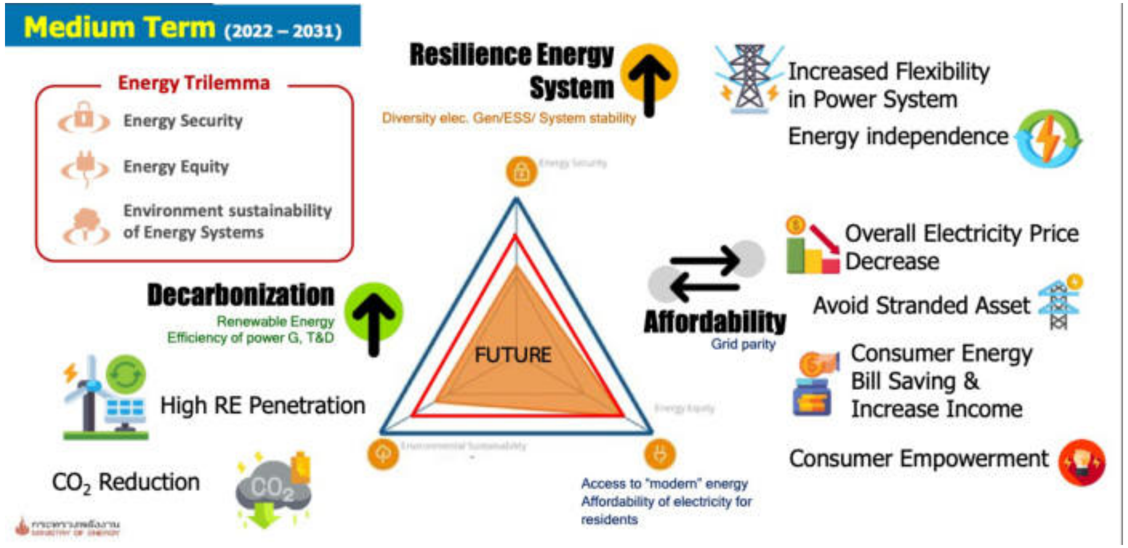
Preparation Stage 2015-2016	Short Term 2017-2021	Medium Term 2022-2031	Long Term 2032-2036
• Policies and Preparation support arrangement Stage • Designate responsible agencies & working group parties to drive Smart Grid Development Plan • Define Smart Grid Development Platform • HR and R&D Supportive Policies	• Piloting and R&D Stage • Promote Smart Grid R&D and Pilot Projects Activities • Establish Policies to encourage Power Utilities investment in Smart Grid Pilot Projects	• Smart Grid Infrastructure Development Stage • Revision of Policies / Rules & Regulations to support Smart Grid Development • Supportive Measures to encourage Power Utilities investment in Smart Grid Infrastructure	• Smart Grid Technology Advancement Stage • Supportive Measures to encourage Power Utilities investment in advance Smart Grid Technology development • Supportive Policies to encourage Consumers investment in the installation of Smart Grid Technology
		Current Stage	

Smart Grid Development Action Plan

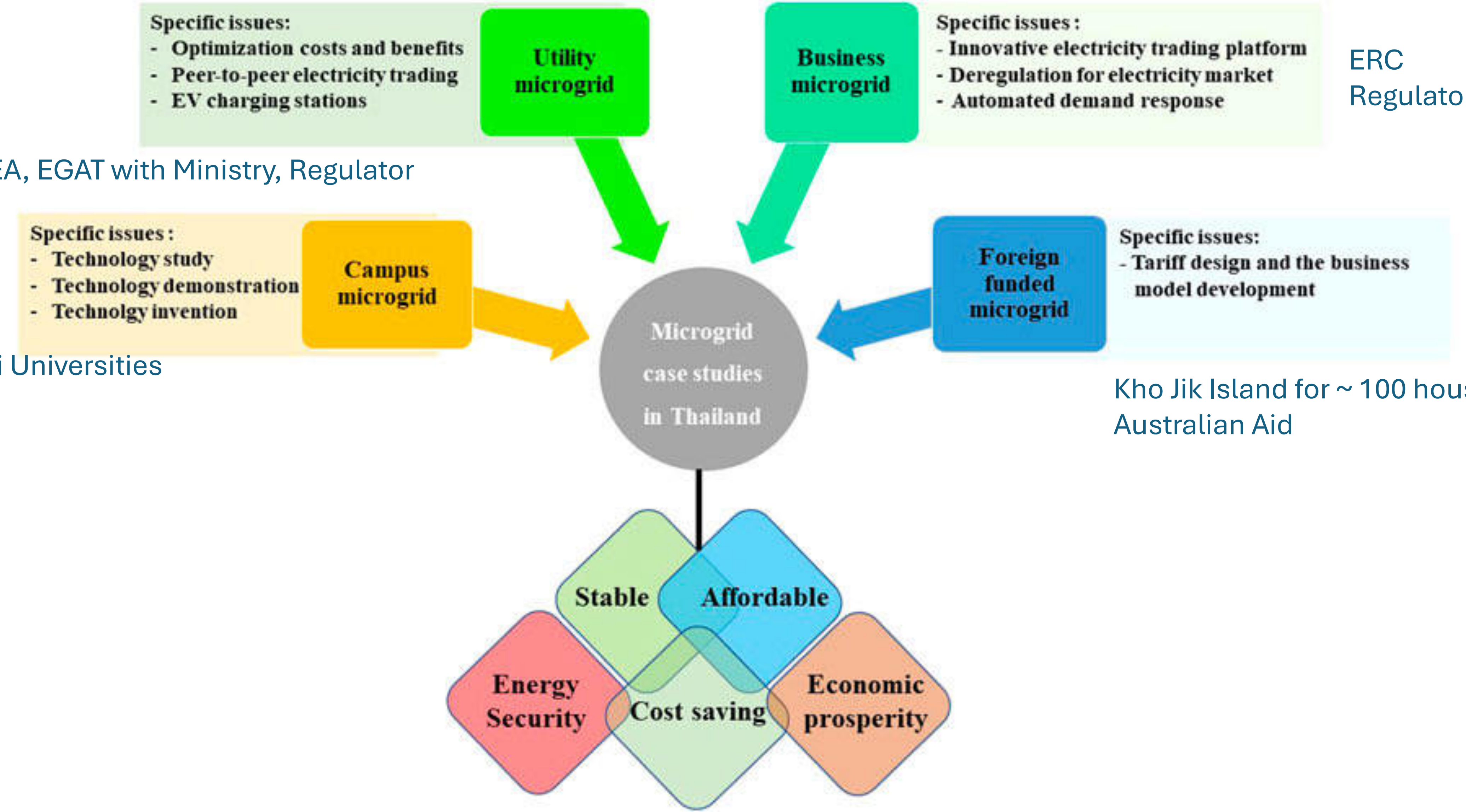


Medium Term 2022 - 2031

Vision : Promote infrastructures development and management of necessary resources in the power distribution system. For support the energy transition to a modern grid system to be more efficient and environmentally friendly.



Micrograds in Thailand



ERC
Regulatory Sandbox

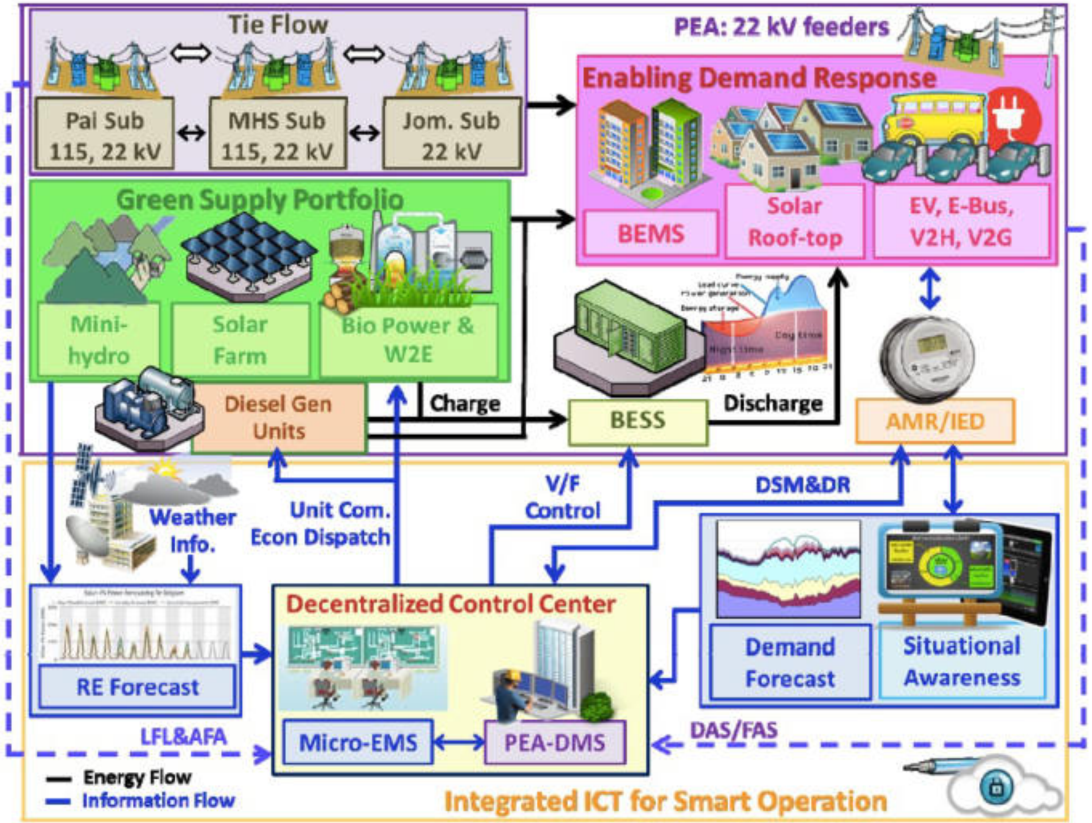
PEA, MEA, EGAT with Ministry, Regulator

Thai Universities

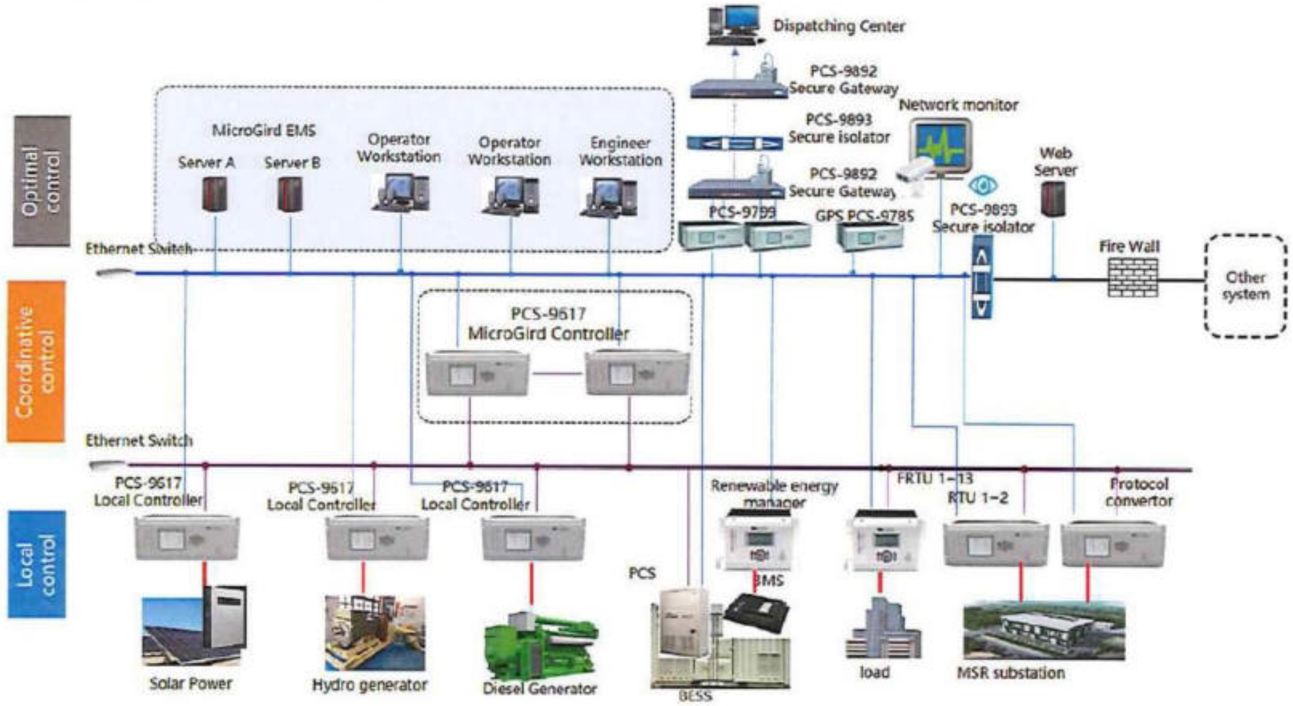
Kho Jik Island for ~ 100 household
Australian Aid

Smart Grid Driven by the Utilities

EGAT – Mae Hong Son



PEA – Mae Sareang



Scenario 1 Before islanding
Scenario 2 Preventive islanding if a supply interruption is planned, or an outage is expected
Scenario 3 Automated islanding in case of unplanned grid failure
Scenario 4 Black start recovery to re-supply loads after grid failure
Scenario 5 Maintaining the islanding
Scenario 6 Reconnection to the main grid

Functions:

1. Peak Shaving and Valley Filling
2. Stabilize Fluctuation
3. Frequency regulation
4. Voltage regulation
5. Black start
6. Load Recovery

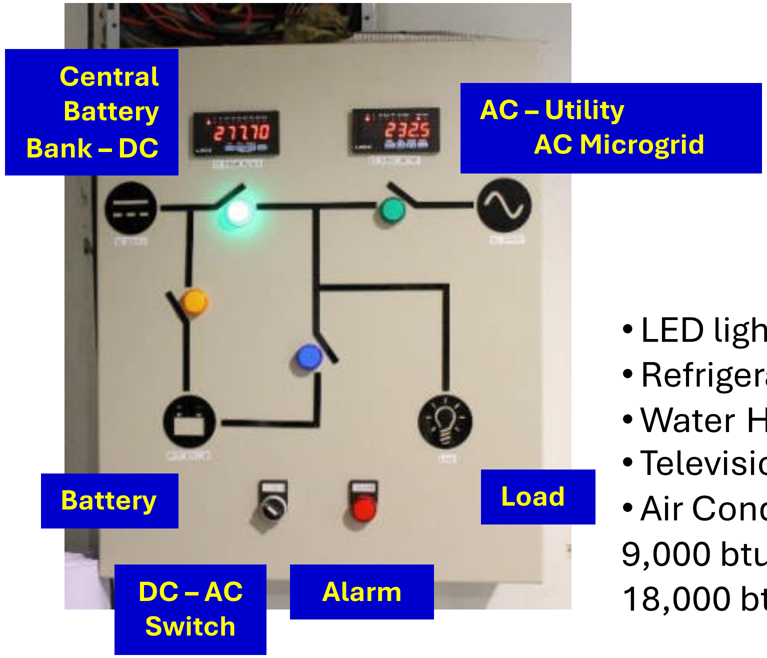
Chiang Mai Rajabhat University

- **Chiang Mai Rajabht University**
  Mae Rim Green Campus
- **Chiang Mai World Green City:**
  Sustainable-Green-Smart Community via Integration of Renewable Energy & Green Technology
- **adiCET:** Community Development through R&D, academic services to enhance local community quality of life and economy

DC Microgrid at adiCET

- Living Laboratory for community transition from AC → AC/DC → DC Community
- Evaluate Low Cost - Low Voltage DC Community Power System at the Smart Community
  - **Phase 1: Lightings 24 VDC/ 1 House 240 VDC**
  - **Phase 2: Household Appliances 260-297 VDC**
- Modify/Testing Household Appliances for DC & AC usage
  - Lighting, Refrigerator, Air Conditioner, Water Heater, Television, Computer, Rice Cooker, Microwave, Washing Machine
- Evaluate appliances during operation, stability and safety
  - Full DC
  - Full AC
  - Mixed DC & AC

DC Microgrid at adiCET



- LED lightings
- Refrigerator
- Water Heater
- Television
- Air Conditioner
9,000 btu, 13,000 btu, 18,000 btu

Phase 2: Testing Modified Household Appliances

Mode	Central Battery Voltage Stage	Usage
Full	297 – 260 VDC	DC use directly from Central Battery bank
Battery Boosting	260 – 250 VDC	DC from Battery bank (260 VDC) & Booster (54 VDC)
Biodiesel Generator Start	250 – 242 VDC	Generator - Charge Battery Bank - Charge Booster Batteries If ran out of fuel, AC from Utility will convert to DC
Battery dead	Below 242 VDC	Automatically switch to AC

Note: Voltage range depends on Charger Specification, battery voltage range and electrical load device requirements.

Issue to overcome

- Voltage fluctuates from the utility line, power monitoring devices
- Communication and monitoring
- The capacitor was damaged when AC was used over the voltage setting.
- Nature Issues/ Human Issues

Smart DC Plug

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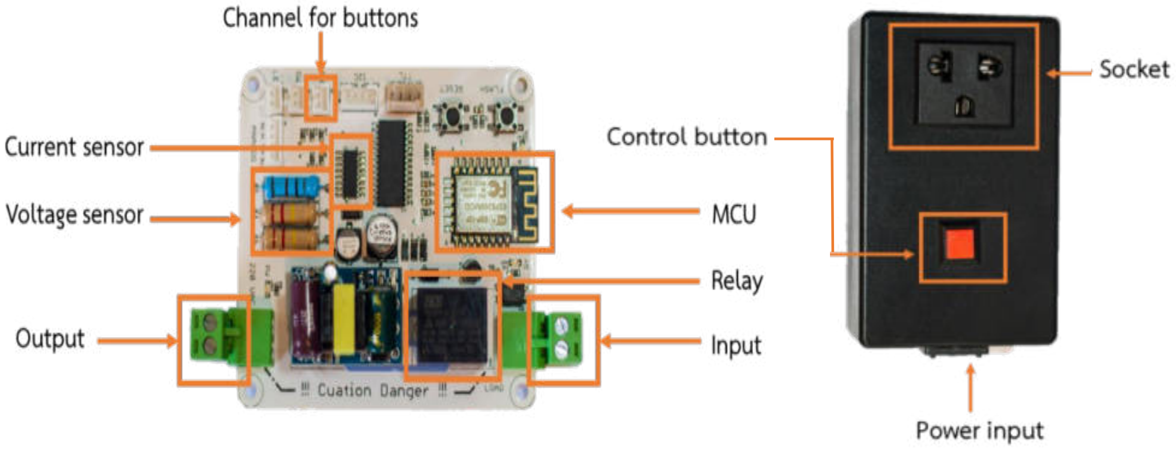
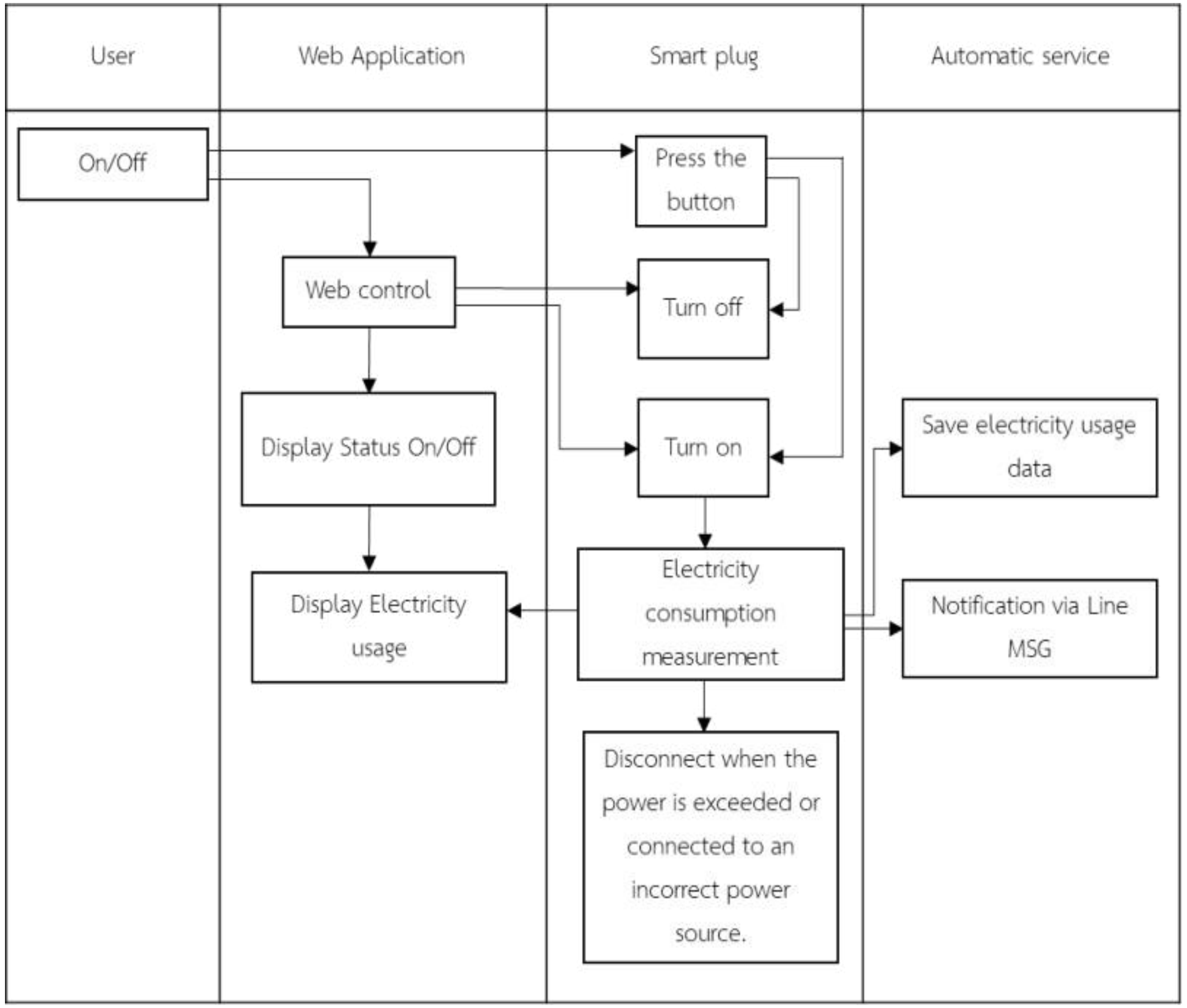
Operating Principles

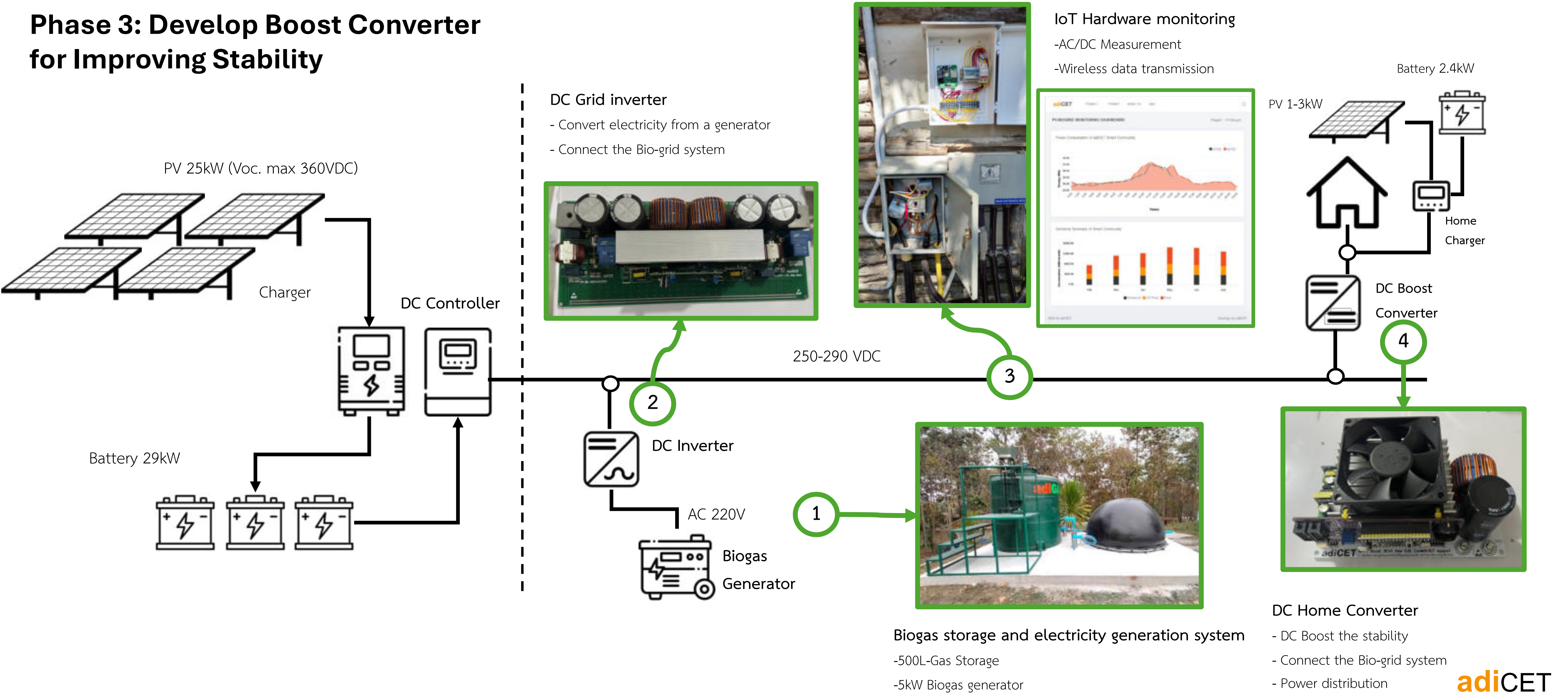
Hardware design





DC Microgrid at adiCET

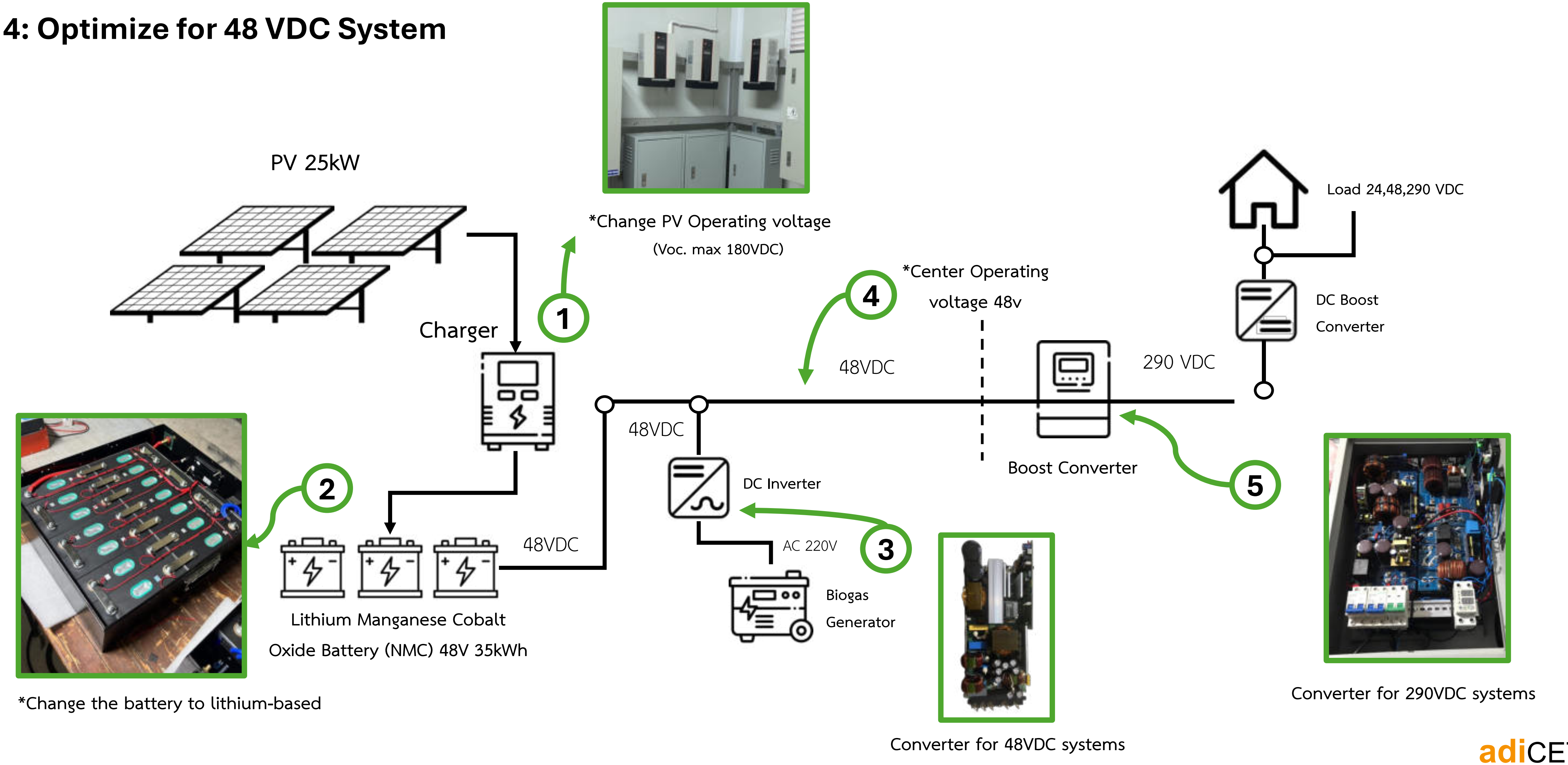
Phase 3: Develop Boost Converter for Improving Stability

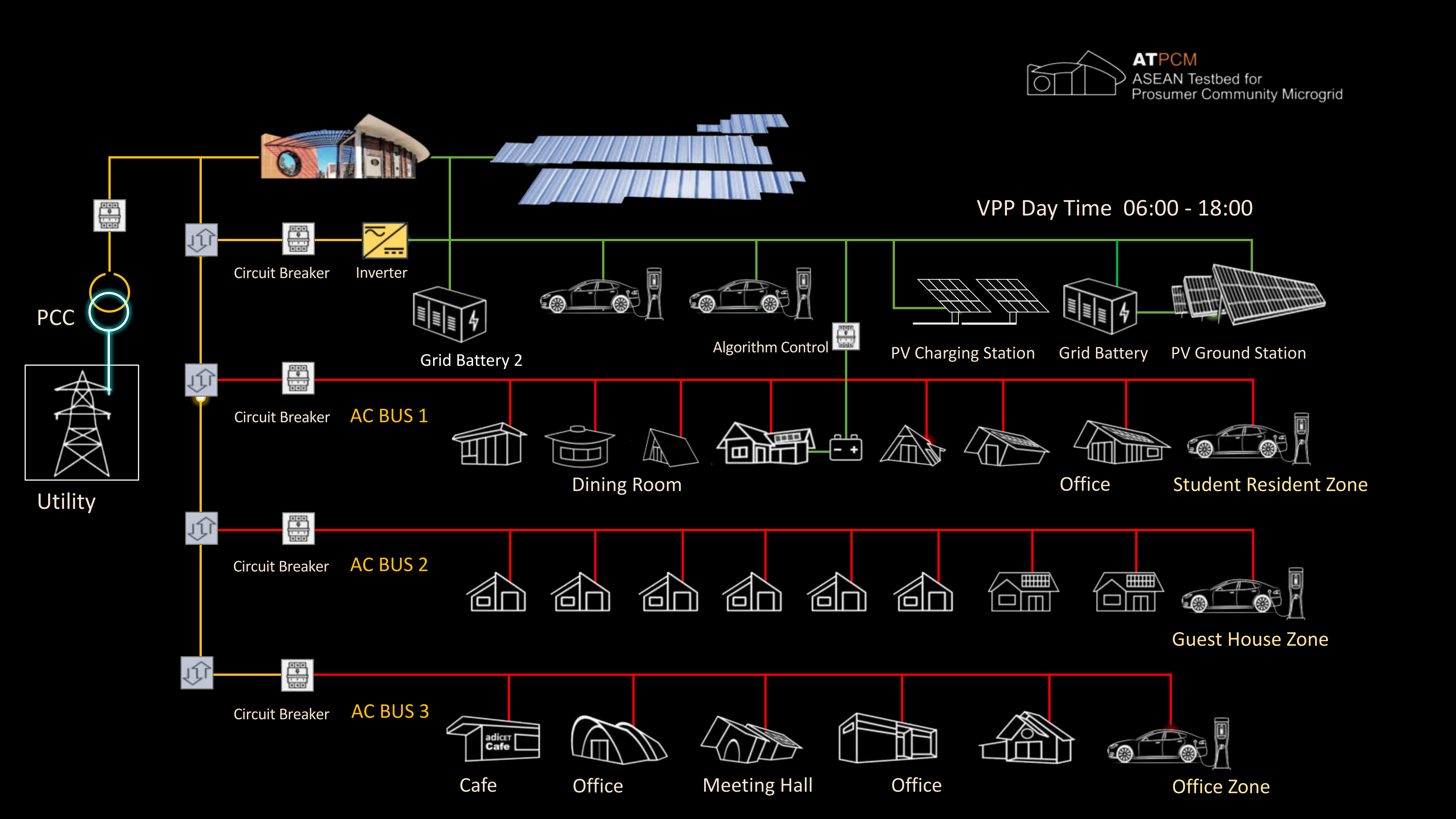


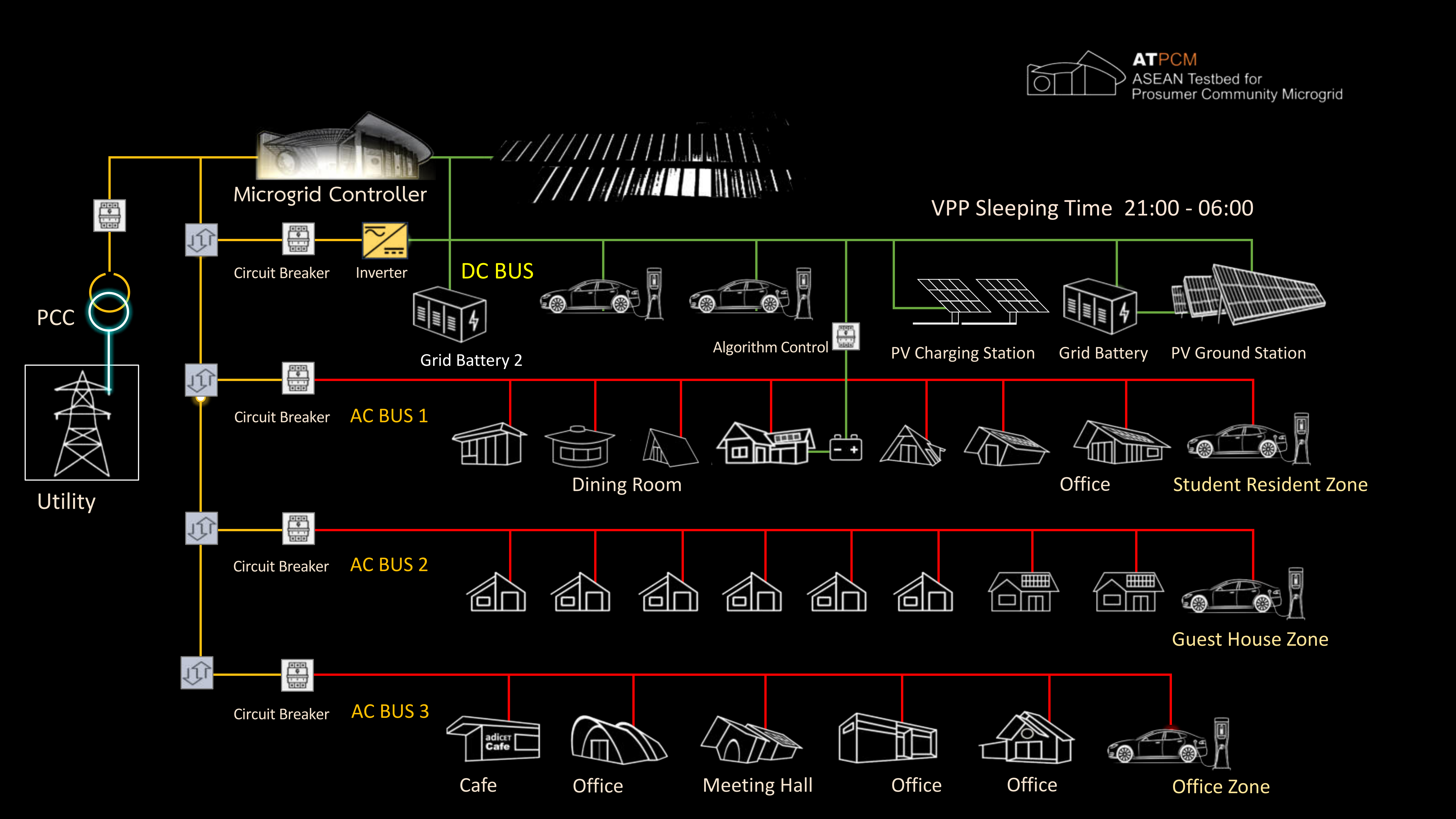
adiCET

DC Microgrid at adiCET

Phase 4: Optimize for 48 VDC System




ATPCM
ASEAN Testbed for
Prosumer Community Microgrid
VPP Day Time 06:00 - 18:00
PCC
Utility
Circuit Breaker
Inverter
Grid Battery 2
Algorithm Control
PV Charging Station
Grid Battery
PV Ground Station
Circuit Breaker
AC BUS 1
Dining Room
Office
Student Resident Zone
Circuit Breaker
AC BUS 2
Guest House Zone
Circuit Breaker
AC BUS 3
adicET Cafe
Cafe
Office
Meeting Hall
Office
Office Zone

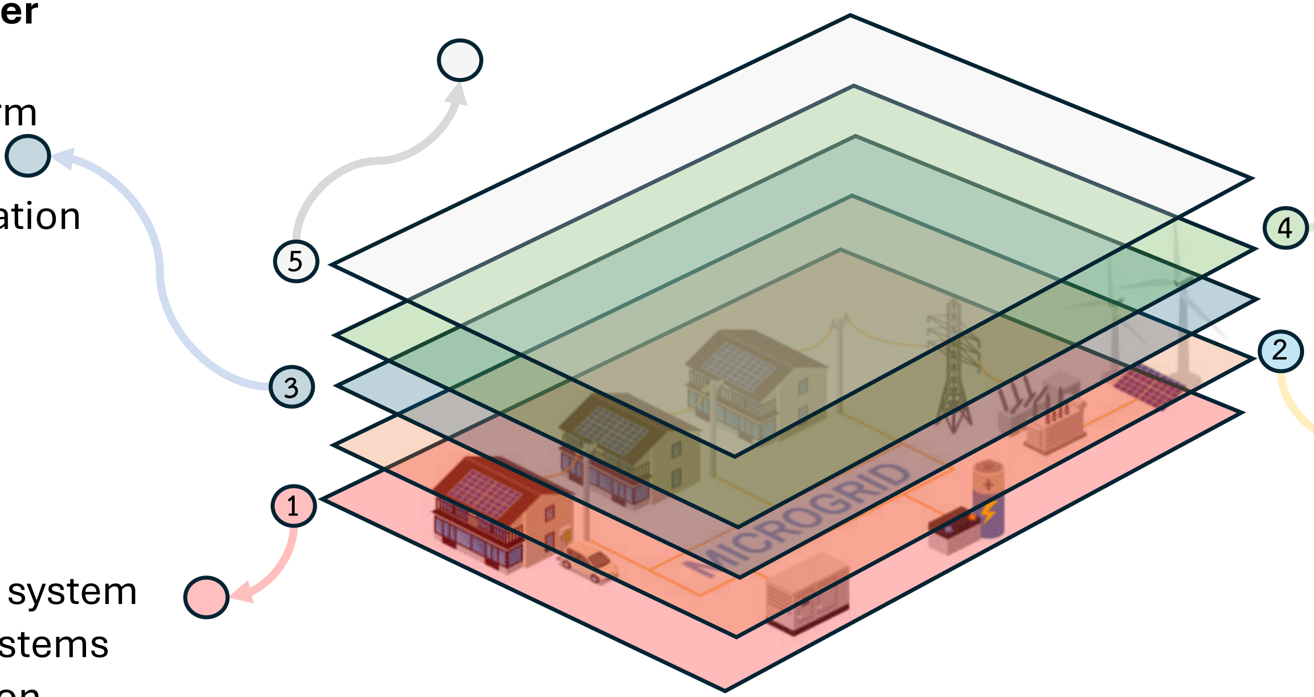

ATPCM
ASEAN Testbed for
Prosumer Community Microgrid
Microgrid Controller
VPP Sleeping Time 21:00 - 06:00
Circuit Breaker
Inverter
DC BUS
PCC
Grid Battery 2
Algorithm Control
PV Charging Station
Grid Battery
PV Ground Station
Circuit Breaker
AC BUS 1
Dining Room
Office
Student Resident Zone
Utility
Circuit Breaker
AC BUS 2
Guest House Zone
Circuit Breaker
AC BUS 3
Cafe
Office
Meeting Hall
Office
Office
Office Zone

Smart Microgrid Project Development

User Layer
- Web display platform
- Settings and notifications
- Rules and Policies

Database & Monitoring Layer
- Real-Time Monitoring
- Big database for Long-term statistical
- Management and notification system

Electricity trading Layer
- Marketing mechanism
- Trading Platform
- Blockchain and smart contracts



Network Layer
- IoT Systems
- Real-Time Protocol

Distribution Layer
- Power generation system
- Energy storage systems
- Power transmission system

CMRU
CHIANG MAI RAJABHAT UNIVERSITY
adiCET

Thank you very much

www.adicet.cmru.ac.th worajit@g.cmru.ac.th www.facebook.com/adicet

LVDC Researches and Standardization in Korea

Hyosung Kim, Professor Emeritus, Researcher

Kongju National University, KOREA

Date : 2025. 02. 24

Contents

I. Story of Presenter

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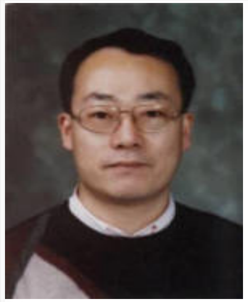


- Hyosung Kim
- Researcher/ Professor Emeritus
- Kongju National University
- hyoskim@kongju.ac.kr

RES (~10 yrs)

ESS (~10 yrs)

DC Systems (~10 yrs)

Std. Field (IEC)

- 2010 — ITU-T DC operating Voltage in Data Center : 260 ~ 400 V
- 2014 — IEC SMB G5, Ahg54, SEG4, member LVDC
- 2017 — IEC SyC LVDC Founding member LVDC
- 2024 — IEC SyC LVDC/ WG1 Project Leader IEC SRD 63603
- 2025 — IEC MSB SWG 21 Member MVDC Grids for AES

Research Field

- 2010~2012 Data Center 380 V DC Distribution Test Bed Korea Telecom, KEIT
- 2012~2015 LVDC safety NRF
- 2013~2015 750 V/ 10 A class DC circuit Breaker, KEPCO
- 2014~2018 LVDC grounding & Circuit Protection Standardization KEIT
- 2016~2023 Arcing in DC breakers NRF
- 2017~2020 Grounding and Circuit Protection [illegible] LVDC systems KEPCO
- 2019~2024 Customer-Side LVDC Systems Steering Member, KEIT Published 15 Domestic Standards
- 2022~2031 Green ship Whole-phase Project (Standardization) KEIT

Case 1 (7 years)

Case 2 (5 years)

?

II. Case 1: DC arc research

Proposed architecture & scope

- Residence of Tier 2 & 3 levels of Multi-tier Framework in Electricity Access Area

Table 1 – Attributes of access related to electricity energy supply for households as given in the Multi-Tier framework

Attribute	Tier 2	Tier 3
Power capacity ratings (W or daily Wh)	Minimum peak power delivery of 50 W Minimum energy delivery of 200 Wh per day	Minimum peak power delivery of 200 W Minimum energy delivery of 1 000 Wh per day
Availability (duration)	Minimum 4 h per day; minimum 2 h in the evening	Minimum 8 h per day; minimum 3 h in the evening
Reliability	No stated requirement	No stated requirement
Quality	IEC Standards on EMC shall be applied	IEC Standards on EMC shall be applied
Affordability	No stated requirement	Cost of standard consumption package of 365 kWh per year should be less than 5 % of household income
Legality	No stated requirement	No stated requirement
Health and Safety	No stated requirement	No stated requirement

Standardization of DC series arc using brass electrodes

Scope Structure Projects / Publications Documents Votes Meetings Collaboration Platform

Work programme > Project: IEC TS 63603-1 ED1

en fr

Detail

Committee	Working Groups	Project Leader	Current Status	Frcst Pub Date	Stability Date
SyC LVDC	WG 1	Mr Hyosung KIM	ACD	2027-05	

History

Stage	Document	Downloads	Voting Result	Decision Date	Target Date
prePNW				2024-03-21	
PNW	SyCLVDC/146/NP	2599 kB	APPROVED	2024-03-22	
PRVN				2024-06-14	2024-06
ACD	SyCLVDC/158/RVN	73 kB 723 kB		2024-08-16	2025-03
CD					2025-03

Project

IEC TS 63603-1 ED1

Arc Hazards and Safety in LVDC - Part 1: Series arc characteristics between brass electrodes

Initial Project Plan

Committee	Enquiry	Approval	Publication
2025-03-19		2026-11-20	2027-05-19

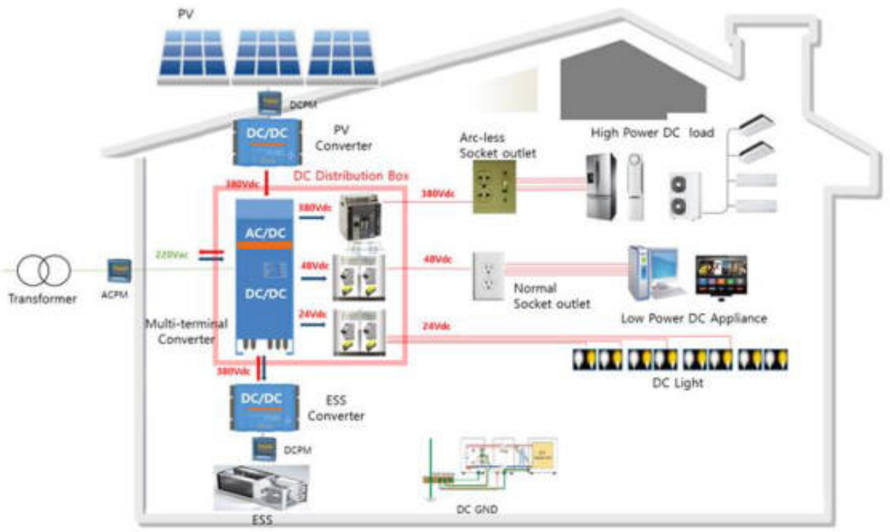
Up-to-date Project Plan

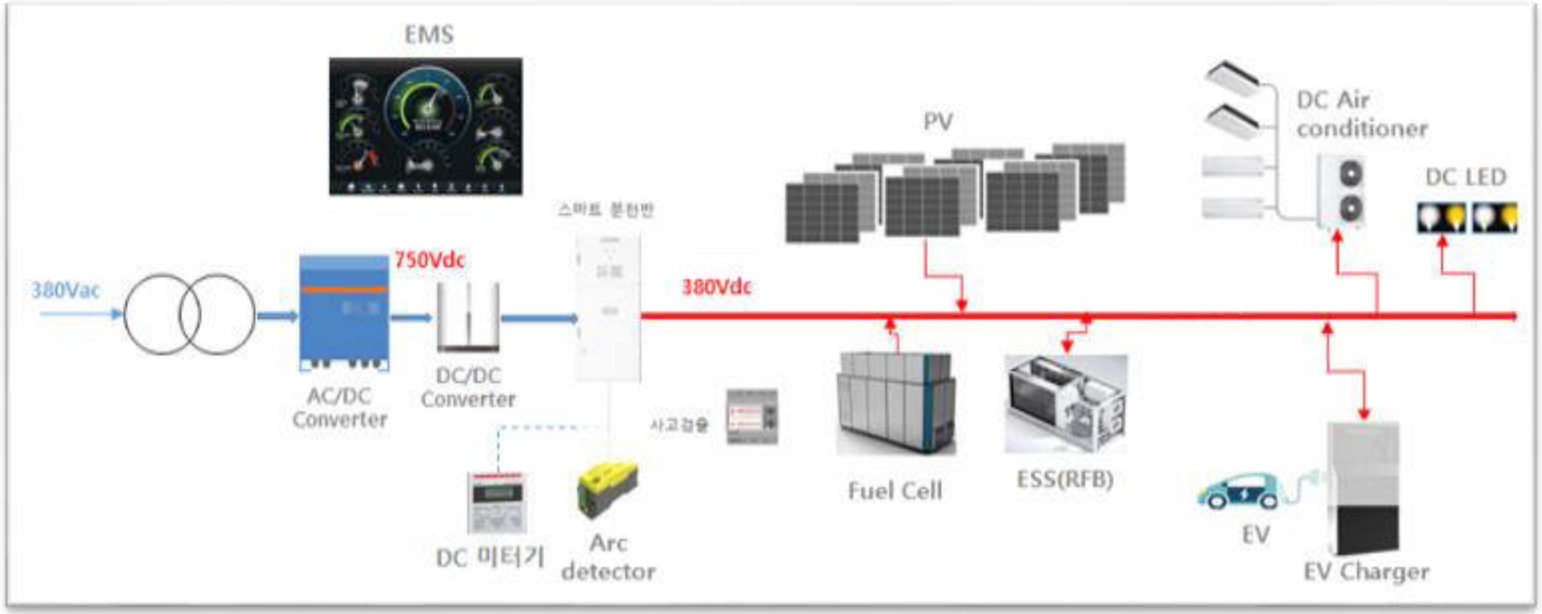
Committee	Enquiry	Approval	Publication
2025-03-19		2026-11-20	2027-05-19

Proposed architecture & scope

- Residential houses and commercial buildings

- **Site Name**: Next-Generation LVDC System Demonstration Site
- **Location**: Research Building of the Korea Electronics Technology Institute (KETI), Gwangju Metropolitan City





II. Case 2: Consumer-side LVDC system research

Demonstration & test site

[2층 시험전경]

II. Case 2: Consumer-side LVDC system research

APEC 2025 KOREA

LVDC Standards for Private Sector in Korea

STD. No.	Title	Propose
SPS-KETI-C0001	Electrical Safety Requirements for Low Voltage DC Consumers	KETI
SPS-KETI-C0002	Test Methods for DC Plugs and Socket-outlets for DC Consumers	KETI
SPS-KETI-C0003	Electrical Test Methods for Arc-Free DC Wall Switches for DC Consumers	KETI
SPS-KETI-C0004	Test Methods for DC Circuit Breakers for DC Consumers	KETI
SPS-KETI-C0005	Test Methods for DC Leakage Circuit Breakers for DC Consumers	KETI
SPS-KETI-C0006	Test Methods for DC Branch Circuit Switches for DC Consumers	KETI
SPS-KETI-C0007	Test Methods for DC Distribution Boards for DC Consumers	KETI
SPS-KETI-C0008	Test Methods for DC Power Conversion Devices for Low-Voltage DC Distribution System Integration	KETI
SPS-KETI-C0009	Test Methods for Arc Fault Detection Devices for Low-Voltage DC Consumers	KETI
SPS-KETI-C0010	Test Methods for Power Conversion Devices for Medium and Large Energy Storage Systems in LVDC Distribution Networks	KETI
SPS-KETI-C0011	Performance Test Methods for Power Quality Measurement Devices in LVDC Distribution Systems	KETI
SPS-KETI-C0012	Test Methods for Hybrid and Semiconductor High-Speed DC Circuit Breakers for LVDC Distribution Systems	KETI
SPS-KETI-C0013	Test Methods for Power Conversion Devices in DC Distribution Systems for Supplying Power to AC Consumers	KETI
SPS-KETI-C0014	Test Methods for Power Conversion Devices for LVDC Building Loads	KETI
SPS-KETI-C0015	Test Methods for Medium-Scale Solar Power Conversion Devices in LVDC Distribution Networks	KETI

감사합니다 !

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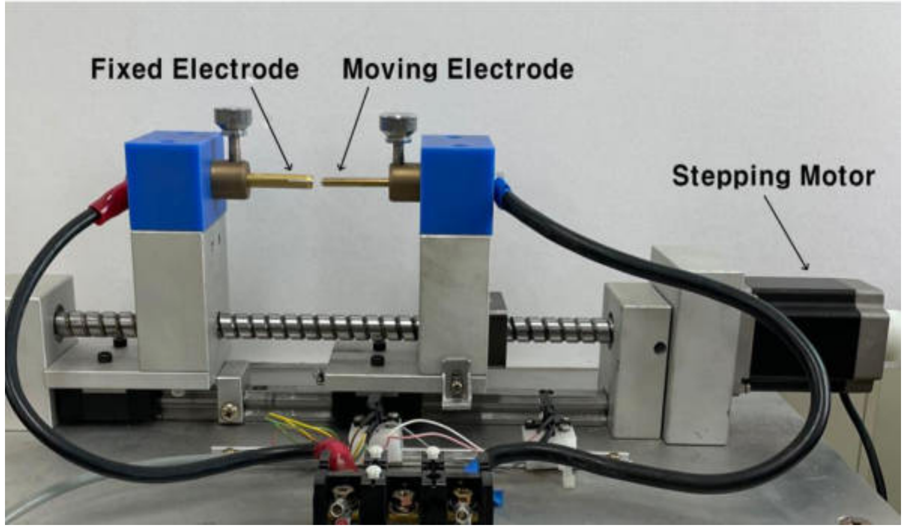
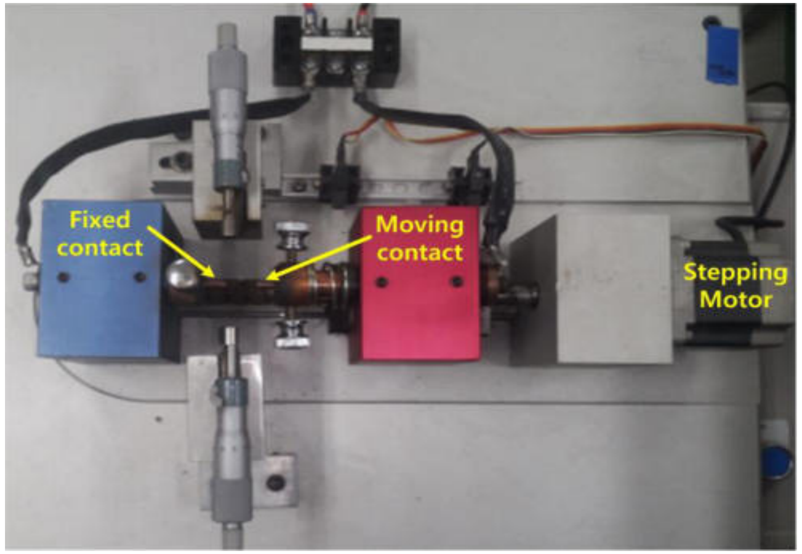
Experimental set-up





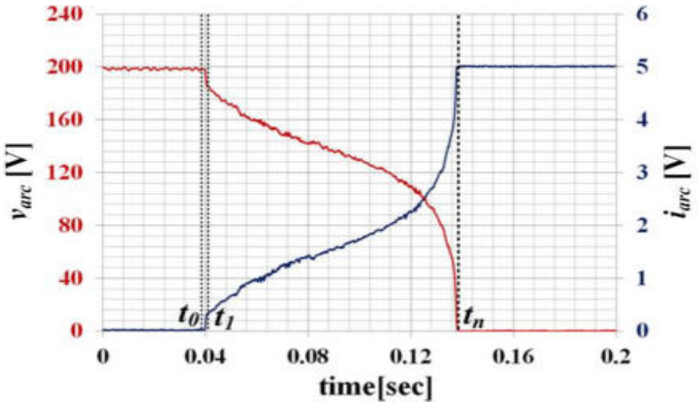
Parameter	Values
Supply Voltage [V]	25, 50, 100, 150, 200
Load Power [W]	50, 100, 200, 300, 400, 500, 800, 1000
Opening Speed, VGap [mm/s]	10, 40, 80, 120

[Experimental setup for socket-outlet & plug]

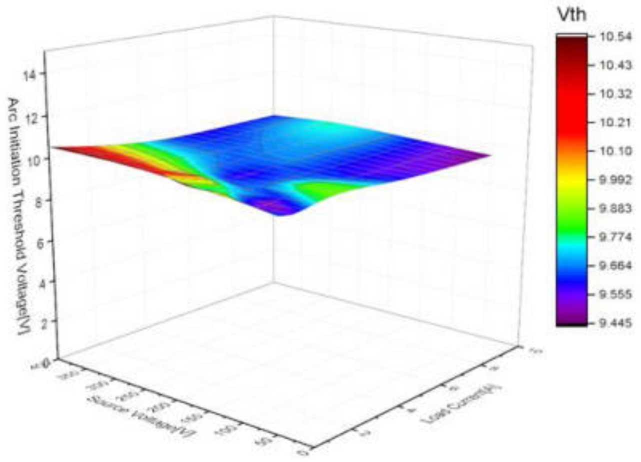
[Experimental setup for wall-mount switch]

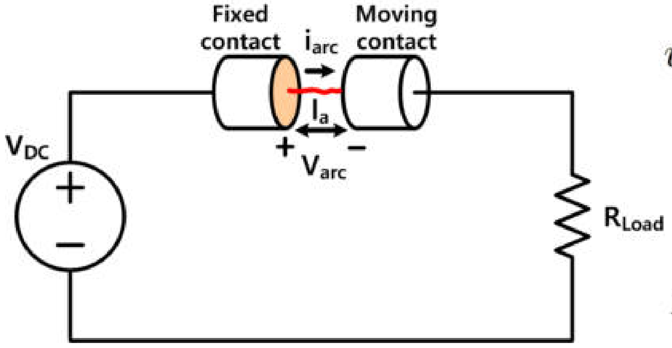
II. Case 1: DC arc research

Series arc: current, voltage, & power



[Typical experimental waveforms of arc voltage (v_{arc}) and arc current (i_L); Supply voltage = 200 V, Load current = 5 A]

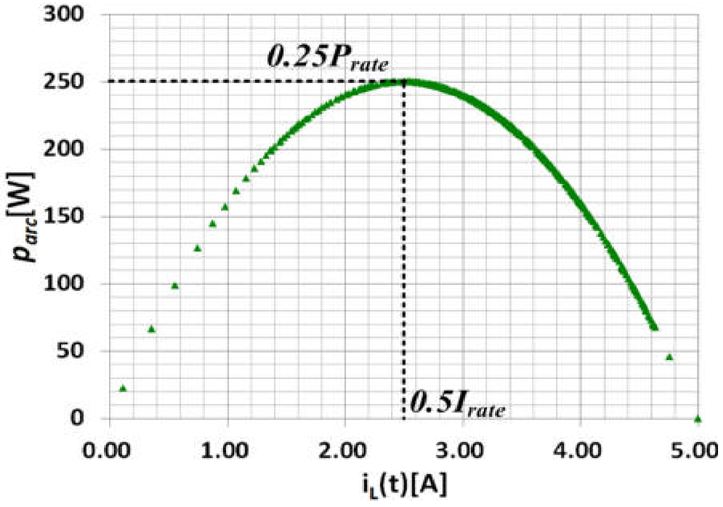




[Break-arc circuit concept]

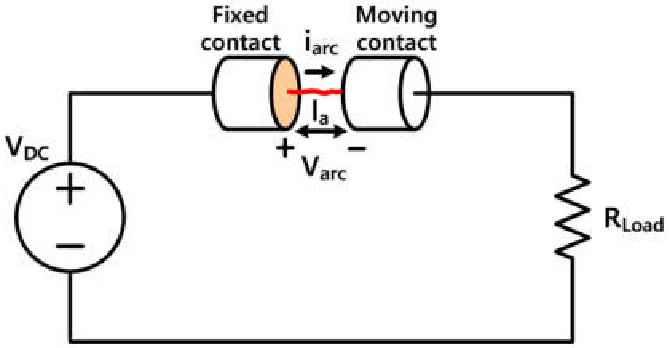
$$v_{\mathrm{arc}} = V_{DC} - i_{\mathrm{arc}} R_{Load}$$

$$p_{\mathrm{arc}} = v_{\mathrm{arc}} \bullet i_{\mathrm{arc}} = V_{DC}\left(i_{\mathrm{arc}} - \frac{i_{\mathrm{arc}}^2}{I_{Load}}\right)$$



[Arc power(p_{arc}) graph against arc current(i_{arc})]

Series arc energy



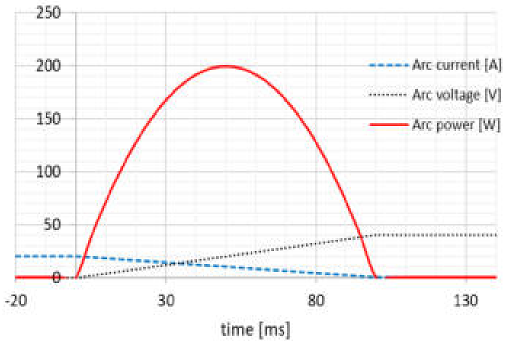
[Break-arc circuit concept]

$$v_{\mathrm{arc}} = V_{DC} - i_{\mathrm{arc}} R_{Load}$$

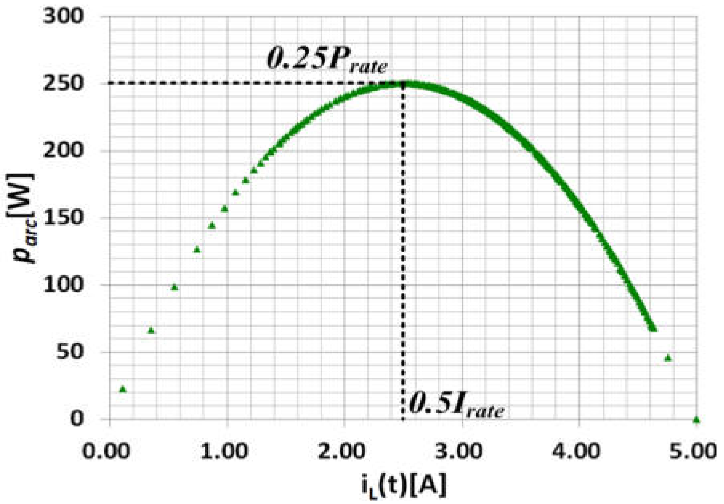
$$p_{\mathrm{arc}} = v_{\mathrm{arc}} \bullet i_{\mathrm{arc}} = V_{DC}\left(i_{\mathrm{arc}} - \frac{i_{\mathrm{arc}}^2}{I_{Load}}\right)$$

When,

$$i_{\mathrm{arc}} = I_{Load} - \frac{I_{Load}}{t_{exit}} \bullet t$$



[Arc voltage, current, and power(p_{arc}) worst case]

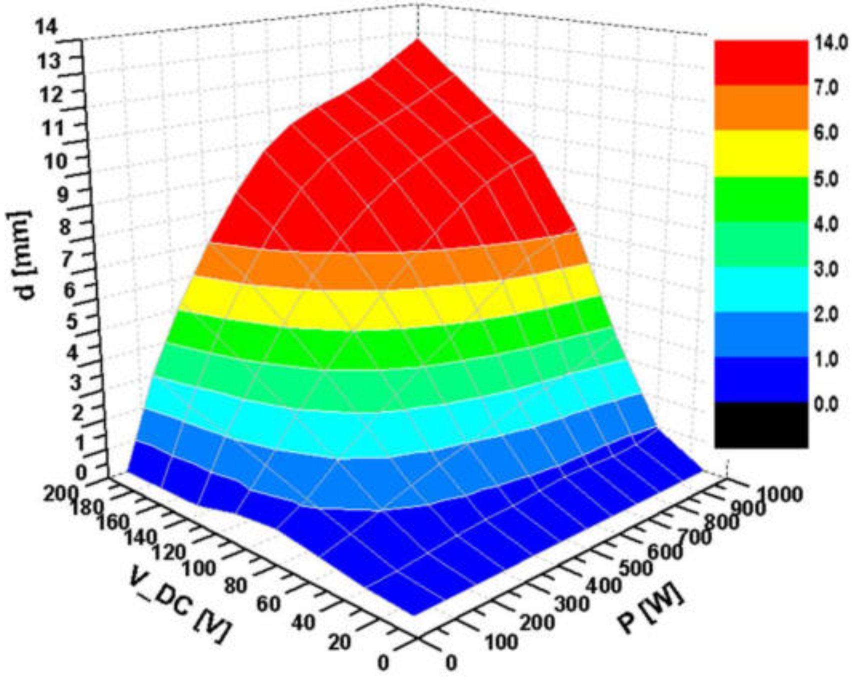


[Arc power(p_{arc}) graph against arc current(i_{arc})]

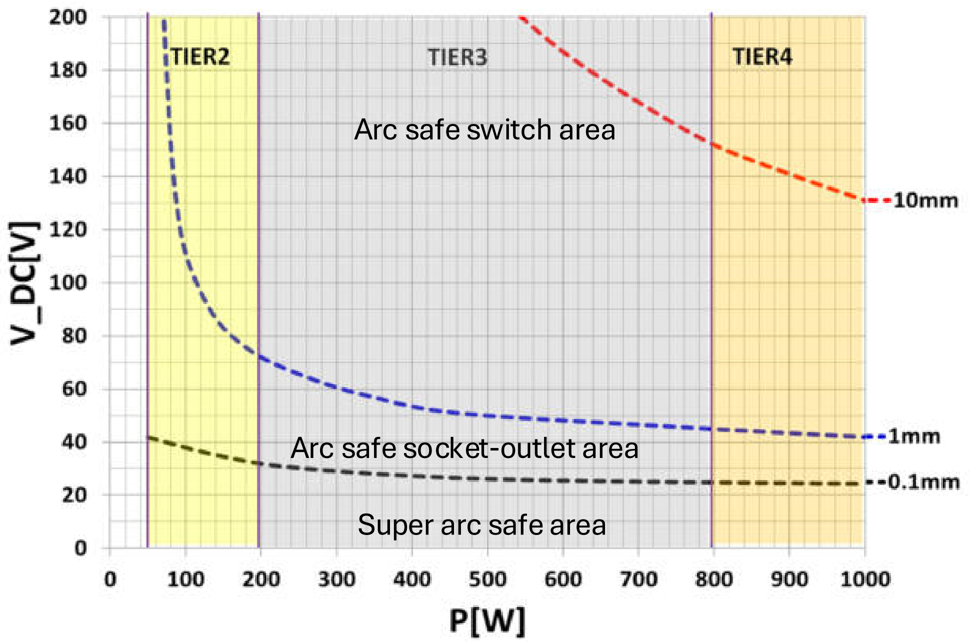
Break-arc energy in worst case,

$$W_{\mathrm{arc}} = \int_0^{t_{exit}} p_{\mathrm{arc}} \bullet dt = \frac{P_{rate}}{t_{exit}} \int_0^{t_{exit}} \left(t - \frac{t^2}{t_{exit}}\right) dt = \frac{1}{6} P_{rate} \bullet t_{exit}$$

Concept of arc-distance safe operation area



[Arc extinction distance graph according to supply voltage and load power]



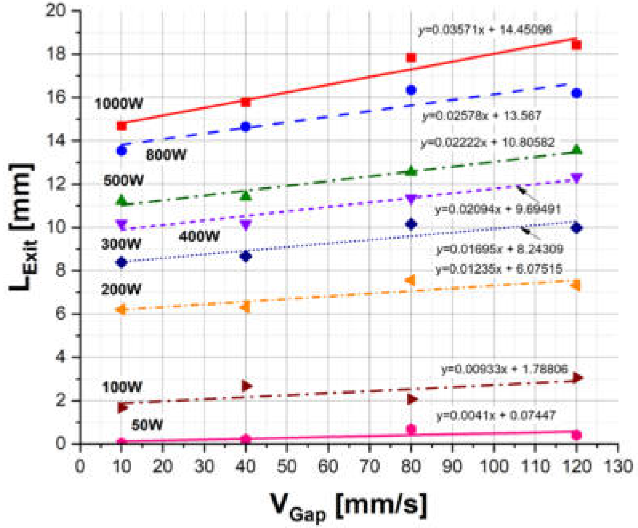
[The relation of supply voltage and load power level which maintains equal arc extinction distance in LVDC system]

II. Case 1: DC arc research

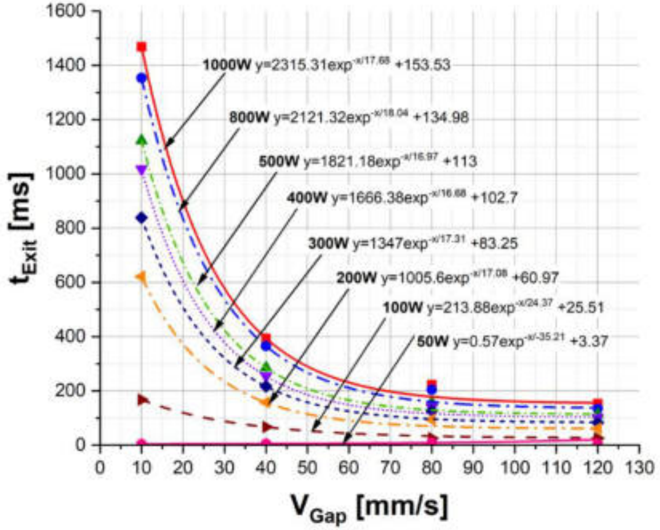
Series arc behavior along with gap speed

Experimental condition

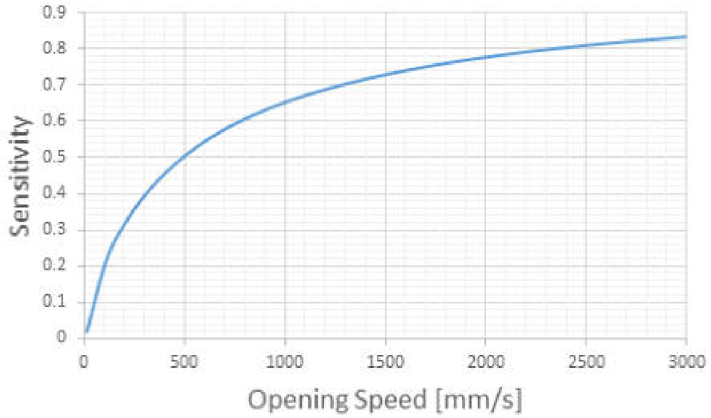
Supply Voltage [V]	25, 50, 100, 150, 200
Load Power [W]	50, 100, 200, 300, 400, 500, 800, 1000
Opening Speed, V_{Gap} [mm/s]	10, 40, 80, 120
Temparature [°C]	24 (±1)
Relative Humidity [%]	55 (±5)



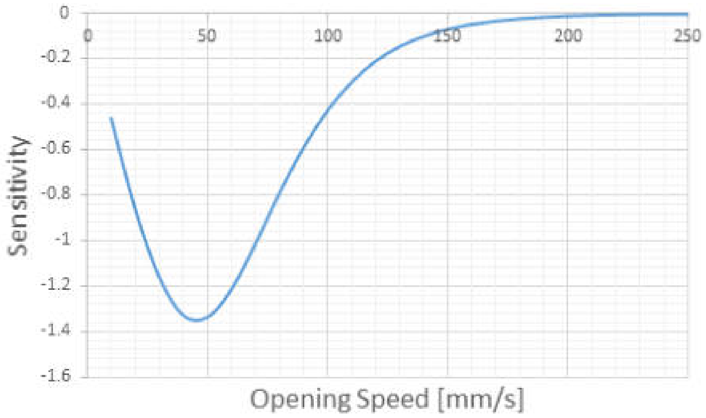
a) arc extinction distance



b) arc extinction time



c) Sensitivity arc extinction distance

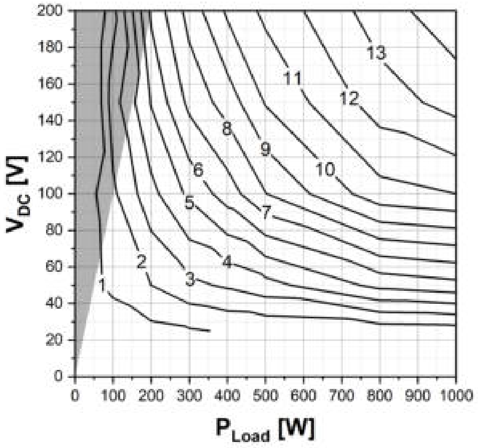


d) Sensitivity of arc extinction time

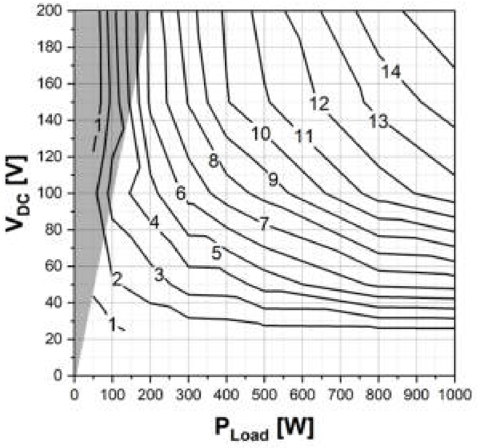
II. Case 1: DC arc research

Arc-distance safe operation area [mm]

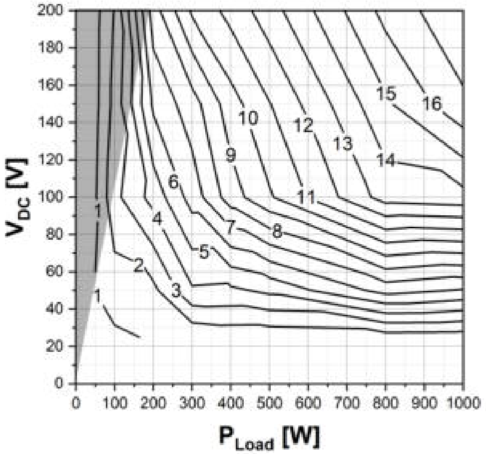
Arc distance < 2~3 mm



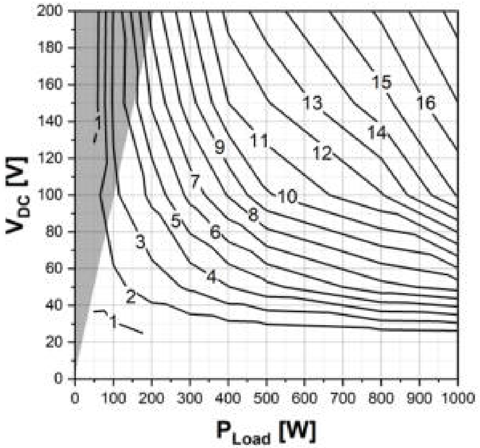
a) Moving speed = 10 mm/s



b) Moving speed= 40 mm/s



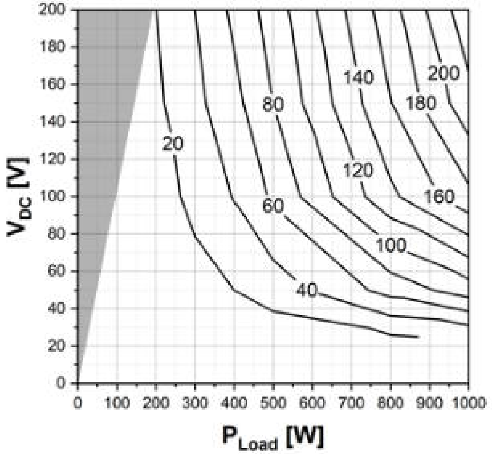
c) Moving speed = 80 mm/s



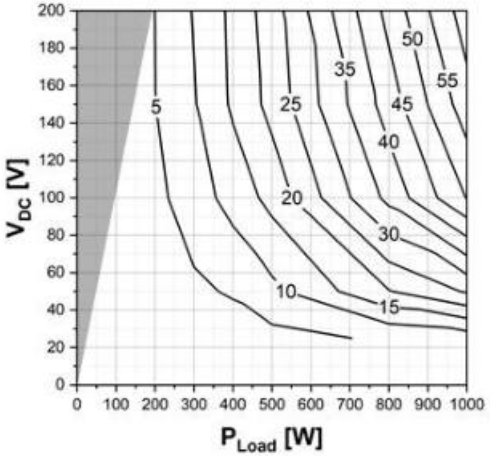
d) Moving speed= 120 mm/s

Arc-energy safe operation area [Joule]

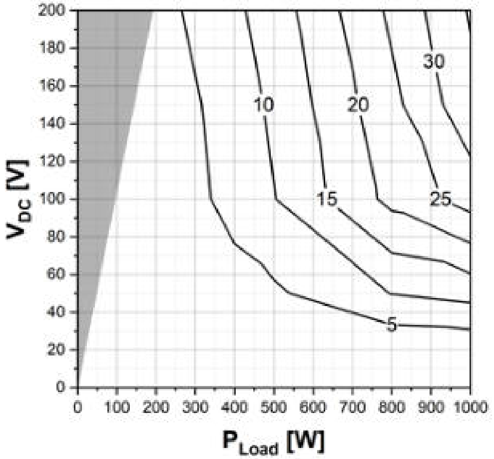
Arc energy < 250 Joule



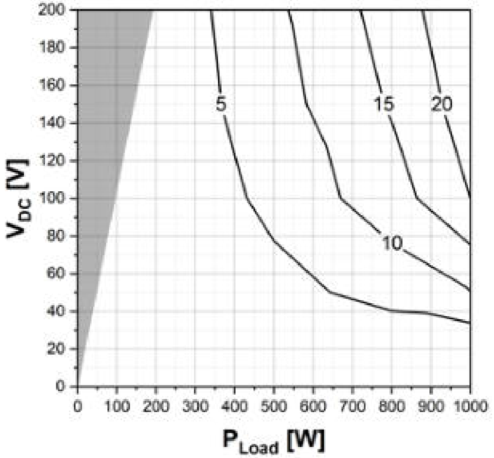
a) Moving speed = 10 mm/s



b) Moving speed= 40 mm/s



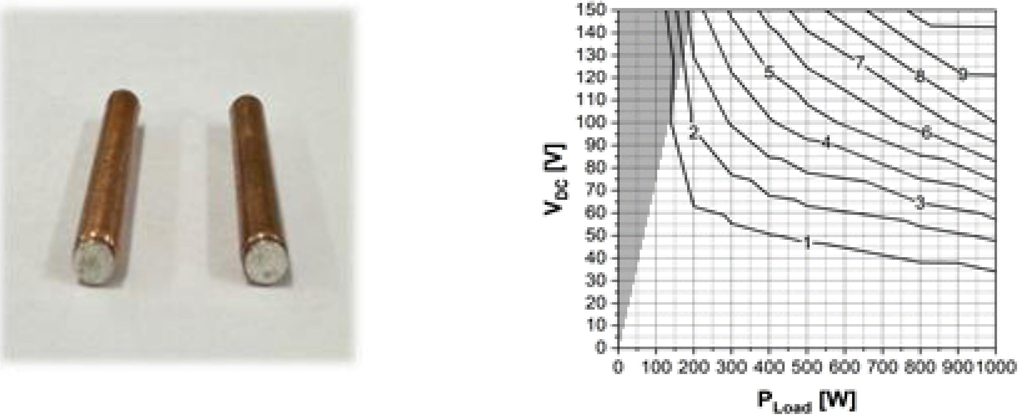
c) Moving speed = 80 mm/s



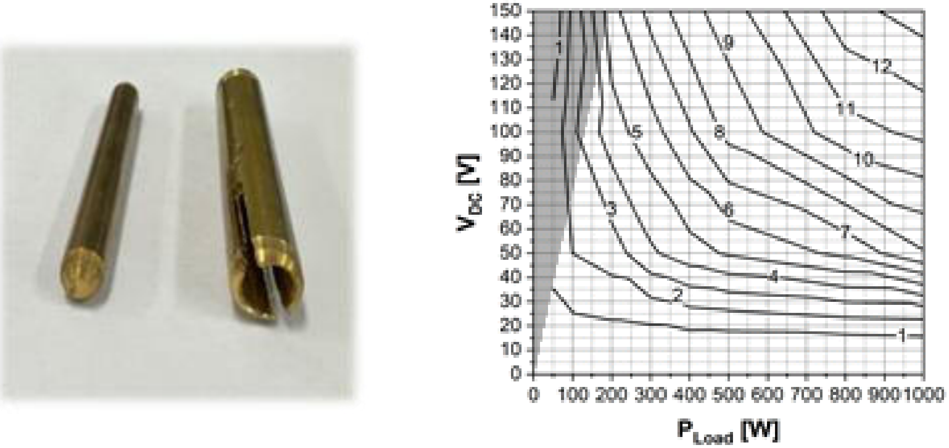
d) Moving speed= 120 mm/s

II. Case 1: DC arc research

Series arc behavior according to the electrode shape

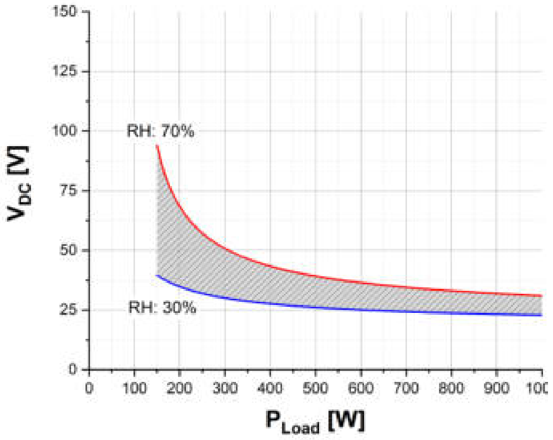


[normal contactor]

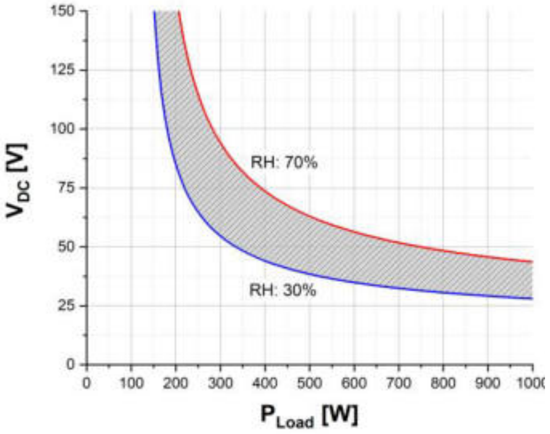


[socket-outlet & plug]

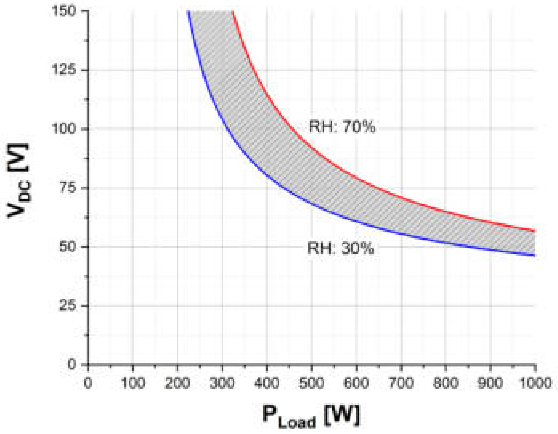
Series arc behavior along with humidity



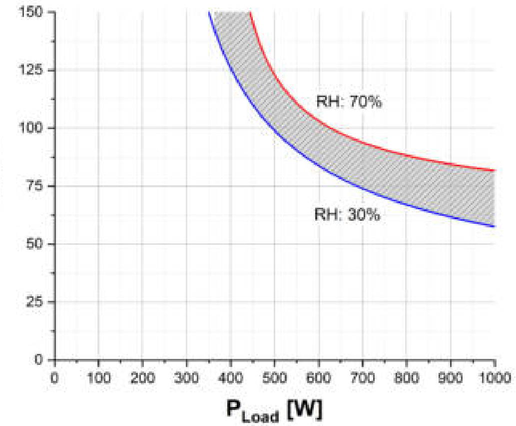
a) l_{exit} = 2mm



b)) l_{exit} = 4mm

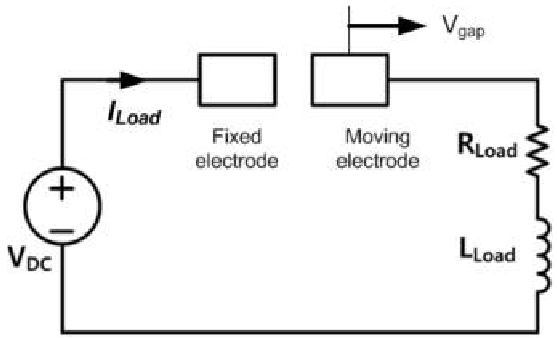


c) l_{exit} = 6mm



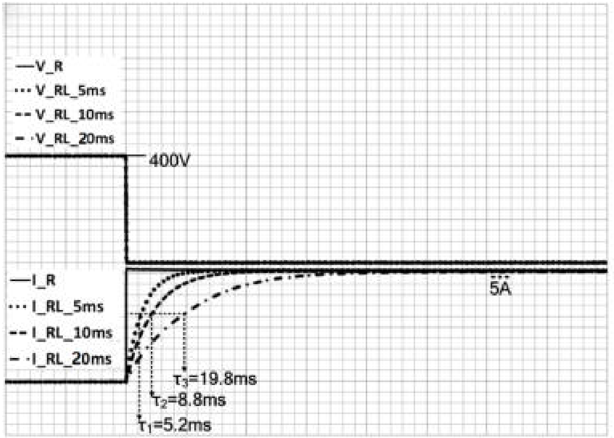
d)) l_{exit} = 8mm

Series arc characteristics on inductive load

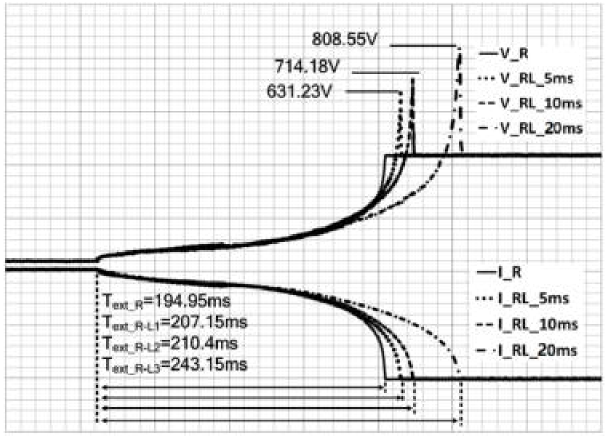


[power circuit concept]

[normal contact electrode]



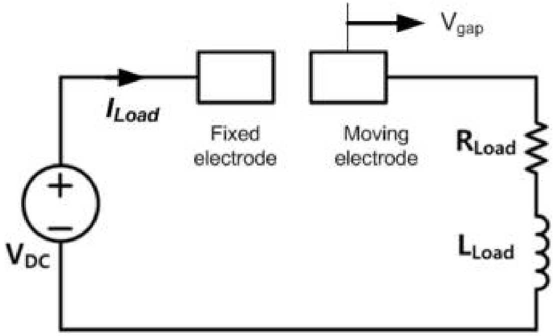
a) *Measure time constant during switch "on"*



b) Measure arc extinction time during switch "off"

II. Case 1: DC arc research

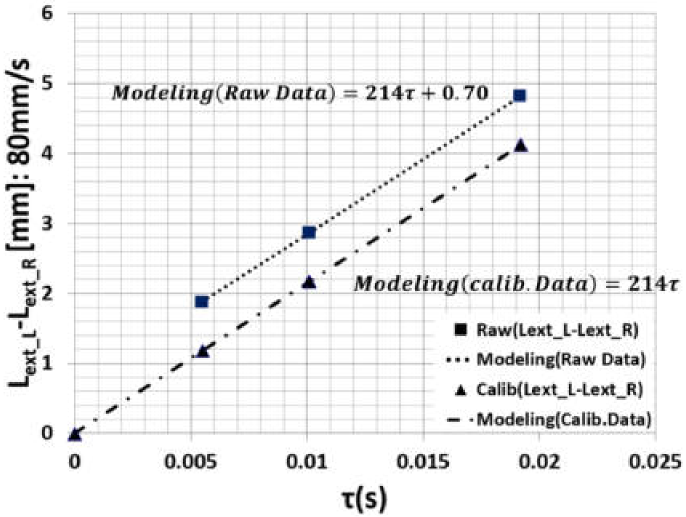
Series arc characteristics on inductive load



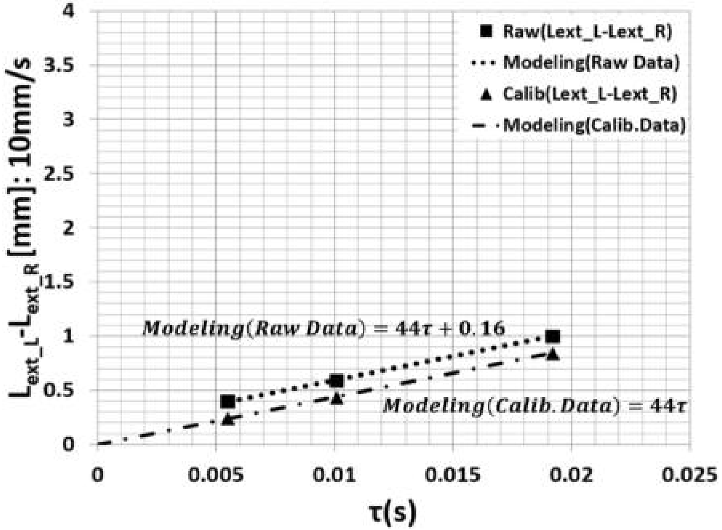
[power circuit concept]

[Experimental condition]

V_{DC} [V]	200, 400
P_{Load} [kW]	1, 2, 4
Time constant [ms]	5, 10, 20
Gap velocity [mm/s]	10, 80
Maximum gap distance [mm]	30
Inside the gap	Air



a) Gap speed of 80 mm/s



b) Gap speed of 10 mm/s

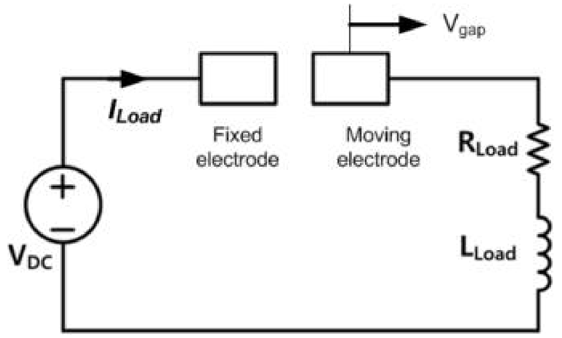
$$\Delta l_{ext\_80mm/s} = l_{ext\_L} - l_{ext\_R} = 214\tau$$

$$\Delta l_{ext\_10mm/s} = l_{ext\_L} - l_{ext\_R} = 44\tau$$

II. Case 1: DC arc research

APEC 2025 KOREA

Series arc characteristics on inductive load

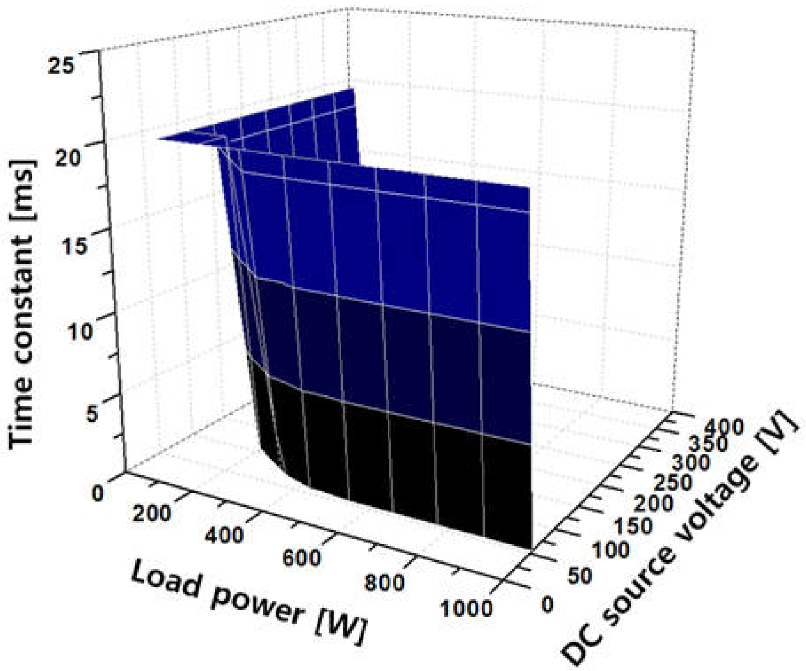


[power circuit concept]

[Experimental condition]

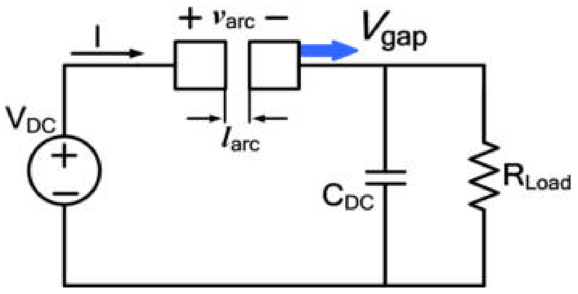
V_{DC} [V]	200, 400
P_{Load} [kW]	1, 2, 4
Time constant [ms]	5, 10, 20
Gap velocity [mm/s]	10, 80
Maximum gap distance [mm]	30
Inside the gap	Air

$$\Delta l_{ext\_10mm/s} = l_{ext\_L} - l_{ext\_R} = 44\tau$$



[Boundary surface of supply voltage – load power according to time constanat of inductive load where the breaking arc extinction distance is 2 mm and gap speed is 10 mm/s]

Series arc characteristics on capacitive load

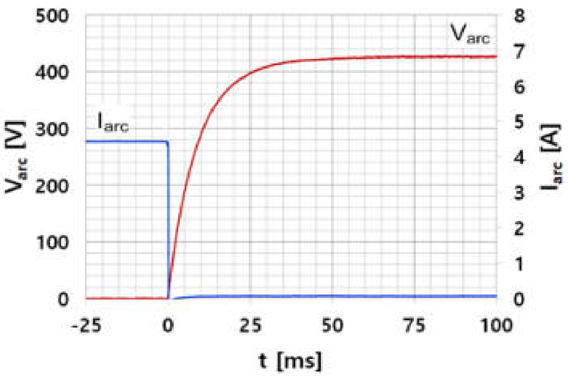


[power circuit concept]

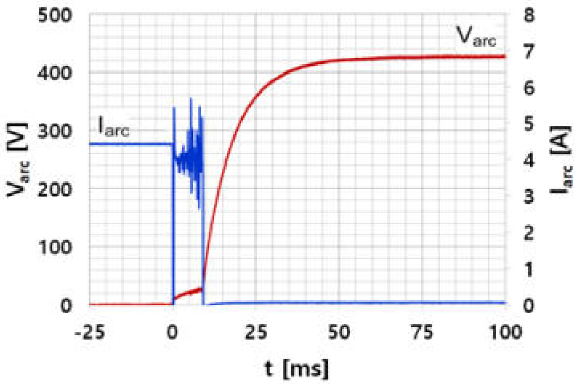
[normal contact electrode]

[Experimental condition]

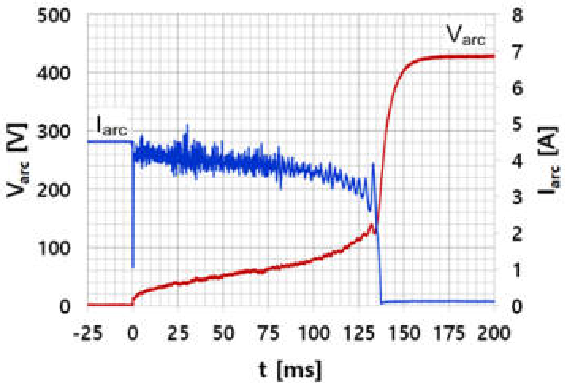
Supply Voltage [V]	50, 200, 400
Load Current [A]	1, 2, 4, 8, 12
Opening Speed [mm/s]	10, 123.5
Atmospheric conditions	Air



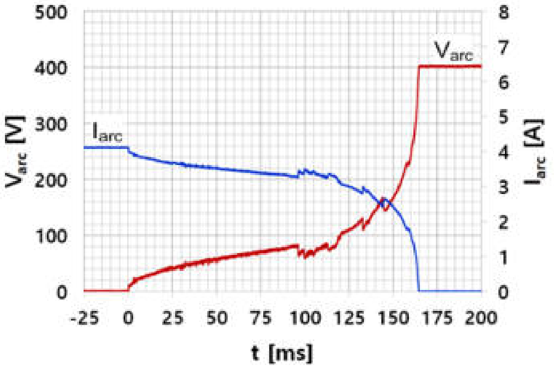
a) *No arc case*



b) Weak arc case



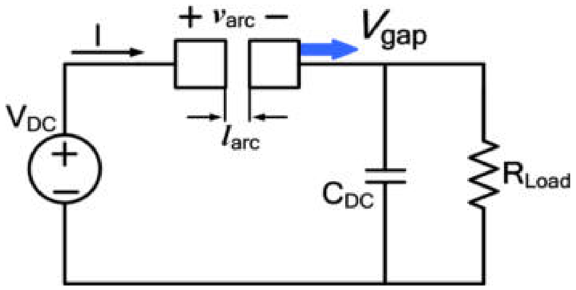
c) Strong arc case



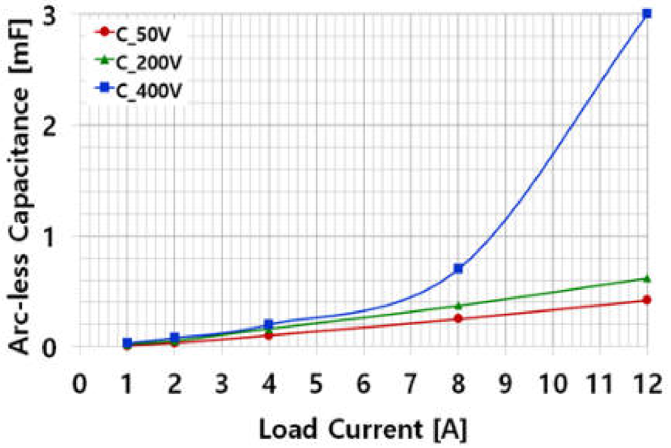
d) Pure resistive load

[Typical experiment waveforms]

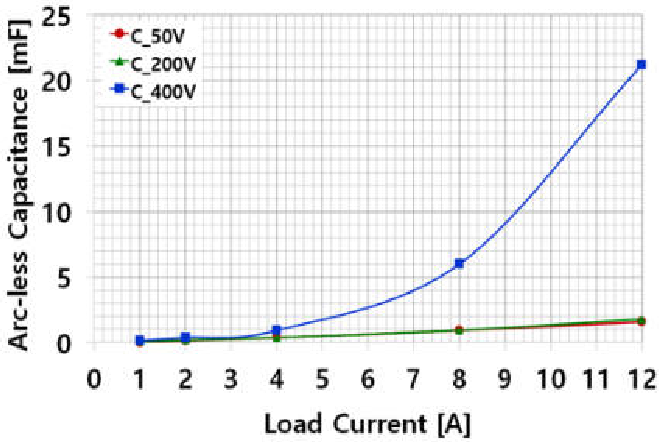
Arcless capacitance boundary



[power circuit concept]



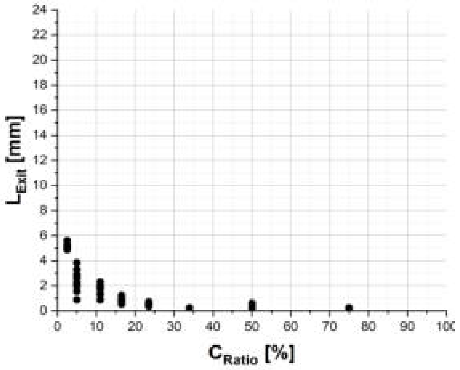
a) V_{gap} = 123.5 mm/s



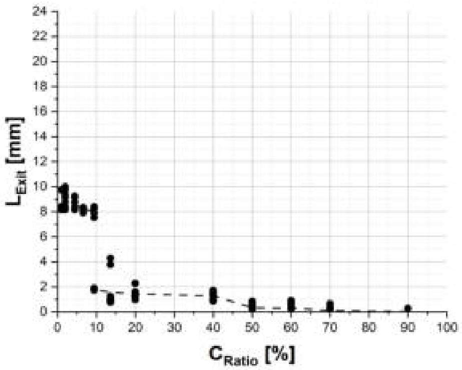
b) V_{gap} = 10 mm/s

[Arcless critical capacitance(C_{crit}) trend line graph according to load current]

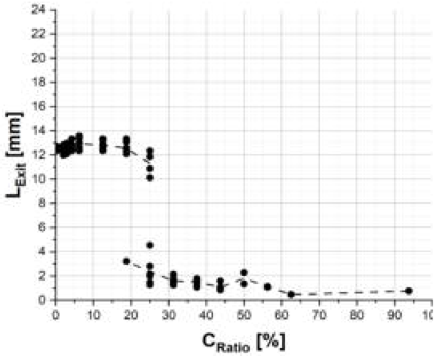
Chaotic characteristics on capacitive load ; bifurcation of arc extinction distance



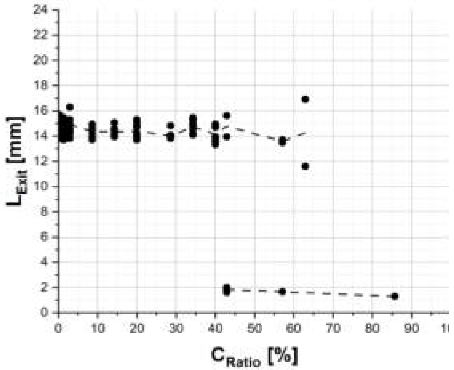
a) 200 V/1 A



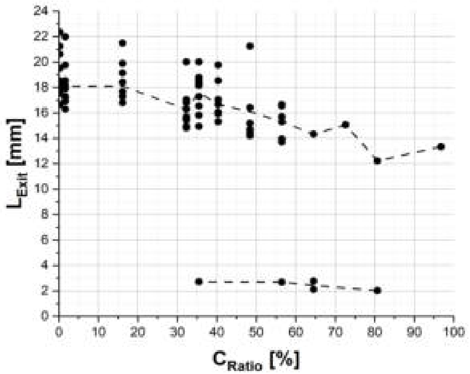
b) 200 V/2 A



c) 200 V/4 A



d) 200 V/8 A

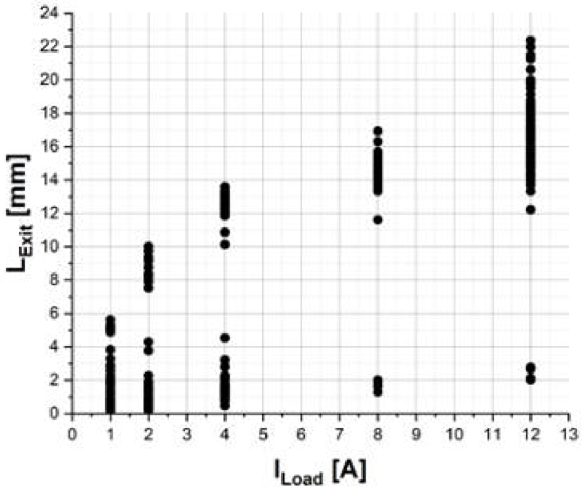


e) 200 V/12 A

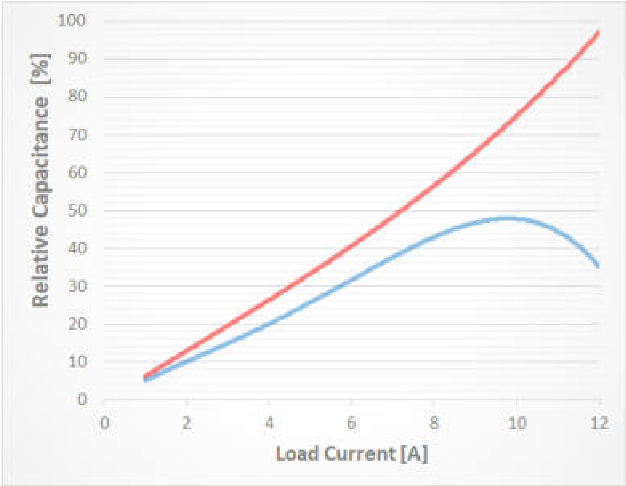
[Arc extinction distance according to relative parallel capacitance]

II. Case 1: DC arc research

Chaotic characteristics on capacitive load ; bifurcation on arc extinction distance



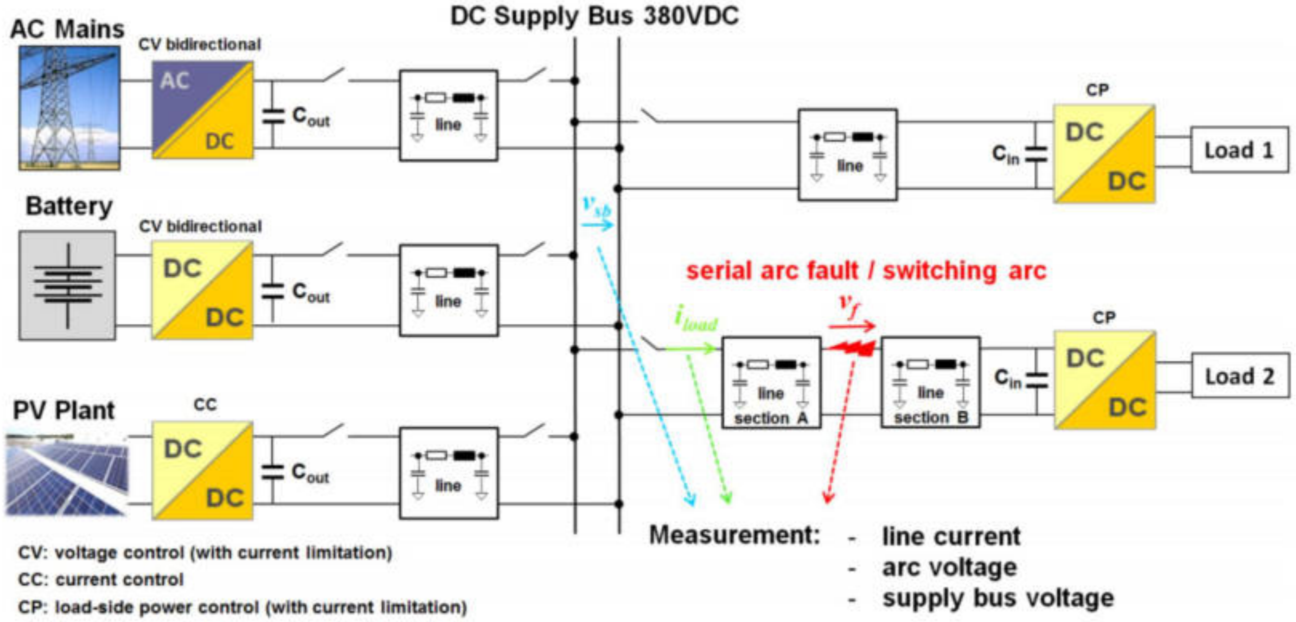
a) Arc extinction distance



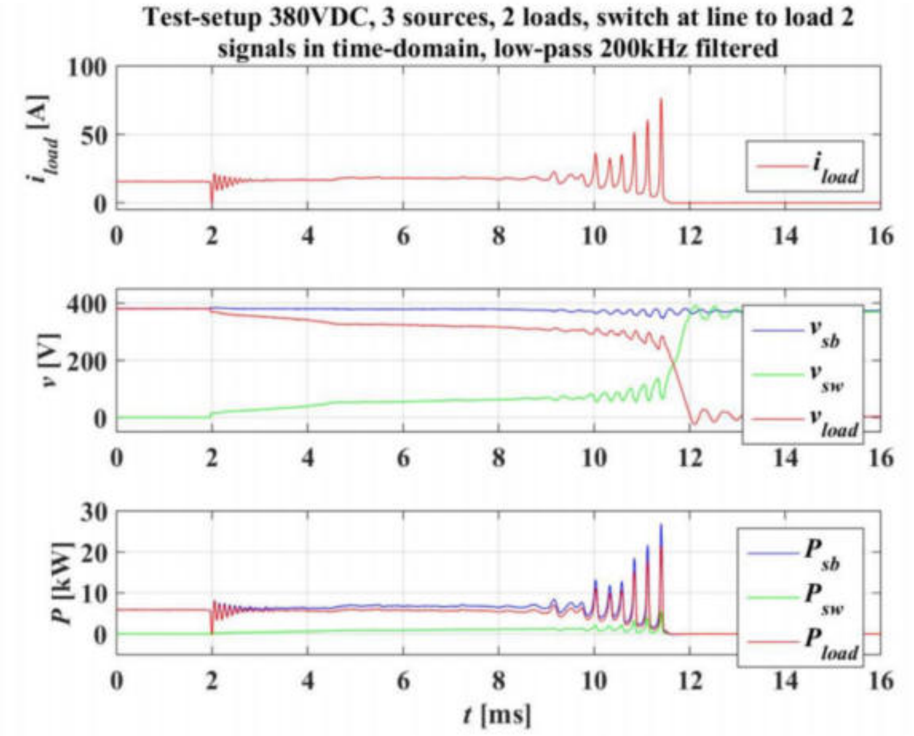
b) Bifurcation domain of parallel capacitance

[Bifurcation behavior of arc extinction distance according to relative parallel capacitance]

Resonance characteristics of capacitive load



[Power system description]



[resonance of break arc]

Standardization of DC series arc using brass electrodes

Scope | Structure | Projects / Publications | Documents | Votes | Meetings | Collaboration Platform

Work programme > Project: IEC TS 63603-1 ED1

en fr

Detail

Committee	Working Groups	Project Leader	Current Status	Frcst Pub Date	Stability Date
SyC LVDC	WG 1	Mr Hyosung KIM	ACD	2027-05	

History

Stage	Document	Downloads	Voting Result	Decision Date	Target Date
prePNW				2024-03-21	
PNW	SyCLVDC/146/NP	2599 kB	APPROVED	2024-03-22	
PRVN				2024-06-14	2024-06
ACD	SyCLVDC/158/RVN	73 kB 723 kB		2024-08-16	2025-03
CD					2025-03

Project

IEC TS 63603-1 ED1

Arc Hazards and Safety in LVDC - Part 1: Series arc characteristics between brass electrodes

Initial Project Plan

Committee	Enquiry	Approval	Publication
2025-03-19		2026-11-20	2027-05-19

Up-to-date Project Plan

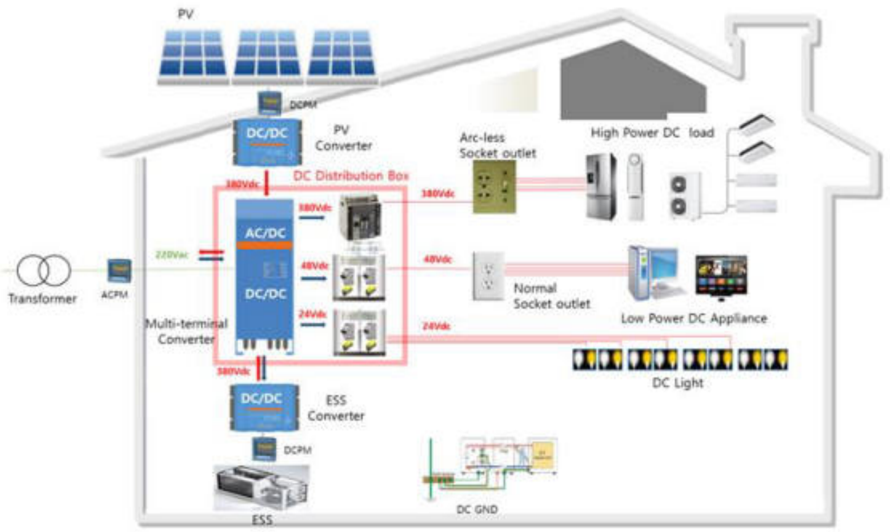
Committee	Enquiry	Approval	Publication
2025-03-19		2026-11-20	2027-05-19

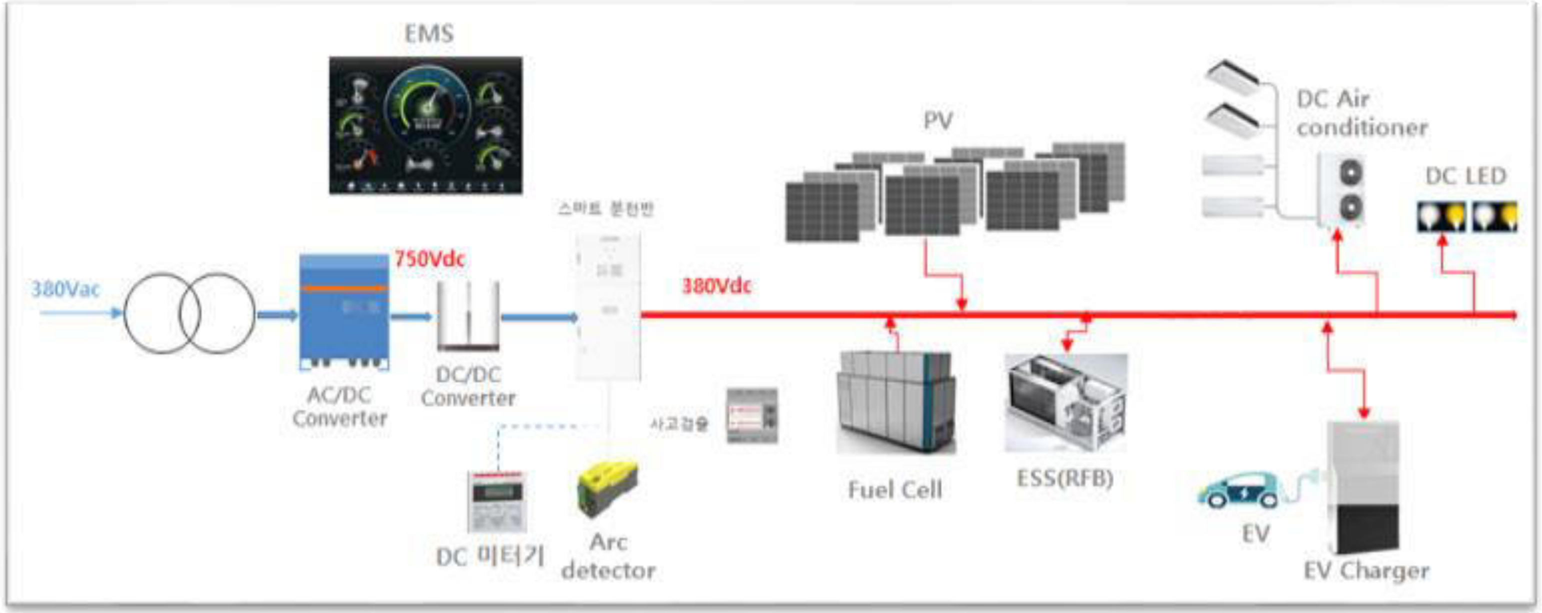
II. Case 2: Consumer-side LVDC system research

Proposed architecture & scope

- Residential houses and commercial buildings

- **Site Name**: Next-Generation LVDC System Demonstration Site
- **Location**: Research Building of the Korea Electronics Technology Institute (KETI), Gwangju Metropolitan City





II. Case 2: Consumer-side LVDC system research

1. AC/DC converter for power quality simulation

- **Function**
  - Power quality simulation : Sag, Swell, Instantaneous interruption, Voltage ripple, Over voltage, Under voltage
  - Current limiting in case of short circuit
- **Specification**
  - Input : 380Vac, Output : 750Vdc, Capacity : 500kW
  - 3-Level NPC topology
  - Current limiting 1,000A, Current limiting time 1s

[AC/DC Converter]

2. Multi channel DC/DC converter

- **Function**
  - DC Power supply
  - ESS connection
  - PV connection
- **Specification**
  - Input voltage : 750Vdc±5%, Capacity : 20kW Efficiency: 98%
  - 4 Channel
    - o Output(2 channel) : 380Vdc(5kW, 2channel)
    - o ESS : 50Vdc(3kW)
    - o PV : 300V~380Vdc(5kW)

[Multi channel converter prototype]

II. Case 2: Consumer-side LVDC system research

3. DC swithes for consumer

- **Function**
  - Branch circuit On/Off
  - Overcurrent and short-circuit current protection

- **Specification**
  - Input voltage : 380Vdc, Rated current: 10A
  - Operation time : 18us ↓

[Prototype]

4. DC leakage current circuit breaker

- **Function**
  - Protection for electric shock and leakage current
  - Overcurrent protection
  - AUX output
    (smart distribution panel status display)

- **Specification**
  - DC380V, 20A, 1kA
  - Rated sensitivity current 15mA

[Current sensor]

[Prototype]

[DC distribution panel]

II. Case 2: Consumer-side LVDC system research

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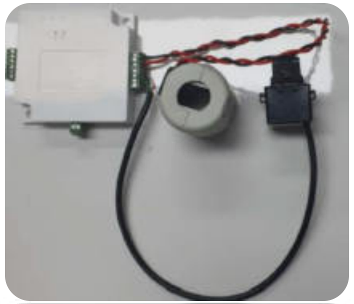
5. DC arc detection device

- **Function**
  - DC arc fault detection and blocking
  - Arc status monitoring

- **Specification**
  - DC arc fault detection time : 200ms ↓
  - 380V DC 35A (Sensor all-in-on DC arc detection device)
  - 380V DC 100A
  - Branch circuit arc fault detection
  - Integrated DC sensor and high frequency sensor

[380V DC 35A]



[380V DC 100A]

6. DC circuit breaker, DC Plug, DC S/W

- **Function**
  - No-arc operation

- **Specification**
  - Rated V, I for DC circuit breaker : 440Vdc, 50/100A
  - Rated V, I for plug : 400Vdc, 10/16A
  - Rated V, I for S/W : 400Vdc, 10A

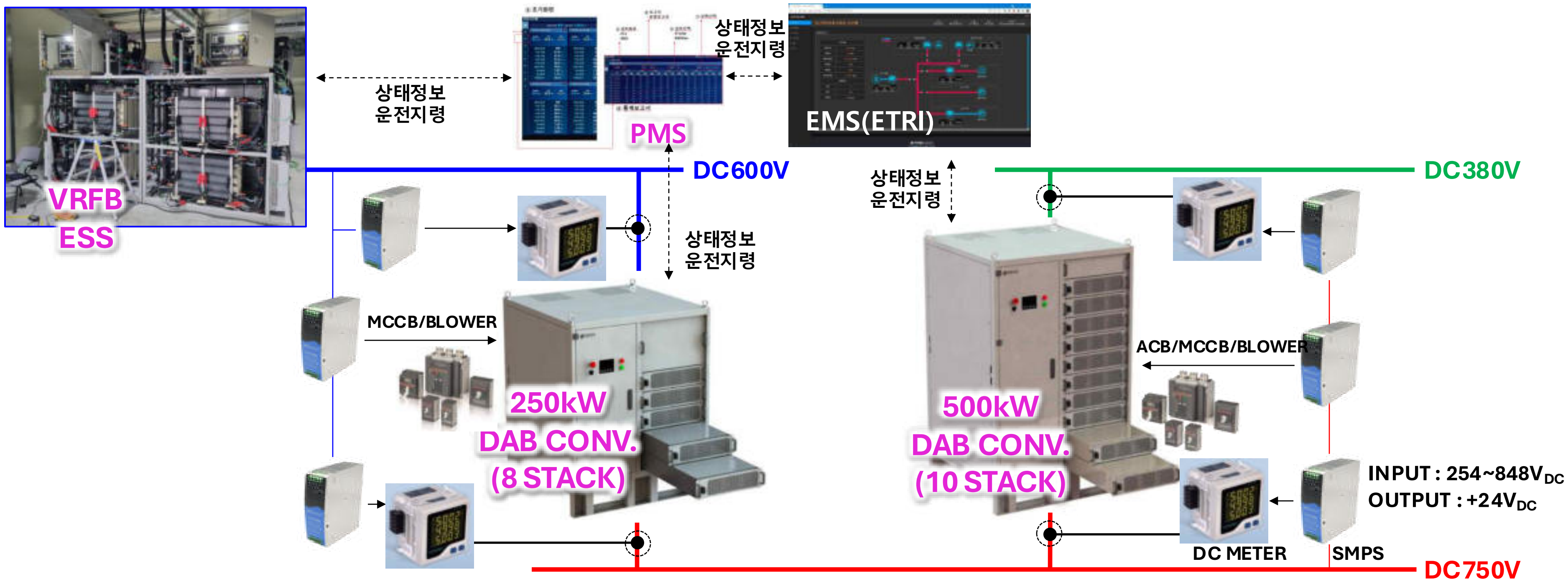
II. Case 2: Consumer-side LVDC system research

7. 250kW DAB converter for ESS

- **Function**
  - Charging&Discharging connected to DC distribution
  - Stand-alone operation during blackout
  - Droop control
- **Specification**
  - Input : 750V_{DC}, Output : 600V_{DC}
  - Capacity : 250kW (32kW * 8STACK)

8. 500kW DAB converter for DC distribution

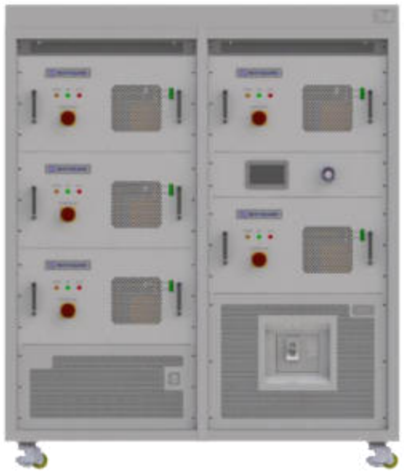
- **Function**
  - DC power supply to the customer
  - Temporary current limitation in case of short circuit fault
  - Droop control
- **Specification**
  - Input V : 750V_{DC}, Output V : 380V_{DC}
  - Capacity : 500kW (50kW * 10 STACK)



II. Case 2: Consumer-side LVDC system research

9. PV Converter

- **Function**
  - DC distribution connection
- **Specification**
  - Input V: 470Vdc, Output V : 750Vdc
  - Input Range : 290Vdc~ 580Vdc
  - Capacity : 250kW (50kW * 5STACK)

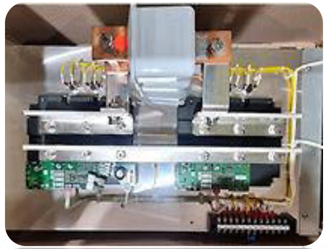


[DC/DC converter prototype]

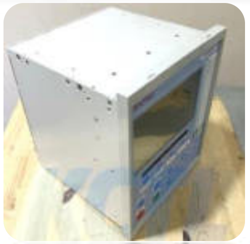
10. DC Micro Grid circuit breaker

- **Function**
  - DC Micro-grid system fault protection
  - DC Micro-grid system measurement, protection and communication functions
  - High speed breaking 10ms
- **Specification**
  - Rated V : 1000Vdc
  - Rated breaking current : ~ 10kA
  - Breaking time : 10ms ↓

[500/250kW Hybrid circuit breaker]



[50kW Semiconductor circuit breaker]



[Relay for DC circuit breaker}

[Distribution for DC Grid]

II. Case 2: Consumer-side LVDC system research

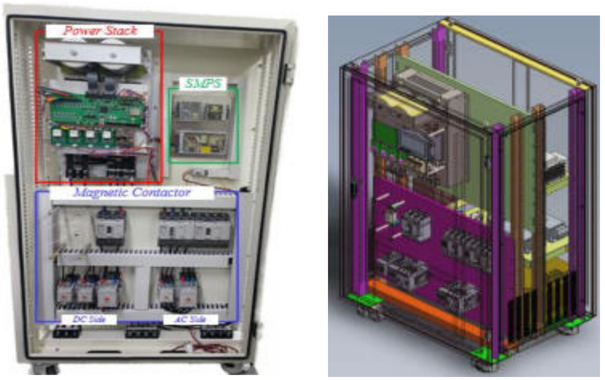
11. DC-PQM

- **Function**
  - Power quality measurement for DC distribution
    → Over Voltage, Voltage Sag, Voltage Swell, Voltage Ripple
    Instantaneous Interruption
  - Fault detection for DC distribution and
    GPS time synchronization
- **Specification**
  - Voltage measurement range : 100V – 1,000V
  - Current measurement range : 0A – 1,500A

[DC-PQM and PQM server system]

12. Interlinking converter

- **Function**
  - Interconnection of AC and DC grid
  - 3phase 380Vac output / Voltage balancing control
  - 750Vdc output / DC voltage control



[Interlinking converter prototype]

II. Case 2: Consumer-side LVDC system research

APEC 2025 KOREA

Power quality assesment

DC Power Grid Power Quality

Nominal Voltage (V_n)	750V ± 75V ($0.9V_n \le V \le 1.1V_n$)	• Rated Voltage : 750 V (=V_n) • Operating Voltage Range : 675V ≤ V ≤ 825V ($0.9V_n \le V \le 1.1V_n$)
Voltage sag	$0.8V_n \le V < 0.9V_n$ • 600V ≤ V < 675V • t < 1min	• Sag Range : 600V ≤ V < 675V ($0.8V_n \le V < 0.9V_n$) • Duration : 1min ↓ • Fault: 1min ↑
Voltage swell	$1.1V_n < V \le 1.2V_n$ • 825V < V ≤ 900V • t < 1min	• Swell Voltage Range : 825V < V ≤ 900V ($1.1V_n < V \le 1.2V_n$) • Duration : 1min ↓ • Fault : 1min ↑
Over-voltage	$V > 1.2V_n$ • V > 900V • Trip when detected	• Over voltage Range : V > 900V ($V > 1.2V_n$) • Duration : - • Fault : Overvoltage detection immediately
Voltage ripple	Vripple < ±2.5%	• Voltage ripple Range : 731.25V ≤ V ≤ 768.75V ($0.975V_n \le V \le 1.025V_n$) • Maintain normal operation as long as the voltage ripple does not exceed the range • Fault after 10 seconds if voltage ripple is out of ranges
Instantaneous Interruption	500ms ↓	• Stop immediately

Power quality of customer

- Voltage Range : 380Vdc±5%
- Voltage Ripple : 1% ↓

II. Case 2: Consumer-side LVDC system research

Demonstration & test site

[2층 시험전경]

II. Case 2: Consumer-side LVDC system research

APEC 2025 KOREA

LVDC Standards for Private Sector in Korea

STD. No.	Title	Propose
SPS-KETI-C0001	Electrical Safety Requirements for Low Voltage DC Consumers	KETI
SPS-KETI-C0002	Test Methods for DC Plugs and Socket-outlets for DC Consumers	KETI
SPS-KETI-C0003	Electrical Test Methods for Arc-Free DC Wall Switches for DC Consumers	KETI
SPS-KETI-C0004	Test Methods for DC Circuit Breakers for DC Consumers	KETI
SPS-KETI-C0005	Test Methods for DC Leakage Circuit Breakers for DC Consumers	KETI
SPS-KETI-C0006	Test Methods for DC Branch Circuit Switches for DC Consumers	KETI
SPS-KETI-C0007	Test Methods for DC Distribution Boards for DC Consumers	KETI
SPS-KETI-C0008	Test Methods for DC Power Conversion Devices for Low-Voltage DC Distribution System Integration	KETI
SPS-KETI-C0009	Test Methods for Arc Fault Detection Devices for Low-Voltage DC Consumers	KETI
SPS-KETI-C0010	Test Methods for Power Conversion Devices for Medium and Large Energy Storage Systems in LVDC Distribution Networks	KETI
SPS-KETI-C0011	Performance Test Methods for Power Quality Measurement Devices in LVDC Distribution Systems	KETI
SPS-KETI-C0012	Test Methods for Hybrid and Semiconductor High-Speed DC Circuit Breakers for LVDC Distribution Systems	KETI
SPS-KETI-C0013	Test Methods for Power Conversion Devices in DC Distribution Systems for Supplying Power to AC Consumers	KETI
SPS-KETI-C0014	Test Methods for Power Conversion Devices for LVDC Building Loads	KETI
SPS-KETI-C0015	Test Methods for Medium-Scale Solar Power Conversion Devices in LVDC Distribution Networks	KETI

Bloomenergy®

Microgrid solutions of Bloom Energy

Inki Choi

First Senior Officials Meeting, 2025: APEC Energy Working Group 69
Feb. 2025
Gyeongju, Republic of Korea

Agenda

1. Bloom Energy
2. Bloom’s Portfolio Tree
3. Bloom’s Solutions
4. Cast study

Inki Choi

Senior Manager, Strategy & Marketing

2025-Present, Senior Manager, Strategy & Marketing, Bloom Energy, Korea

2016-2024, Business Strategy/Sales/Project Management Manager, KC Cottrell, Korea

2011-2015, Strategic Planning Analyst/Engineer, DB Group (Formerly Dongbu Group), Korea

2007-2010, M.S in Aerospace engineering, California Institute of Technology, USA

1998-2006 B.S. in Mechanical engineering, Seoul National University, Korea

1. Bloom Energy_1) Overview

Bloomenergy

Bloom Energy at a glance

Mission: To make clean, reliable energy affordable for everyone in the world.

$1.3B
2023 Revenue

32B kWh
Produced without combustion

>1.2GW
Deployed

990+
Installations

$12B
Backlog

>$1B
Cumulative R&D

1. Bloom Energy_2) Customers

Bloomenergy

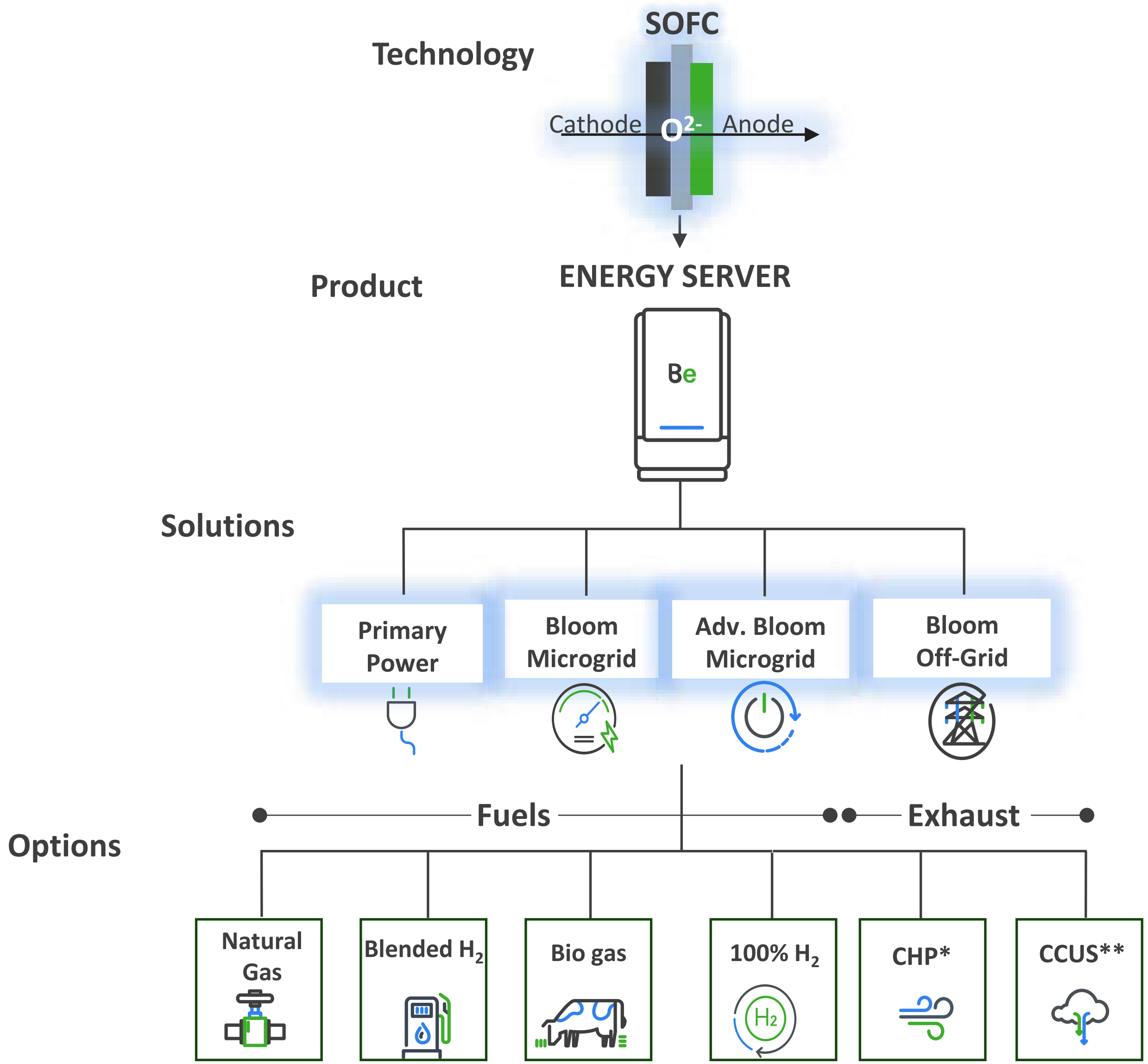
Market Segments Served

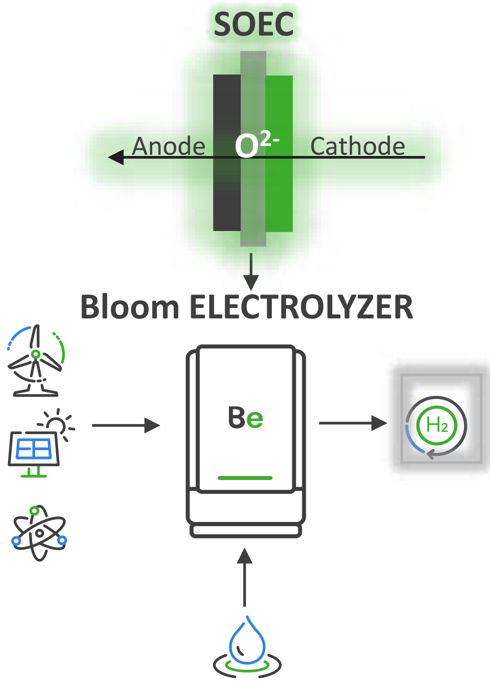
Diverse customer ecosystem with Fortune 500 customers

Segment	Customers
Cloud Services & Technology	Google, Equinix, SoftBank, IBM, Cyxtera, Intel, Extreme, Oracle, Nokia Connecting People, Adobe, LinkedIn, Microsoft, II-VI, Digital Realty, CoreSite
Consumer Retail, Food & Beverage	Walmart, Ahold Delhaize, The Coca-Cola Company, Kellogg's, Safeway, Taylor Farms, FedEx, URBN, Staples, Macy's, IKEA, Williams-Sonoma, Inc., Americold, Target, The Home Depot, the Wonderful company, Pacific Cheese, Macerich, ramar foods international, TJX
Telecom, Media, & Entertainment	Cox Enterprises, Comcast, AT&T, Verizon, kt, Gillette Stadium, crypto.com Arena, nxtra by airtel
Manufacturing	Keysight Technologies, Sanmina, Owens Corning, JSR Micro, cefla, Xilinx, GF, flex, TaylorMade, StanleyBlack&Decker
Biotech & Pharma	Genentech (A Member of the Roche Group), Medtronic, ThermoFisher Scientific, BioMed Realty, Takeda, BD, Gilead, illumina, Regeneron, Agilent Technologies
Energy & Utilities	American Electric Power, PG&E, KOWEPO Korea Western Power Co., Ltd., KOSPO, KHNP, delmarva power (An Exelon Company), SK, Korea East-West Power Co., Ltd., KOEN 한국남동발전 Korea Energy, KOMIPO

2. Bloom's Portfolio Tree

Bloomenergy





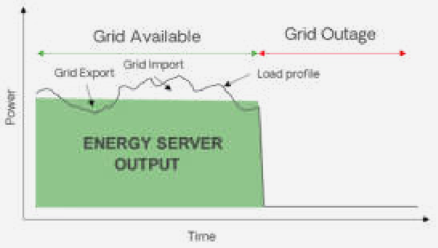
*. Combined Heat & Power
**. Carbon Capture, Utilization & Storage

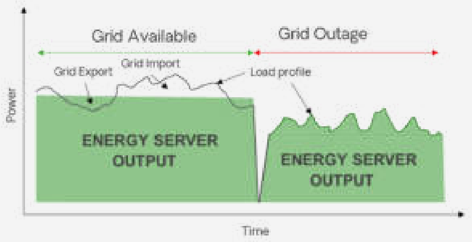
3. Bloom's Solutions

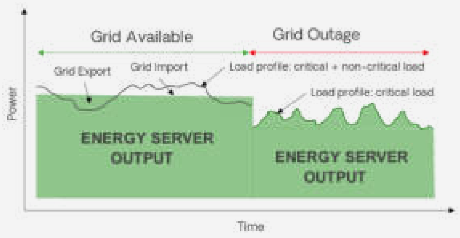
Bloomenergy

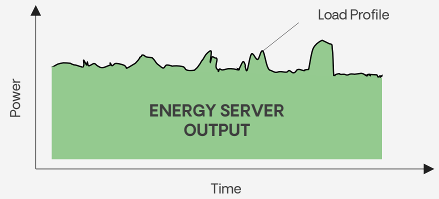
	Primary Power	Bloom Microgrid	Advanced Bloom Microgrid	Bloom Off-Grid
Value Proposition	**Baseload Power** Low cost, clean, onsite	**Resilient Power** Power through grid outages	**Uninterrupted Power** Premium power quality	**Load-Following Power** Premium power quality

Profile Schematic

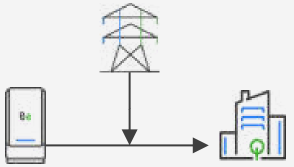


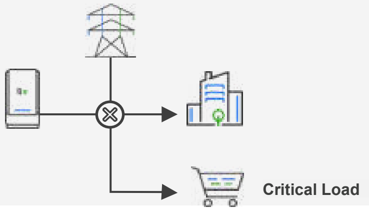


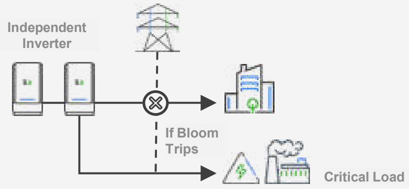


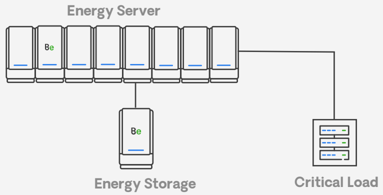


Architecture









Use Case

EIP Energy & Innovation Park, New Britain

STOP & SHOP

California Institute of Technology

Quanta Computer

4. Case Study

Bloomenergy

Parent Organization	Location	Industry	Bloom Installation
California Institute of Technology (Caltech)	Pasadena, CA, USA	Colleges & Universities	4.2 MW across 5 sites on campus with Advanced Bloom Microgrid

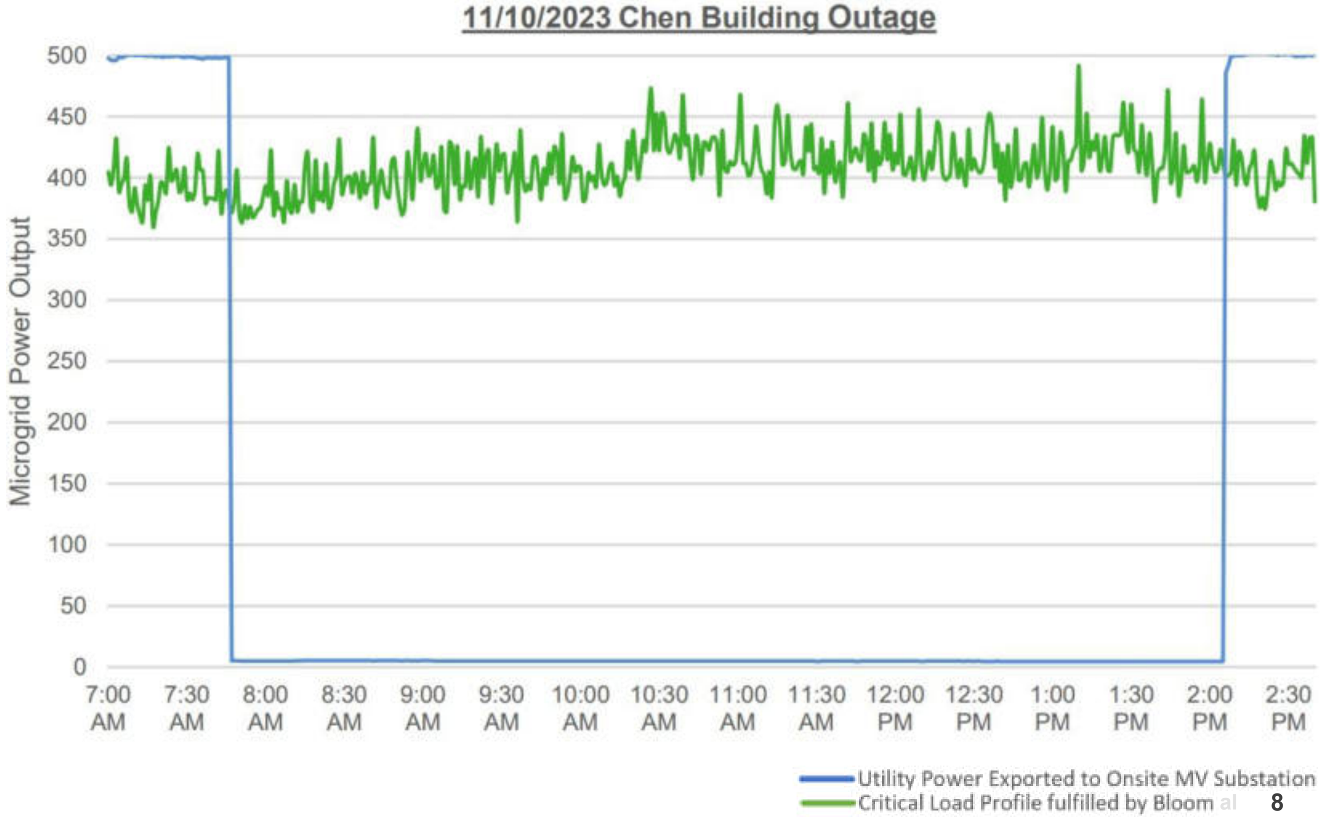
Milestones

2009	2015-2019	2021…
First Installation 1MW Primary Power	Additional 2MW Primary Power	Additional 1.2MW Advanced Bloom Microgrid

Sustainability Metrics for the 1.2MW Microgrid

Metrics	Since 2021 (– Nov. 2023)
Avoided Downtime	4 Outages; ~6.5 Hours
Longest Outage Duration	~6 Hours
CO_2 Reduction (lbs.)	11,157,176
Total kWh Delivered	40,780,106
Gallons of Water Saved per MWh	2,304

Power Supply through a Utility Outage



Successes and Challenges to Investment

Santiago Barcón
PQ Barcon
Mexico

Contents

- Mexico
- Challenges
- Opportunities

Mexico

- Most of the Systems installed had been AC
- Little coordination between state agencies and the state-owned utility CFE
- Before the Energy Reform in 2014 CFE was in charge and decided how to install the rural electrification systems
- But even before that States won the “right” to participate and the process became cumbersome and, in some cases, aimed to win votes
- AC systems are more familiar and spare parts, mainly motors, easily available

Challenges

- Demonstrate that DC systems are better in the long run, even in some cases more expensive
- Train young engineers in the DC systems installation procedures and operation
- Built at least 10 projects in different areas
- Get finance at good interest rates (loans in Mexico are at 15 % when inflation is at 4 %)
- Find 9nsurance mechanisms

Opportunities

- Use Academia to develop short and easy to understand installations
- Show success histories from other economies
- Local integration of DC inverters
- Create network of service centers
- Tie x % of home distributed generation saving to rural dc systems
- BESS
- 100 % tax deduction for donated DC systems

Session 4:
Case Studies on Small Island Microgrids, Flexible DC Power Systems, and Renewable Energy Integration

Isolated Community PV/Biogas Microgrid

Asst. Prof. Dr. Hathaithip Sintuya
Asst. Prof. Dr. Worajit Setthapun
Assoc. Prof. Dr. Wattanapong Rakwichian

The APEC Workshop on Driving Trade & Investment for DC Power Systems and Microgrid Frameworks Through Public Policy Alignment
Feb 24-25, 2025
Hwabaek Convention Center (HICO), Gyeongju, Republic of Korea

adiCET - Chiang Mai World Green City

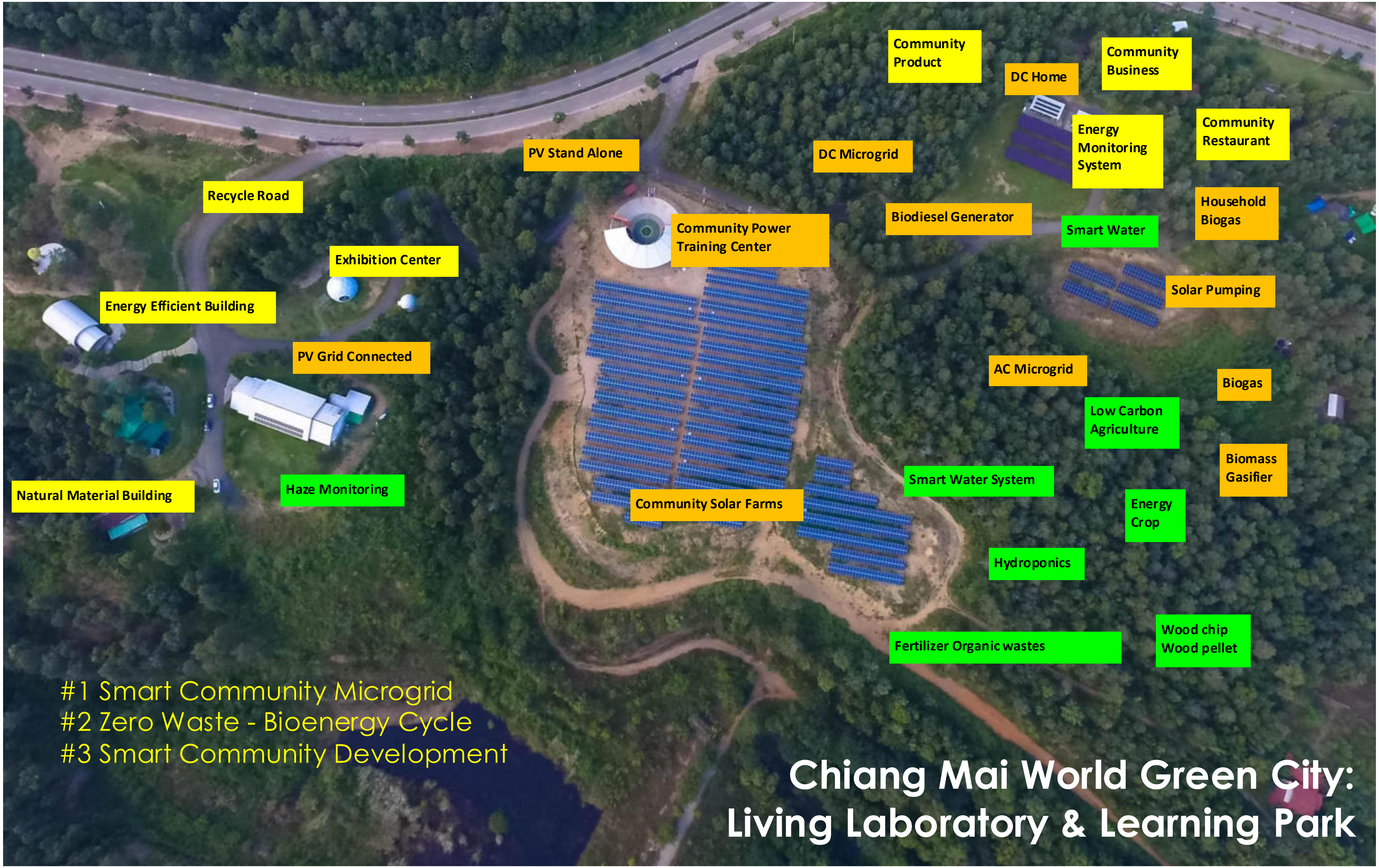
Chiang Mai Rajabhat University

Mae Rim Green Campus, Chaing Mai, Thailand

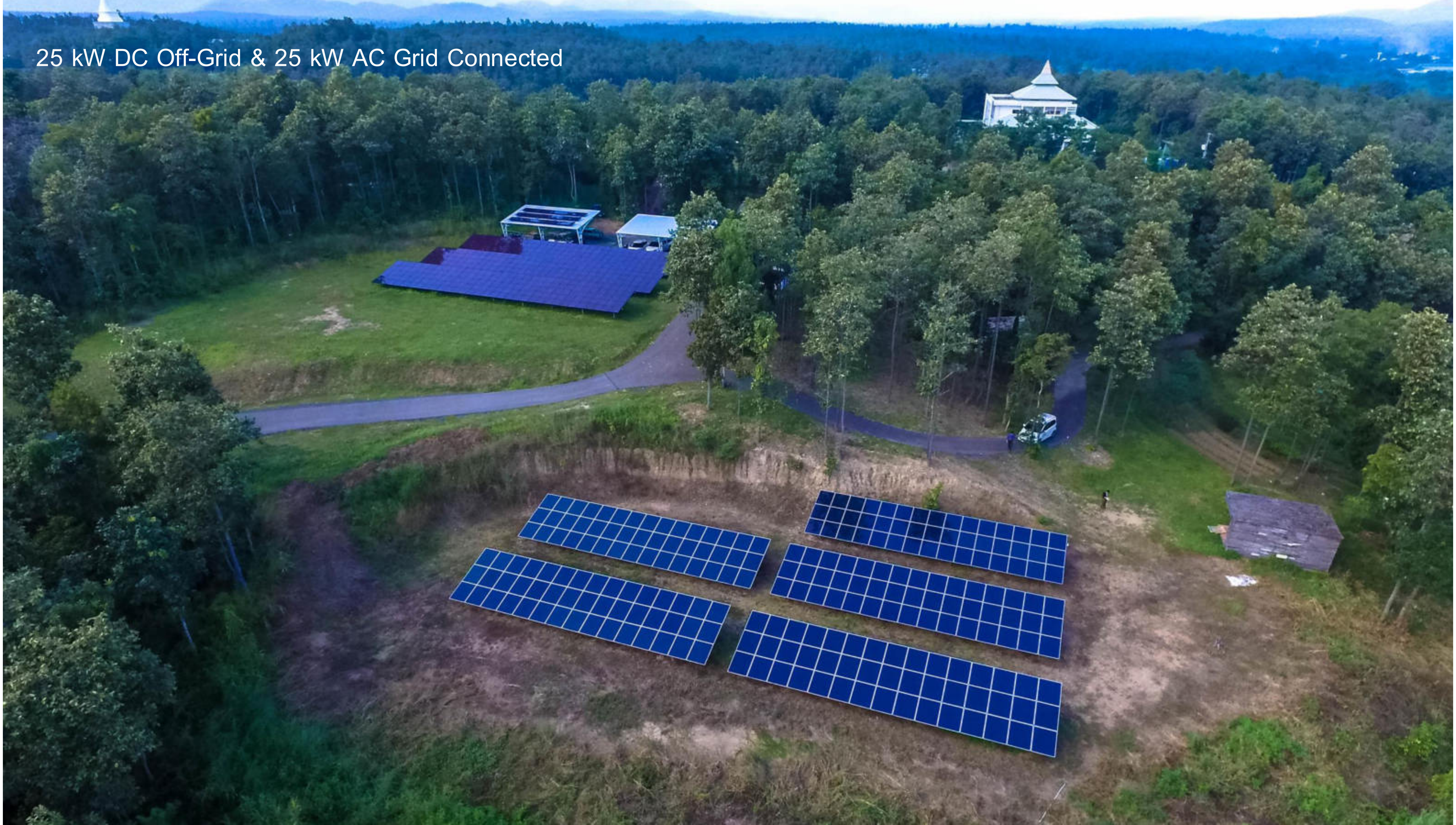
Chiang Mai World Green City:

Sustainable-Green-Smart Community via Integration of Renewable Energy & Green Technology

Asian Development College for Community Economy and Technology (adiCET): Developing the community through the integration of graduate-level teaching, research, and academic services to enhance the quality of life and the local economy.



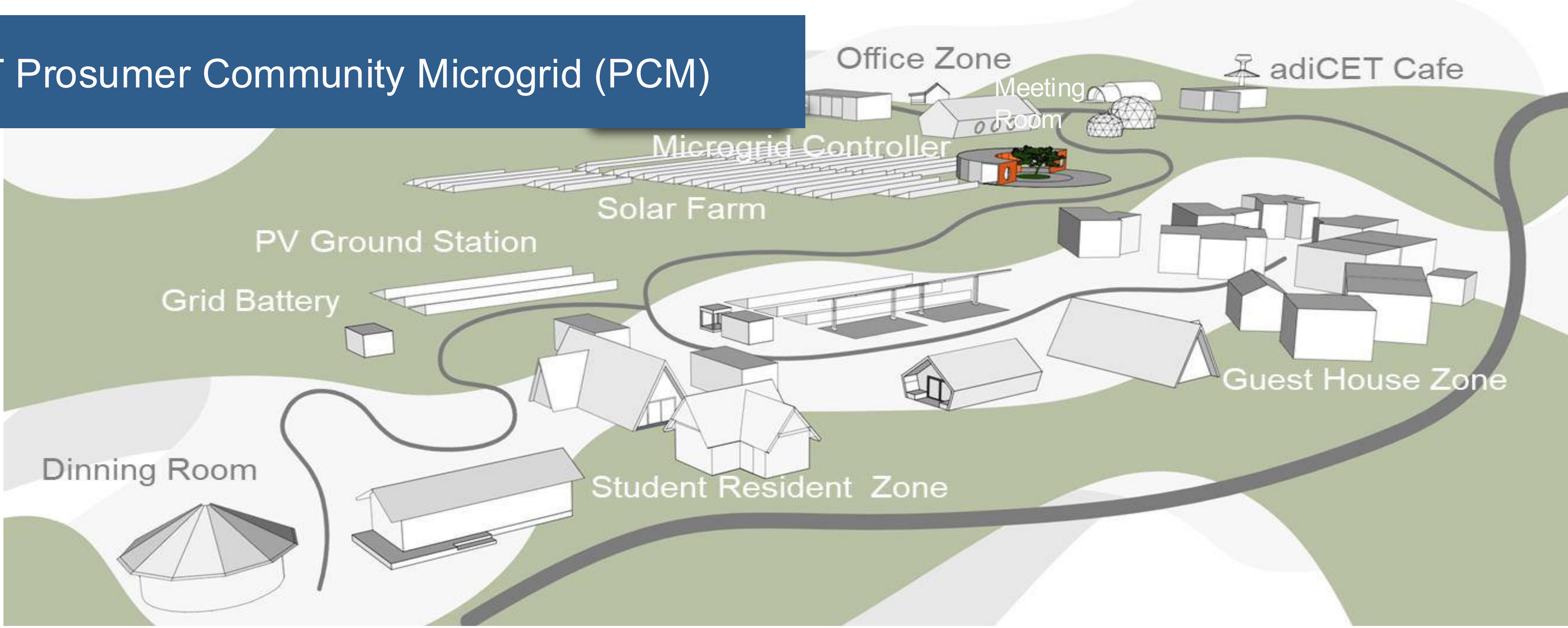
Community Product
DC Home
Community Business
PV Stand Alone
DC Microgrid
Energy Monitoring System
Community Restaurant
Recycle Road
Household Biogas
Community Power Training Center
Biodiesel Generator
Smart Water
Exhibition Center
Solar Pumping
Energy Efficient Building
PV Grid Connected
AC Microgrid
Biogas
Low Carbon Agriculture
Biomass Gasifier
Haze Monitoring
Smart Water System
Natural Material Building
Community Solar Farms
Energy Crop
Hydroponics
Fertilizer Organic wastes
Wood chip Wood pellet
#1 Smart Community Microgrid
#2 Zero Waste - Bioenergy Cycle
#3 Smart Community Development
Chiang Mai World Green City:
Living Laboratory & Learning Park


25 kW DC Off-Grid & 25 kW AC Grid Connected

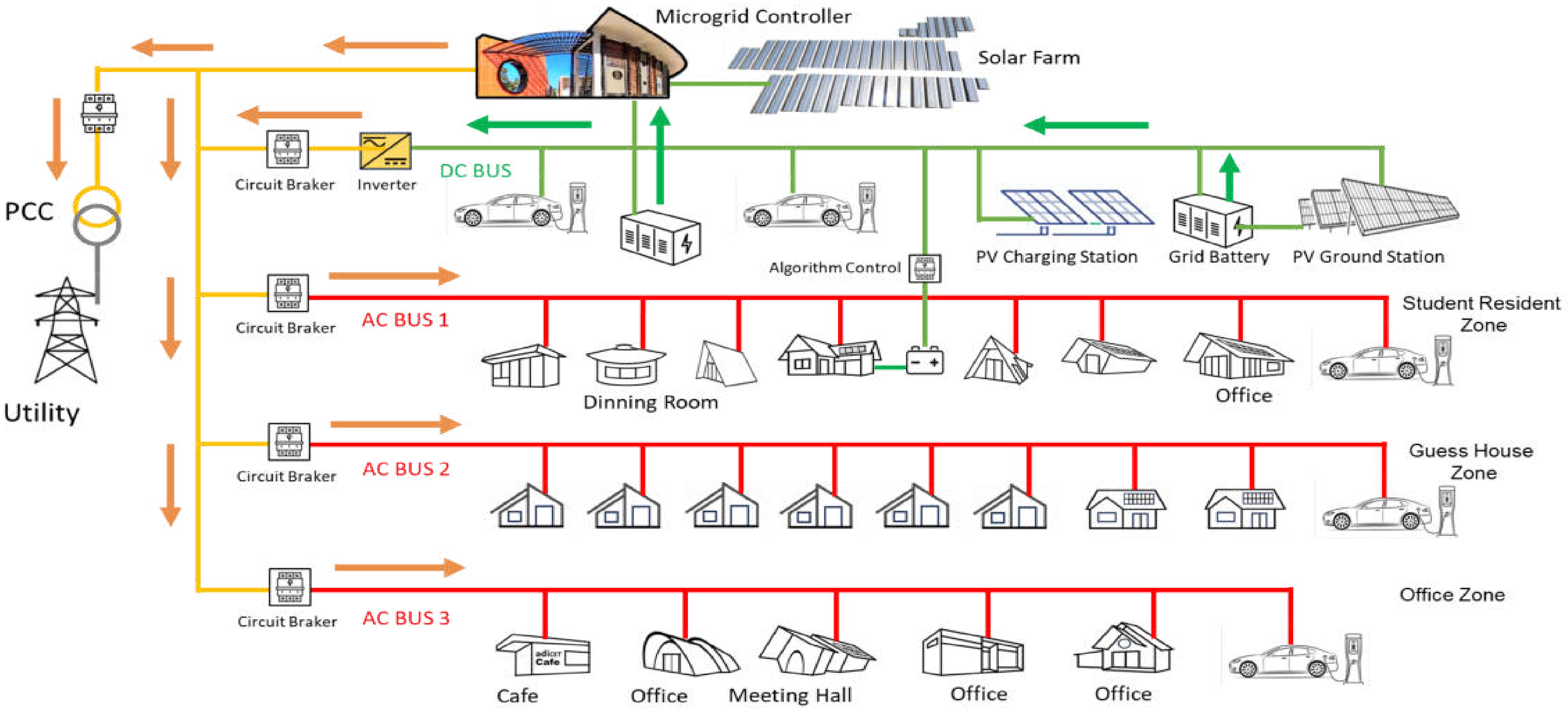
Smart Community DC Microgrid
Biomass Gasifier
AC PV System
Biodiesel Generator
DC PV System
Biogas
Home
Home
Smart Farm
Home
Home
Home
Home
Restaurant
Minimart
Office
Coffee Shop
Load:
1 office
1 minimart,
1 restaurant
1 coffee shop
1 farm
6 houses

adiCET

adiCET Prosumer Community Microgrid (PCM)

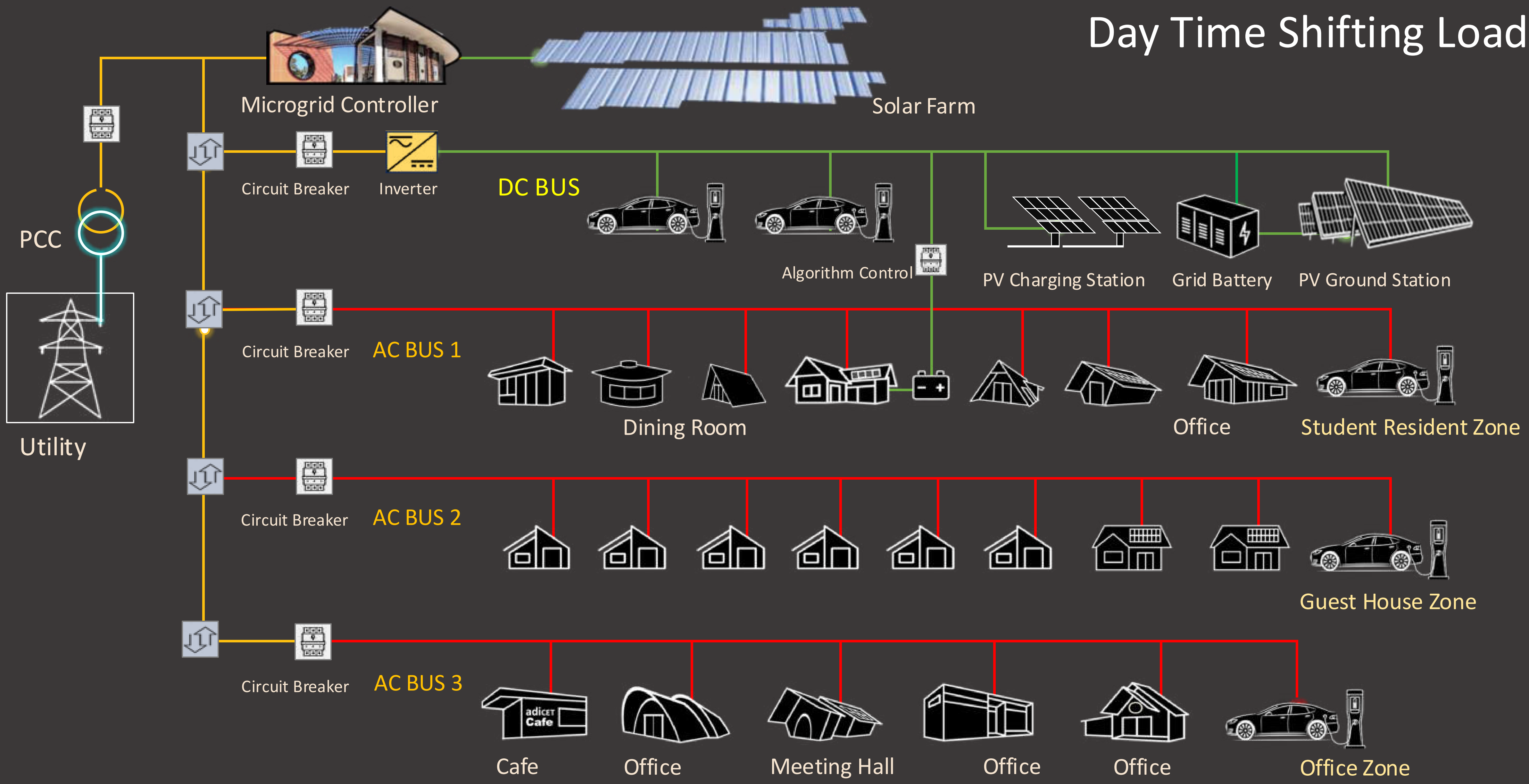


adiCET Full Feeder Microgrid Testbed and Experiment



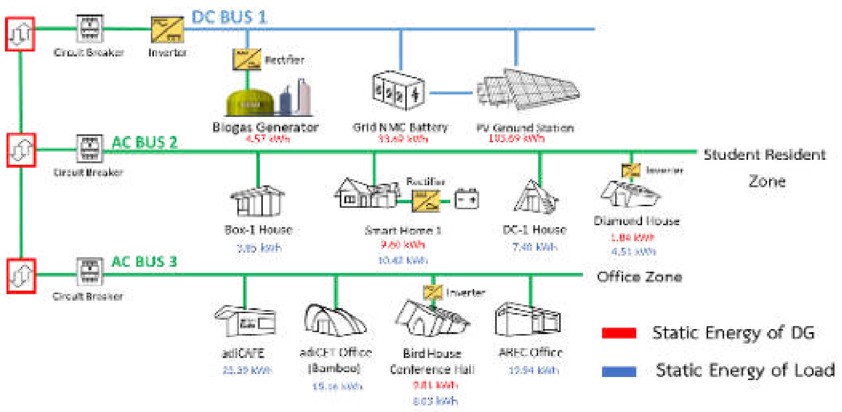
SMgrid

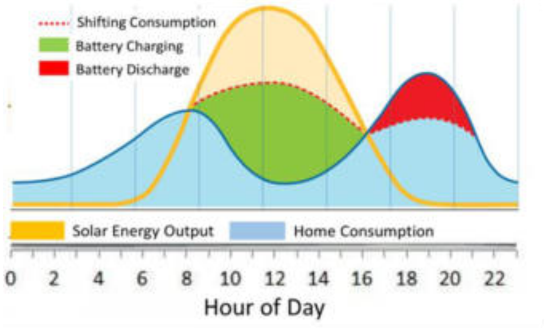
Day Time Shifting Load

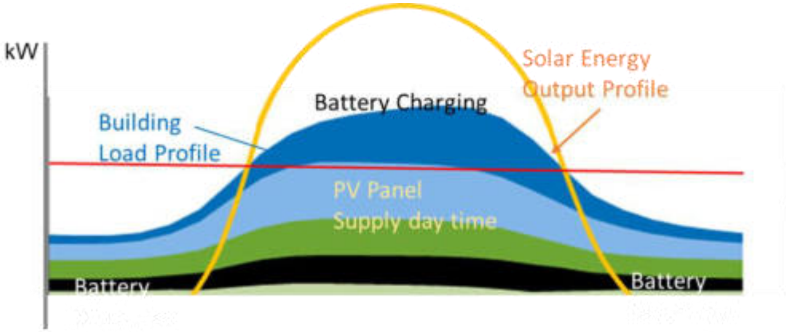


Isolated Microgrid

Isolate Microgrid Community PV-BioGrid Model





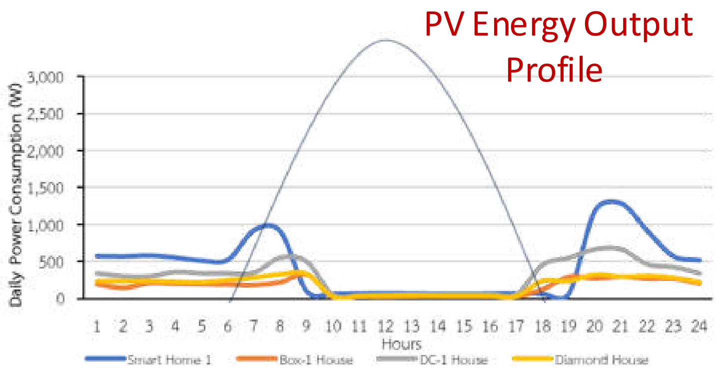


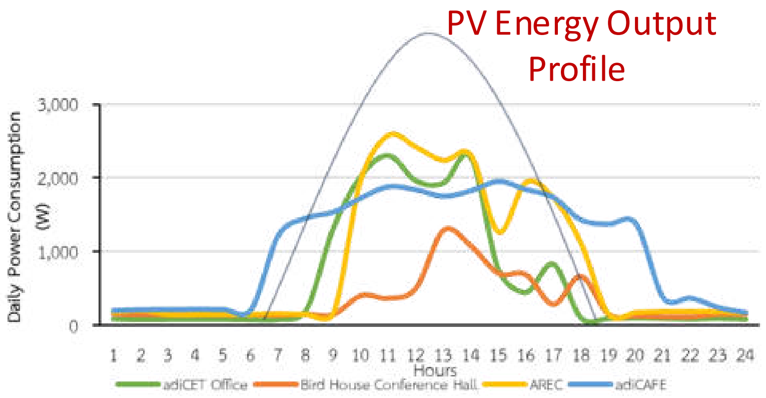
The load profile of the building that consumes from solar energy was verified to shift the load to be consistent with the dynamic load of the building in the bus load. The AC bus community load was divided into 2 zones

AC BUS 2: student residential zone *off peak day time* load with peak load during the morning, evening

AC BUS 3: office and small business zone *daytime load* with peak load during the daytime.

adiCET

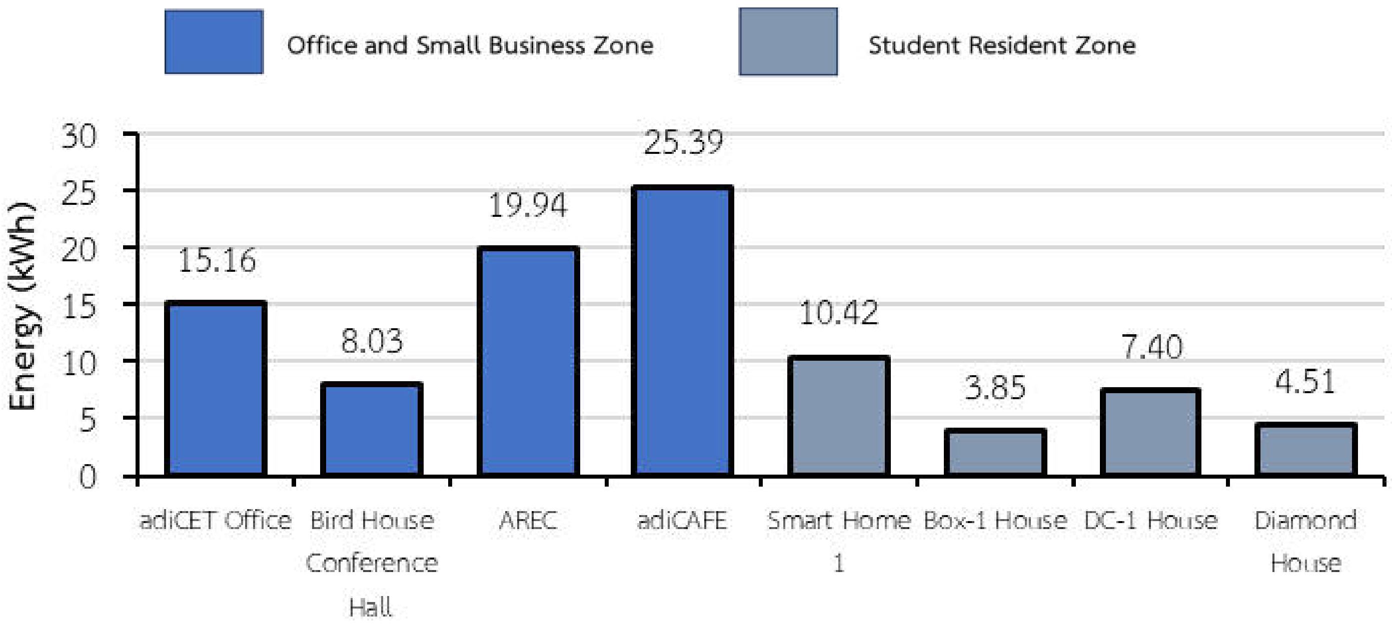




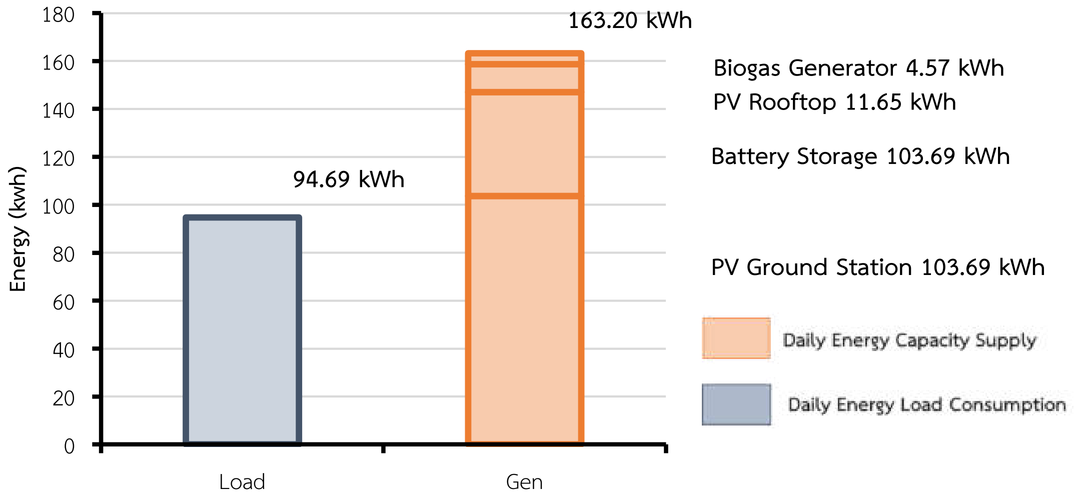
Daily PV Energy Output 103.69 kWh
Daily Load Consumption 94.70 kWh

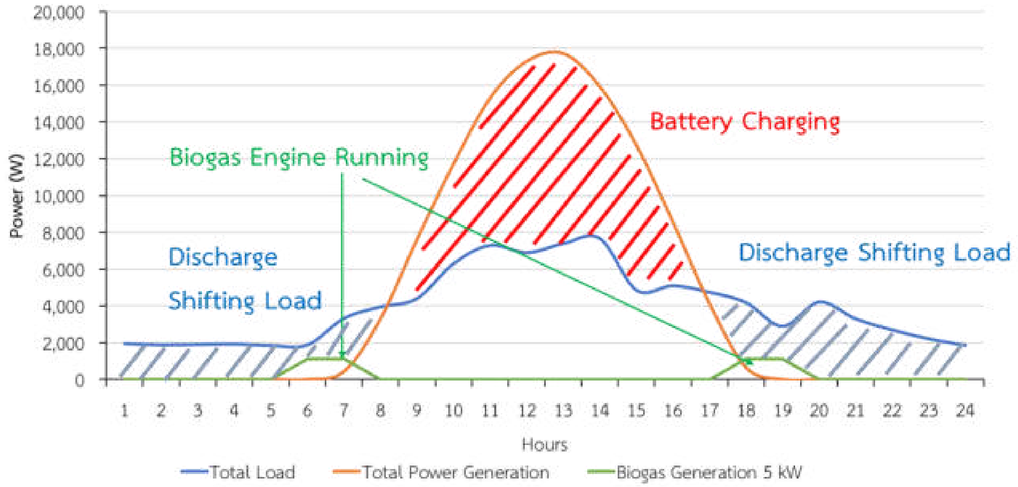
Total 68.52 kWh

Total 26.18 kWh



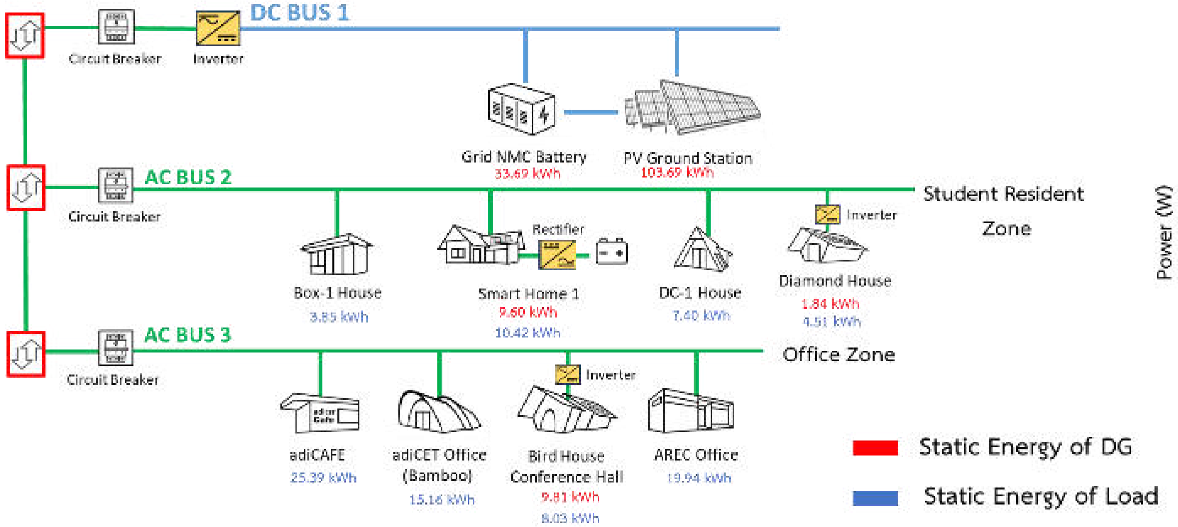
Isolated Community PV-battery-Biogas Microgrid Model

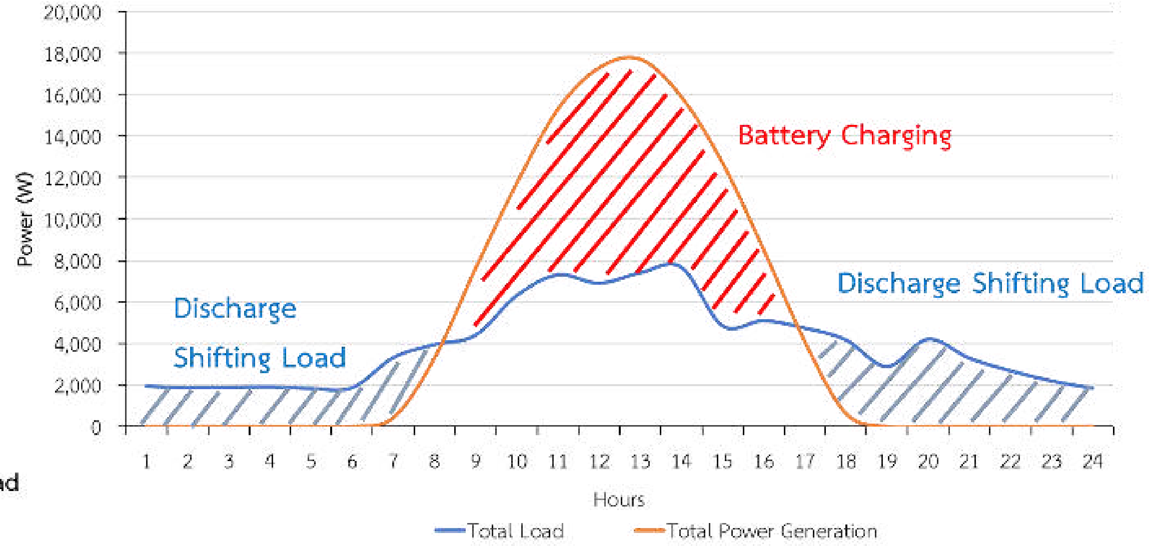




Isolated Community PV-battery-Biogas Microgrid Model: the Isolated Community PV-battery-Biogas Microgrid Model can sufficiently meet the electricity demands, providing stability and reliability.

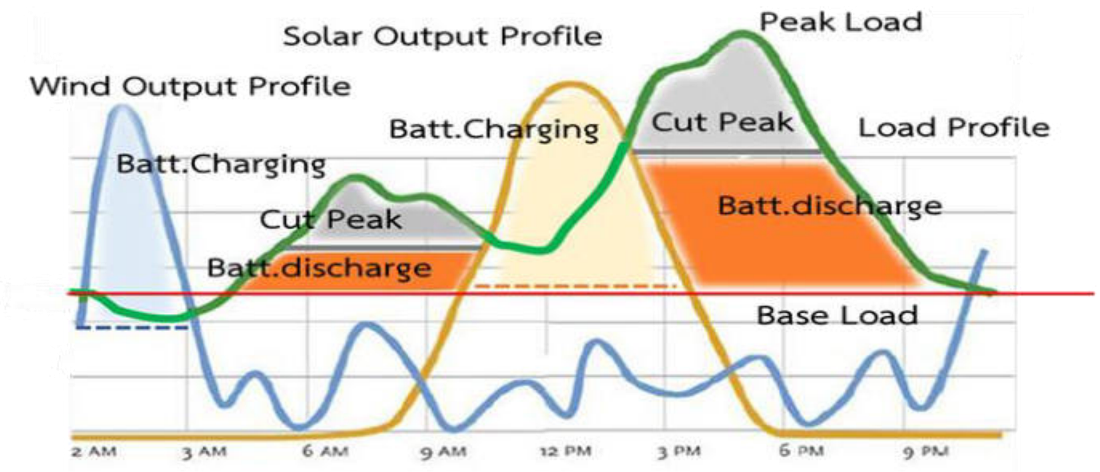
Isolated Community PV-battery Microgrid Model





Isolated Community PV-Battery Microgrid Model: the Isolated Community PV-Battery Microgrid Model can sufficiently meet electricity demands, providing stability and reliability without using electricity from biogas.

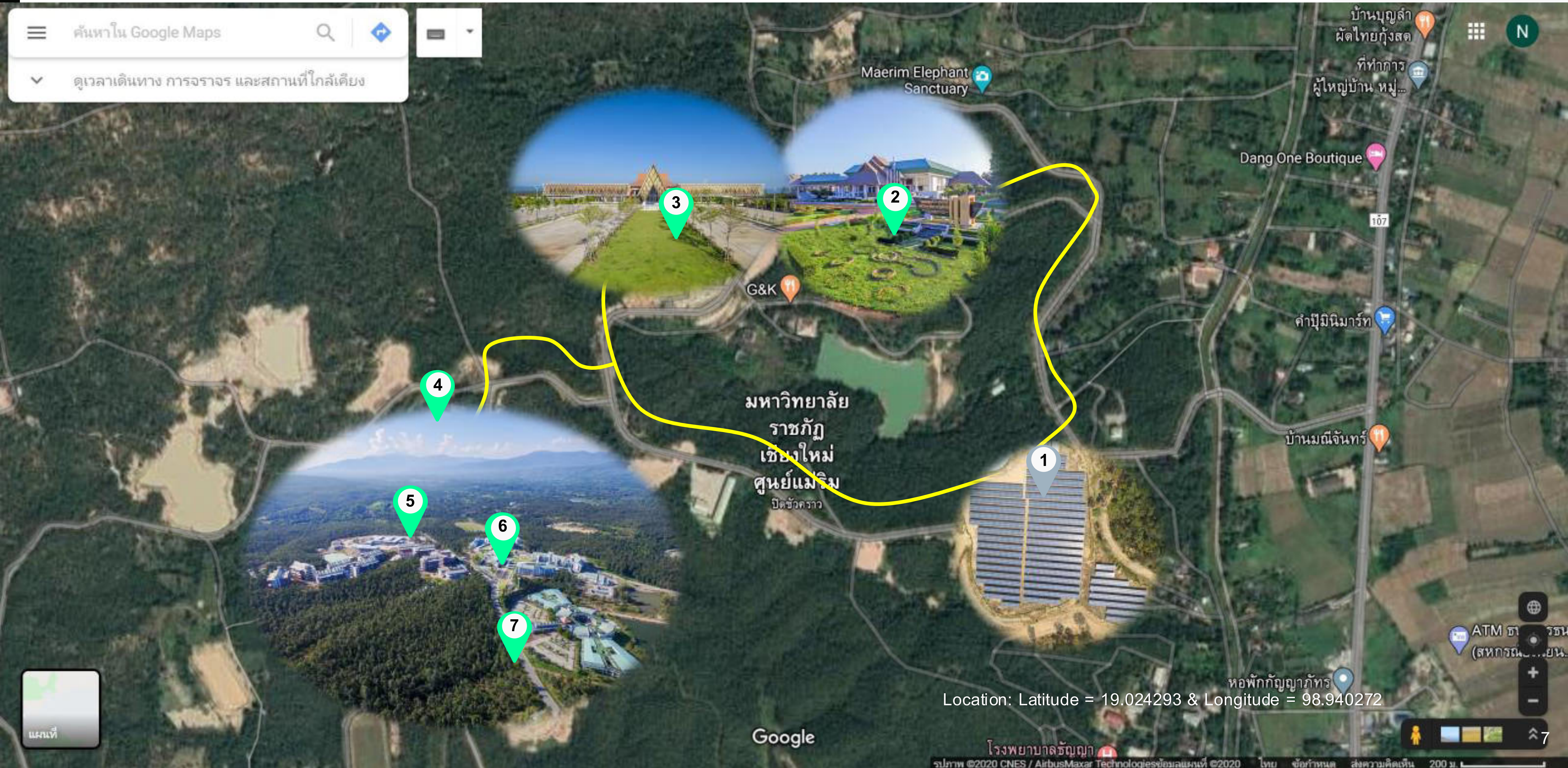
Isolated Community PV-Wind-Battery Microgrid Model



Battery price decreased 700% compared to 10 years ago Isolated Community PV-Wind-Battery Microgrid Model can be used for the Optimization

The Isolated Community PV-Wind-Battery Microgrid Model, which utilizes a Hybrid Solar and Wind system combined with Battery Storage, the Energy Management System (EMS) to manage Battery Storage for load shifting and shaving Load. This process helps shift Load Balance to Pattern Profile Base Load.

Campus Power Distribution



Smart Campus - Chiang Mai Rajabhat University

Solar Roof
(Viengbua Campus)
550 kWp

Solar Roof
(Mae Rim Campus)
990 kWp

ENGY Wall
100kW/500kWh

EGAT Micro EMS

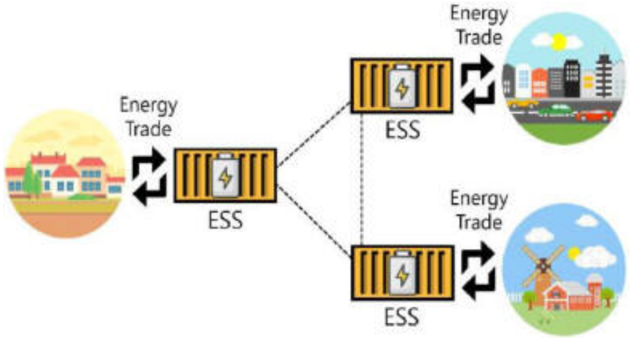
Energy Trading Platform
(Peer-to-Peer)

ENZY Platform

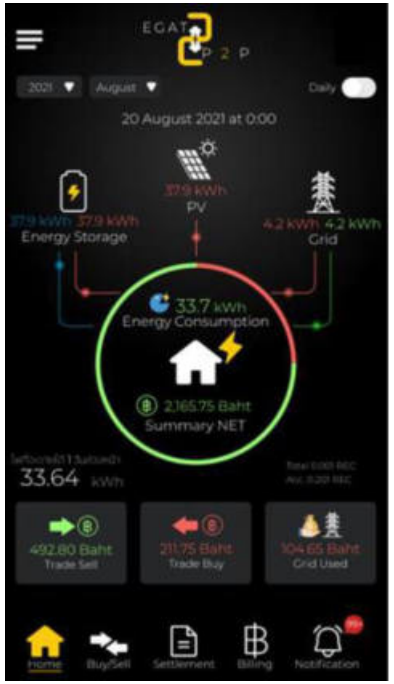
EV Charging Station

Electric Vehicle

Smart Street Lighting



EGAT Micro EMS



Energy
Trading Platform

V2G

Smart Street Lighting

EV Conversion

OVERVIEW CMRU SMART CAMPUS

Maerim
Rooftop : 876 kWp
Carport : 122 kWp

Wiang Bua
Rooftop : 260 kWp
Carport : 130 kWp

Rooftop and Carport Solar

ENZY Energy Management System

Smart Street Lighting

Smart Street Light System
Smart Street Light with IoT
309 Sets

Battery Energy Storage

Size : 100 kW/200 kWh

Battery Energy Storage

EV Charger

EV Car

EV Golf Cart
14 seats, 7.5 kW/72V - 2 units

EV Charger
Pulsar Plus : Type2, 7.4 kW- 2 Units

Quasar : CHAdeMo DC Bi-Directional
Charge 7.4kW, Discharge 7.2 kW - 1 unit

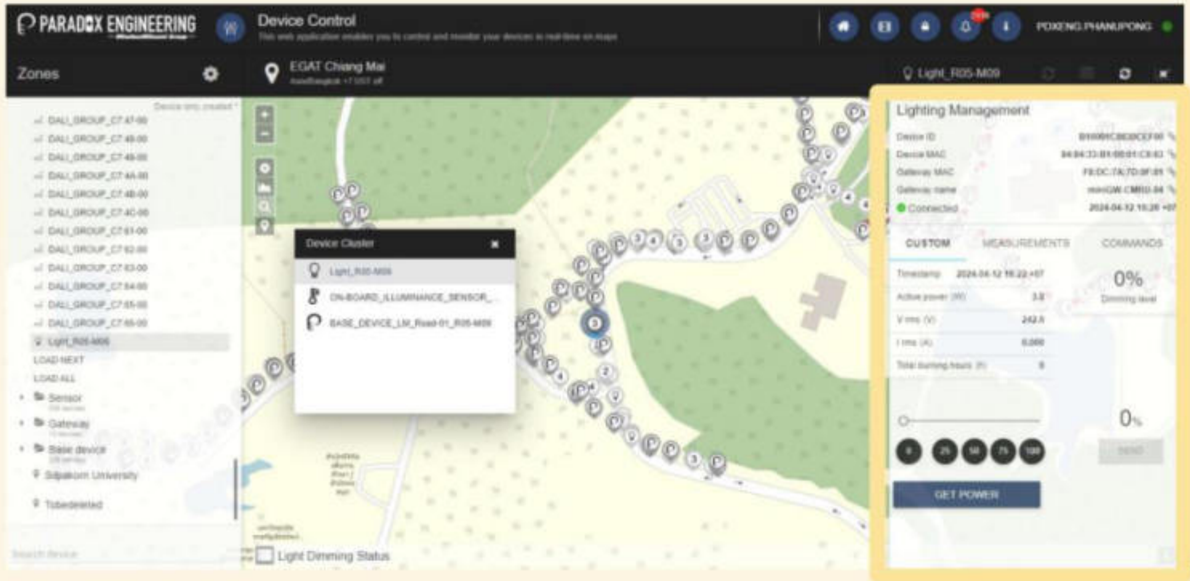
ROOFTOP SOLAR (MAE RIM)

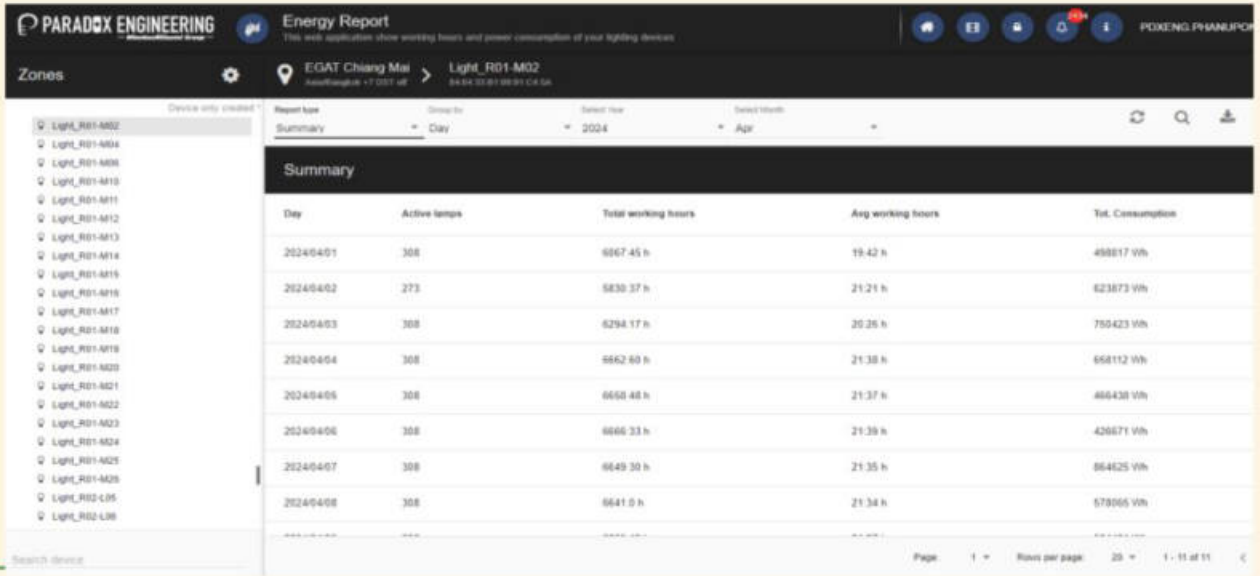
CARPORT SOLAR (MAE RIM)

CARPORT SOLAR (WIANG BUA)

ROOFTOP SOLAR (MAE RIM)

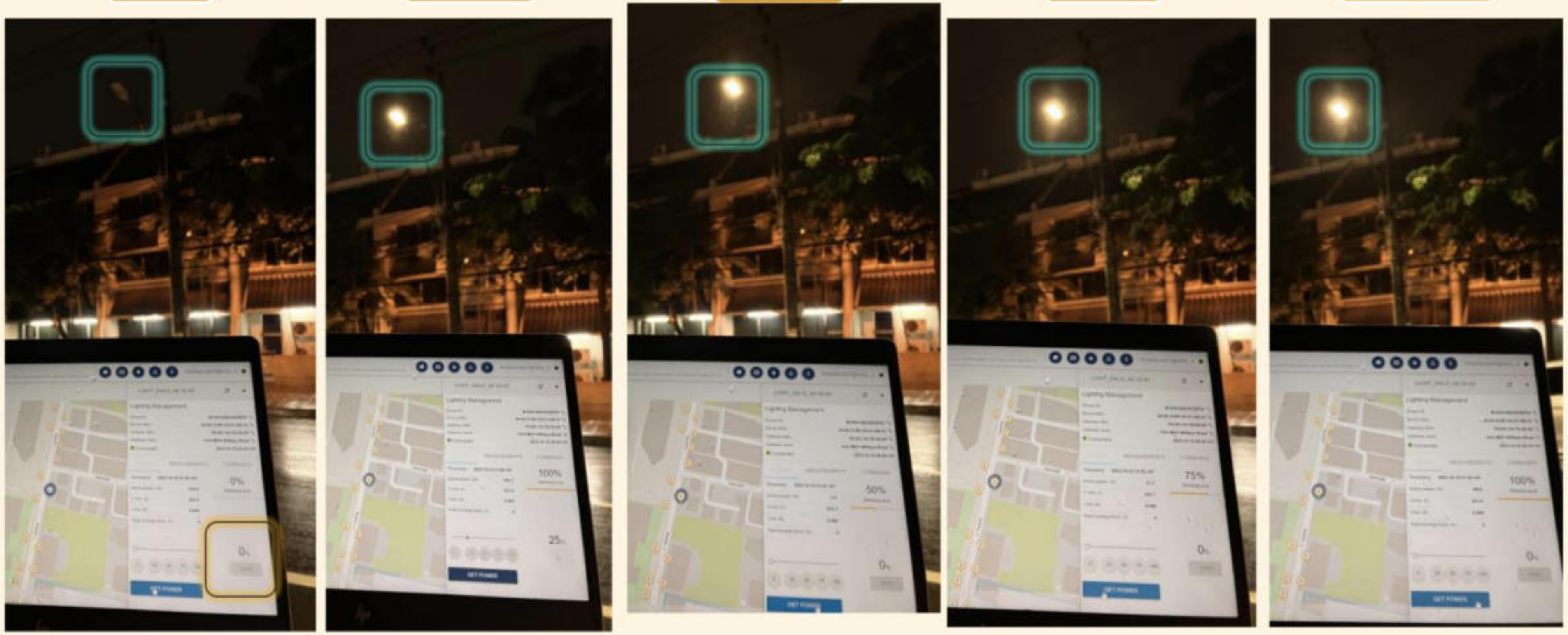
SMART STREET LIGHT



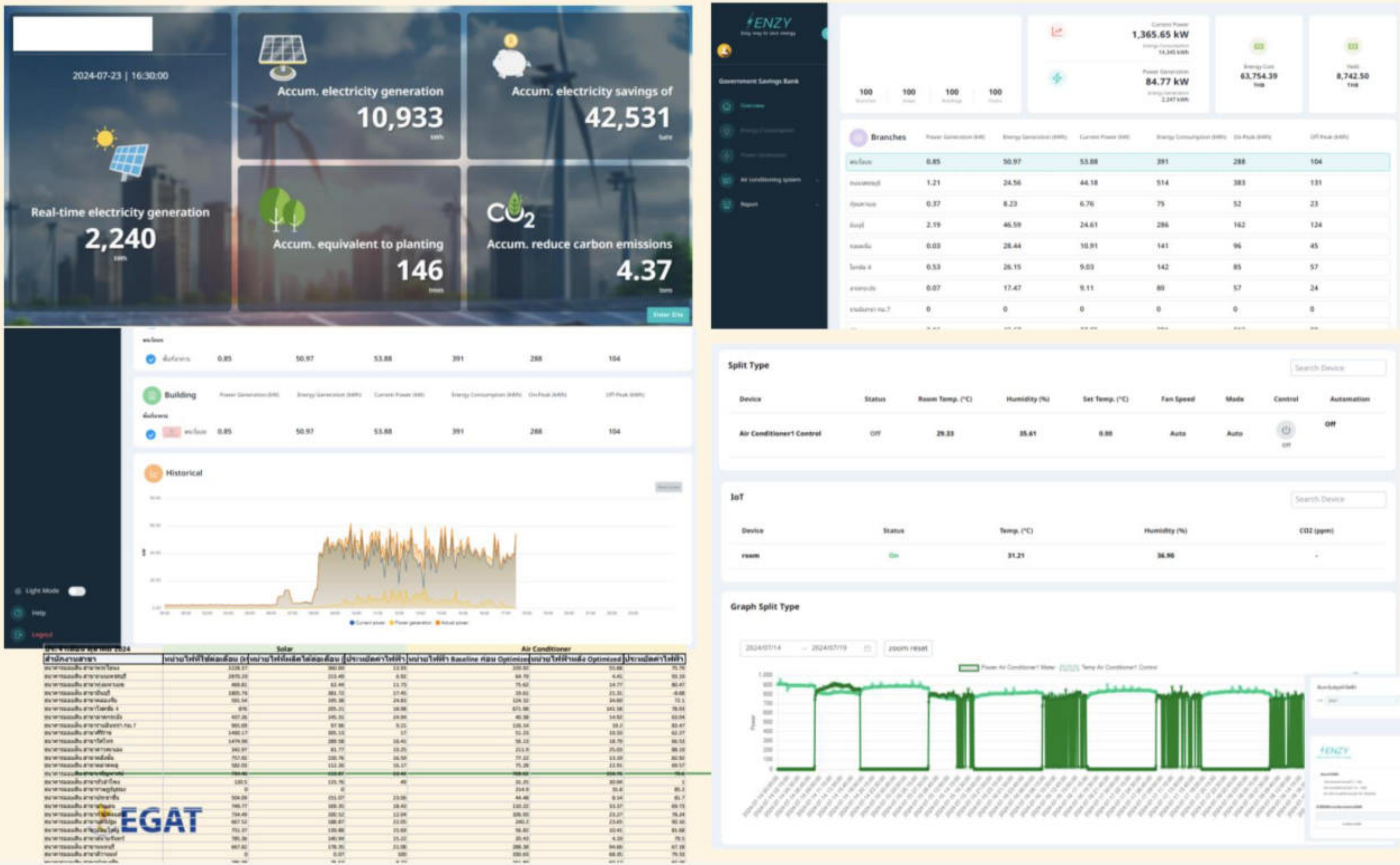


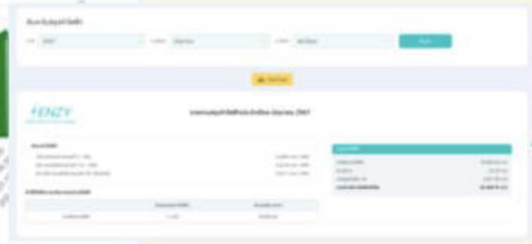
SMART STREET LIGHT

0% 25% 50% 75% 100%



ENZY ENERGY MANAGEMENT SYSTEM

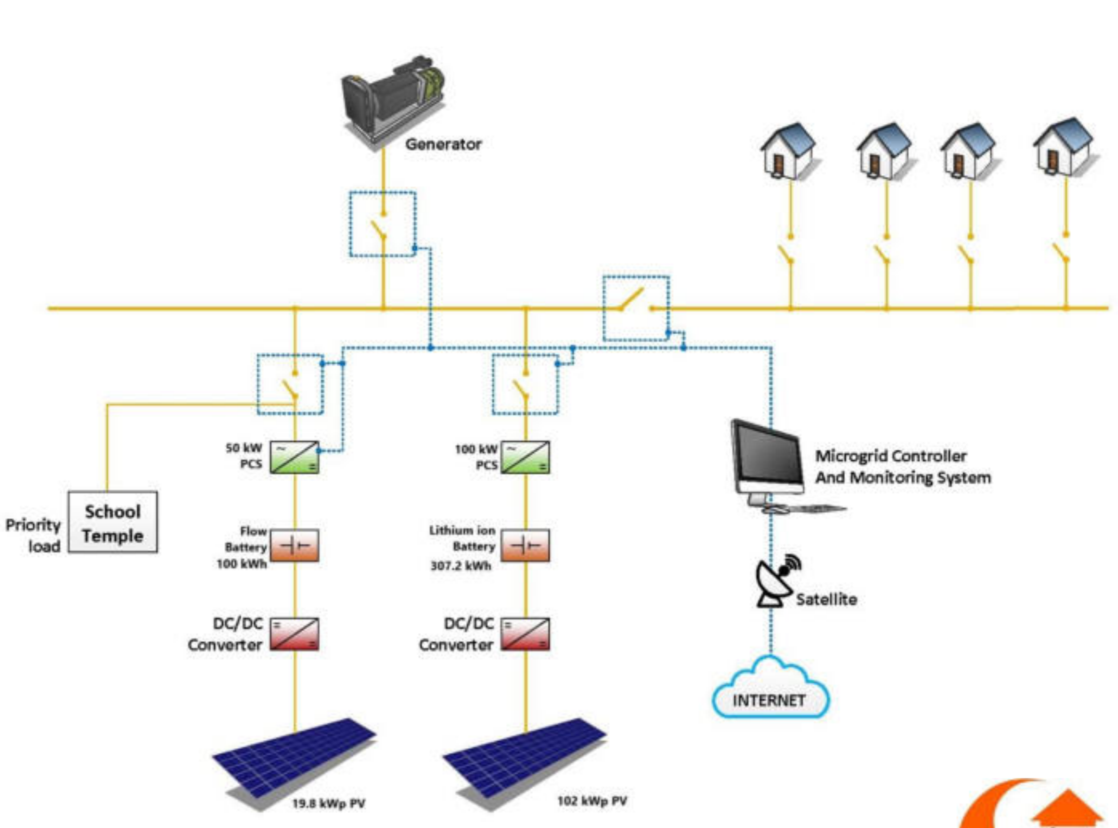


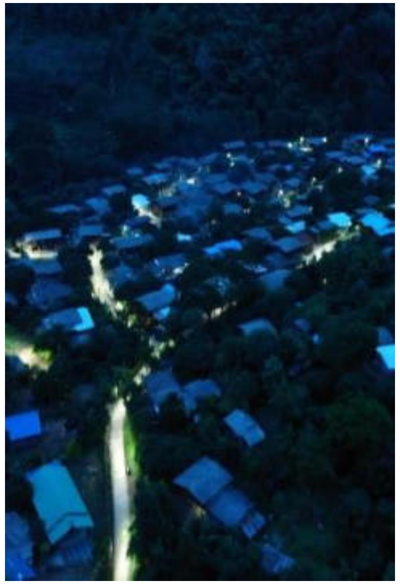


- Overview Dashboard
- Generation & Consumption Overview
- Optimized air cond. (Temp vs Kw Graph)
- Monthly energy report

Microgrid model for electricity generation in rural villages

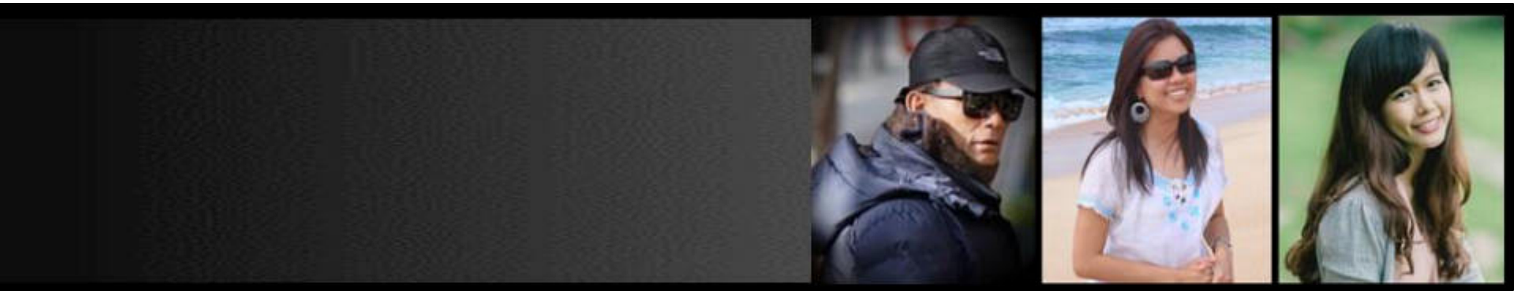
Microgrid system Diagram of Pha Dan





the main PV 102 kWp with Lithium Ion Battery and a stand-alone system of 19.8 kWp with Flow battery connecting to the main microgrid.

Thank you



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DC Power Technologies Promote Renewable Energy Integration

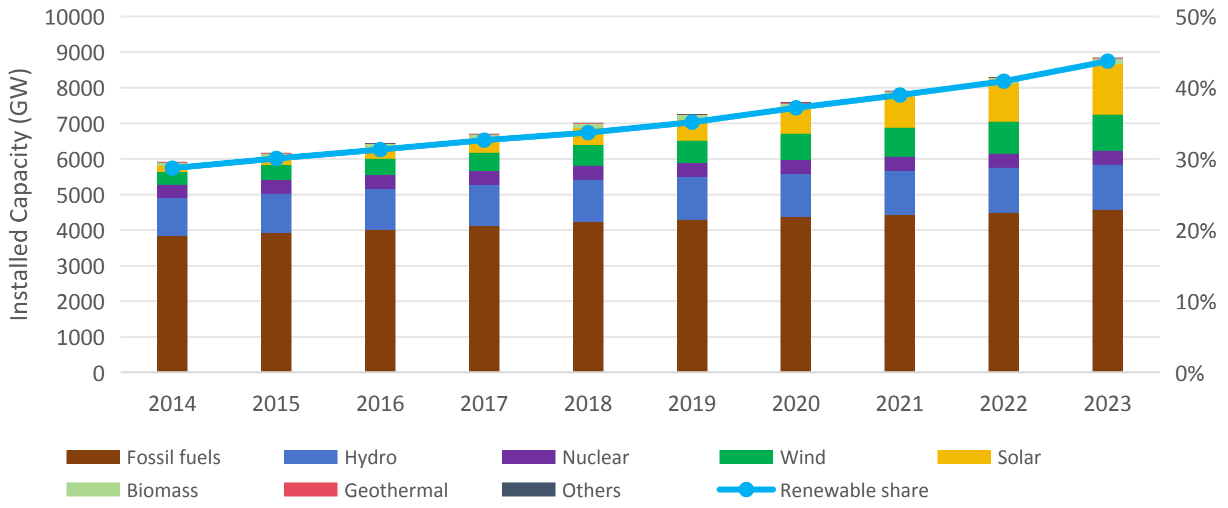
Chen Chen
Global Energy Interconnection Economic and Technology Research Institute

Feb. 2025

New Challenges along with Energy Transition

The APEC economies are pivotal in the global energy transition.

- Renewable share: 43% in installed capacity, 28% in electricity generation (2023).
- APEC economies contribute more than 60% to global renewable installed capacity and generation.
- New challenges to traditional power system: Integration of inverter-based wind and solar power. Recent advancements in DC technologies are providing various technical supports in promoting renewable energy development and integration, especially in renewable energy exploitation, long-distance transmission, and flexible accommodation.



Installed capacity and ratio of renewables of APEC economies

Most renewables are far from load centers. Long-distance transmission is essential.

Weak supporting capability of renewable energy generation for the power grid.

The integration of distributed renewables is reshaping distribution networks.

Challenges to the secure and stable operation of AC systems

New challenges along with energy transition

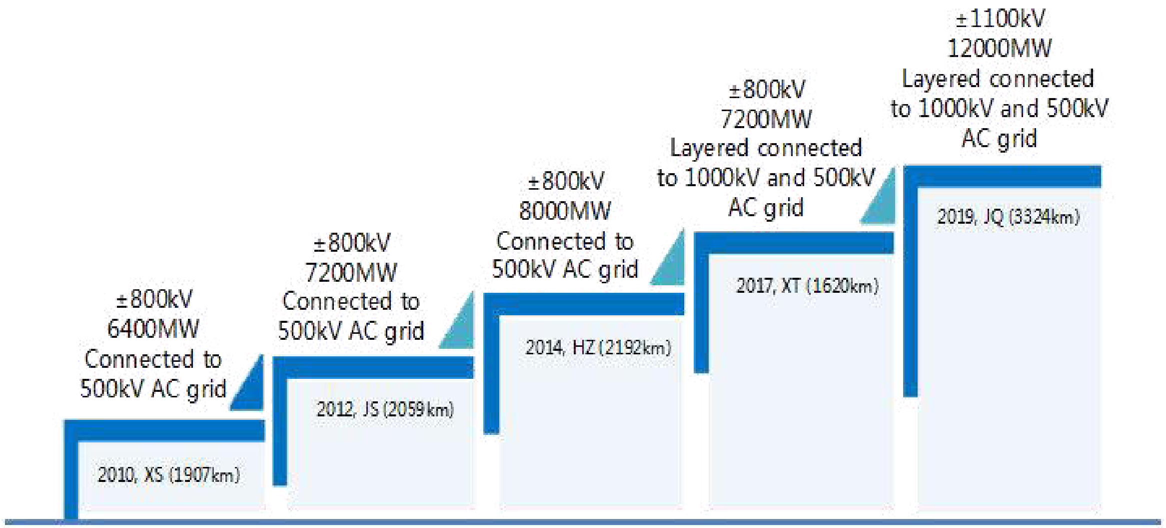
Rapid Development of DC Technologies

- Comparison of 4 types of DC technologies that have been applied in engineering projects (**LCC-HVDC, VSC-DC, HVDC Grid** and **DC Microgrid**).

DC technology	Application Scenarios	Application Maturity	Operational Flexibility	Cost of Equipment and Construction
LCC-HVDC	Long-distance power transmission, AC grids interconnection, etc.	High	Low	Low
VSC-DC	Renewable transmission, flexible interconnection between AC grids, etc.	Moderately High	Moderately High	Moderately High
HVDC Grid	Networking of renewable energy bases, etc.	Moderate	High	High
DC Microgrid	DC loads directly supplied by distributed renewables, etc.	Moderate	High	Moderately High (compared to AC microgrid)

Mature LCC-HVDC technology

- **LCC-HVDC technology** has been extensively applied in engineering projects.
- Highest technical standard reaches ±800/1100kV UHVDC. As of 2024, China has **18 operational LCC-UHVDC projects**, with the maximum transmission capacity reaching 12GW and the longest transmission distance exceeding 3300km.
- LCC-HVDC technology utilizes semi-controlled devices. As a result, the operational power and voltage cannot be independently controlled, posing a risk of commutation failure.



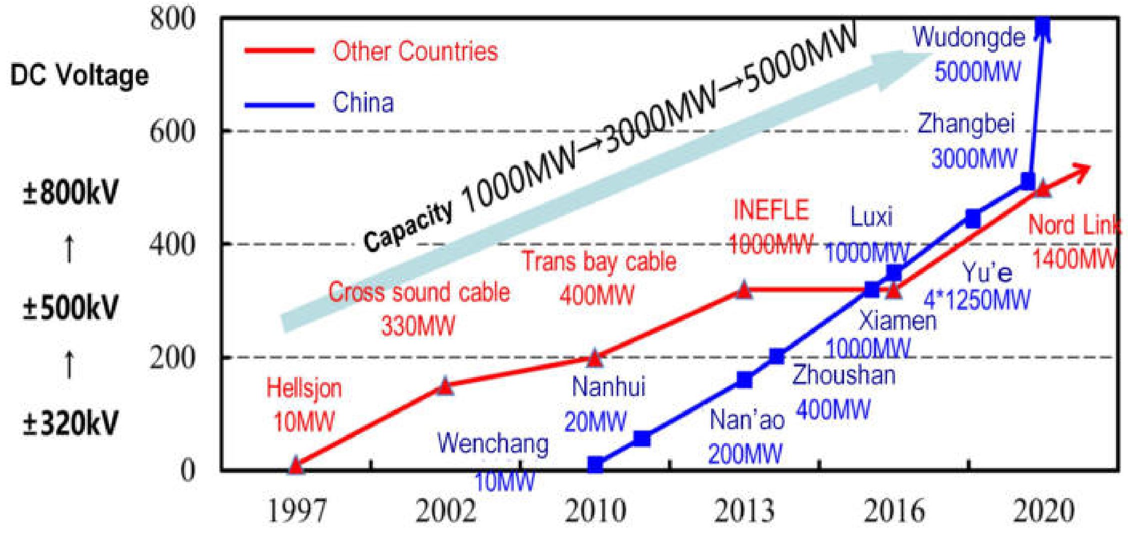
Milestones of LCC-UHVDC transmission technology

Changji-Guquan ±1100kV/12GW UHVDC project

Growing applications of VSC-DC technology

➢ **VSC-DC technology** enables rapid and independent control of operational power and voltage. It is progressively being applied in scenarios such as power transmission from onshore and offshore renewable energy bases, flexible interconnection of AC grids, etc.

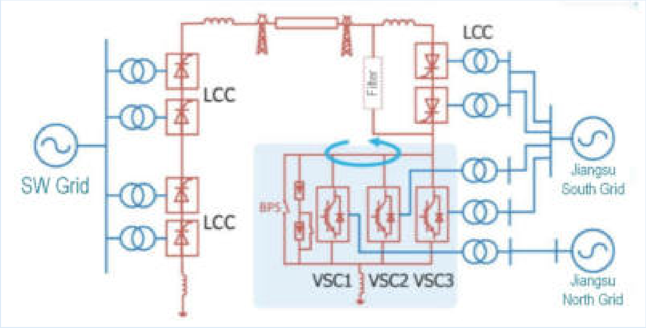
- **VSC-HVDC transmission** provides voltage and frequency support to both sending and receiving AC systems, making it suitable for wind and solar transmission. Recently, voltage levels and capacities of VSC-HVDC transmission have continued to increase. The world's first VSC-UHVDC project, the Gansu-Zhejiang UHVDC transmission project (±800kV/8GW), is currently under construction.



The increase of operational voltage and capacity of VSC-HVDC

Case I:
Rudong offshore wind VSC-HVDC transmission project: The world's highest voltage (±400kV) and largest transmission capacity (1100MW) offshore VSC-HVDC system.

Case II:
Baihetan-Jiangsu UHVDC transmission project: The world's first hybrid UHVDC project combining LCC- and VSC- HVDC, distributes half of the transmitted power to each technique at the receiving end.

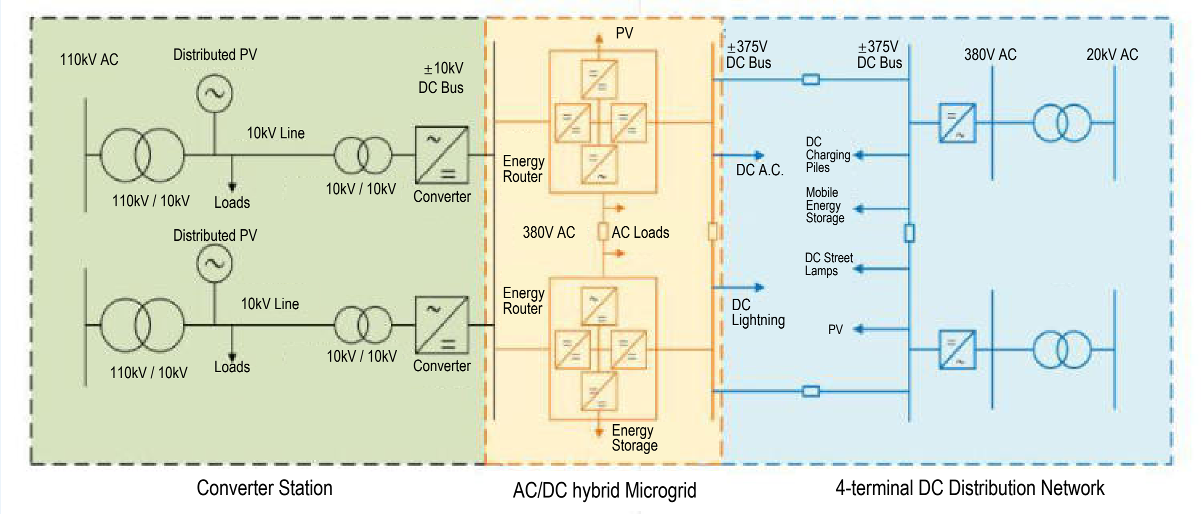


Growing applications of VSC-DC technology

- **VSC-DC interconnection between AC grids:** To address the large-scale integration of distributed PV into AC distribution networks, VSC-DC technology is employed to interconnect different power supply areas.
- This approach transforms the traditional tree-like structure of AC distribution grids, enabling flexible and controllable transfer of distributed PV power between different areas. Therefore, reverse power flow from the distribution network to the transmission grid can be effectively prevented.

Case:

Zhejiang Haining distribution network VSC-DC interconnection project: 10kV and 20kV distribution networks are interconnected through medium-voltage VSC-DC interconnection. This allows the surplus PV power from the 20kV areas to be transferred directly to the 10kV areas. Such an approach prevents the reverse power flow from moving up to the 110kV transmission grid, promoting the local accommodation of distributed PV generation within the distribution network.



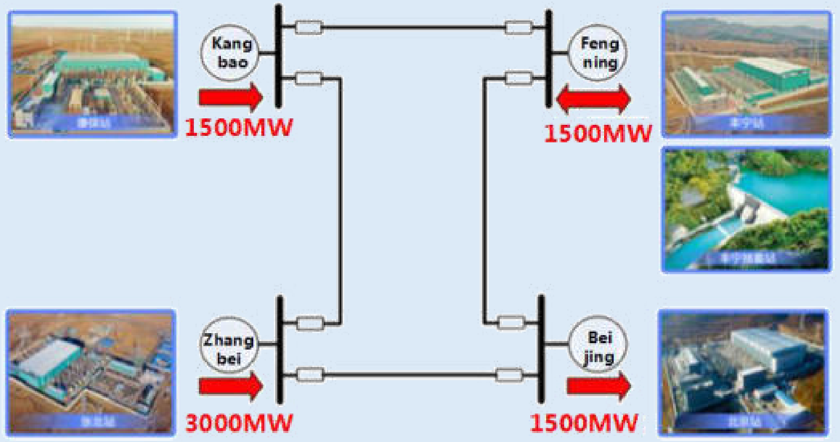
Zhejiang Haining distribution network VSC-DC interconnection

HVDC Grid demonstration projects

- Based on VSC-HVDC technology, **HVDC Grid technology** connects multiple converter stations into a network. Utilizing the networking advantages of VSC-DC technology, HVDC Grid enhances system operational flexibility through dynamic adjustment of network topology.
- Demonstration projects for networking renewable energy bases have been put into operation, enabling efficient and stable transmission with multi-renewable energy complementation.
- Challenges for HVDC Grid application and construction include reducing the costs of DC circuit breakers, energy dissipation devices, and DC/DC converters, as well as addressing the complexities of dispatching, control, and protection strategies.

Case:

Zhangbei ±500kV VSC-HVDC Grid project: Using ±500kV HVDC lines, the HVDC Grid connects wind, PV, and pumped hydro storage. It comprises two sending-end converter stations (3GW / 1.5GW), one regulating station (1.5GW), and one receiving-end station (3GW). These components form a four-terminal VSC-HVDC Grid using a "hand-in-hand" ring connection, enabling stable multi-energy complementary. This system can annually supply 14TWh of green electricity to Beijing, equivalent to one-tenth of the city's annual electricity consumption.



Structure of Zhangbei ±500kV VSC-HVDC Grid

Expanding application scenarios of DC Microgrid technology

- **DC Microgrid technology:** Microgrids also exhibit a **DC-oriented development trend** in the integration of renewables, energy storage, and DC loads. By using VSC-DC technology to connect and control all these DC items, this DC Microgrid can reduce AC-DC conversion losses and enable functionalities such as flexible power flow distribution, smooth switching between grid-connected and islanded modes, and system black starts.
- DC Microgrids have been constructed in industrial parks, buildings, islands, and rural areas.

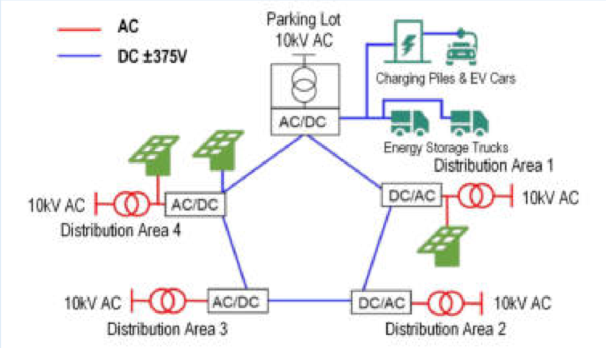
Industrial Park Case:

Electrolytic aluminum factory in Inner Mongolia

Electrolytic aluminum is stable, high-capacity DC load, which can be directly supplied by PV generated DC power through low-voltage DC Microgrid. The total installed capacity of the PV in the factory is 14.72MW, which, through a DC Microgrid and a DC control system, supplies four sets of electrolytic aluminum equipment (two sets at 3.6MW each and two sets at 4.5MW each).

Island Case:

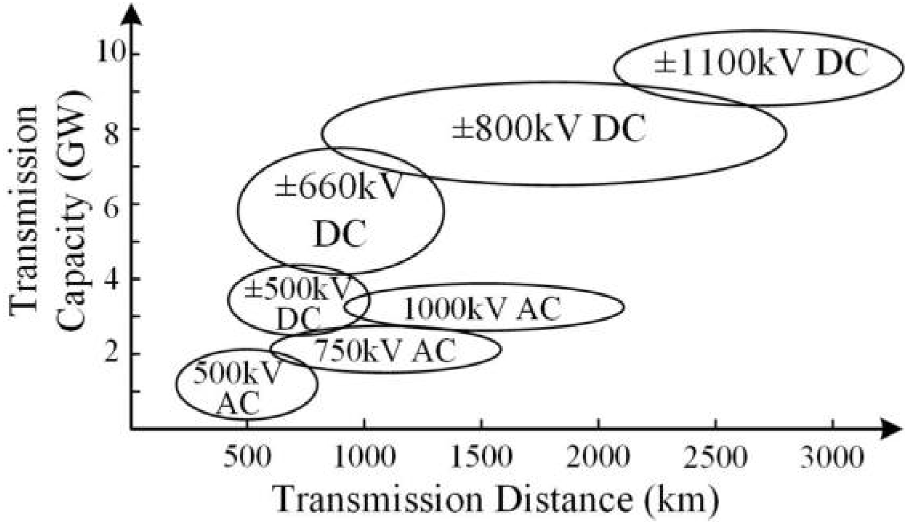
Meizhou Island DC Microgrid



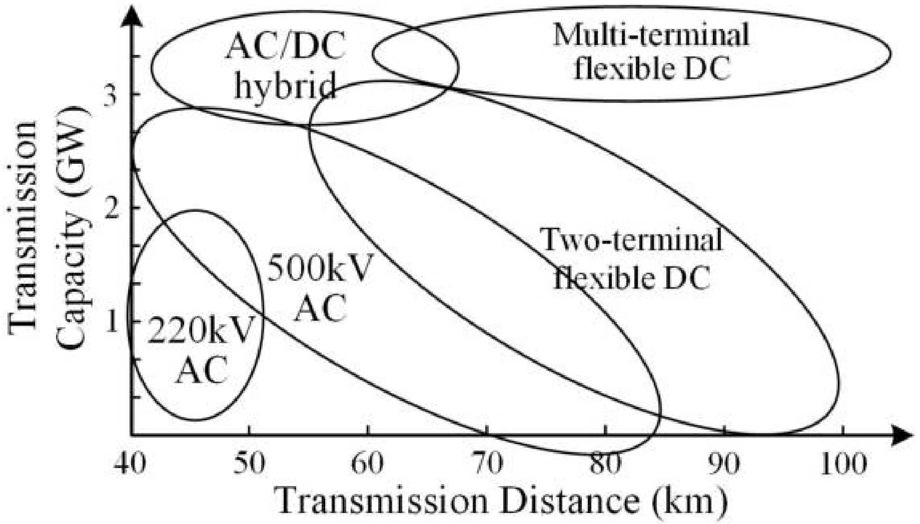
Using ±375V VSC-DC technology, four distribution stations and one parking lot within a 1.5km range in the Meizhou Island are interconnected to form a 5-terminal ring-type DC Microgrid. This enables power mutual transmission, PV orderly accommodation, remote control of low-voltage loads, and participation of energy storage in demand response.

Observations and Suggestions

- **AC/DC hybrid will be the fundamental form of future power system**
  - Various DC power technologies have rapidly developed and played a crucial role in integrating renewable energy. However, due to limitations in technology maturity, construction cost, and technical standards, **constructing "DC Power Systems" faces challenges**.
  - Traditional AC systems are large in scale, technologically mature, and equipped with reliable devices. DC technologies are also evolving towards better adaptation to AC power systems. AC/DC hybrid systems will be the fundamental form for future high share renewable energy power systems. Optimal technical and economic combinations can be achieved through integration of multiple technologies.



Onshore renewables transmission techniques



Offshore renewables transmission techniques

Observations and Suggestions

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Innovations and future applications of DC technologies

In the progress of energy transition, DC technologies and equipment will develop towards **more reliable, flexible, cost-effective, and intelligent,** promoting the safe and stable operation of power systems with high share of renewable energy. Noteworthy innovations include:

Performances Improvement and Cost Reduction of VSC-DC Equipment	• Improve key equipment performances such as the current-carrying capacity of VSC-DC inverters and the breaking capacity of DC circuit breakers. • Reduce the cost of VSC-DC equipment across all voltage levels, making it more cost-competitive, especially for distribution networks and microgrids.
Innovations in HVDC Grid Networking and Operation	• Apart from advancements in VSC-DC inverters and DC breakers, the development of HVDC Grids requires systematic innovation in dispatch and control, modeling and simulation, condition analysis, protection strategies, fault defense, etc. This will facilitate breakthroughs in networking for onshore and offshore renewable energy bases.
Wide Application of Grid-forming Technology	• By optimizing control strategies and enhancing device overload capacity, VSC-DC inverters can exhibit similar external characteristics to synchronous generators, which will improve renewable energy integration and system operational stability. Grid-forming technology will be widely applied in renewable energy bases integration and supporting the system at key nodes.

Observations and Suggestions

- **Promote the discussion and formulation of DC operating voltage technical standards**
  - Currently, there is no unified technical standard for DC operating voltages, causing poor equipment compatibility and high R&D costs.
  - **Suggestion:** Promote discussions and the formulation of DC operating voltage technical standards globally, refining voltage sequences for different scenarios (such as low-voltage for household use, medium-voltage for distribution networks, and high-voltage for transmission).
- **Leverage the advantages of AI, using the digital and intelligent development of DC technologies to drive the digital and intelligent transformation of the entire power system.**
  - DC technology facilitates the large-scale integration of renewable energy, characterized by multiple dispatching objects, operational modes, and control parameters. These characteristics are highly suitable for the extensive application of AI technologies.
  - **Suggestion:** Use the AI applications for DC technologies as a breakthrough point to promote the digital and intelligent transformation of the entire power system, driving this transformation through new applications and technologies in different scenarios.

Thank you for listening !

Chen Chen
Global Energy Interconnection Economic and Technology Research Institute
Feb. 2025

R&D Activities for Hybrid AC/DC Distribution Network(MVDC Grid) Technology in ROK(Republic of Korea)

Contents

Key Drivers for MVDC Grid

APEC 2025 KOREA

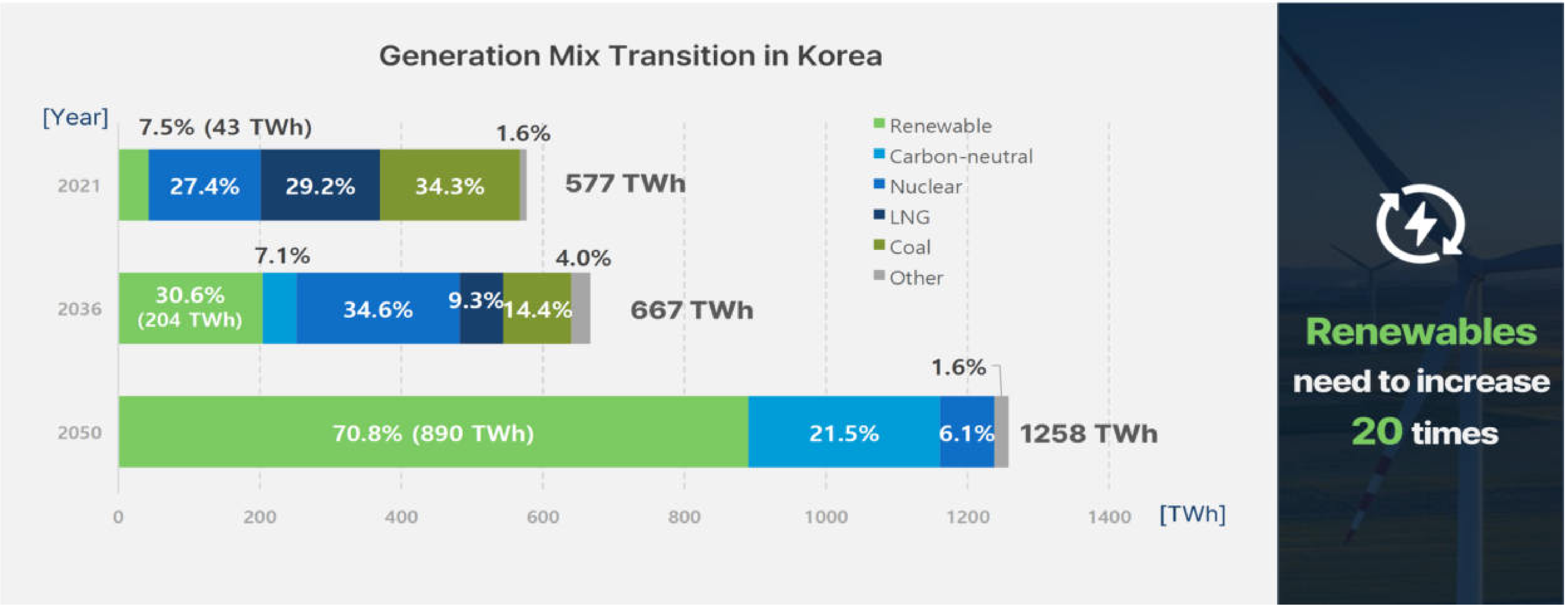
- We aims for an **All-Electric Society(AES)** that requires
  - Integration of **renewables** and **distributed energy**;
  - Support for **electric vehicles** and **storage**;
  - Meeting rising **demand**;
  - Efficient coupling of **energy sectors** (electricity, gas, heat);
  - Ensuring reliable, high-quality supply amid **growing uncertainties**

- An **AES** need advanced **grid solutions** that are
  - **sustainable** with a high-level of renewables and escalating demand;
  - **efficient** for integration of new technologies and other sectors;
  - **flexible, controllable** and **resilient** under growing uncertainties

Source: MVDC Grid for All-Electric Society, IEC MSB White Paper Proposal, 2024.4.17.

Key Drivers for MVDC Grid

- Renewable energy (RE) target has progressively increased towards being carbon neutral by 2050
  - ✓ RE generation share goal: 20% (2030) → 30-35% (2040) → 60-70% (2050)
  - ✓ Currently, RE share is 7%, 75% of which is small-sized

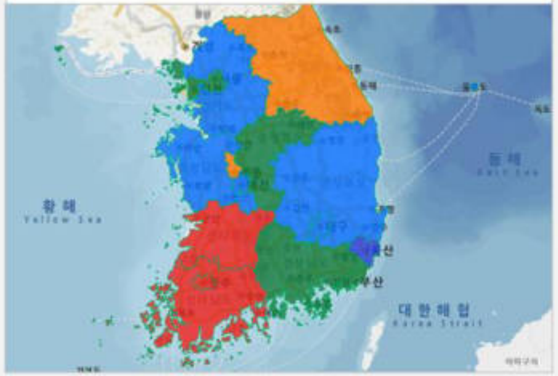


Key Drivers for MVDC Grid

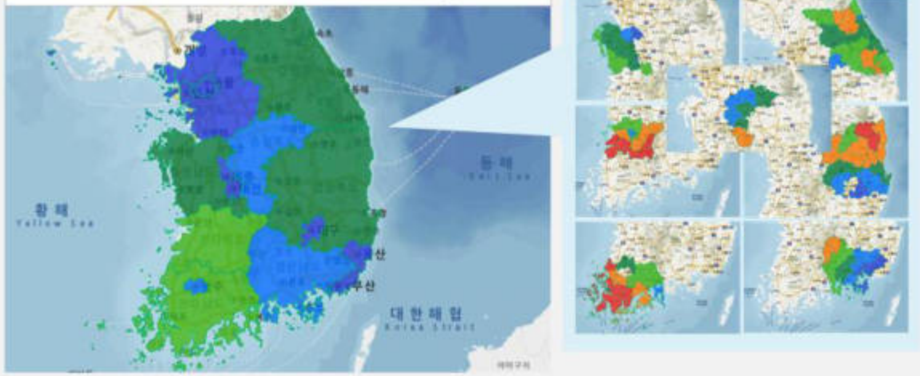
RE Adoption Issues

Saturated Networks for RE Connections

Trans. Network Availability

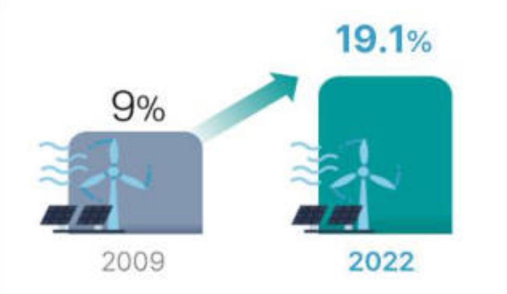


Distr. Network Availability

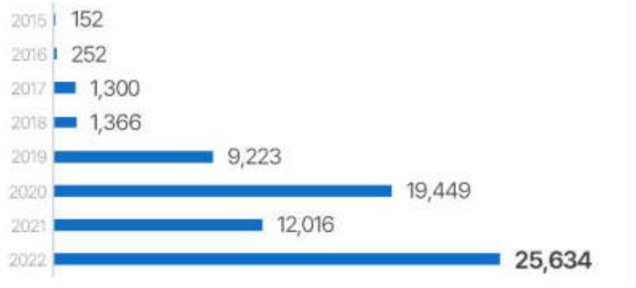


RE Curtailments (Line congestions & Flexibility shortage)

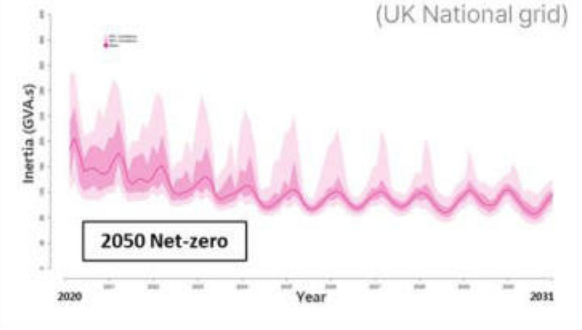
RE Share in Jeju



Curtailed RE in Jeju [MWh]



Decreasing Grid Inertia



Long-term Supply Instability

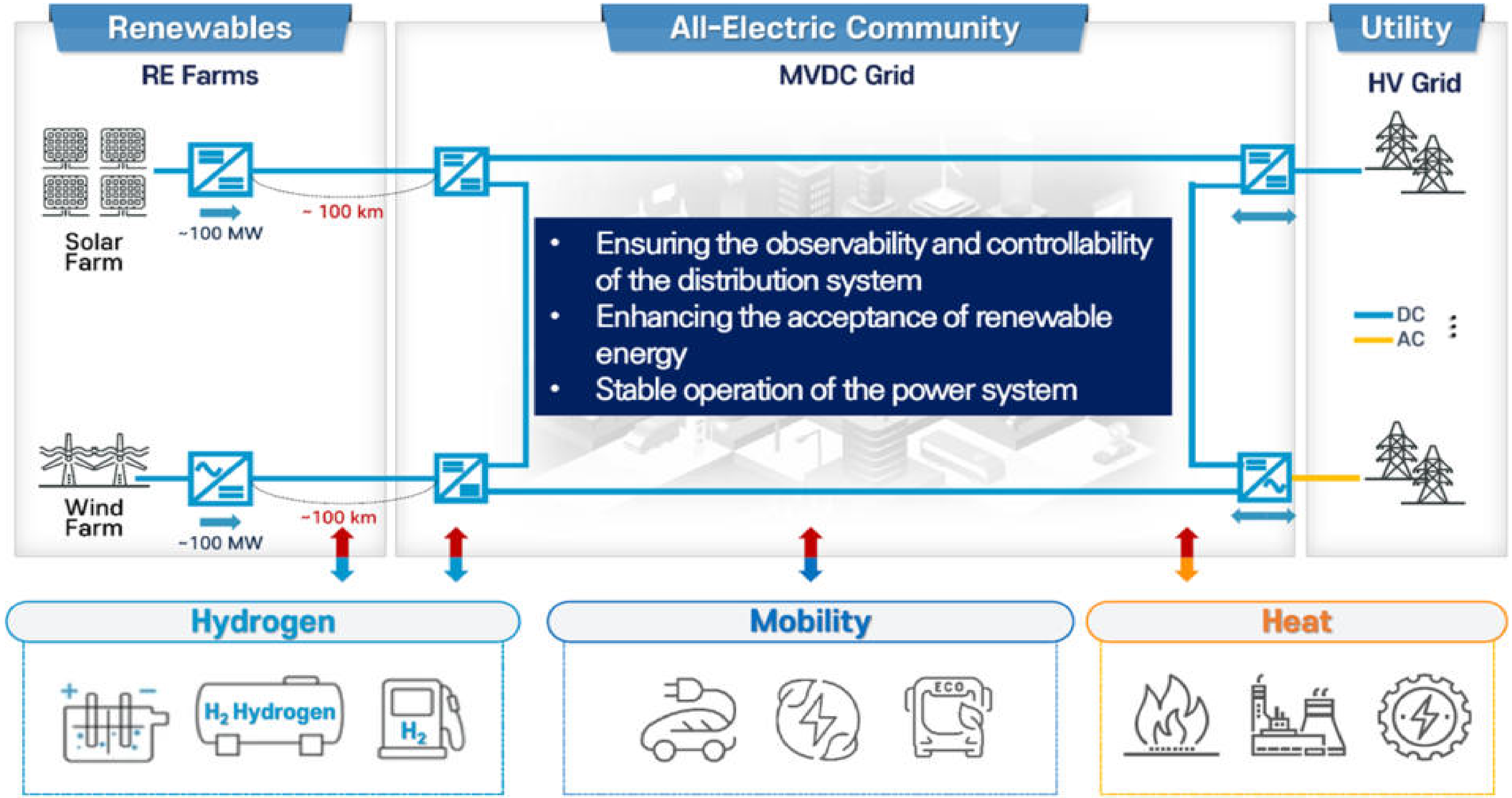
Energy Prices in Europe Hit Records After Wind Stops Blowing

The U.K. went all in on wind power. Here's what happens when it stops blowing

MVDC Grid

- Medium Voltage Grid is a central herb that powers our communities, and integrates a variety of new technologies and energy sectors.
- MVDC Grid can provide and innovative platform to accelerate the path to decarbonized energy systems.

> Sustainable with Renewable Energy
> Modular and Scalable
> Sector-Coupled
> Simple and Efficient Connections
> Reliable and Resilient



Source: MVDC Grid for All-Electric Society, IEC MSB White Paper Proposal, 2024.4.17.

MVDC Grid

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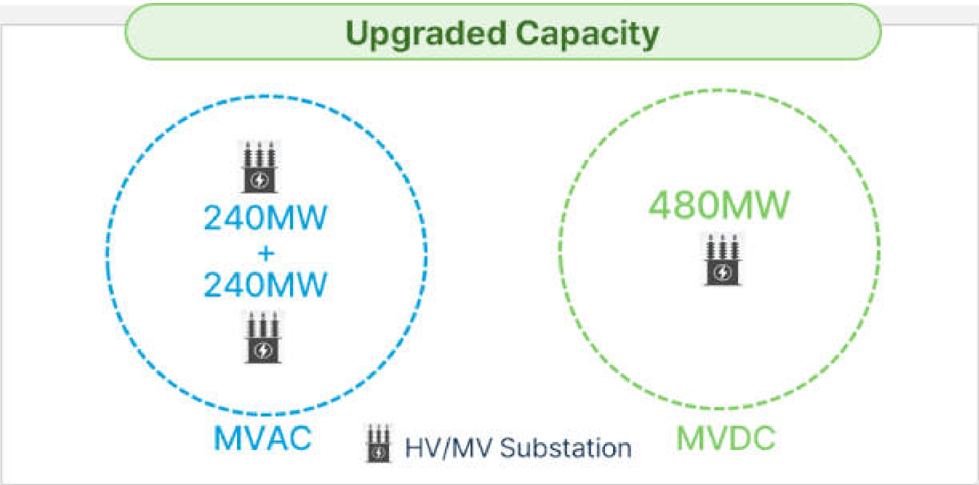
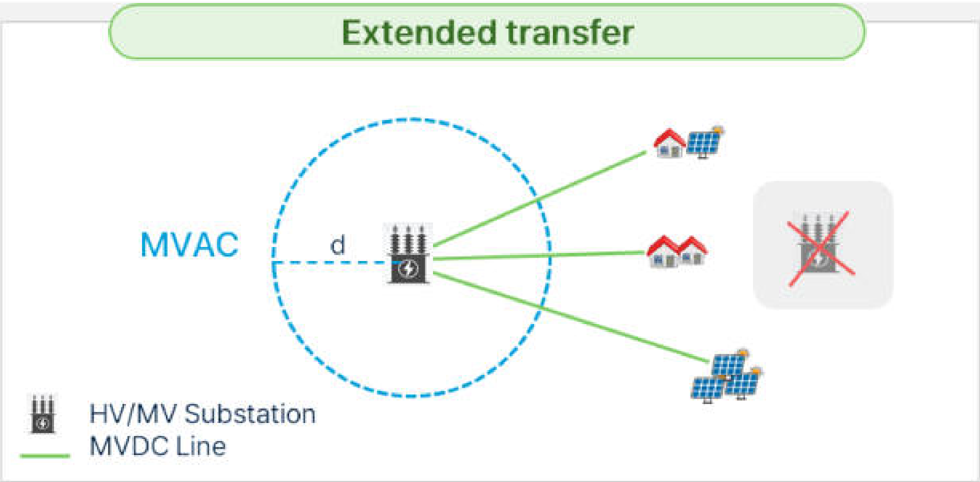
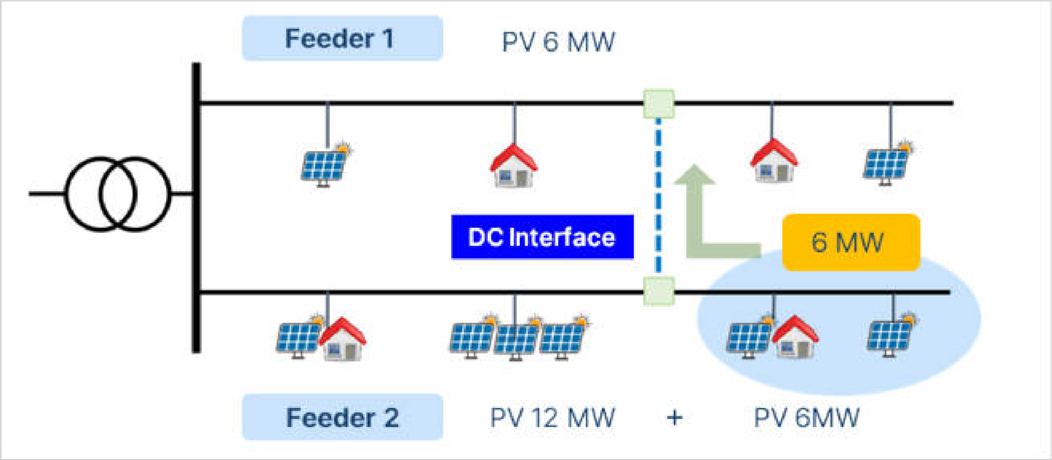
Network Utilization

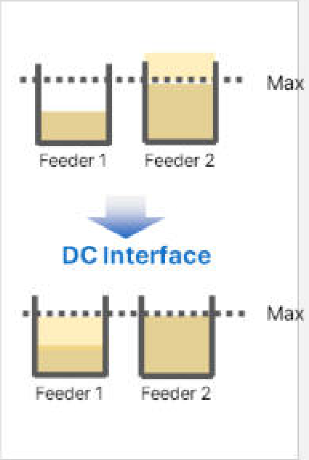
Network Availability





Soft Open Point (SOP)





MVDC Grid

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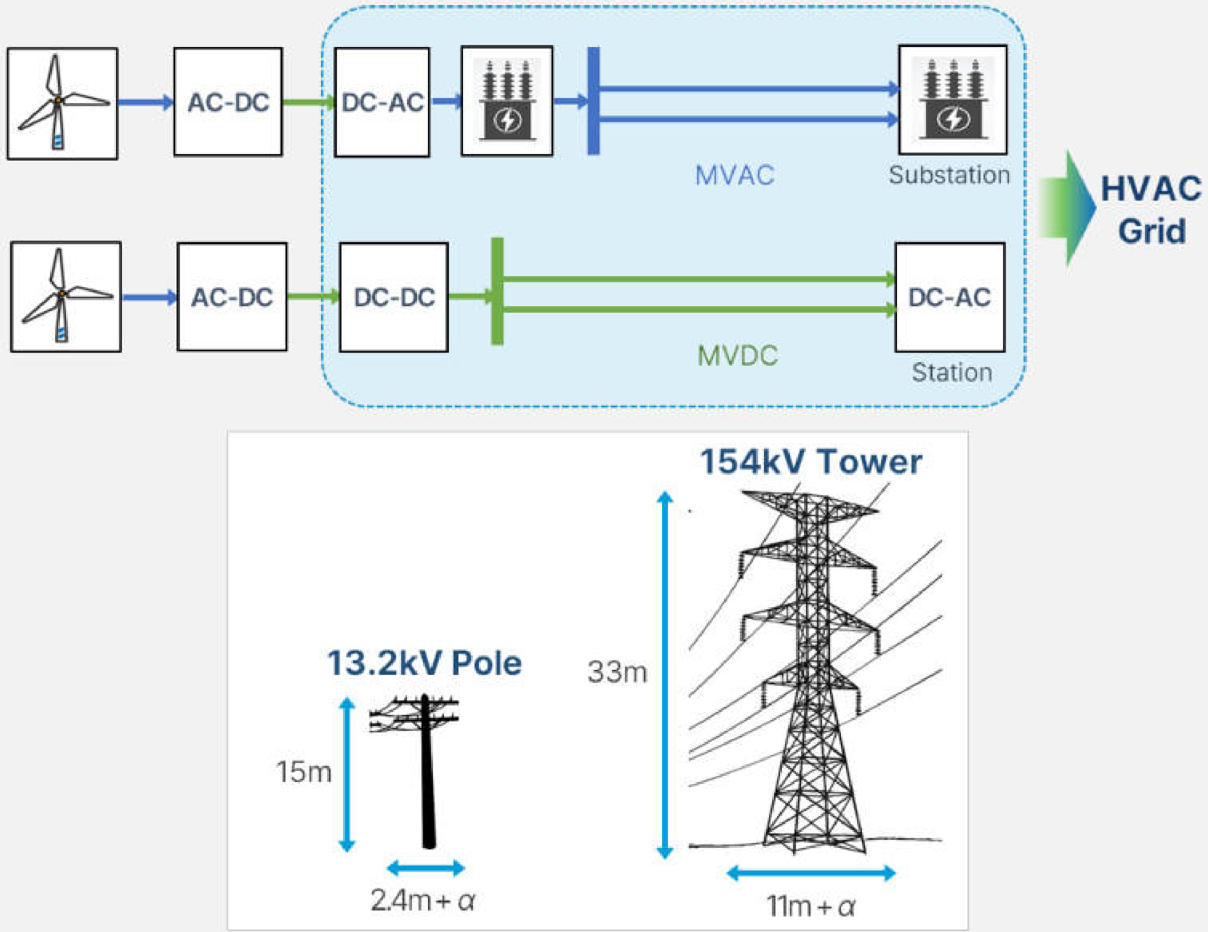
Facilitated RE Interconnection

Simple structure, easy collection of multi-sources, improved efficiency and longer power transfer

	MVAC	MVDC
Voltage	13.2kVac	18.7kVdc
Max Power	40MW	100MW
Max delivery	21km (at 40MW)	59km (at 40MW)
Loss	-	1.9~4.7% less

- Simulation with 13.2kV AC and 18.7kV DC feeders in Korea
- Distribution line type: ACSR-OC 240mm^2

154kV$_{AC}$ connection can be avoided for 40 to 100MW



MVDC Projects

Region	Title	Description	Purpose
Europe	Angle-DC Project, UK	±27kV back-to-back interconnection of Anglesey and North Wales.	Increasing power transfer between two regions.
	FEN Research Campus, Germany	multi-terminal ±2.5kV grid in Aachen university.	Testing MVDC converters & multi-terminal operations.
	Network Equilibrium, Western Power Distribution(WPD), UK	A 20MW back to back converter linking two different 33kV networks.	Controlling power flow between two networks to improve utilization of the networks.
	Tjaereborg Onshore Wind Project, Denmark	4.3km 9kV DC link between onshore wind farm and AC grid	Demonstrating grid integration of offshore wind farm.
Asia	Tangjiawan Science Park, Zhuhai, China	3-terminal ±10kV grid with PVs and batteries	Piloting 3-terminal configuration and grid operations.
	Baolong Industrial Park, Shenzhen, China	±10kV grid linking two S/Ss, AC sensitive loads at MV, and AC/DC microgrids at LV	Piloting S/Ss interconnection and MVDC grid operations.
	MVDC Distribution, Japan	1.5kV/380V connection, microgrid of solar, wind, battery and DC loads	Piloting MV/LV interconnections and grid engineering.
	MVDC Tie Pilot, KEPCO, Korea	±35kV 30MW DC circuit	Testing operation with current AC lines and equipment.
America	Eagle Pass, Rapid City, Blackwater, etc., USA	Back-to-back applications (±13kV, ±15.9kV, ±21 kV, ±31 kV, 57 kV, and 80 kV and power ranges from 36 MW up to 350 MW.)	Interconnecting two asynchronous grids.
	Mackinac Project, USA	200MW converter station operating with ±71 kV	Controlling power flow and voltages between two regions in the same grid.

Multi-terminal Grids — MV-LV Integration — Renewable Energy Transmission

MVDC Grid R&D Initiative in R.O.K.

APEC 2025 KOREA

To develop MVDC core technology for AC/DC hybrid distribution grid operation in 2030, aiming to deal with the surging demand for grid-connection of distributed energy resources

Advanced AC/DC Hybrid Distribution Network R&D Project

Period	2022~2028 (7yrs)
Budget	$222 million (Gov. $159M, PS $63M)
Vision	Contributing to economic growth by responding to growing electricity demand and achieving government goal for renewable energy
Purpose	Dealing with growing grid−connected DERs and stabilize distribution grid via MVDC technology

Objectives & KPIs

MVDC core technology for AC/DC hybrid distribution grid in 2030

Grid connection demand

- Improve DER connection limit by 60%
- Improve grid availability by 30%

Efficient operation

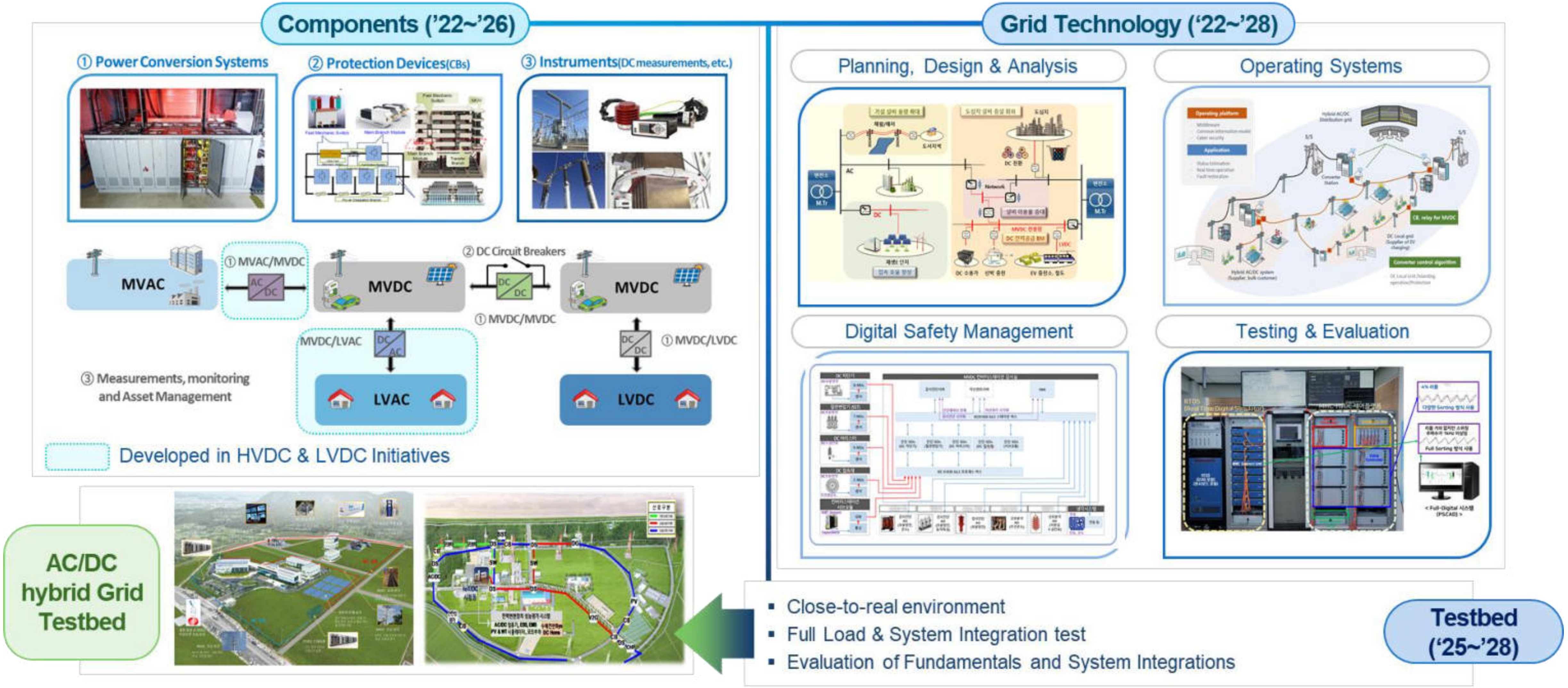
- Reduce power conversion loss by 10%
- Fault-robust operation: 90%
- Limit voltage variations within 3%

Public acceptance

- Create national standards
- Meet EMF safety standards
- Reduce size by over 20%

Source: Korea Energy Technology Evaluation and Planning Institute

MVDC Grid R&D Initiative in R.O.K.



Source: Korea Energy Technology Evaluation and Planning Institute

MVDC Grid R&D Initiative in R.O.K.

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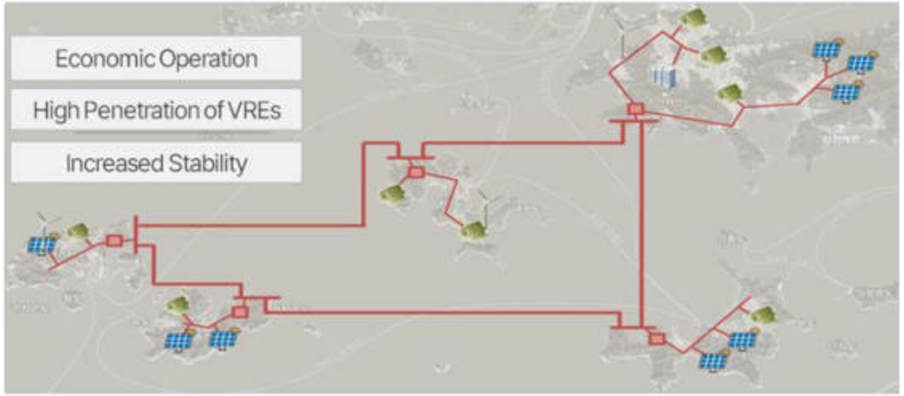
Cat.	Sub-Projects	Scope
Compo-nents	MV DC-DC Converter Station	▪ DC ±**20kV 20MW** modular multi-level converter (**MMC**) station
	MV-LV DC Converters	▪ DC **20kV/1.5kV 2MW** modular converter: bi-directional power flow
	Multi-terminal (MT) Control Syst. & Converter Station Engineering	▪ MT MVDC integrated control & operation, **MV AC-DC control & protection** ▪ MVDC converter station engineering
	MV DC Circuit Breakers	▪ **42kV 9kA** DC hybrid **circuit breakers** (Commutation & inverse current injection types)
	MVDC Protection Devices	▪ Switches, disconnect switches, and arresters: (SW) Rat. V. 42kVdc, lifecycle > 5,000, (DS) Rat. V. 42kVdc, lifecycle > 2,000, (AR) Discharge curt. 10kA, Impact curt. 100kA Varistor V. 250V/mm
	Measurement, Diagnosis & Evaluations for Converter Stations	▪ 42kV/500A sensors, **IEDs & platforms** for monitoring, diagnosis & **asset mgmt**. (IEC 61850 Ed. 2) ▪ **Reliability evaluation** algorithms & standards, etc.
Grid	Grid Design and Analysis	▪ **AC-DC hybrid grid planning & design**, modeling & analysis, and protection & grounding ▪ Local DC grids design (**railways, EV charging network**, etc.)
	Grid Operating Systems	▪ AC-DC hybrid grid **operating systems** for utility & community microgrid ▪ Network & energy management, **protection coordination**, black start, grid support
	Grid Safety Management	▪ AC-DC hybrid grid **safety operating** environments using **digital twins**
	Test & Evaluation for Grid Operation Syst.	▪ **Test/evaluation tech. & platform** for AC-DC hybrid grid operation systems ▪ Real-time simulation environment, performance tests, distribution grid operation code, etc.
Test bed	Testbed Pre-construction study	▪ Technical requirements for AC-DC hybrid grid testbed, and MVDC ecosystem analysis
	AC-DC Hybrid Distr. Grid Testbed	▪ AC-DC hybrid grid testbeds & total operating center for **field evaluations**

Source: Korea Energy Technology Evaluation and Planning Institute

Step Up to Field Trials

Field-test Grid and Business Applications for Real-World Readiness



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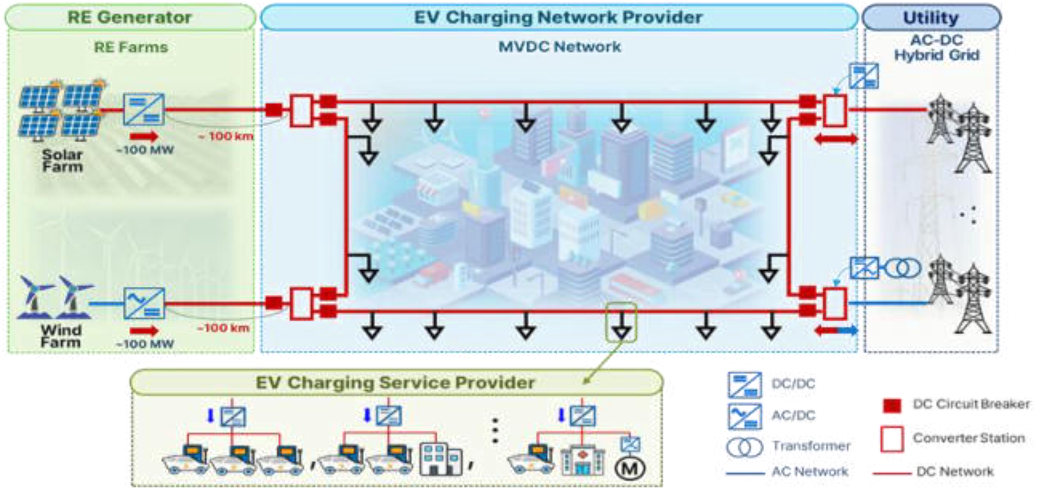

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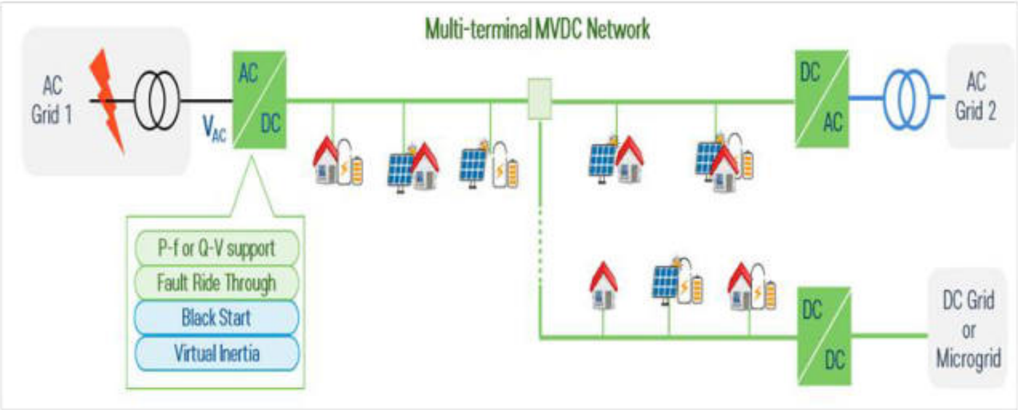

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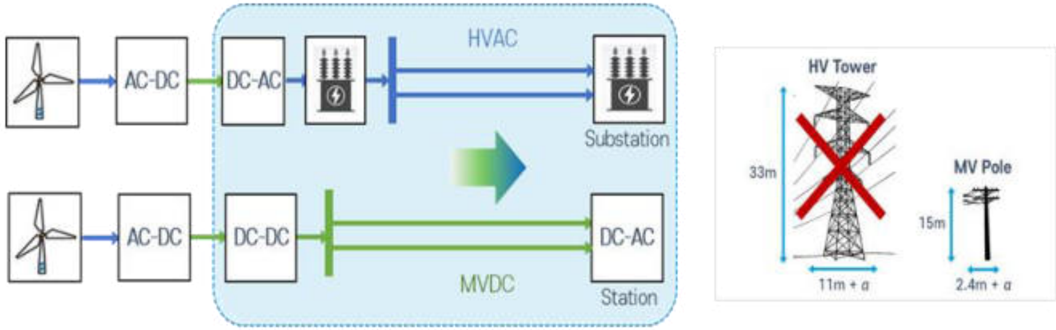


< Renewables Integration >

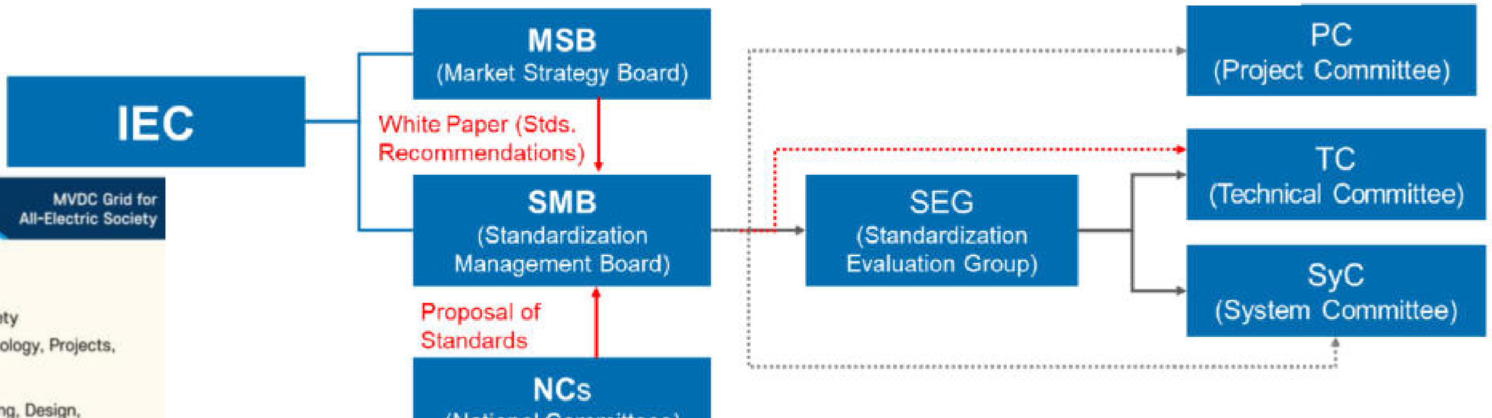
DC Standardization Status

SDO	Activity	Description
IEC	• TC 115 • TC 14/17/20/36/37/99, SC 17A/17C/22F/36A • SyC LVDC • MSB (SWG 21)	• HVDC transmission (TSs and TRs only) • HVDC converter, cables, switchgear, etc. (ISs, TSs, and TRs) • LVDC systems level (1 IS, and 7 documents in progress) • White paper (MVDC grids for an All-Electric-Society) in progress
CIGRE	• A3: High voltage equipment • B1: Insulated cables • B4: HVDC and power electronics • C6: Active distribution systems and distributed energy resources	• MVDC and some HVDC equipment • TB 852: DC cables up to 800kV • HVDC systems and advanced power electronics • C6/B4 TB 875: MVDC Distribution Systems
CIRED	• WG 2019-1: DC distributin networks • WG 2021-1: DC and hybrid AC/DC	• WG 2019 final report for DC networks on distribultion level • DC components, planning & operation, standardization, regulatory framework, and MV & LV distr. network use cases
IEEE	• 1709: DC power systems on ships • 2974: System commissioning of MV and LV DC distribution network • WGI10: High Voltage Direct Current • LVSD/37.17	• IS for 1-35kV MVDC on ships • IS for system commissioning for MV/LV distr. Network • ISs for HVDC components and systems • IS for general purpose LVDC circuit breaker

MVDC Grid and Standardization, IEC SMB CAG Meeting, 2024.6.,KERI, Suel-Ki Kim

Standardization Efforts

- **MVDC Grid** selected for IEC MSB 2025 White Paper Project (April-May, 2024)
- **SEG Application** submitted to IEC SMB and under review (September, 2024)
- **SEG Establishment** approved at IEC SMB meeting (October, 2024)
- **A new TC** to be considered after SEG's in-depth Analysis (October, 2025)



< IEC Standardization Structure >

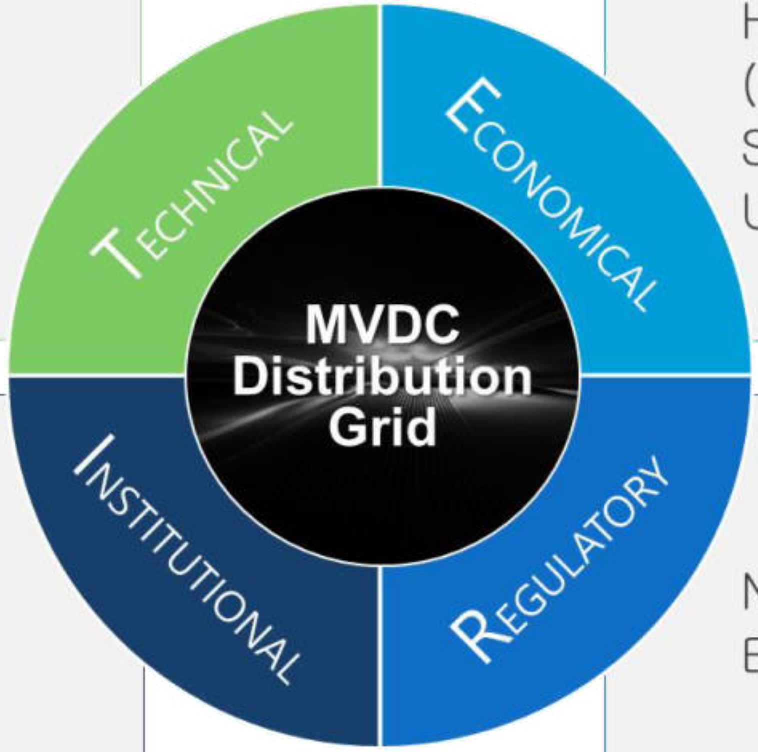
MVDC Grid and Standardization, IEC SMB CAG Meeting, 2024.6.,KERI, Seul-Ki Kim

Challenges

APEC 2025 KOREA

Control, Protection and Reliability of AC-DC Hybrid Grid

High Installation Costs (Converters, Control Systems, Infrastructure Upgrades)



Timely Standardizations (Operation, Protection, Testing & Evaluation, Safety..)

Non-Cost Reflective Electricity Prices

KERI 한국전기연구원

Distributed Power System
Research Center

감사합니다
Thank you

www.keri.re.kr

Session 5 – Case Study: Successes and Challenges to Microgrid and DC Power Initiatives in the Republic of Korea

Transition to Distributed Energy System in Korea

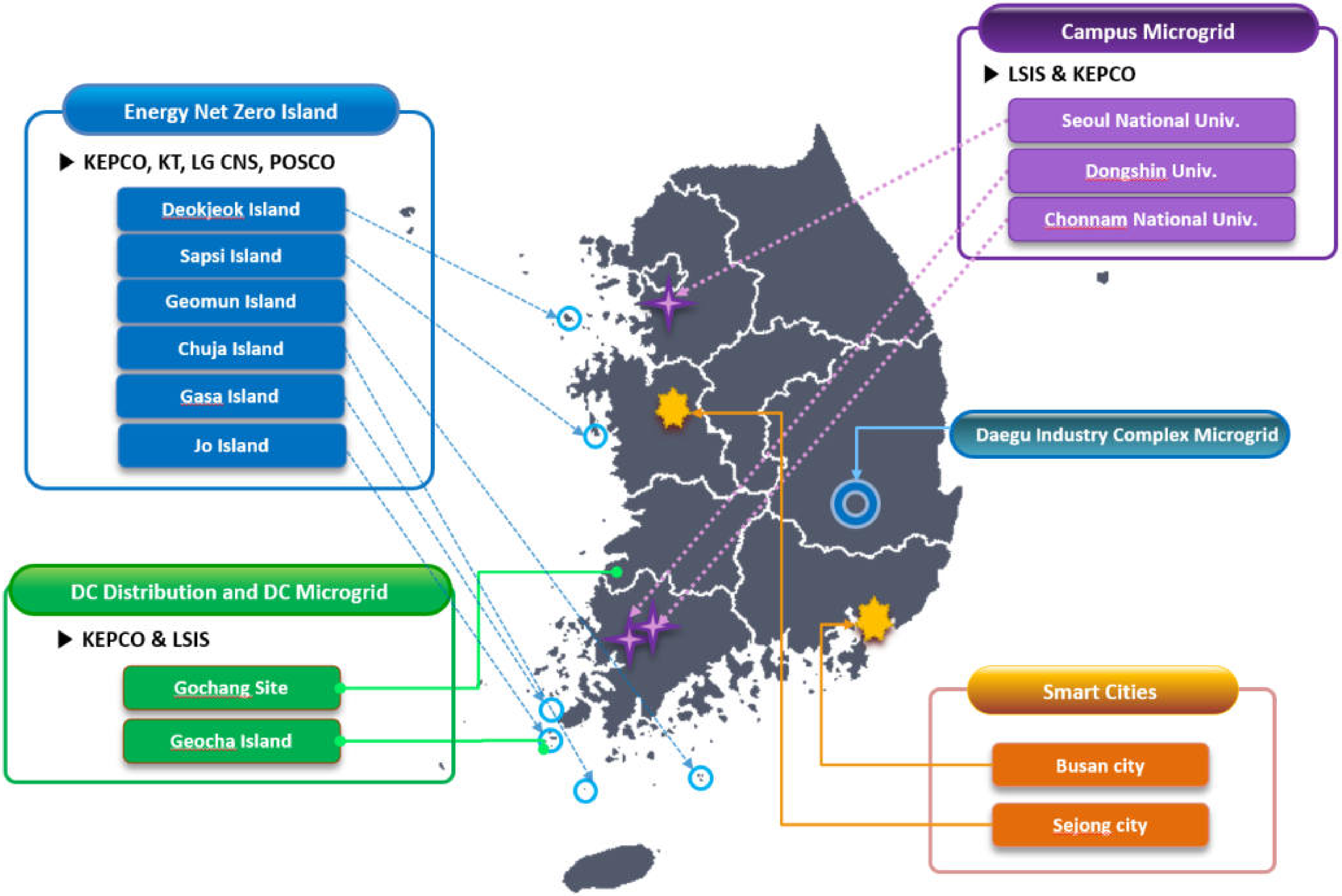
Feb. 24 2025

Dr. Dongjun Won, Inha University

Outlines

- **Deployment of Microgrid in Korea for 15 years**
- **Transition to Distributed Energy System**
- **Development of new DER based System in Korea**
  - New Market
  - Distribution System Planning
  - Non-Wires Alternatives(NWAs)
  - Distribution System Operator(DSO)
  - TSO/DSO/VPP Coordination
  - Local Flexibility Market

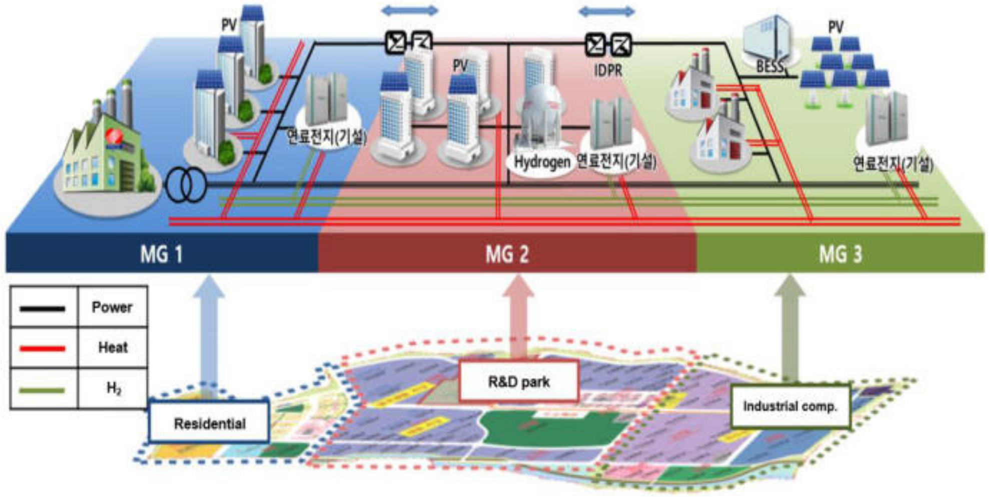
Deployment of Microgrid in Korea for 15 years



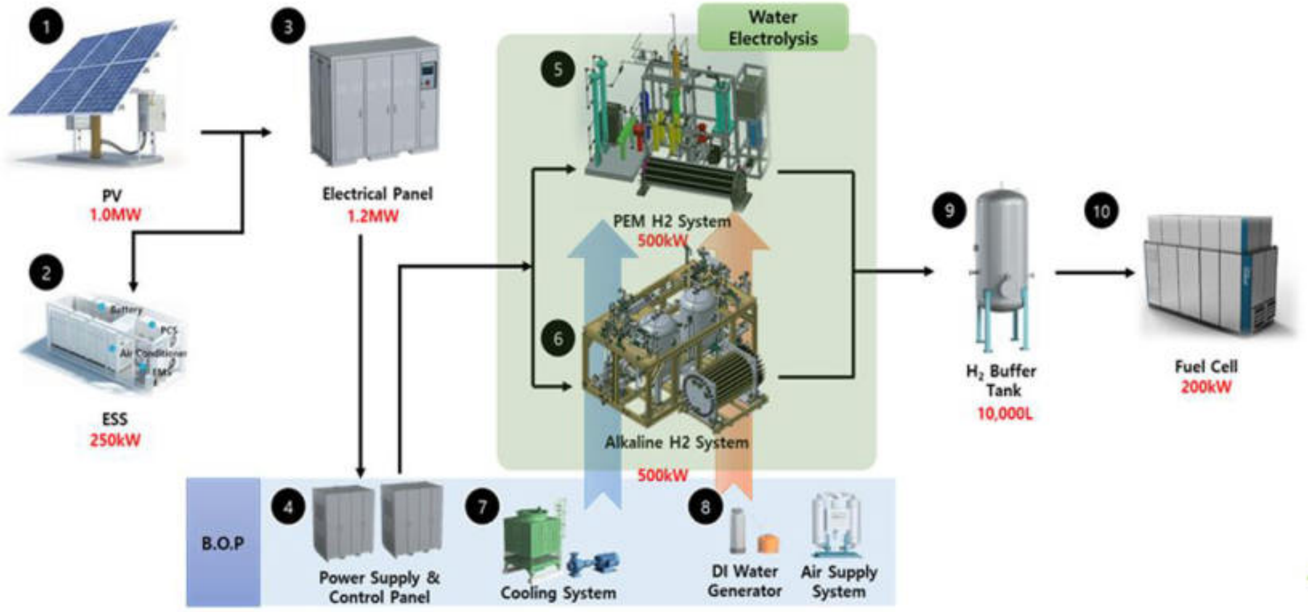
P2G based Multi-Microgrid (KEPCO RI, 2022)

APEC 2025 KOREA

- 3 Microgrids : Residential, R&D park and Industrial complex
- Sector coupling technology : Power to Gas(H_2)
- PV 1MW, ESS 250kW/500kWh, Electrolyzer 1 MW, FC 200kW
- Energy trading with blockchain
- Open microgrid platform by KEPCO RI



Multi microgrid and energy trading



Sector coupling of electric power and H_2

Energy superstation : Charging station microgrid

- Application of sector coupling technology in Korea DER roadmap
- Hybrid charging station for electric and hydrogen vehicles
- Microgrid operation with PV, ESS and fuel cell will be implemented
- Will provide ancillary service

EV charging station, PV and ESS

H_2 compressor and storage

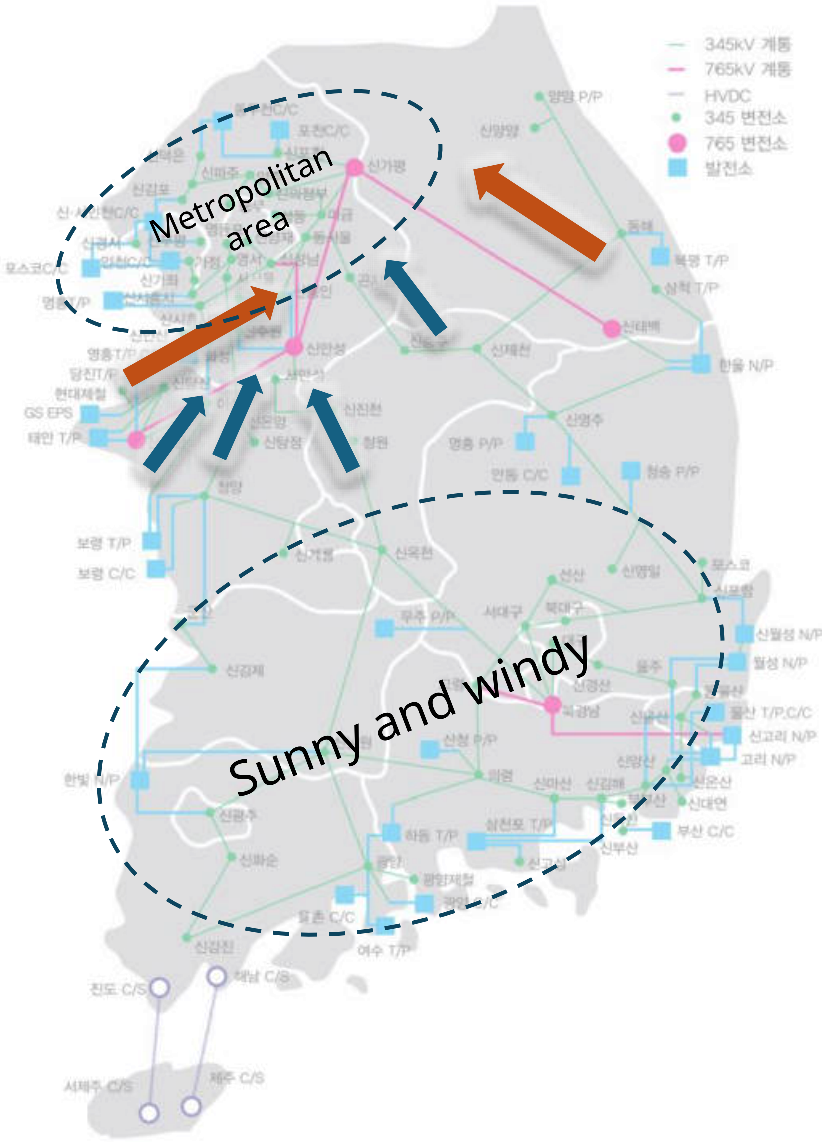
Hydrogen vehicle charging station

Image sources : Yangjae green car station, Seoul, Korea, www.H2news.kr

Difficulties in power system operation with renewables

APEC 2025 KOREA

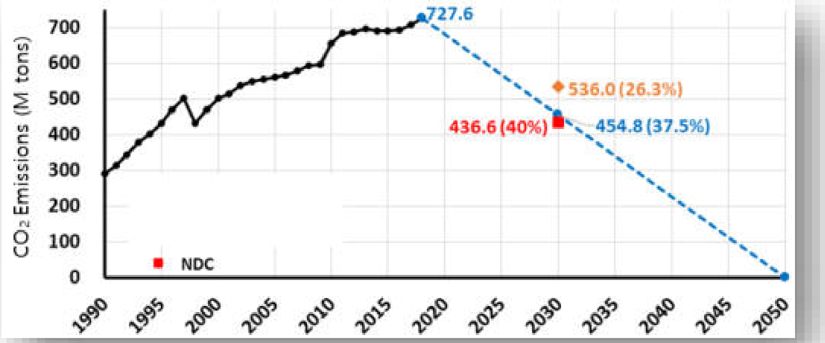
1. Increase of uncertainty and variability
2. Low base generation, reserve and inertia
3. Congestion of network
4. Inconsistency in renewable energy and consumption location → Need for distributed energy system



Transition to Distributed Energy Resource(DER) System

APEC 2025 KOREA

- **Aggressive NDC Target for Carbon Neutrality**
  - Renewable energy, electrification with EV etc.
  - Need to solve power grid problems (Renewable curtailment, network congestion, instability in frequency and voltage etc.)



"It's GRID, stupid!"

- **In June 2023, DER Promotion Act in Korea is announced**
  - Paradigm shift to distributed energy system
  - Deploy Distributed Energy Resources (Renewables, EV, ESS, MG, SMR etc.)
  - Increase the hosting capacity of existing power system
  - Localize energy generation and consumption
  - Deploy non-wires alternatives(NWAs) solutions
  - Create new markets for DER

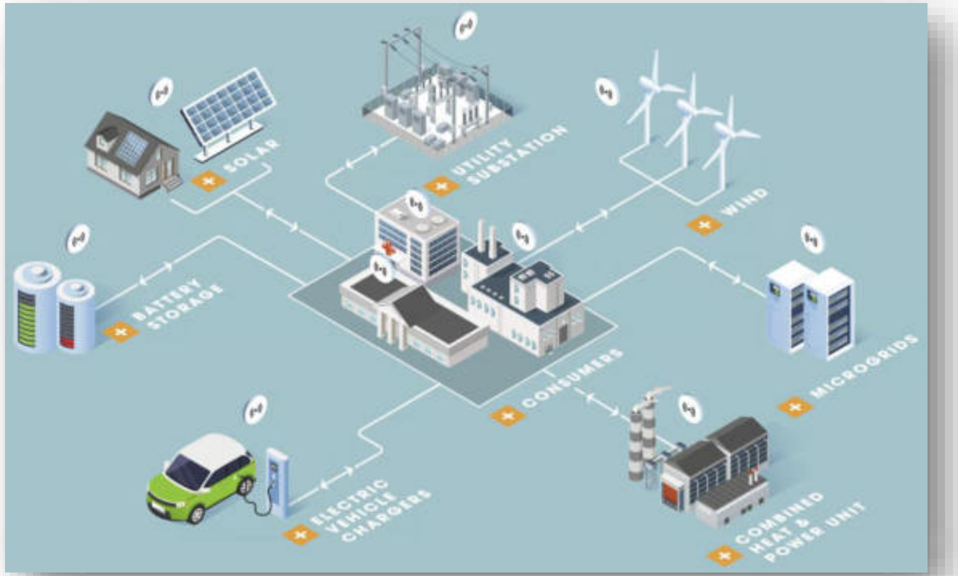
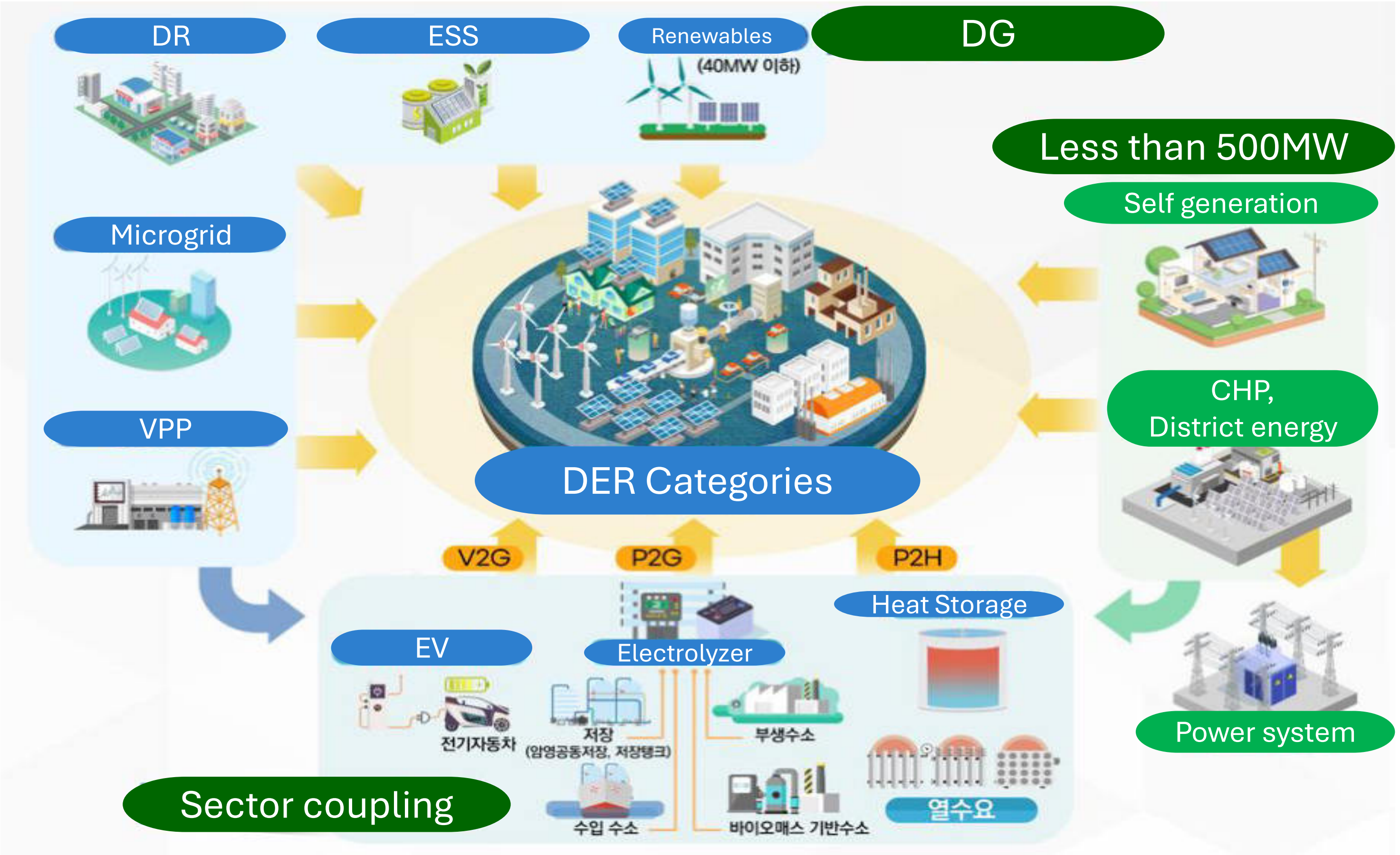


Figure source : https://www.stantec.com/en/markets/energy/grid-modernization/distributed-energy-resources

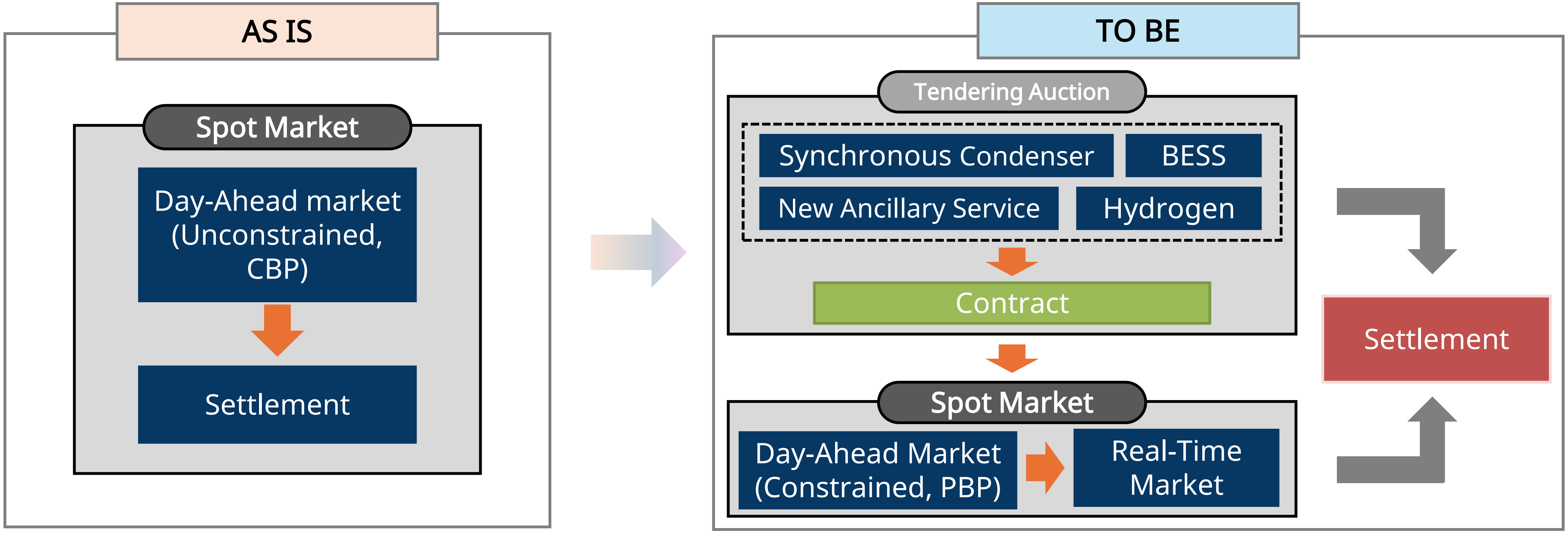
DER Promotion Act (June 2023)

- **Key action plans**
  - Basic National DER promotion plan every 5 years
  - Mandatory DER installation in large customers
  - Mandatory system impact study for large new loads
  - Sandbox area for DER promotion
  - VPP market
  - Locational Marginal Pricing (LMP)
  - Distribution System Operator (DSO)



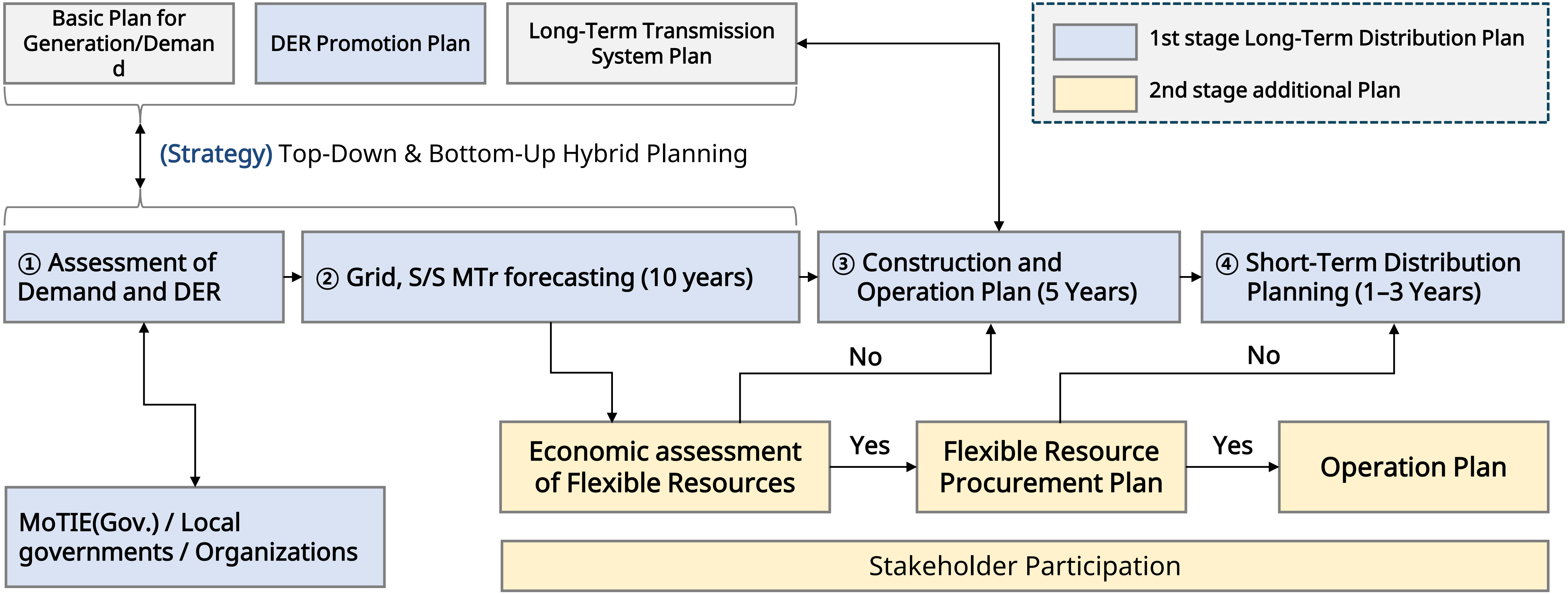
Development of New Market in Korea (2024)

- Spot Market (Day-Ahead) → Tendering Auction (Centralized) + Spot Market (Real-Time)
  - Promote DER (DR, ESS, H_2 etc.) to handle the variability of renewable energy
  - DER has more chances to get benefit from the market by providing flexibility



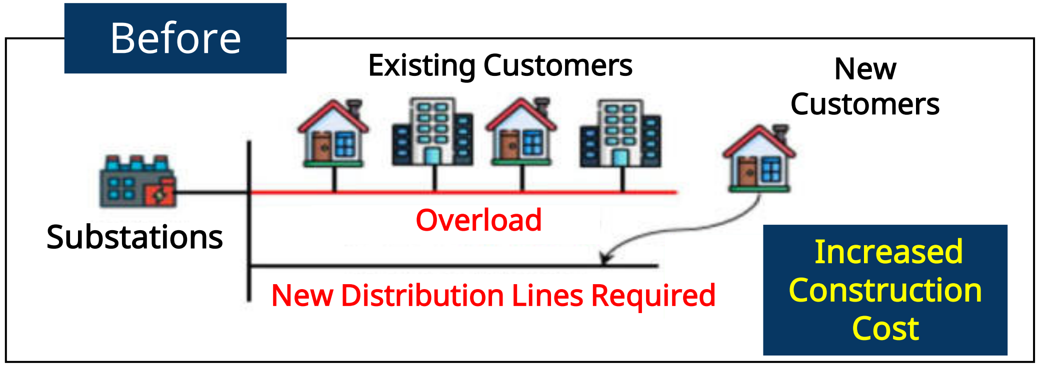
Distribution System Plan in Korea (2024)

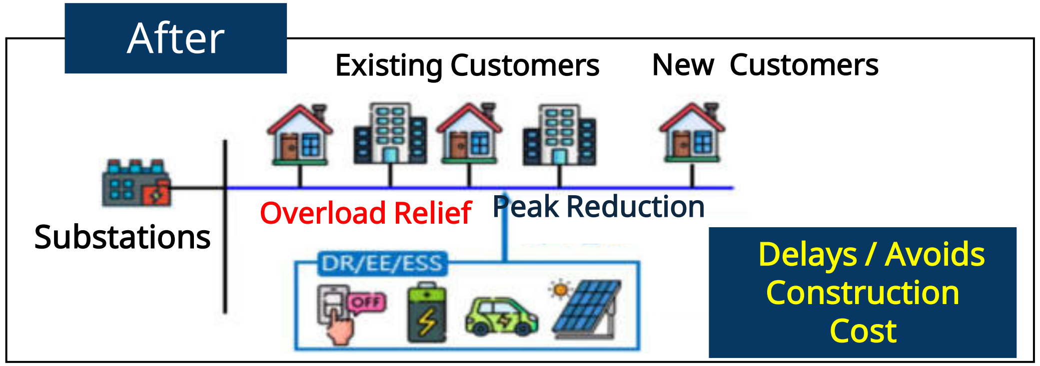
- Distribution system plan become a part of public plan



Non-Wires Alternatives(NWAs) in Jeju island

- Definition : Alternatives to delay the grid investment with application of DER





- Utilization of Flexible DERs (ESS, EV, etc.) to expand distribution benefits and provide flexibility

<< Jeju ESS Project >>

- Operator: LG Energy Solution
- Installation Area: Seogwipo City
- Capacity: 2.5 MVA (PCS) / 6.267 MWh (Battery)
- Connection Line: Pyosun S/S 1D (Exceeding 10 MW)
- Project Cost: 3 billion KRW (100% private investment)
- Purpose: participation in wholesale market as VPP and avoidance of over-generation penalty + NWA

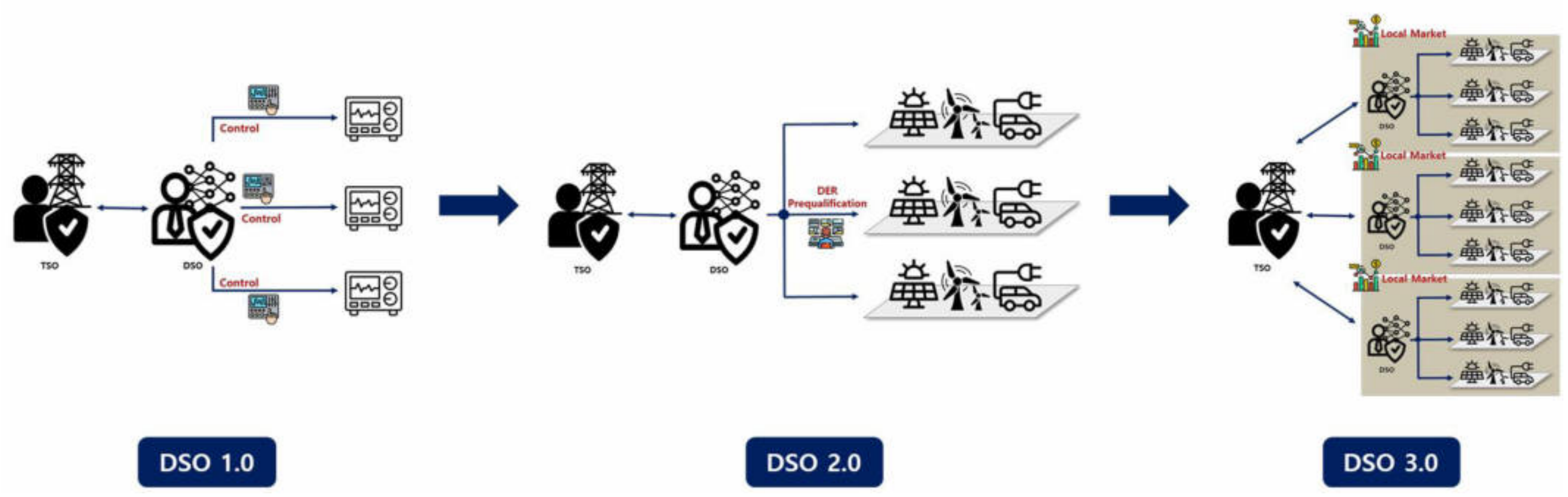
<< Jeju V2G Integration Project >>

- Operator: Hyundai Motor Group
- Installation Area: Jeju Island
- Capacity: 11 kW chargers 130 units
- Purpose: Participation in wholesale markets and demand response program + NWA (Sandbox project)

DSO (Distribution System Operator) by KEPCO (2024)

- ## Definition of DSO
  - A ‘neutral’ operator responsible for the active control, dispatch, and market operation of DER and distribution system

DSO 1.0	DSO 2.0	DSO 3.0
• Utilization of controllable resources • Providing limited local flexibility	• Integrated management of DERs • Providing global system flexibility	• Decentralized management of variability and uncertainty of RES through market

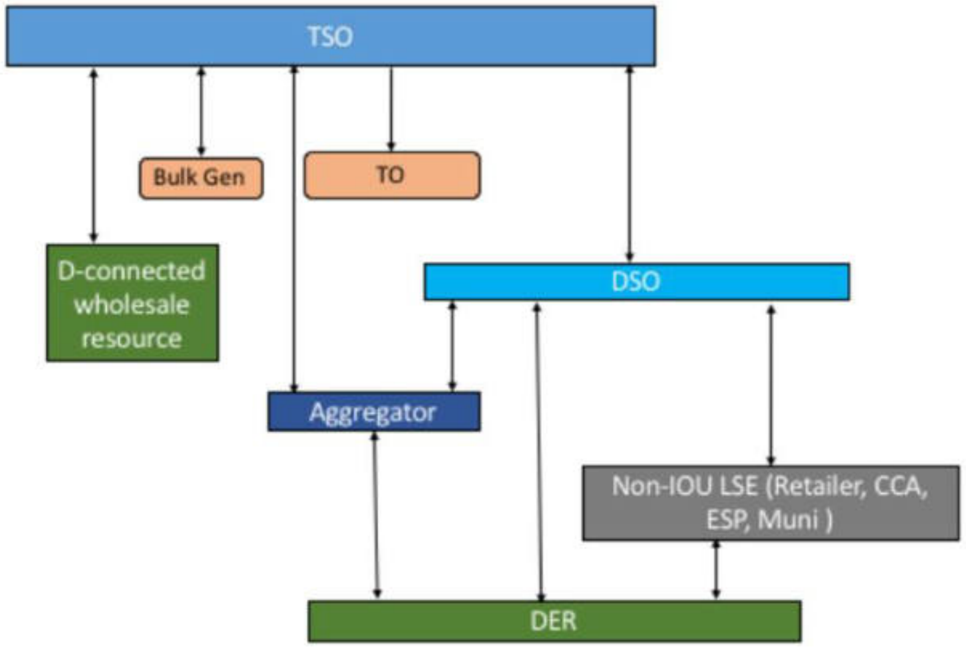


TSO/DSO/VPP Coordination and Governance

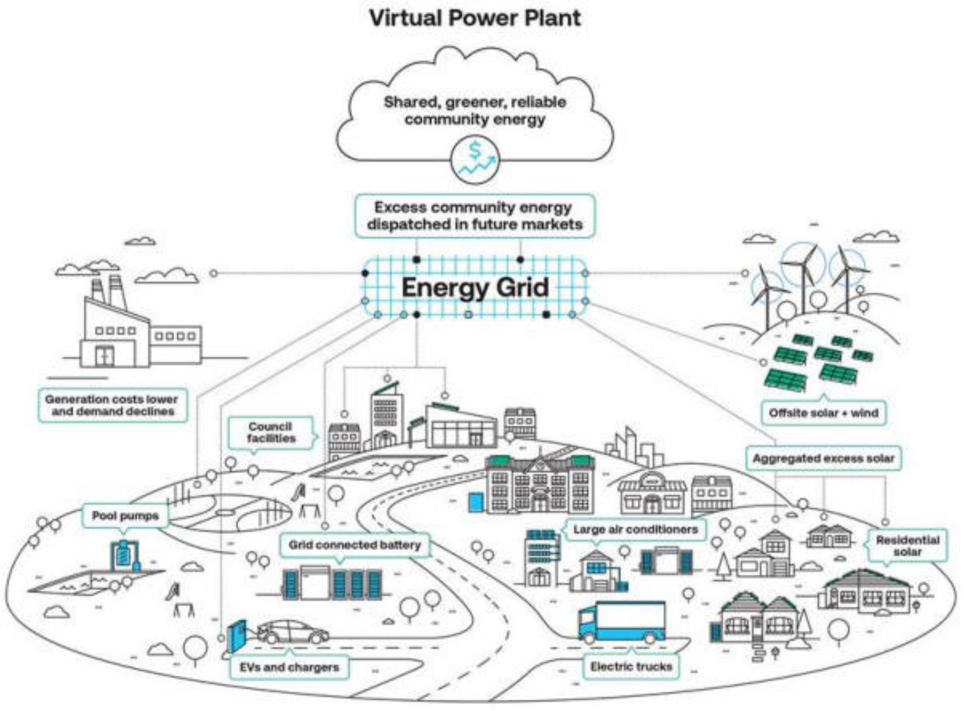
APEC 2025 KOREA

- VPP participate in wholesale market but DERs are located in distribution system
- Need coordinated control between TSO-DSO-VPP

TSO-DSO Coordination in NY

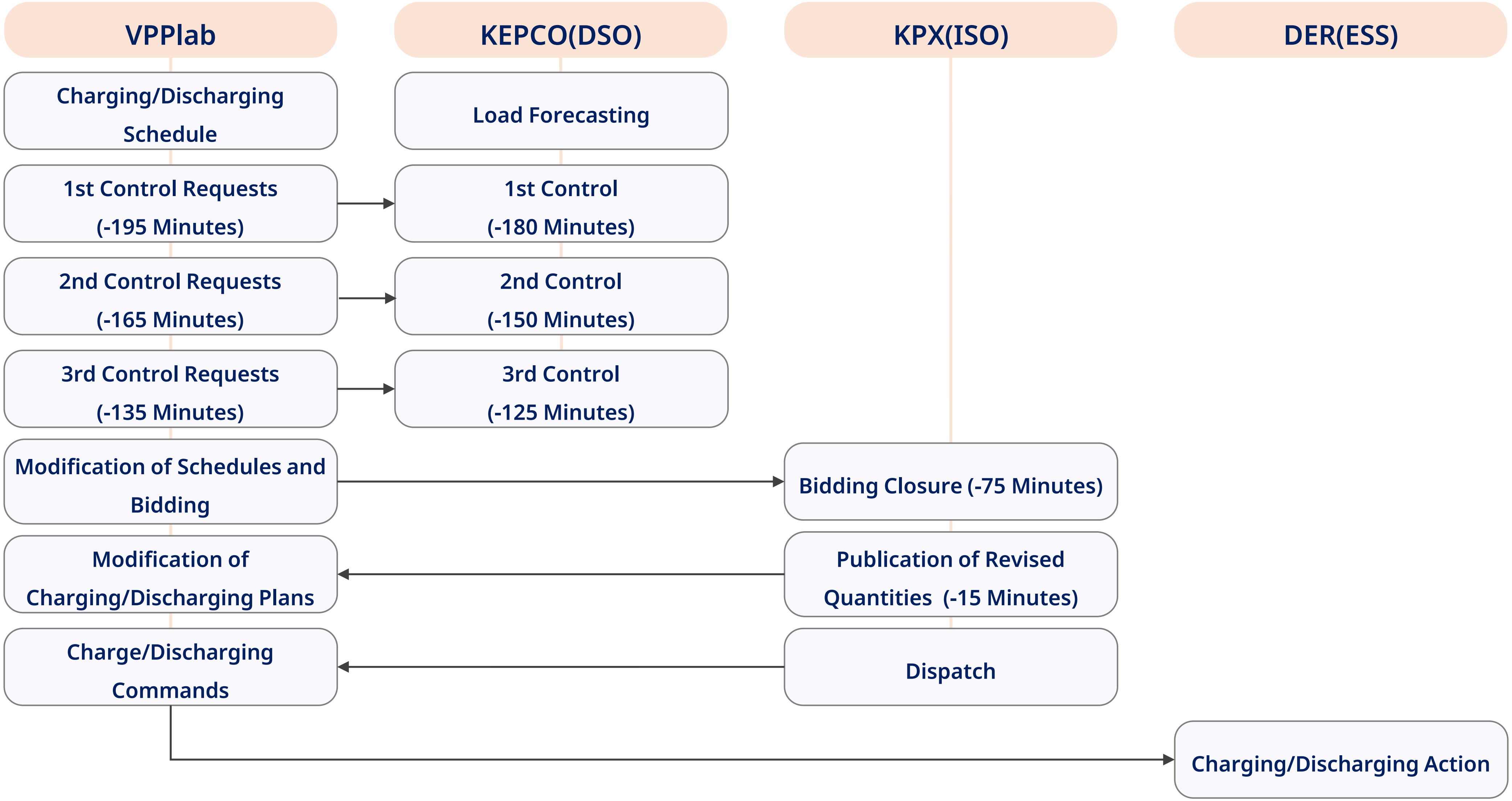


Virtual Power Plant and grid operation



TSO: Transmission System Operator, DSO: Distribution System Operator, VPP: Virtual Power Plant

Example of TSO/DSO/VPP Coordination in Jeju island



Local Flexibility Market

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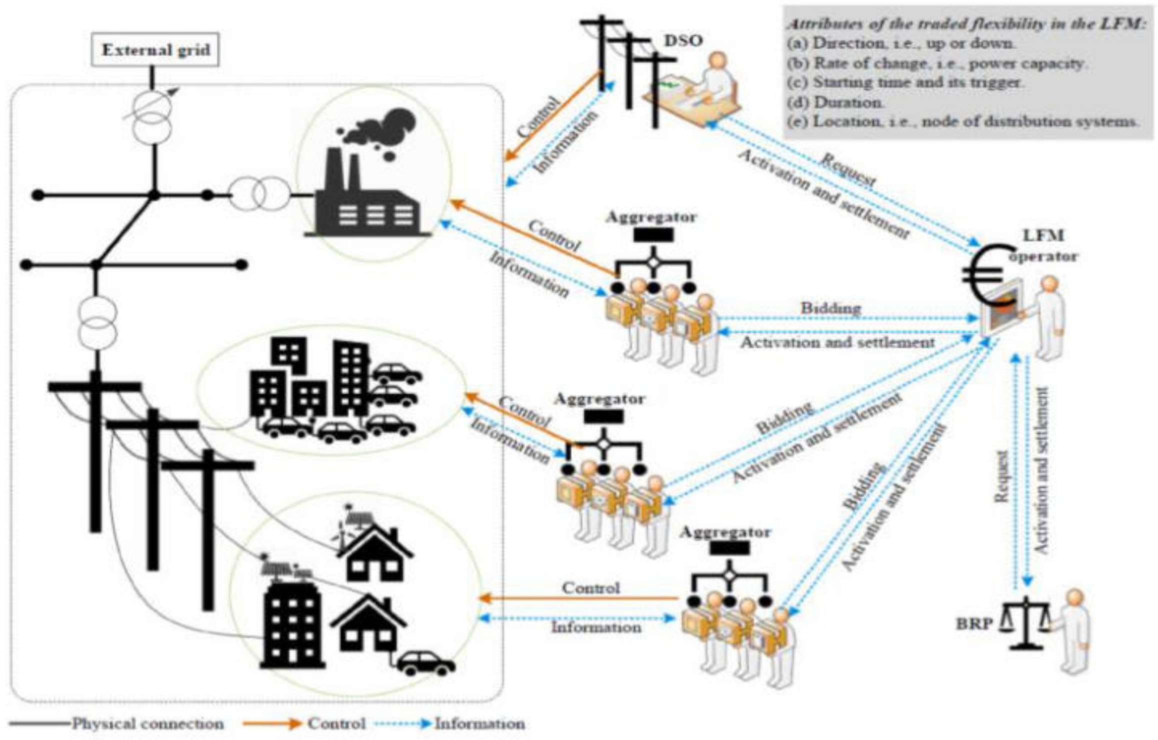
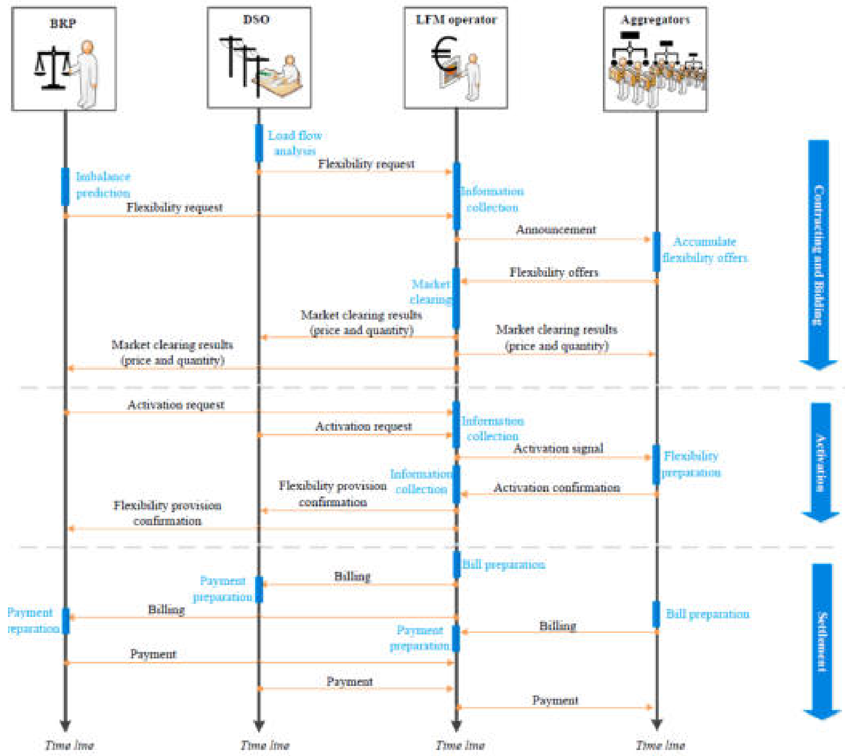
- Introduce local flexibility market to respond to the uncertainty and variability of local DERs
- Market operation and bidding strategies for DER and aggregators
- Local solutions for reactive power/voltage control

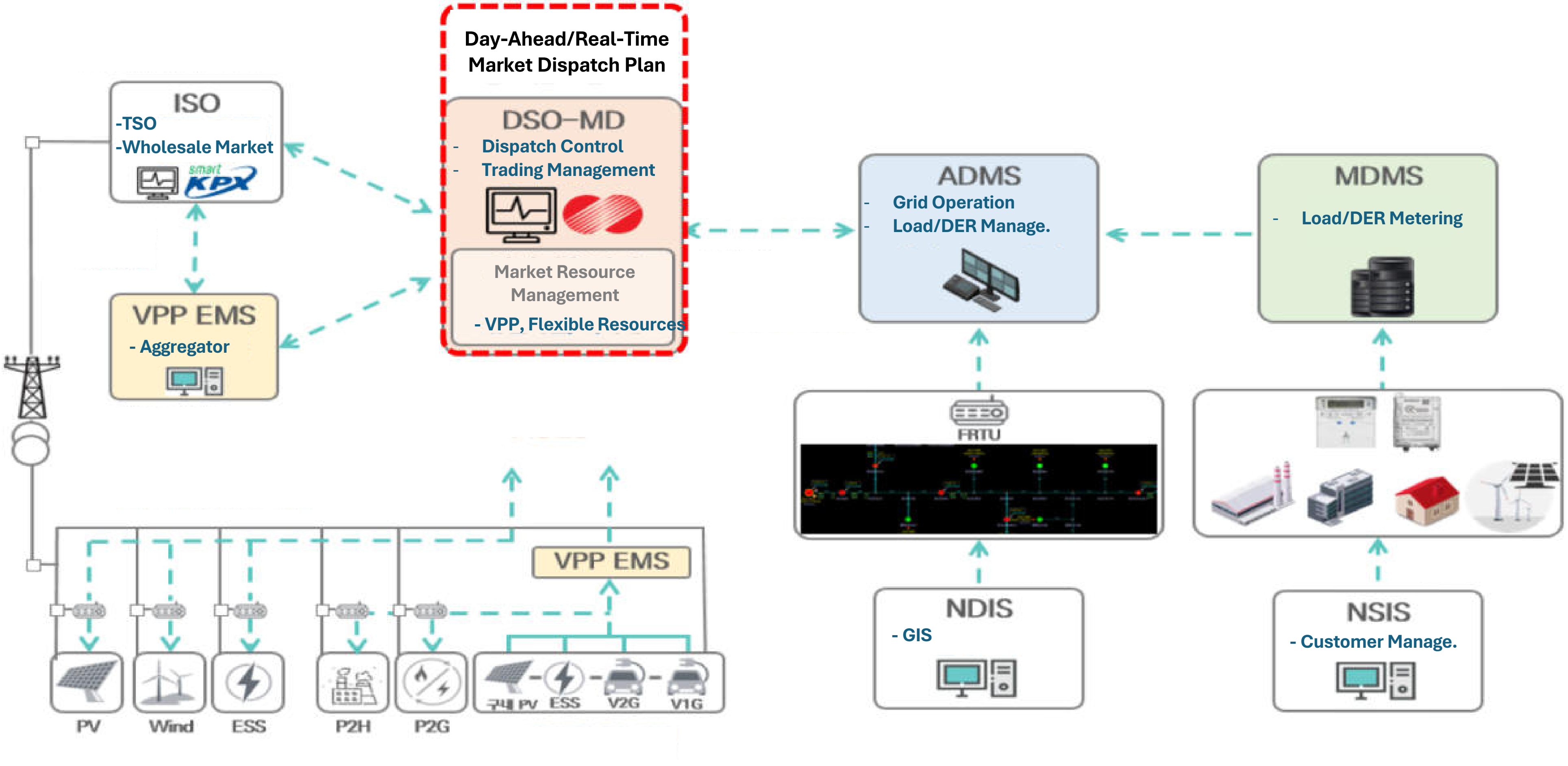
Local Energy Market Structure and Operation





Platform for VPP Bidding & Flexibility Market in Korea

- Establish a system (DSO-MD) for VPP market bidding and grid congestion management
- Prepare for the future DSO and LFM in Korea



Korea's Action Plan for DSO and LFM

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Design Local Flexibility Market

◆ Design Market Structure: To enhance the value of local flexibility

➢ DERs → Value Stacking / DSO → Cost reduction and neutral operation

Collaboration Framework with Wholesale Market

◆ Collaboration framework with wholesale market and operations

➢ MO – Stabilize price fluctuation / Retailer – Minimize energy cost / DSO – Optimize distribution system operation

Develop human resources and knowledge

◆ Develop human resources and knowledge for DSO and LFM

➢ Local flexibility market and DSO → National energy paradigm innovation

Opportunities and Challenges for Emerging and Developing Economies

Santiago Barcón
PQ Barcon
México

Contents

- Opportunities
- Challenges

Opportunities

- Lower the cost of the DC systems
- Use more efficiently to “avoid resell” the parts
- Provide “Luz de la Buena” to the communities
- “Luz de la Buena” is how the people without being connected to the electrical grid call Power
- A PV systems has to provide Power to start motors

Opportunities

- Lighting and some back up is welcome, but the need to operate motors is primordial

- Development of local producer of inverters and motors will be very important

- Imports cost fluctuations on exchange rates potentially can kill the project developments, so local integration lowers the risk

Challenges

- Convince authorities that Power is needed
- Since the figures of service population has been published considering “light” and not “power” the high figures of service will diminish and is a difficult political decisions
- Train the electricians and users on the difference between DC and AC, mainly in breakers
- Involve Universities and Technical Schools in the effort

Driving Trade & Investment for DC Power Systems and Microgrid Frameworks Through Public Policy Alignment

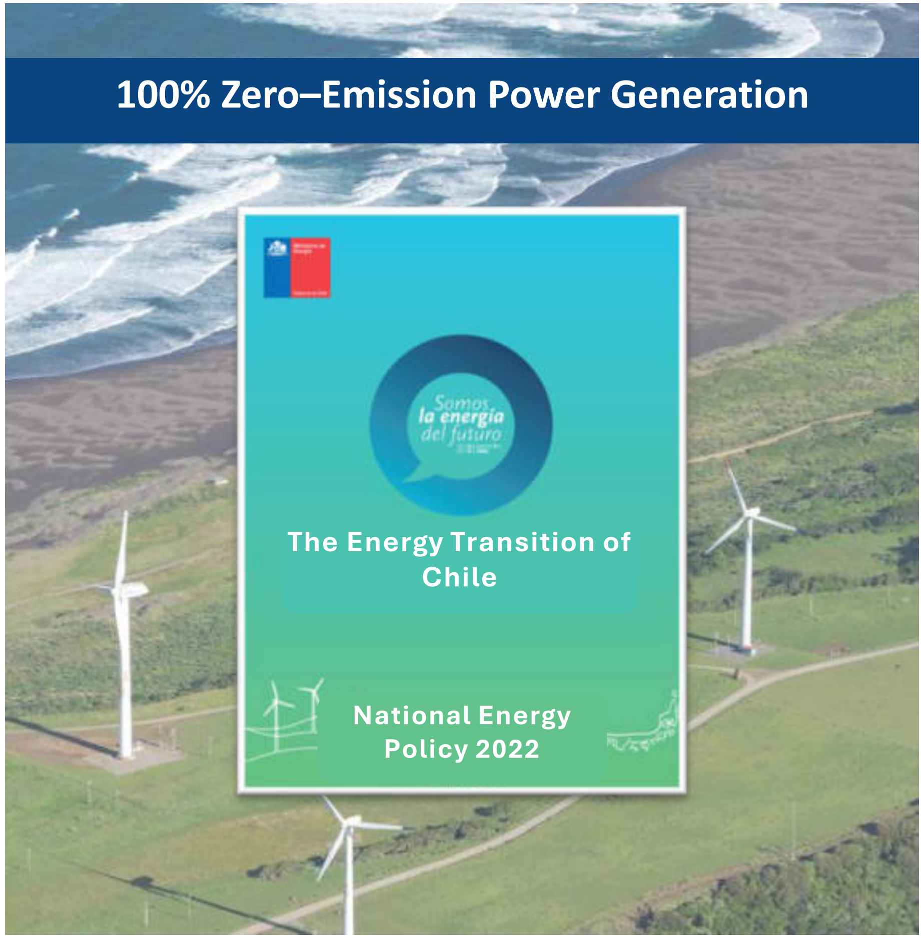
Panel: Opportunities and Challenges for Emerging and Developing Economies.

Panelists:
- Danae Cancino, Regulatory Analyst, Ministry of Energy, Chile
- Santiago Barcón, CEO, PQ Barcon, Mexico
- Anastasiia Koltunova, Legal Officer, World Trade Organization

Moderator: Gwen Wang-Reeves, Engagement Director, GE Vernova

Decarbonization Commitment

APEC 2025 KOREA



Renewable Energy Integration

We must increase the share of renewable energy sources in our energy mix to accelerate the decarbonization process.

Enhance Grid Modernization

Upgrade and modernize the electrical grid to efficiently incorporate a larger share of renewable energy.

Invest in Clean Energy Technologies

Promote investments in technologies that support zero-emission electricity generation.

Ensure a Just Transition

Implement policies and initiatives that support a fair and equitable transition.

Chile's Electric System

APEC 2025 KOREA

National Electric System (SEN):

- Capacity: 36,729 MW.
- **Supplies more than 99%** of the total electricity consumption.
- Only 1 system in Chile.

Medium Systems (SSMM):

- Capacity: Between 1.5 MW and 200 MW.
- **Supplies less than 1%** of the total consumption.
- Currently we have 10 systems.

Isolated Systems (SSAA):

- Not formally defined, but typically smaller than 1.5 MW.
- **Supplies less than 0.01%** of the total consumption (serving around 10,000 users).
- More than 100 systems exist across Chile.

Opportunities for DC microgrids: Isolated Systems

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Isolated systems are located in 11 (of 16) different regions:

Operated by distribution companies:

- 30 systems with an average of 200 users.

Operated by locals:

- 23 systems with an average of 140 users.
- 50 systems with an average of 12 users.

Isolated Electric Systems Challenges

- **Unattractive Market:** Isolated Systems are **not appealing to distribution companies** due to high risk, low profit margins, geographical challenges, and low demand.

- **Reputational Risk for Large Companies:** Large companies avoid these systems due to **long replacement times**, **tariff hikes, and reputational risks**.

- **Lack of Small-Scale Providers:** There is **no market for small-scale electricity distribution providers**, and companies from other sectors see the operation of Isolated Systems as risky due to lack of experience and financial support.

- **No Concessions in 40 Years:** Under the current regulation, **no company has applied for a concession** in isolated areas over the past four decades.

Huatacondo Microgrid

First intelligent micro-grid in Chile based on renewable energies

- Breaking the barrier of **bringing cutting-edge technology to small**, remote towns.
- Generating **efficient and replicable solutions** for electric distribution.
- **Strengthening and stabilizing** isolated and interconnected electricity systems.
- Direct **involvement of the community:**
  - Decision-making processes.
  - Turning them into **operators.**
  - **Assigning responsibilities** for efficient energy use and minor maintenance.

Huatacondo
Source: Energy Center (Centro de Energía)

Regulation

APEC 2025 KOREA

Regulatory complexity:

- The need for tailored regulations for the operation and management of microgrids.
- Technical regulations on service quality standards, equipment, and communications.
- Legal provision for a regulatory sandbox to facilitate innovation and pilot projects.

Governance in the electricity sector

Regulatory stability ensures long-term investment horizons.

Ministry of Energy
Creates and coordinates **policies and regulations** to facilitate the efficient development and functioning of the energy sector.

National Energy Commission
Autonomous institution. Defines and regulates **tariffs** and develops **technical standards** for the generation, transmission, and distribution segments.

Superintendency of Electricity and Fuels
Ensures **regulatory compliance** among sector participants and administers sanction

National Electric Coordinator
Operation of the National Electric System (ISO).

Experts Panel
Binding judgments about **discrepancies and conflicts** that arise from the application of electricity and gas service legislation.

Status of Microgrids in Chile: AC vs. DC

- The Chilean law's legal principle of non-discrimination between technologies ensures that neither AC nor DC microgrids are favored by regulation.

- AC microgrids are traditionally preferred due to compatibility with the Electric National System.

- DC microgrids are attracting interest for specific applications, such as isolated areas and industrial systems, due to the rise of solar energy and battery storage.

Developing Technical Capacities

More engineers specialized in DC technology.

Greater diversity.

A diverse workforce drives innovation and strengthens the energy sector.

Addressing the need for specialized skills in DC technology creates an opportunity to promote women's leadership and participation.

Diagnosis of the situation of women's insertion in the energy sector

Source: Developed by Deuman in collaboration with the Center for Women's Studies, for the Ministry of Energy, 2021.

Driving Trade & Investment for DC Power Systems and Microgrid Frameworks Through Public Policy Alignment

Danae Cancino
Ministry of Energy

APEC 2025
KOREA

Solutions

Eliminating barriers to trade through compatible regulatory frameworks for microgrids and DC power

APEC Workshop on Driving Trade and Investment for DC Power Systems and Microgrid Frameworks Through Public Policy Alignment

Christian Roatta, Senior Trade and Multilateral Affairs Specialist
UL Solutions
Feb. 24, 2025

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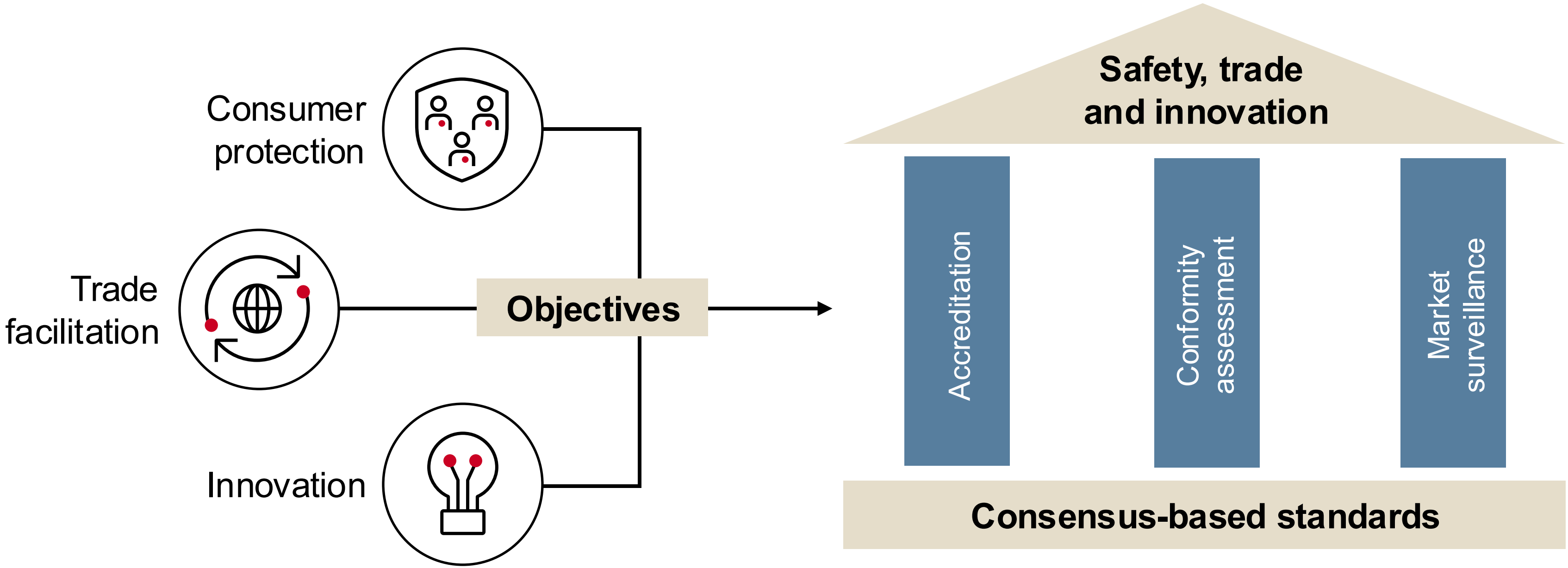
Regulatory frameworks and conformity assessment



Strong frameworks must balance regulator, manufacturer and consumer interests

Elements of regulatory frameworks

Standards and technical requirements: The written minimum requirements applicable to a given product or service to be used to verify compliance and perform conformity assessment.

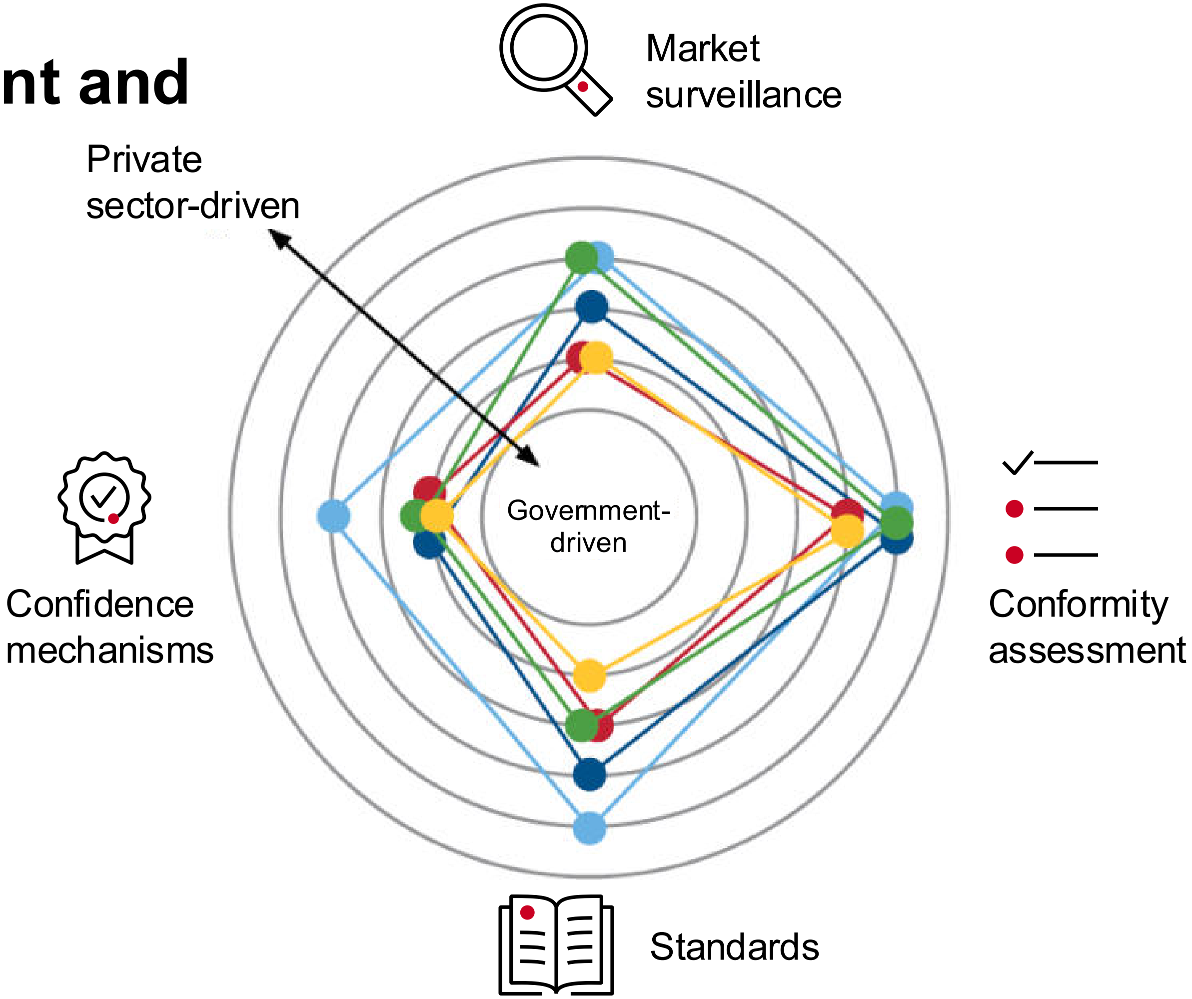
Conformity assessment: The process used to verify compliance with standards, schemes, regulations and other specifications. This includes evaluation, testing, inspection, validation, verification, certification and accreditation. Conformity assessment is generally performed by either first, second or third parties, depending on the system and a determination of the level of risk.

Confidence building and accreditation: A mechanism to assess and assure competence of the conformity assessment providers and method; accreditation is third-party attestation related to a conformity assessment body, conveying a formal demonstration of its competence, impartiality and consistent operation in performing specific conformity assessment activities.

Surveillance: Systematic iteration of conformity assessment activities as a basis for maintaining the validity of the statement of conformity; this can be pre-market testing or inspection, or post-market surveillance.

Roles of government and private sector

- United States
- European Union
- China
- Japan
- Brazil



Good practices for effective regulatory frameworks

- **International standards:**
  - Using international standards as the basis of technical regulations or conformity assessments is key to greater regulatory alignment and reducing barriers to trade.
  - International standards as defined in the World Trade Organization Technical Barriers to Trade (WTO TBT) Committee Decision on International Standards[1]
- **Technical regulations** – Periodically review technical regulations and conformity assessment procedures to examine increasing alignment with relevant international standards, including review of any new developments in relevant international standards.

[1] WTO | Principles for the Development of International Standards, Guides and Recommendations

Good practices for effective regulatory frameworks

Conformity assessment:

- Conformity assessment approaches are not one-size-fits-all.
- Regulators have the flexibility to choose and regularly review the appropriate method of demonstrating conformity according to their policy objectives, market characteristics, risk assessment and confidence needs.[1]
- The conformity assessment development process is about appropriately identifying, analyzing, evaluating and managing risk in an efficient, effective manner while facilitating trade in line with international obligations.
- Regulators should assess the risks to public health, safety, security, the environment and privacy, as well as the impact noncompliance would have on society at large.

[1] WTO TBT Committee Guidelines on Conformity Assessment

Good practices for effective regulatory frameworks

- **Confidence building and accreditation:**
  - Most frameworks consider bodies to which they can entrust the accreditation function and determine which conformity assessment activities require such accreditation.
  - Promote confidence by establishing a clear set of requirements from which the conformity assessment providers will be selected and allow applications from organizations independent of their geographical location. This will allow the largest pool of providers to offer services and enable the marketplace to allocate resources more efficiently.
- **Surveillance:**
  - It is common for an economy to undertake several surveillance methods concurrently. This improves effectiveness while preserving enough flexibility to cover the variety of circumstances where noncompliance might be identified.
  - **Consider resources** – Third-party systems, like the U.S., build inspection/auditing into pre-market certification services so that post-market surveillance is less costly.

What does regulatory compatibility mean for microgrids?

Microgrids and component technologies experience significant challenges to demonstrating compliance.

Example: Batteries

- Safety risks
- Accelerated product life cycles
- Evolving regulatory landscape
- Limited local testing capabilities
- Supply chain issues
- Slow testing laboratory turnaround times

Compatible frameworks foster innovation, promote consumer safety, and facilitate trade and investment in microgrid frameworks.

Key takeaways

- When implemented in line with best practices, regulatory frameworks can simultaneously protect the public, facilitate trade and foster innovation.
- Effective regulatory frameworks have four common components: standards and technical requirements, conformity assessment, accreditation, and market surveillance.
- While there is no one-size-fits-all approach for conformity assessment, public–private partnerships are critical to effective regulatory frameworks.
- Regulatory frameworks that are grounded in the horizontal principles of the WTO TBT Agreement enable economies to achieve the three core objectives of consumer protection, trade facilitation and innovation.

CLO25EV2280650

Thank you

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The TBT Agreement and trade in DC power system and microgrid components

Anastasiia Koltunova

Trade and Environment Division,

World Trade Organization

Workshop on driving trade & investment for DC power systems and microgrid frameworks
Korea,
25 February 2025

Setting the scene: linkages between climate technologies, trade and regulatory measures

Trade

Climate technologies (like microgrid)

Standards, regulations, conformity assessment procedures decline in the cost of solar panel systems

scale economies

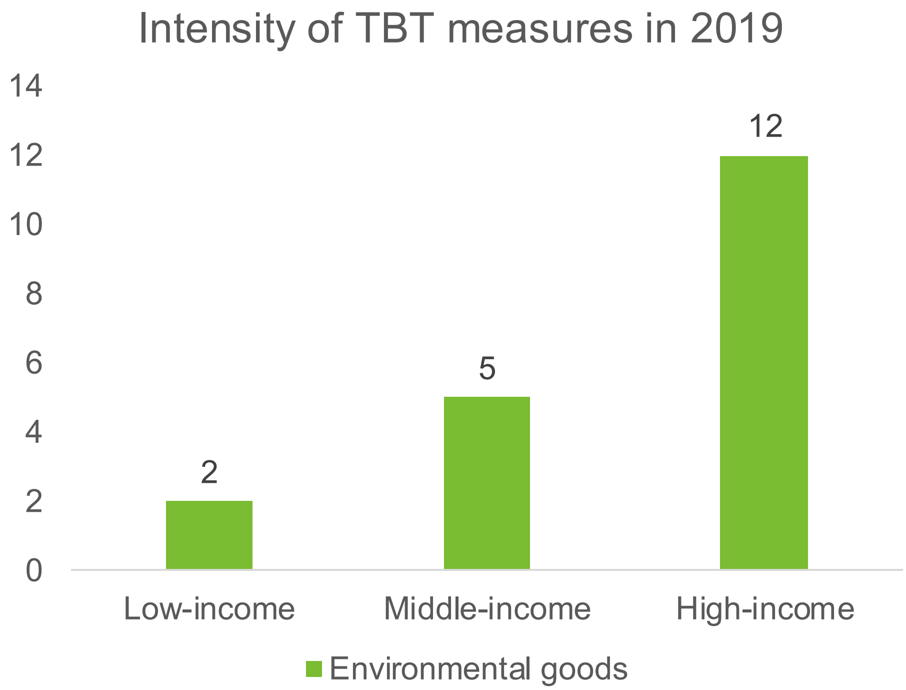
international trade and value chains

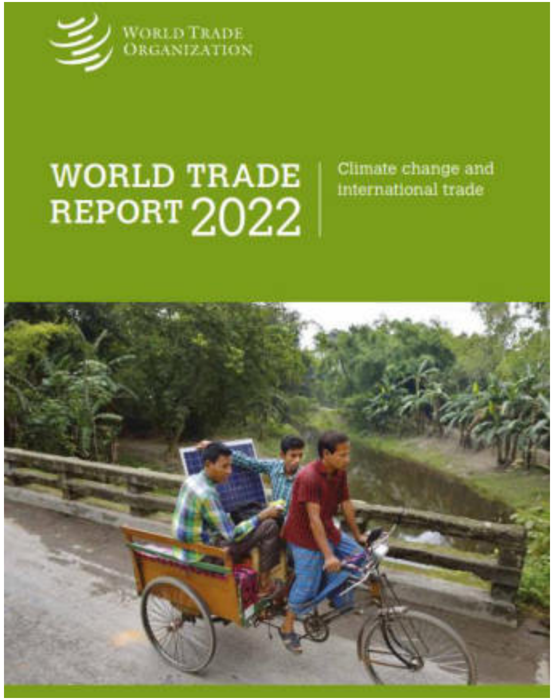
Source: [World Trade Report 2022: Climate change and international trade]

Trade

Climate technologies (like microgrid)

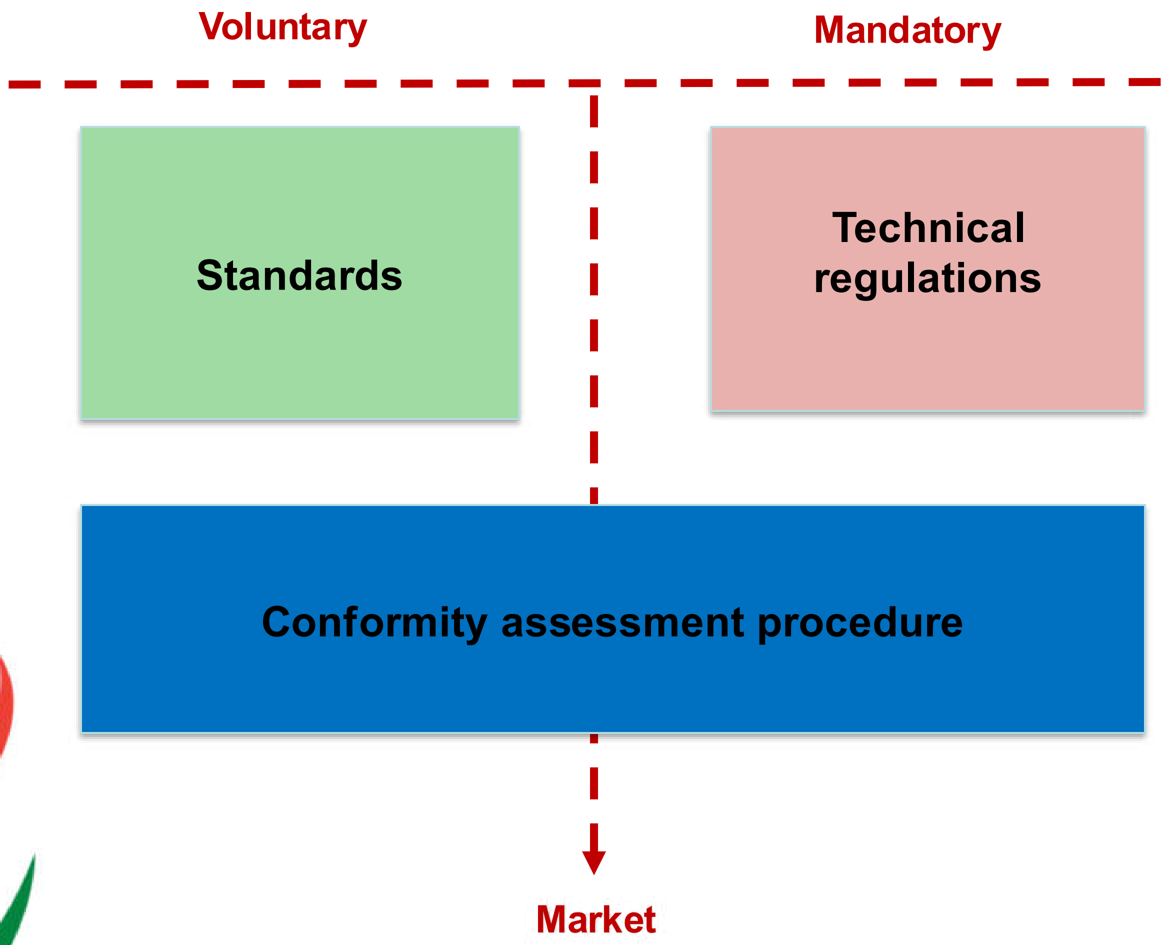
Standards, regulations, conformity assessment procedures





Source: [World Trade Report 2022: Climate change and international trade]

The Agreement on Technical Barriers to Trade (TBT Agreement)


Voluntary
Mandatory
Standards
Technical regulations
Conformity assessment procedure
Market

Objectives of the TBT Agreement

Pursuit of trade liberalization…

Members' right to regulate…

avoiding ***discriminatory*** **and *unnecessary* barriers to trade**

allowing WTO Members to fulfill legitimate objectives at levels they consider appropriate

international standards (*harmonization*)

Key disciplines under the TBT Agreement

1. Non-discrimination
2. Prevention of unnecessary obstacles to international trade
3. Transparency
4. Use of international standards (harmonization)

The implementation of these disciplines is supported by the WTO TBT Committee

Use of international standards

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Also: national standards

Members **shall** use…

relevant international standards

… as a *basis* for

technical regulations

conformity assessment procedures

except!

when *ineffective* or *inappropriate* for policy objectives

(e.g. fundamental climatic or geographical factors, or technological problems)

The TBT Committee

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Two main themes of Committee work

1

review of measures
“specific trade concerns”
(mostly based on notifications)

2

Information exchange on cross-cutting issues (harmonization, transparency, …): leading to decisions and recommendations

CAP Guidelines

WORLD TRADE ORGANIZATION

G/TBT/54

19 March 2024

(24-2418)

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Committee on Technical Barriers to Trade

GUIDELINES ON CONFORMITY ASSESSMENT PROCEDURES

NON-PRESCRIPTIVE PRACTICAL GUIDELINES TO SUPPORT REGULATORS IN THE CHOICE AND DESIGN OF APPROPRIATE AND PROPORTIONATE CONFORMITY ASSESSMENT PROCEDURES

DECISION

Adopted at the meeting of 13-15 March 2024

The WTO Agreement on Technical Barriers to Trade (TBT Agreement) recognizes that WTO Members may require a positive assurance of conformity with technical regulations or standards to fulfil their legitimate objectives, such as the protection of human health or safety, or the environment; and national security requirements. Building on previous decisions and recommendations, including in the Eighth and Ninth Triennial Reviews, the TBT Committee agreed to develop non-prescriptive practical guidelines to support regulators in the choice and design of appropriate and proportionate conformity assessment procedures.[1]

CAP guidelines: which conformity assessment procedure to use in different situations?

WORLD TRADE ORGANIZATION

G/TBT/54

Factors

e.g. nature of the product or existing quality infrastructure, **risk**, uncertainty …

Measure

(what "measure" → ensure level of protection?)

"Level of protection"

e.g. "certification"

Thank you!

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WTO | Technical Barriers to Trade

Case Study
Enabling Business Models in Mexico

Santiago Barcón
PQ Barcon
México

Contents

- Some general figures of Mexico
- People
- Power Quality
- PQ Barcon
- General Advice

Some general figures of Mexico

- 2 million square kilometers
- 3,200 Km of border with USA
- 9,000 Km of shorelines
- 135 million people
- 70 languages but Spanish the official one
- Sonora State, second best in solar after Atacama in Chile

Some general figures of Mexico

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- 90 GW installed capacity
- 11 GW of solar PV and 7 GW in wind.
- 4.5 GW in distributed generation (included in the 11 GW)
- Peak demand at 50 GW
- 110,000 Km of transmission lines
- 850,000 Km of distribution lines
- 48 M Users

Some general figures of Mexico

- Comisión Federal de Electricidad, CFE, the state-owned utility, to keep 54% of the market
- Generation is based in gas and 80% imported from USA
- One nuclear plant
- Several hydropower
- Most of the units are dual (gas/heavy oil or gas/diesel) mostly for backup

Some general figures of Mexico

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- HV level 400, 230 and 115 kV
- MV at 85, 69, 34.5, 23 and 13.8 kV
- Standards closer to IEC but NEMA still used
- But Electrical Installations in LV to NFPA70
- Big manufacturing base of electrical equipment's with exports over 40 billion UD dollars

Some general figures of Mexico

- Quality of supply acceptable but heading south due to lack of investment in the last 12 years
- Demand growing at 3.5%, 1.5 to 2.5% more than the economy
- Energy efficiencies not the top priority
- Competitors of CFE: Iberdrola, Enel, Invenergy and others

People

- Mexico graduates 120,000 engineers per year
- Still profiting from this pyramid, but starting to finish
- Safety a pending matter. Our rate of electrical deads is unacceptable
- Part is due other our culture
- Most of the graduates do not speak English
- Women now majority in chemical and environmental engineering

Power Quality

- A term that is know but very seldom consider
- Everything is blamed to CFE that control, transmission and distribution
- After 70 years of monopoly, users are in Stockolm Syndrome
- Grid Code is operational bud has not been in forced for load centers
- About to change

PQ Barcon

- Brings over 3 decades of experience in Power Quality and reactive compensation
- Provides consulting and equipment, designed in house, for utilities and industry
- From 240 V to 230 KV, active and passive solutions
- Largest systems in Mexico supplied by us
- Teams up with leading component manufacturers from Europe, Canada and Korea

PQ Barcon

- Over 40 employees
- Equal share of women and men in Engineering
- IEEE Life Senior Member and very active in the standards
- Publish at least 4 papers per year and trains hundreds of engineers across the country for free
- Coauthors of “Power Quality: Reactive Compensation and Harmonic Filternin” with McGraw Hill

PQ Barcon Challenges

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- Cash Flow
- Get young talent and motivate it
- Competition with big players is not easy
- But better than dishonet ones
- Utility problems are frequently blamed on our equipment
- Get Grid Code compliance inforced by the authorities

PQ Barcon Opportunities

- Economy growing at 2 % but electicity consumption at 4 %
- Clearer rules than last 6 years
- Regardless Trump’s tariffs the economies are dependant of each other so little can change
- Productivity in internal process
- The new book: “How to be a Good Engineer. Ten commandments and 100 Top Tips” allows to get the best talent


SANTIAGO BARCÓN
CÓMO SER UN BUEN INGENIERO
DIEZ MANDAMIENTOS
Y 100 CONSEJOS
PARA LOGRARLO
LID

General Advice in doing business in Mexico

APEC 2025 KOREA

- Get local advice, and hear it
- Do not apply other economies standards, specially on punctuality and direct communication
- Be innequivocal in compliance
- Ask three times in different ways
- Personal touch is a must
- Red tape is a fact, plan that things will get longer

Standards, Conformity Assessment, and Facilitating Investment

Joseph Conrad

25 Feb 2025

First Senior Officials Meeting, 2025: Energy Working Group 69

ANSI

A NONPROFIT
ORGANIZATION

THAT
COORDINATES
THE U.S. STANDARDIZATION SYSTEM

AND
REPRESENTS U.S. INTERESTS
TO INTERNATIONAL STANDARDS ORGANIZATIONS

Most economies
(top down)

Standards development priorities are driven by government or national standards bodies

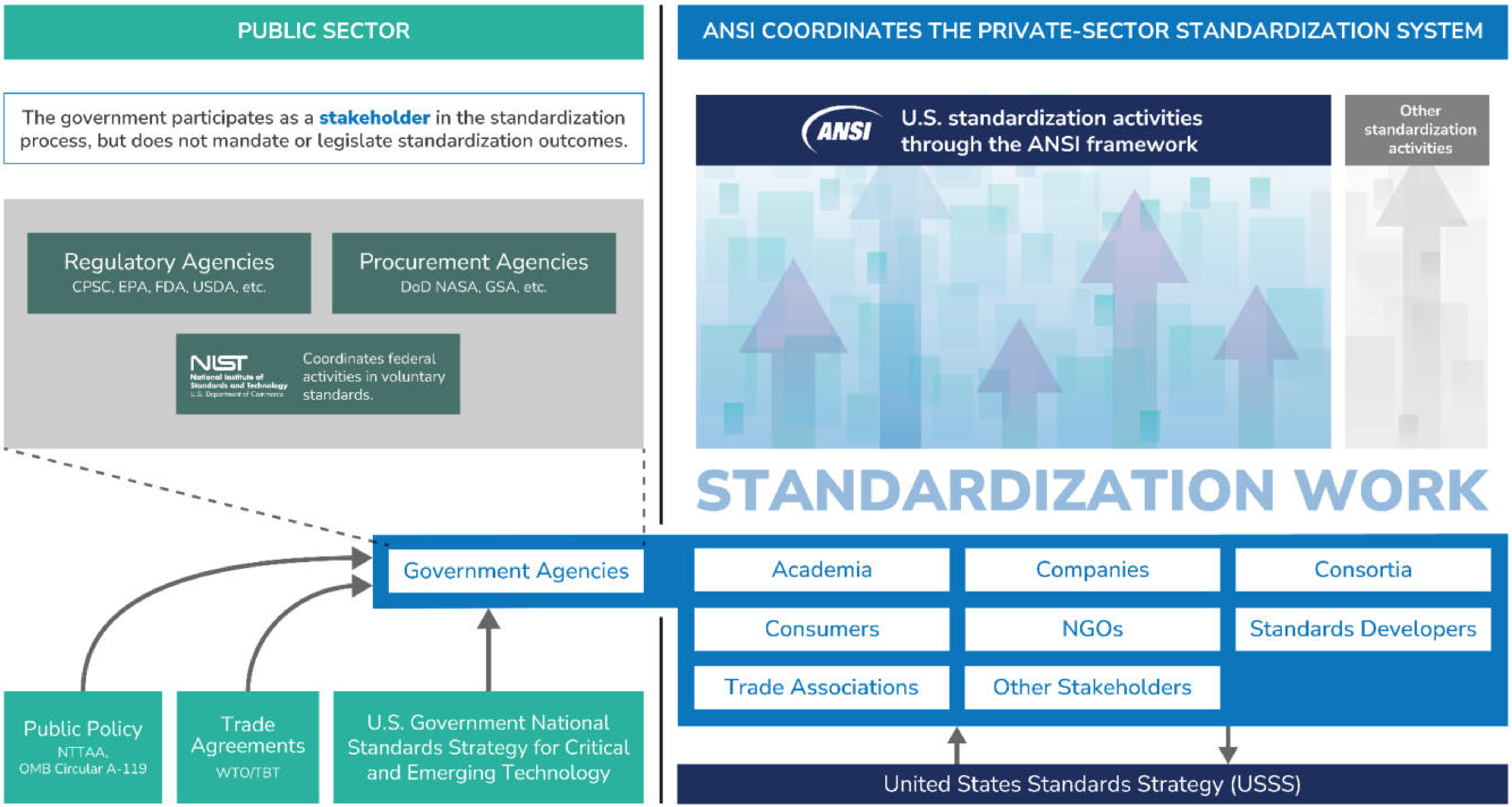
U.S. system
(bottom up)

Standards development priorities are driven by users and markets

The Public/Private Partnership

The cornerstone of the U.S. standardization system

Government and industry together develop standards to achieve policy objectives


PUBLIC SECTOR
The government participates as a stakeholder in the standardization process, but does not mandate or legislate standardization outcomes.
Regulatory Agencies
CPSC, EPA, FDA, USDA, etc.
Procurement Agencies
DoD NASA, GSA, etc.
NIST
National Institute of Standards and Technology
U.S. Department of Commerce
Coordinates federal activities in voluntary standards.
Government Agencies
Public Policy
NTTAA,
OMB Circular A-119
Trade Agreements
WTO/TBT
U.S. Government National Standards Strategy for Critical and Emerging Technology
ANSI COORDINATES THE PRIVATE-SECTOR STANDARDIZATION SYSTEM
ANSI
U.S. standardization activities through the ANSI framework
Other standardization activities
STANDARDIZATION WORK
Academia
Companies
Consortia
Consumers
NGOs
Standards Developers
Trade Associations
Other Stakeholders
United States Standards Strategy (USSS)

ANSI **coordinates**, **supports**, and **safeguards** the U.S. standards ecosystem.

ANSI **does not** write standards.

Coordinates and ensures the integrity of the U.S. standards and conformity assessment system

- Bridge between public and private sectors
- Neutral forum for coordination
- Accredits SDOs and approves American National Standards
- Repository for information on standards and conformity assessment and related activities in the U.S. and abroad

Represents the U.S. globally

- Official U.S. representative in regional and international non-treaty standardization forums
- Facilitates access to these for U.S. stakeholders
- Coordinates capacity-building programs
- Promotes U.S. interests

ANSI plays a **coordinating role** in conformity assessment.

INFORMATIONAL	Monitors the conformity assessment space →	Promotes education and understanding of conformity assessment
ADVOCACY	Works to promote market-driven, private-sector led solutions to standardization and conformity assessment issues	
INTERNATIONAL REPRESENTATION	Administers the International Conformity Assessment Committee (ICAC) *which is the U.S. TAG to:* →	ISO Conformity Assessment Committee (CASCO)

WHEREAS:

ANAB (ANSI National Accreditation Board) —an affiliate of ANSI—plays a **performing role** in conformity assessment.

Offers accreditation services and trainings	Internationally, has comprehensive signatory status with: IAF, ilac

Standards and Conformity Assessment

?

Increased Investment

Benefits of Standards and Conformity Assessment

- **Users**
  - Decreases burden of compliance
  - Decreases cost of goods and services
  - Encourages innovation and economic competition
  - Minimizes wastes, limits errors and increases productivity
  - Facilitates international trade and avoids unnecessary obstacles to trade

- **Regulators**
  - Eliminates or reduces cost of developing standards
  - Reduces enforcement costs
  - Provides flexibility – choice among standards
  - Allows for timely and effective solutions to legitimate regulatory concerns
  - Helps to protect against externalities

Standards and Conformity Assessment

Reduces Risk

Increased Investment

Reduces Risk

Investors

- Forecasting confidence
- Reduction in administrative burden

Consumers

- Increased product knowledge
- Better local tailoring

Regulators

- Fills existing domestic regulatory gaps

Suppliers/Builders

- Greater access to the global market

Investors

- Better terms
- Increased willingness to lend

Consumers

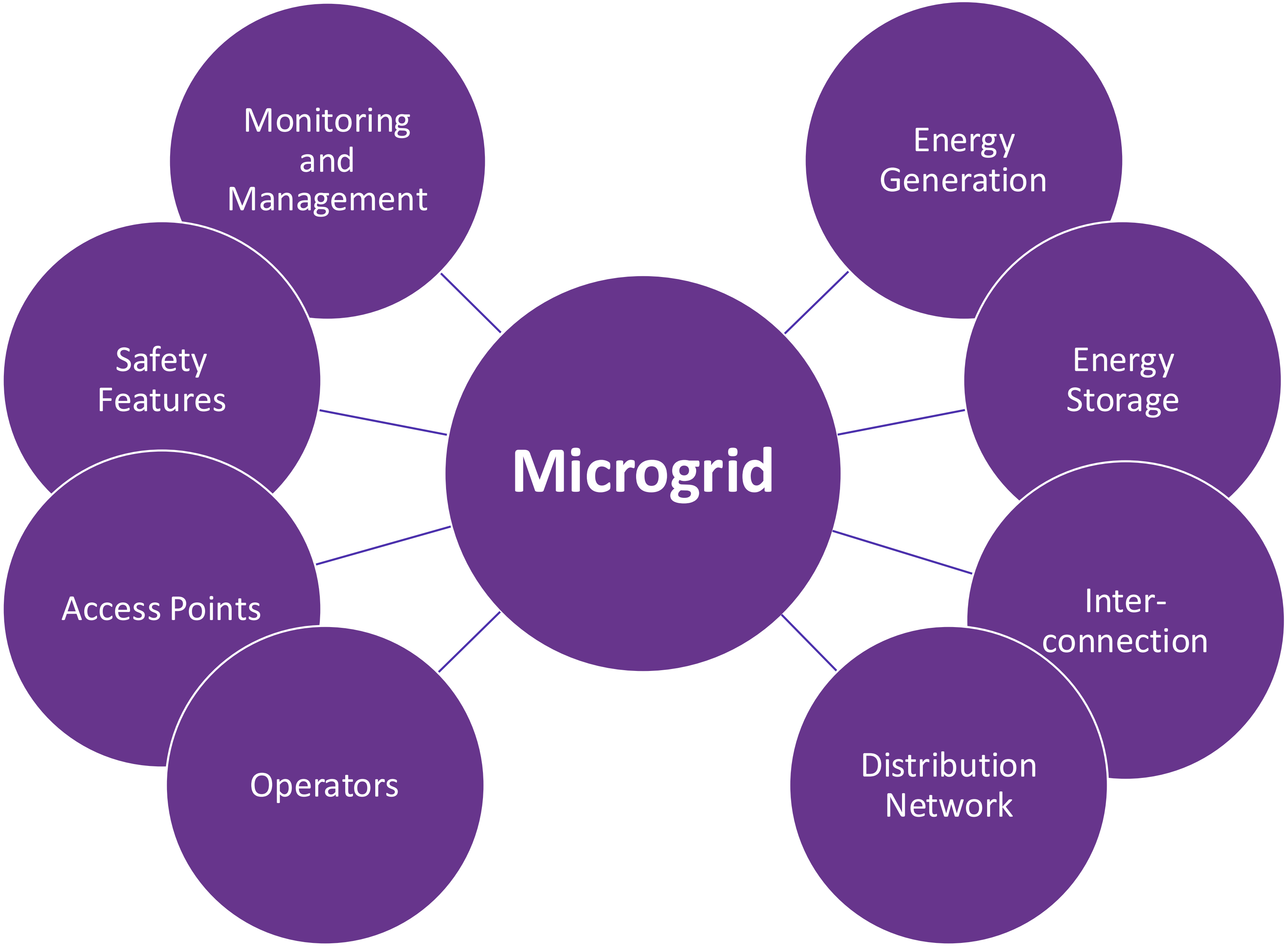
- Safer, better-fit systems
- Cheaper in the long term

Regulators

- Decreased duplication of efforts

Suppliers/Builders

- Increased product availability
- Decreased rework


Monitoring and Management
Energy Generation
Safety Features
Energy Storage
Microgrid
Access Points
Inter-connection
Operators
Distribution Network

Rural/Remote Communities

Emergency Response

Secure Facilities

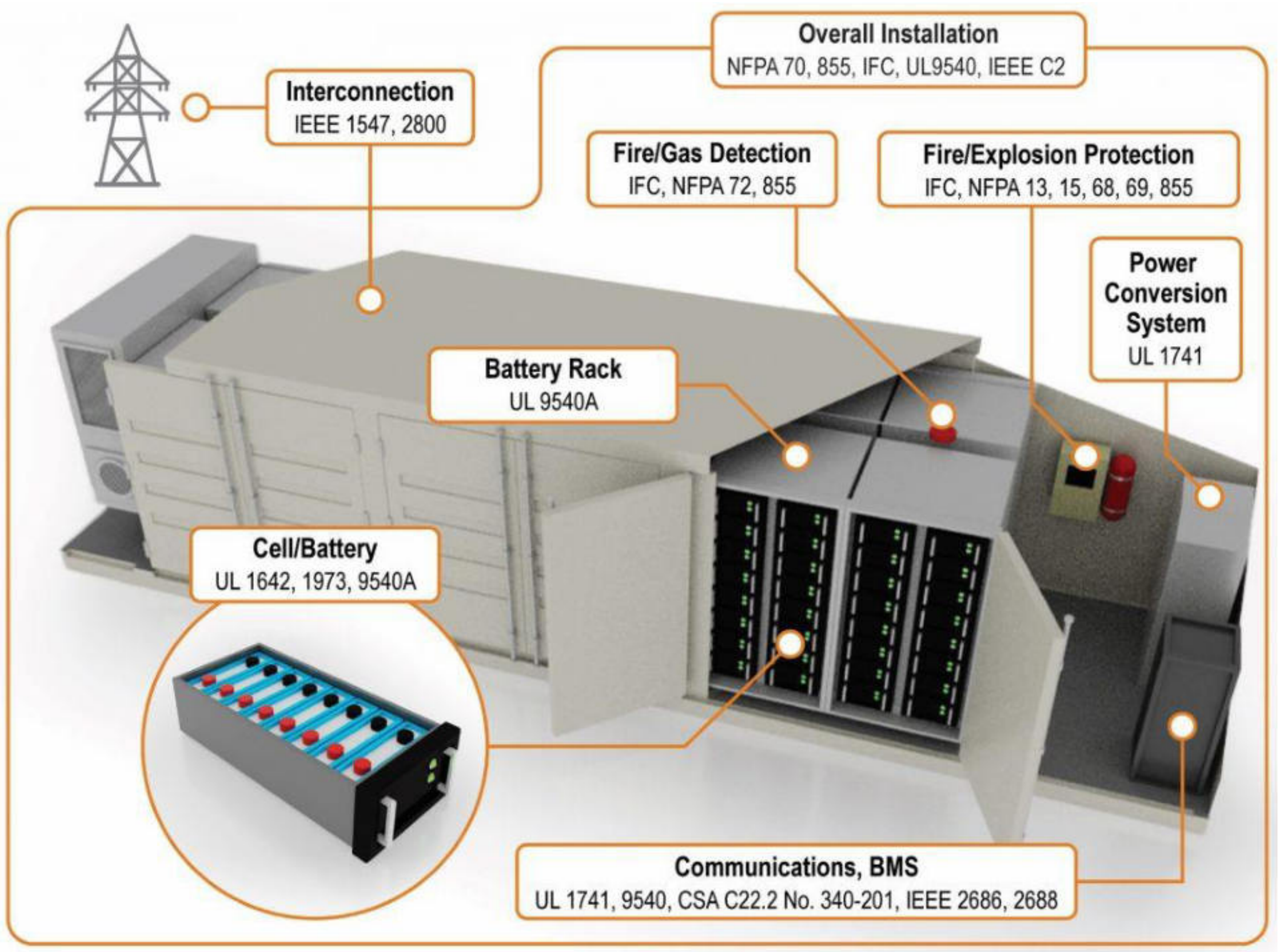
Power Grid Support

Renewables

- Local environment
- Load needs
- Storage needs
- Storage type
- Energy generation type
- Component -> Module -> System level

- IEC 62898 series
- IEEE 2030 series
- UL 3001, 3005, 3010
- NEC 2026 update

- NFPA, ASTM, ASME, NEMA, etc.
- CEN/CENELC, CSA, ISO, etc.



Sandia National Laboratories

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American National Standards Institute

REGULATIONS AND PRACTICES ON STANDARDS AND CONFORMITY ASSESSMENT IN VIET NAM

Man Thuy Giang
Manager – Research and Development Center
Viet Nam Standards and Quality Institute
Commission for Standards Metrology and Quality of Viet Nam

Gyeongju, February 2025

Legislation Basics

Two Laws regulate standardization and conformity assessment activities:

- Law on Standards and Technical Regulations (2006)
- Law on Quality of Products and Goods (2007)

Legislation Basics

Law on Standards and Technical Regulations deals with the:

- development and publishing standards;
- development and promulgating technical regulations;
- conformity assessment activities

➔ *ensure proper implementation of WTO membership obligations and eliminate technical barriers to trade*

Legislation Basics

Main principles for standards and technical regulations development:

- to improve products quality and efficiency of socio-economic activities;
- to ensure safety, security, health, hygiene;
- to protect environment, fauna, flora, natural resource;
- openness, transparency, non-discrimination;
- do not cause unnecessary obstacles to production, business and trade;
- to ensure consensus-based;
- to harmonize with international, regional, foreign national standards, except in cases where such standards are not suitable for the geographical, climatic, technical and technological characteristics of Viet Nam or affect domestic interests.

Legislation Basics

Law on Quality of Products and Goods specifies two groups of products and goods:

- Group 1: does not pose a potential risk of causing unsafety to humans, animals, plants, the environment, ect
- Group 2: poses a potential risks of causing unsafety to humans, animals, plants, the environment, ect

Legislation Basics

Enterprises must:

- declare applicable standard for their product or good
- for group 2, declare the conformance with relevant technical regulations; product or good must be marked with conformity mark (QR)

Declarations is based on conformity assessment results conducted by first party or third party.

Conformity assessment schemes and the requirements for bodies providing conformity assessment services are in accordance with the provisions in relevant international standards (such as ISO/IEC 17065; ISO/IEC 17025; ISO/IEC 17021-1 and related other parts;...)

Regulations allowing recognition of test results and certifications by recognized conformity assessment bodies.

Technical Regulations for electric products

Group 2 electric and electronic products currently include:

- household electrical appliances (QCVN 4:2009 on electrical safety and QCVN 9:2012 on electromagnetic compatibility);
- LED lightings (QCVN 19:2019);
- Electric vehicle conductive charging system: are drafting and will be published in 2025
- No regulations on microgrid at this moment

All safety requirements are based on the safety provisions in relevant domestic or international standards by reference to these standards in the technical regulation.

Domestic standards related to DC power system and Microgrid

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Current situation

No.	Products field	Number of TCVNs
1	Smart grid	11
2	Solar energy	39
3	Wind energy	7
4	Electric vehicle charging system	9
5	Lithium battery and charging cables	10

All domestic standards are identical with international standards (IEC)

Domestic standards related to DC power systems and Microgrid

Plan for 2025-2026

No.	Products field	Number of TCVNs
1	Wind energy	29
2	Plugs, socket-outlets, vehicle connectors and vehicle inlets (Electric vehicle)	6
3	Battery energy storage systems (BESS)	18

- All domestic standards are identical with international standards (IEC)

Domestic standards related to DC power systems and Microgrid

- Domestic standards on clean and renewable energy will be prioritized in the coming years on the basis of harmonization with international standards;
- To consider the need to develop technical regulations related to DC power systems and microgrid;
- To develop conformity assessment regulations according to international common principles to facilitate international trade.

THANK YOU!

APEC 2025
KOREA