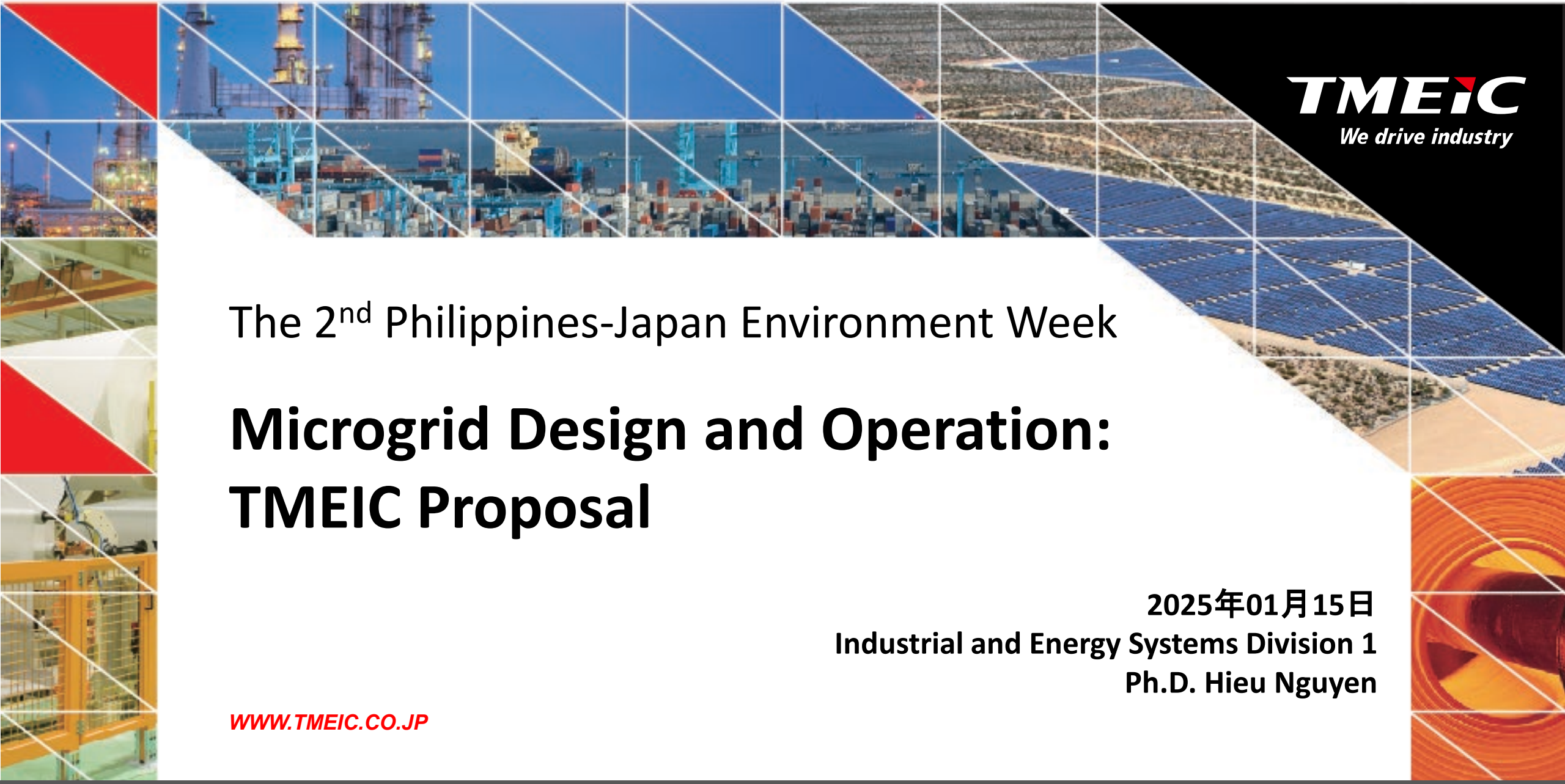

The 2nd Philippines-Japan Environment Week

Microgrid Design and Operation: TMEIC Proposal

2025年01月15日

Industrial and Energy Systems Division 1
Ph.D. Hieu Nguyen

WWW.TMEIC.CO.JP

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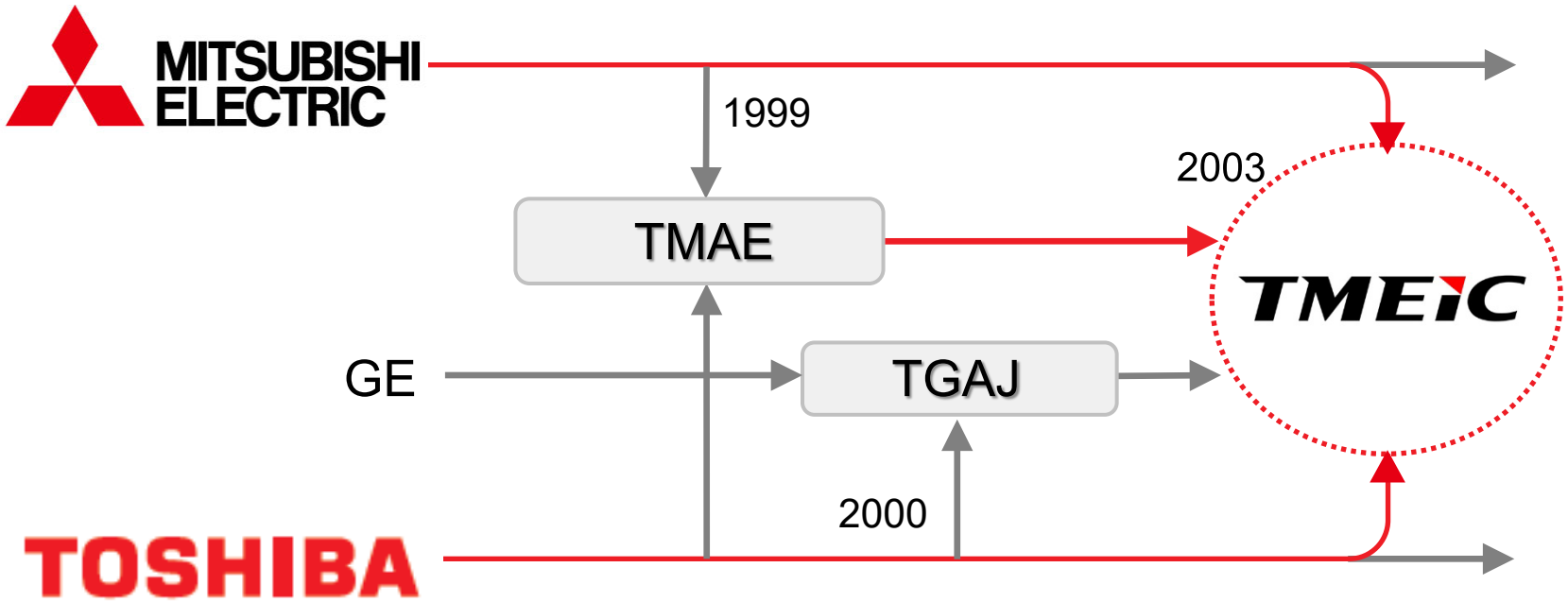
- TMEIC: Who We Are?
- ESS for Microgrid: TMEIC's Proposal
- Grid Forming Inverter: A Key Technology for Microgrid

TMEIC: Who We Are?

Established in 2003 through the integration of the industrial systems divisions of Toshiba Corporation and Mitsubishi Electric Corporation, and TMA Electric Corp. (TMAE), and Toshiba GE Automation Systems Corp. (TGAJ).



Shareholders: 50% Toshiba Infrastructure Systems & Solutions Corporation (*wholly owned subsidiary of Toshiba Corporation)
50% Mitsubishi Electric

TMEIC: Who We Are?

Corporate Profile

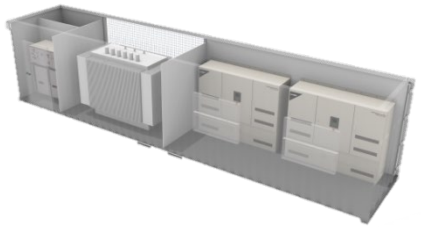
Start of Operations	October 1, 2003
Capital	JPY 15,000,000,000
Investment Ratio	Toshiba 50%; Mitsubishi Electric 50%
Head Office	TOKYO SQUARE GARDEN, 3-1-1 Kyobashi, Chuo-ku, Tokyo 104-0031, Japan
President & CEO	Akira Kawaguchi
Group Companies	Japan:1, Overseas:15 (incl. Affiliate: 1)
Number of Employees	4,505 Worldwide as of March 31, 2023

TMEIC Headquarter
(Tokyo Square Garden Bldg.)

TMEIC: Who We Are?

TMEIC: Who We Are?

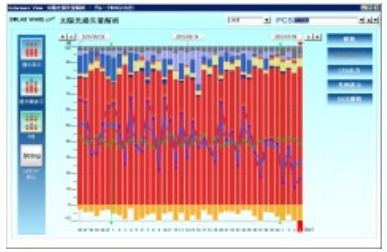
AC-Station



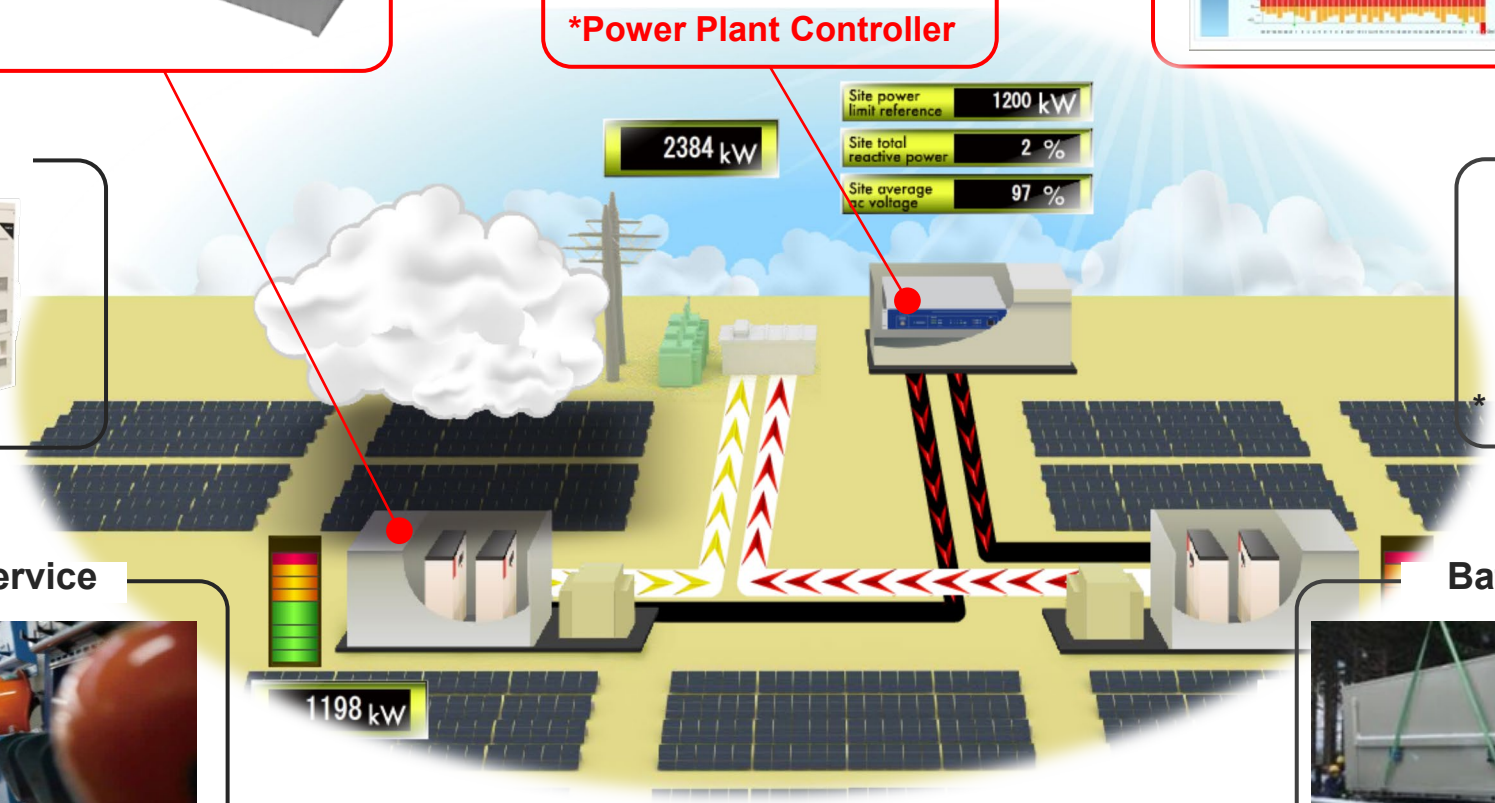
PPC*

*Power Plant Controller

Monitoring



PV Inverter



ESS * Inverter

* Energy Storage System

Field Service

Battery

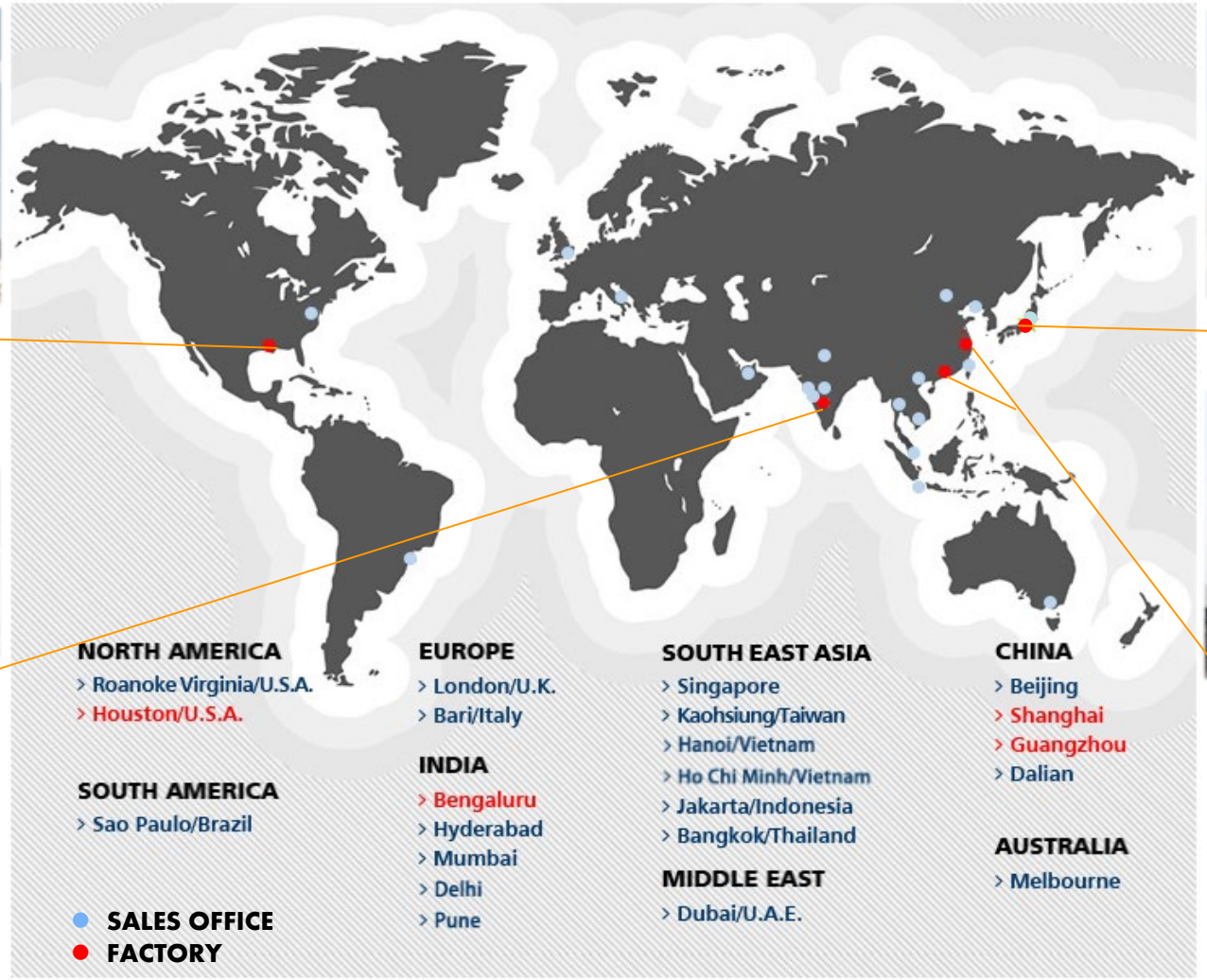
Solar Power Plant

TMEIC: Who We Are?

TMEIC Global Network

Houston, USA

Bengaluru, India



Tokyo, Japan

Shanghai, China

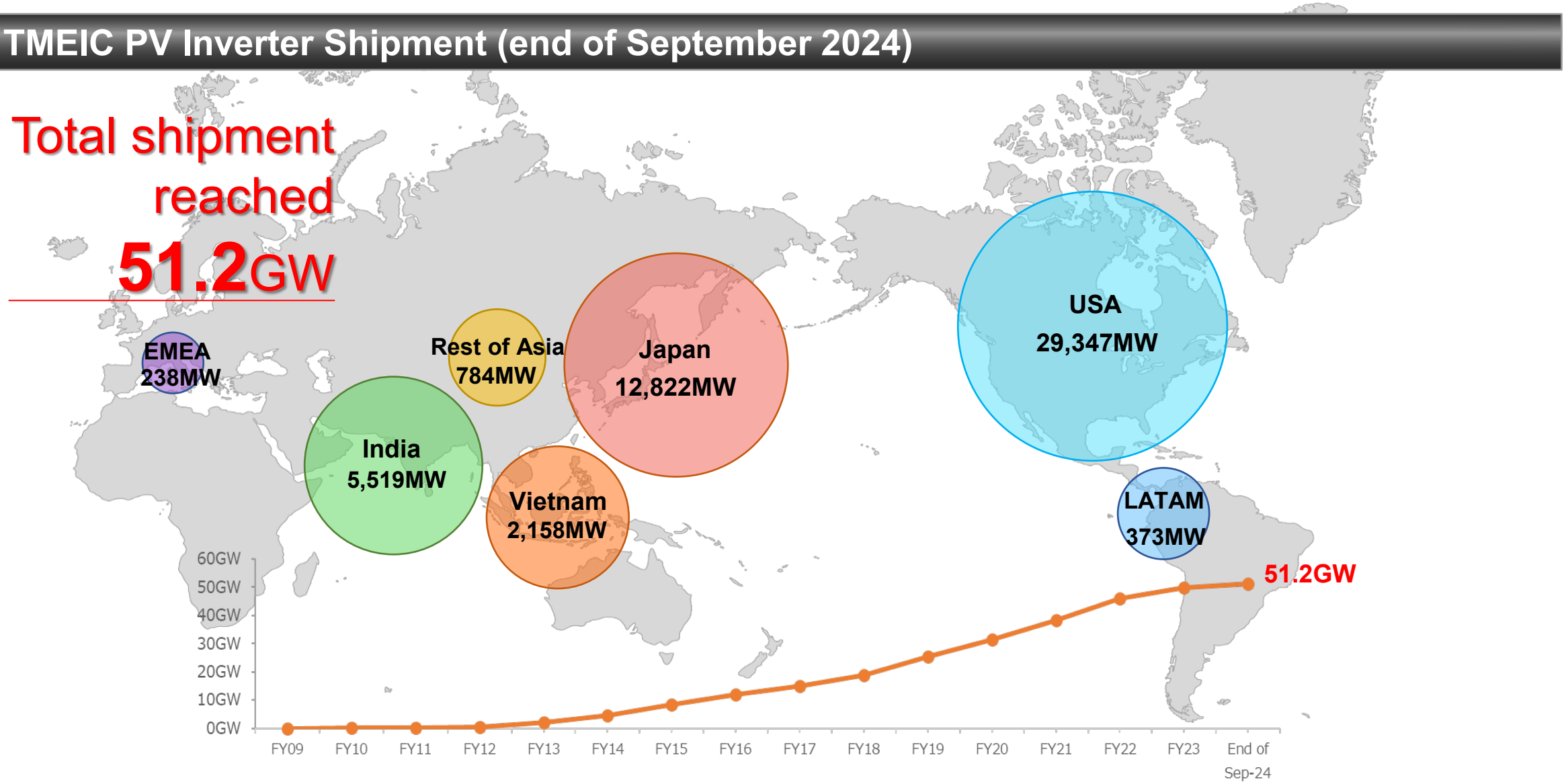
Global PV Inverter Production
10GW*/Year

*normal shift

TMEIC: Who We Are?

TMEIC PV Inverter Shipment (end of September 2024)

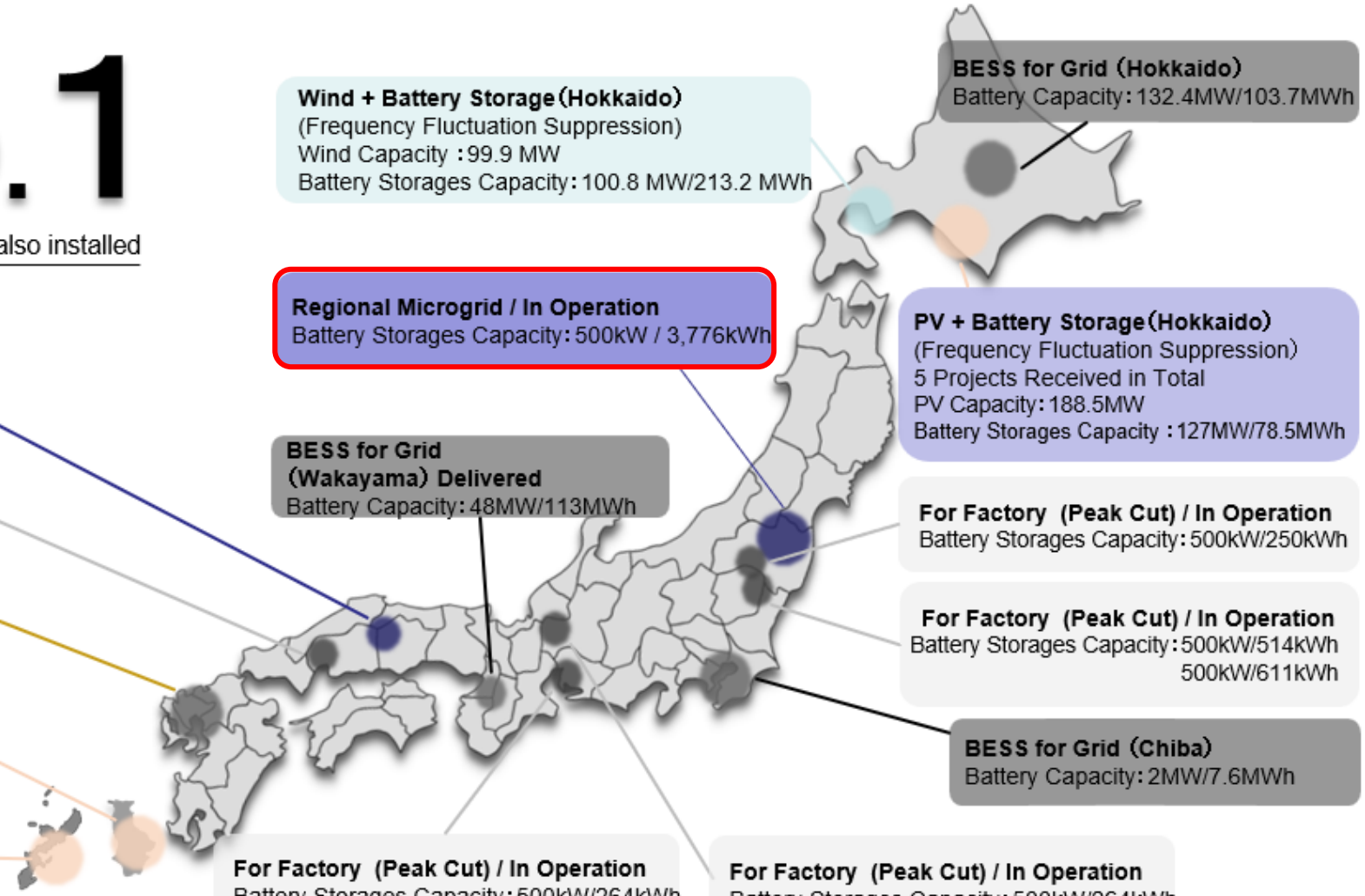
Total shipment reached **51.2GW**



TMEIC: Who We Are?

PCS For Battery Energy Storage Japan Market Share No.1

※A number of commercial bases have also installed



Regional Microgrid / In Operation
Battery Storages Capacity：1,500kW / 1,644kWh

For Factory (Peak Cut) / In Operation
Battery Storages Capacity：500kW/250kWh

BESS for Grid（Saga）
Battery Capacity：10.8MW/34.5MWh

PV + Battery Storage (Tokuno-island) / In operation
(Frequency Fluctuation Suppression)
PV Capacity：1.75MW
Battery Storages Capacity：2.0MW/1.0MWh

PV + Battery Storage (Okinawa)/In Operation
(Frequency Fluctuation Suppression)
PV Capacity：1.99MW
Battery Storages Capacity：2.0MW/1.7Wh

Wind + Battery Storage（Hokkaido）
(Frequency Fluctuation Suppression)
Wind Capacity：99.9 MW
Battery Storages Capacity：100.8 MW/213.2 MWh

BESS for Grid（Hokkaido）
Battery Capacity：132.4MW/103.7MWh

Regional Microgrid / In Operation
Battery Storages Capacity：500kW / 3,776kWh

PV + Battery Storage（Hokkaido）
(Frequency Fluctuation Suppression)
5 Projects Received in Total
PV Capacity：188.5MW
Battery Storages Capacity：127MW/78.5MWh

BESS for Grid (Wakayama) Delivered
Battery Capacity：48MW/113MWh

For Factory (Peak Cut) / In Operation
Battery Storages Capacity：500kW/250kWh

For Factory (Peak Cut) / In Operation
Battery Storages Capacity：500kW/514kWh
500kW/611kWh

BESS for Grid（Chiba）
Battery Capacity：2MW/7.6MWh

For Factory (Peak Cut) / In Operation
Battery Storages Capacity：500kW/264kWh

For Factory (Peak Cut) / In Operation
Battery Storages Capacity：500kW/264kWh

TMEIC: Who We Are?

Hokkaido (Shiriuchi)
PV Panel installed capacity 24MW
Interconnection output 17.5MW
Installed storage battery output 12.5MW, capacity 7.2MWh

Hokkaido (Yakumo)
PV panel installed capacity 102.3MW
PV output 75MW
Battery storage system capacity：Output 52.5MW/27MWh

Kyushu (Tokuno-Island)
PV panel installed capacity 2.6MW
Interconnection output 1.75MW
Installed storage battery capacity 1.029MWh
High input / output characteristics(2CA), Controlled by 2MW PCS

Hokkaido (Abira)
PV Panel output 64.6MW
PCS output 48MW
Battery storage system capacity : Output 34MW/17.5MWh,

TMEIC: Who We Are?

TMEIC: Who We Are?

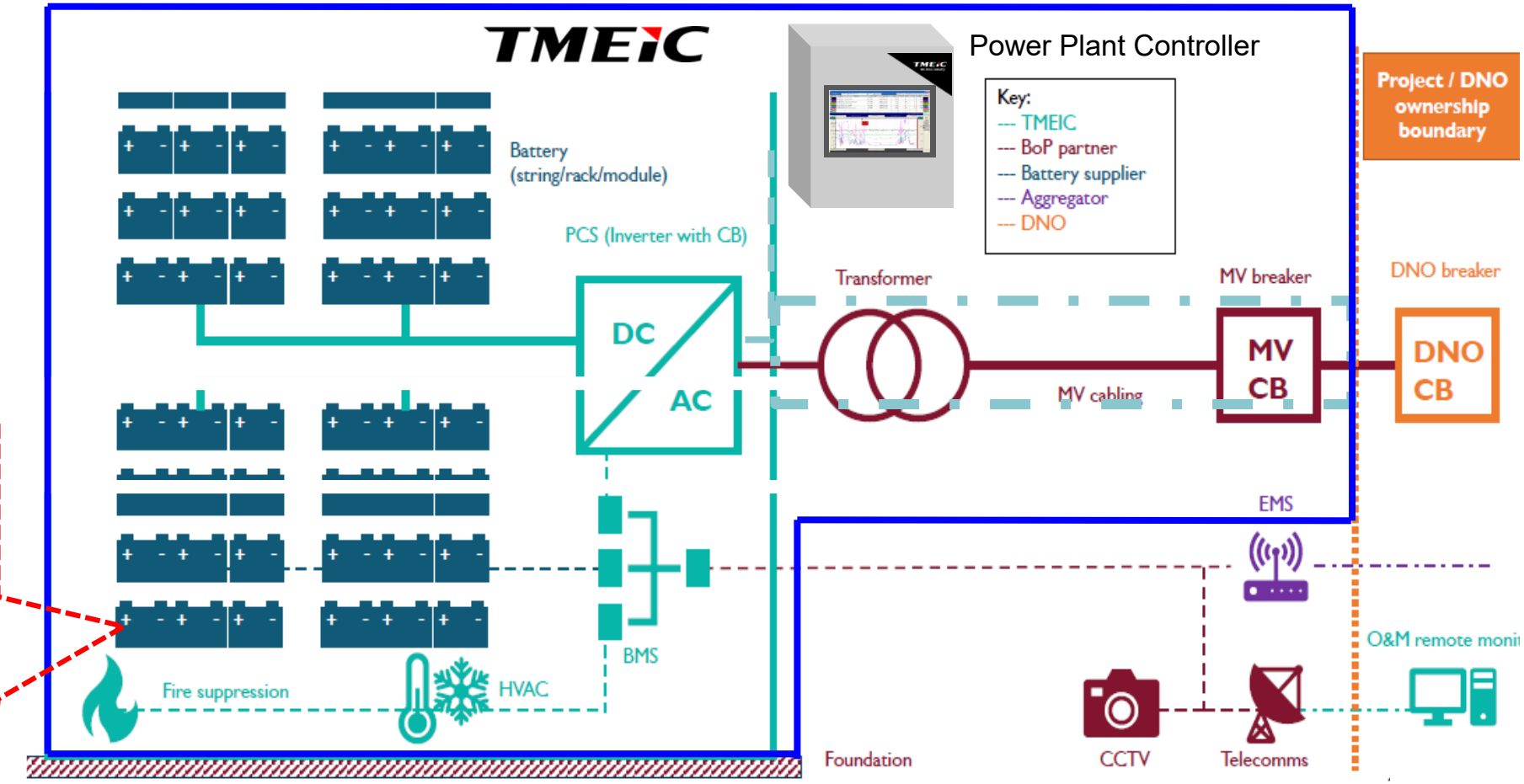
ESS Typical Configuration and Scope of Supply

SAMSUNG SDI

CATL

LG Energy Solution

Gotion



TMEIC: Who We Are?

Inverter for PV projects

SOLARE WARE U Specification

Item		PVU-L0800ER	PVU-L0840ER	PVU-L0880ER	PVU-L0920ER
Output side (AC)	Rated Power	800kW / 800kVA	840kW / 840kVA	880kW / 880kVA	920kW / 920kVA
	Rated Voltage	600V	630V	660V	690V
	Rated Frequency	50Hz / 60Hz (+0.5Hz, -0.7Hz)			
	Rated Current	702Arms @50℃			
	Maximum Current	770Arms @25℃			
Input side (DC)	Maximum Power@98%Eff.	816kWp	857kWp	898kWp	939kWp
	Maximum Voltage	1500Vdc			
	MPPT Operation Range (starting-up from 1450V)	875Vdc ~ 1300Vdc	915Vdc ~ 1300Vdc	960Vdc ~ 1300Vdc	1005Vdc ~ 1300Vdc
Maximum Efficiency ※		99.1% (※)			
Weight ※		< 1000kg			
Inverter Dimensions (W X H X D)		1100 X 2000 X 1100 mm (W X H X D)			
Floor space (W x D)		1.21m2			
Enclosure Protection Ratings		IP 55/ NEMA 3R			
Installation		Outdoor			
Ambient Temperature Range		-25 ~ 50℃			
Maximum altitude		2000m (>2000m power derating (Max.4000m))			
Communication type		Modbus, Ethernet			
Standards Compliance		UL1741, UL174SA / IEEE1547 / NEC2017, IEC62109-1,2 / IEC61000-6-2,4 / IEC61727, IEC62116 / IEC61400, BDEW / IEC61683 / IEC60068			
Standard Number of Input		6 (Maximum 8 per Inverter) Each input rating is a maximum of 400A			
AC protection		Fuses			
DC protection		Fuses			
MPPT number for PV		1			
Standard Control Power Supply		Control Power Supply from Inverter output and Capacitor backup circuit (3sec. compensation)			

TMEIC: Who We Are?

Inverter for ESS projects

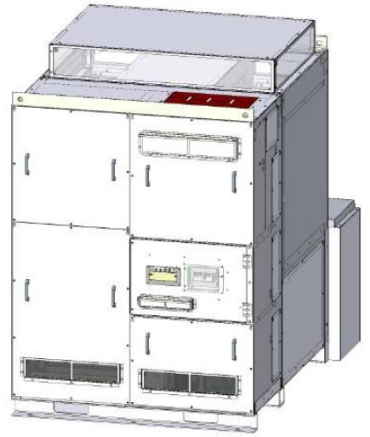
SOLARE WARE U Specification

Item		BSU-L640ER	BSU-L0800ER	BSU-L0840ER
Output side (AC)	Rated Power	640kW / 640kVA	800kW / 800kVA	840kW / 840kVA
	Rated Voltage	480V (+10%, -12%)	600V (+10%, -12%)	630V (+10%, -12%)
	Rated Frequency	50Hz / 60Hz		
	Rated Current	702Arms @50℃		
	Maximum Current	770Arms @25℃		
Input side (DC)	Maximum Power	653kWp@98% Efficiency	816kWp@98% Efficiency	857kWp@98% Efficiency
	DC Voltage Range	710Vdc ~ 1300Vdc	875Vdc ~ 1300Vdc	915Vdc ~ 1300Vdc
	MPPT Operation Range	N/A		
Maximum Efficiency ※		99.1%		
Weight		<1000kg		
Inverter Dimensions (W X H X D)		1100 X 2000 X 1100 mm		
Floor space (W x D)		1.21m2		
Enclosure Protection Ratings		IP55 / NEMA3R		
Installation		Outdoor		
Ambient Temperature Range		-25 ~ 50℃		
Maximum altitude		2000m >2000m power derating (Max.4000m)		
Communication type		Modbus TCP		
Standards Compliance		UL1741, UL174SA / IEEE1547 / NEC2017 / IEC61000-6-2,4 / IEC61727, IEC62116 / IEC61400, BDEW/ IEC60068		
Standard Number of Input		1		
AC protection		Fuses		
DC protection		Fuses		
Standard Control Power Supply		Control Power Supply from Inverter output and Capacitor backup circuit (3sec. compensation)		

TMEIC: Who We Are?

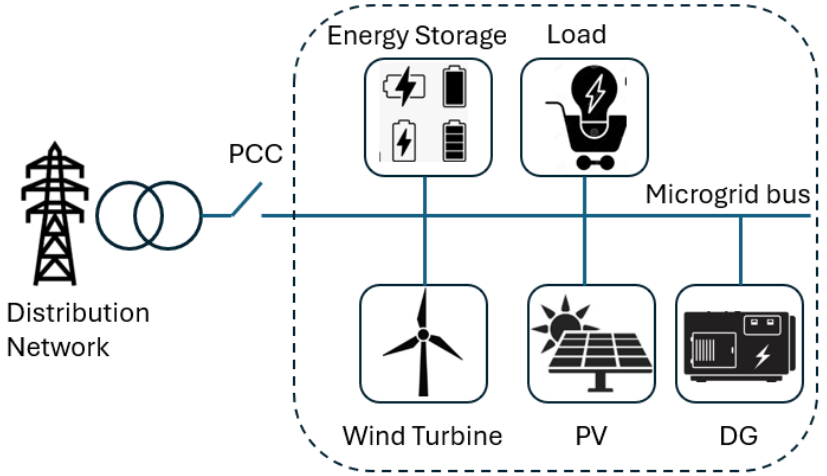
Inverter for ESS projects

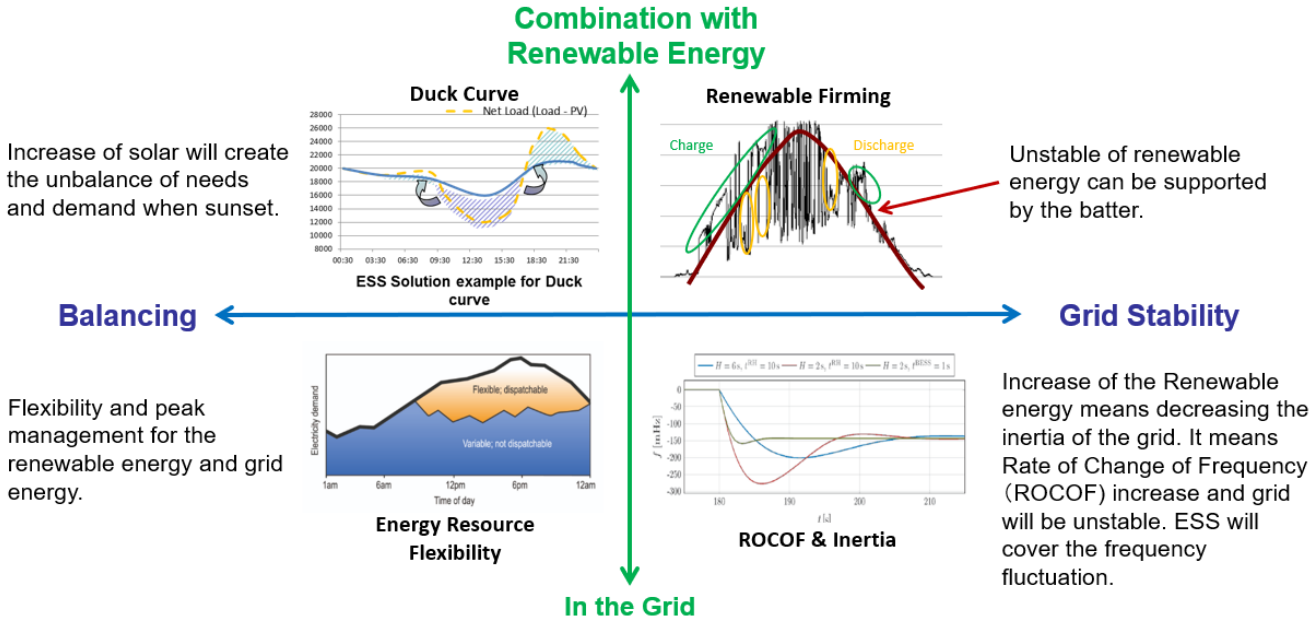
Item		BSA-L1400ENN/UNN
Output side (AC)	Rated voltage	660V
	Rated power @25˚C, 1480V, 660Vac	1400kW
	Rated current @25˚C	1225Arms
	Rated frequency	50Hz/60Hz
Input side (DC)	DC voltage range	1000Vdc~1500Vdc
Maximum efficiency		98.5%
Inverter dimensions		1,540x2,000x2,040mm
Weight		≤2,000kgs
Enclosure rating		Inverter Station (IP55)
Installation		Inverter Station: Outdoor
AC protection		Breaker
DC protection		Fuses
Communication Controller - SCADA		Modbus TCP



ESS for Microgrid: TMEIC's Proposal

- Increase in requirement for microgrid design with energy storage system (ESS) in ASEAN e.g. industrial parks, islands (Indonesia, Philippine), etc.
- ESS application for microgrid
  - Support PV from system operational point of view
  - Maximize operational revenue
  - Support to realize a microgrid without DG by grid forming inverter (GFM) technology





TMEIC Will Provide

- System design for PV and/ or ESS projects
- Revenue simulation and analysis
- Energy storage system operational profile
- Plant control system

ESS for Microgrid: TMEIC's Proposal

Example: confirm the revenue via design & simulation

Input

- Fuel cost (diesel generators, etc.)
- Capacity of generation sources, load profile, etc.

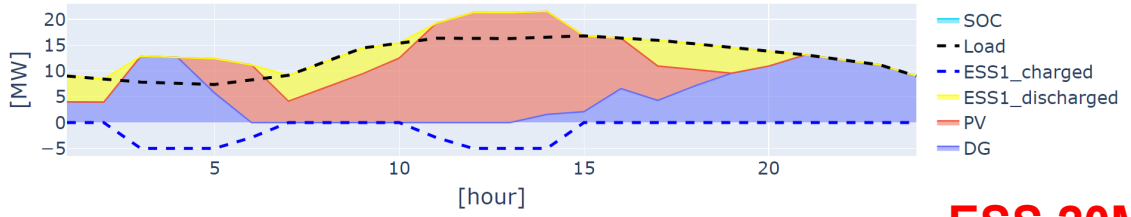
PV output

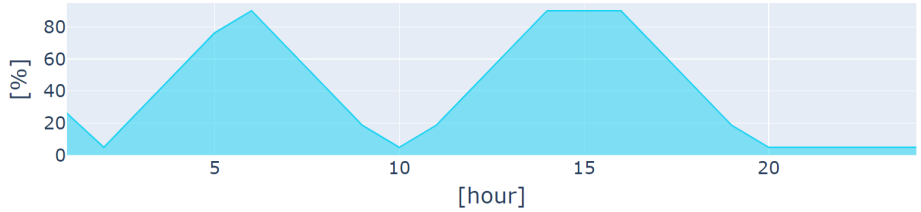
hour	out_pu
0	0
1	0
2	0
3	0
4	0.19
5	0.38
6	0.57
7	0.75
8	0.87
9	1
10	0.92
11	0.85
12	0.72
13	0.57
14	0.42
15	0.28
16	0.19
17	0.09
18	0
19	0
20	0
21	0
22	0
23	0

Load

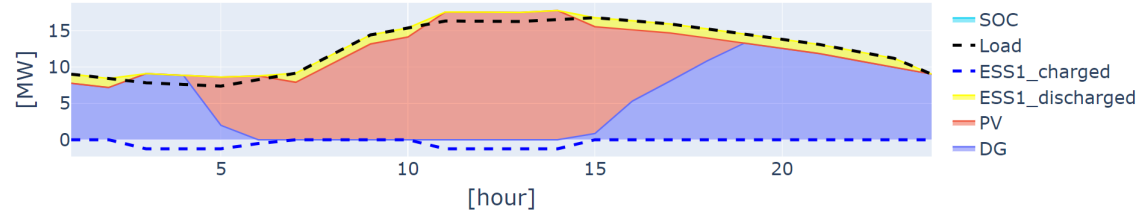
hour	MW
0	90.25882
1	84.32941
2	78.4
3	76.09412
4	73.78824
5	82.68235
6	91.57647
7	117.9294
8	144.2824
9	153.8353
10	163.3882
11	163.0588
12	162.7294
13	165.3647
14	168
15	163.7176
16	159.4353
17	152.5176
18	145.6
19	138.3529
20	131.1059
21	121.5529
22	112
23	90.25882

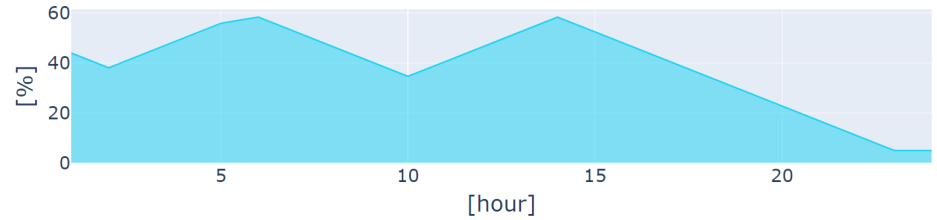
TMEIC Solution





ESS 20MW/20MWh

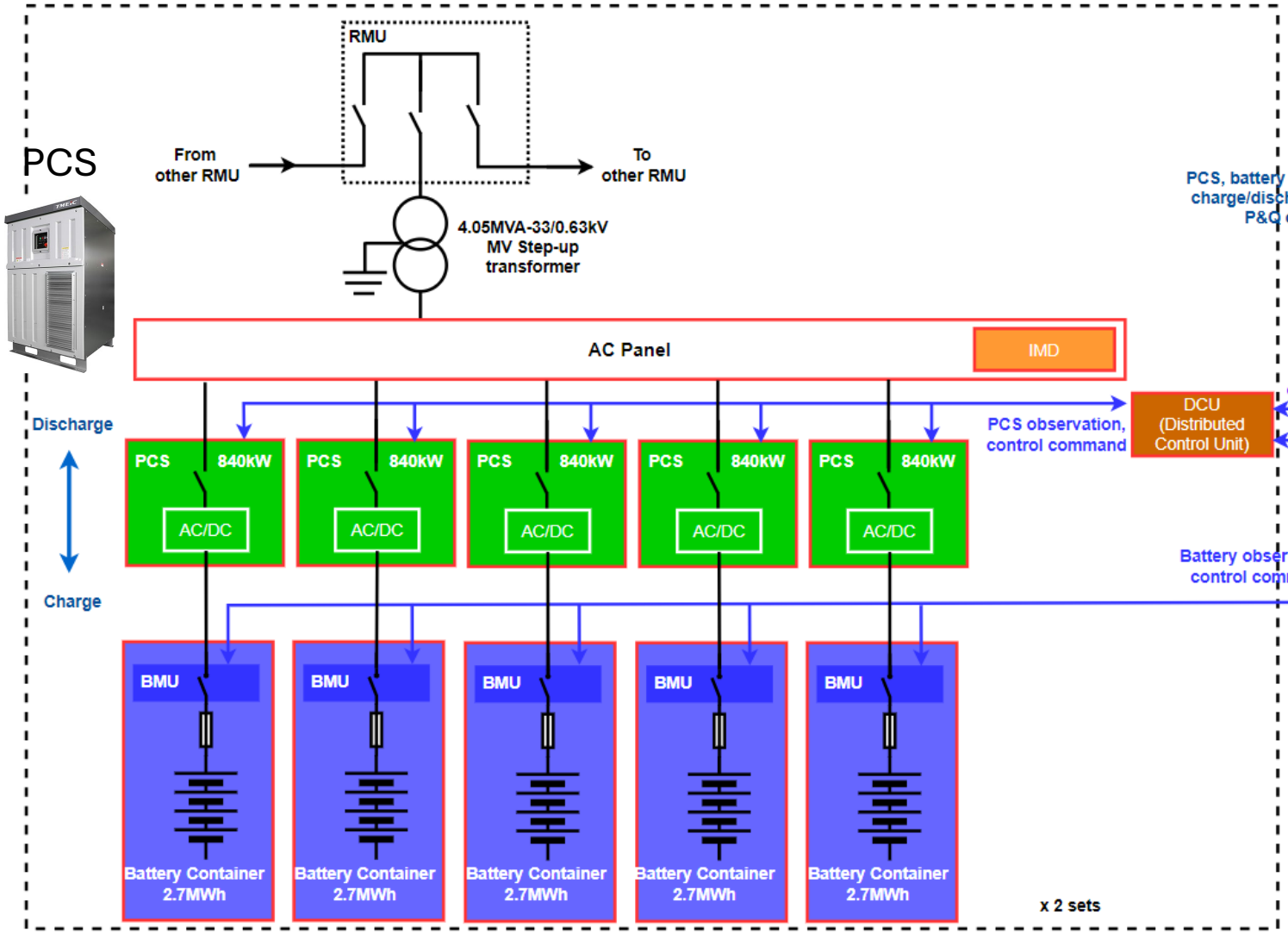


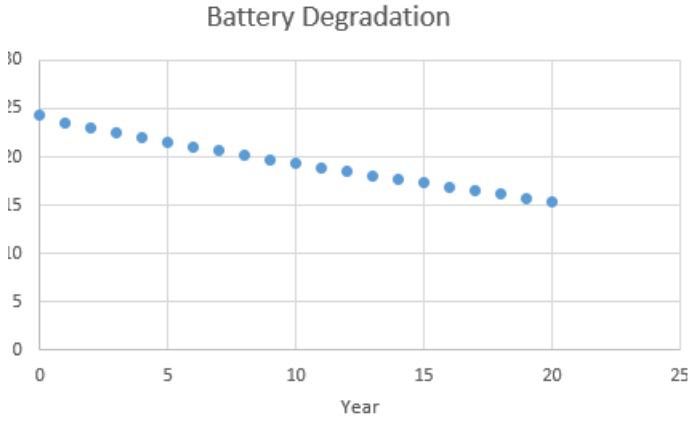


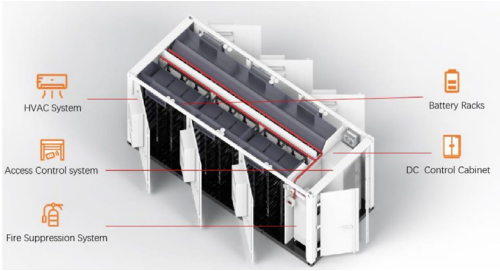
ESS 5MW/20MWh

ESS for Microgrid: TMEIC's Proposal

ESS 5MW/20MWh





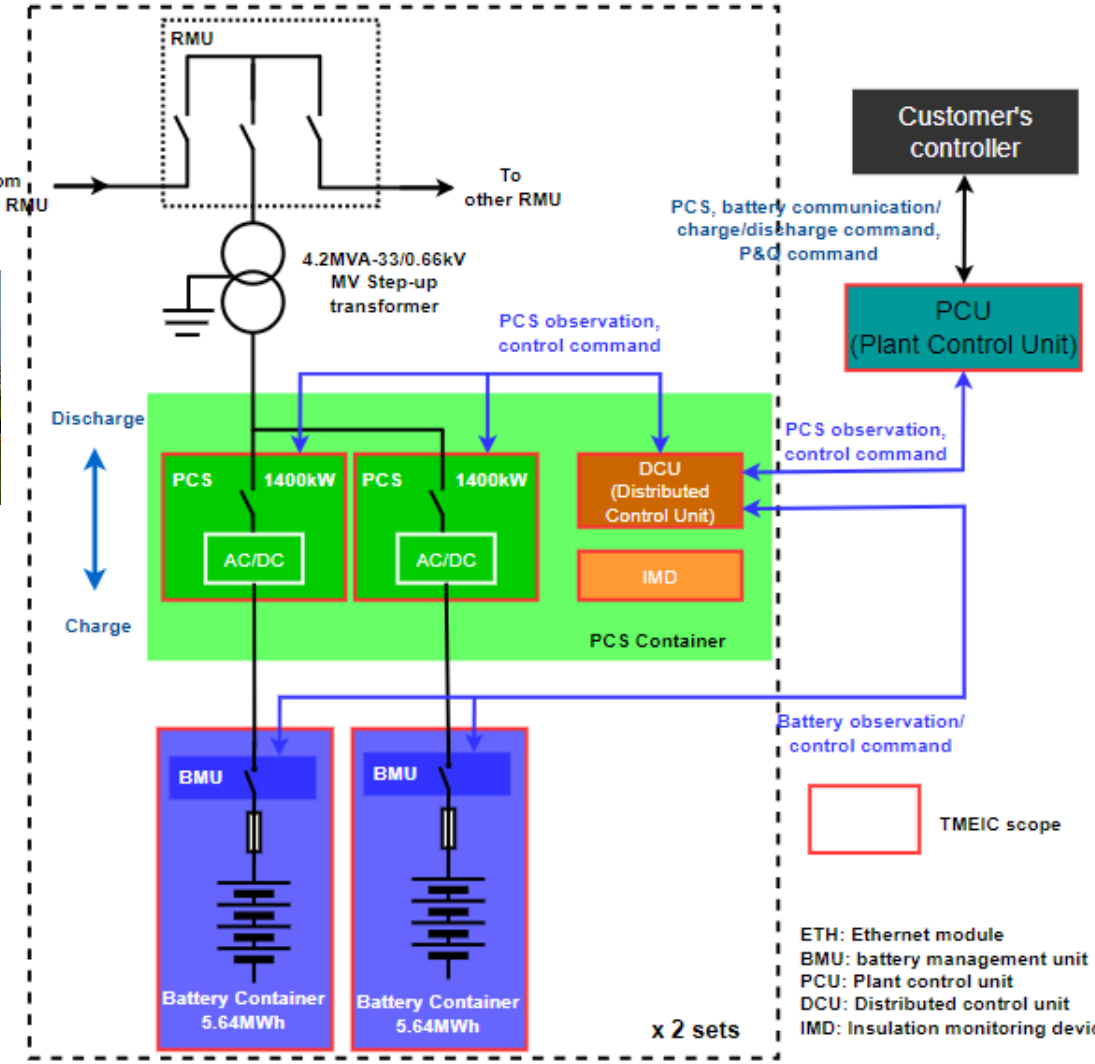


Battery container

ESS for Microgrid: TMEIC's Proposal

ESS 5MW/20MWh

PCS container



Battery container

Grid Forming Inverter: A Key Technology for Microgrid

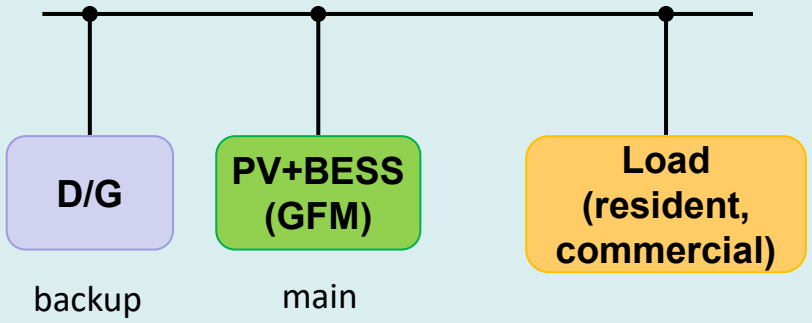
Power Resources Characteristics

	Synchronous Generator	Conventional Inverter (GFL)	Grid forming Inverter (GFM)
Inertia as energy buffer	✔ (Physical inertia)	N/A	✔ (Synthetic inertia)
Frequency response	✔	✔	✔
Stable Operation in IBR-rich grid	✔	N/A	✔
Islanding operation	✔	N/A	✔
Adoption in industry	✔ (Widely-used)	✔ (Widely-used)	Approaching Market Entry

Grid Forming Inverter: A Key Technology for Microgrid

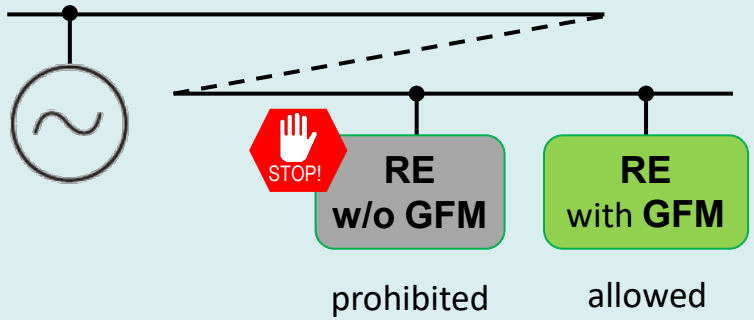
Effective Utilization of GFM

Off-Grid, Co-location RE system



- GFM becomes possible to supply electricity solely through PV generation during daylight hours
- Black-start of RE power output is possible without other generators
- 100% Renewable Energy supply or "RE with backup generation" can be designed

Connecting to weak/unstable Grid



- Conventional RE plants cannot connect to an unstable Grid, but GFM can connect instead
- GFM function provides inertia and frequency response capability to unstable power system

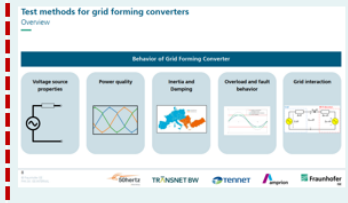
Grid Forming Inverter: A Key Technology for Microgrid

Source: MarketsAndMarket

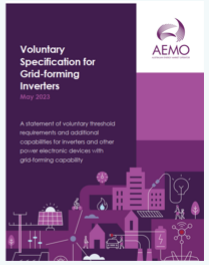
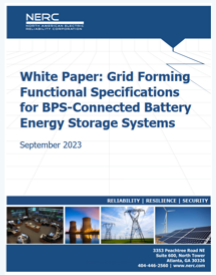
Market Player

Report Metric	Details
Market Size available for years	• 2021–2028
Base year considered	• 2022
Forecast period	• 2023–2028
Forecast units	• Value (USD Million)
Segments covered	• By Type, By Application, By Voltage, By Power Rating, And By Region
Geographies covered	• Asia Pacific, North America, Europe, Middle East & Africa, and South America
Companies covered	• Huawei Technologies Co. Ltd. (China), General Electric (US)Power Electronics (Spain), SMA Solar Technology (Germany), Games Electric (Germany), and FIMER (Italy), Growatt New Energy (China), TBEA Xingjiang Sunoasis (China), Fronius International (Austria), Goodwe (China), Schneider Electric (France), SolarEdge Technologies (Israel), Sungrow Power Supply (China), Delta Electronics (UK) and Enphase Energy (US), Altenergy Power System (US), Sensata Technologies (US), Delphi Technologies (UK), TMEIC (Japan), and KACO New Energy (Germany)

Grid Forming Inverter: A Key Technology for Microgrid

National Grid ESO (UK)	AEMO (Australia)	Fraunhofer ISE (Germany)
"Compliance Guidance Notes for NOA Stability Compensation Service"	"Voluntary Specification for Grid-forming Inverters: Core Requirements Test Framework"	"Specification for Grid Forming Inverter-Based Resources"
Test procedure mainly for off-line simulation	Test procedure mainly for off-line simulation	Test procedure for actual machine
		

Target of development

National Grid ESO (UK)	AEMO (Australia)	UNIFI (US)	NERC (US)
GC0137 Minimum Specification Required for Provision of GB Grid Forming (GBGF) Capability	Voluntary Specification for Grid Forming Inverters	Specification for Grid Forming Inverter-Based Resources	Grid Forming Functional Specifications for BPS-Connected Battery Energy Storage Systems
			

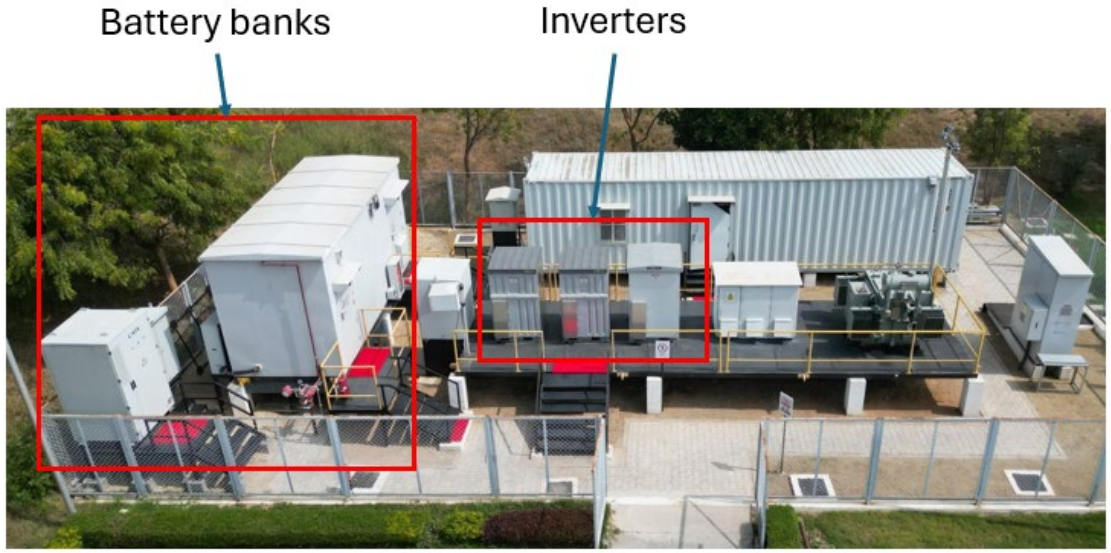
Target of development

Single GFM Unit Test

Test was carried out in Fraunhofer (Germany) in Jul. 2024

Multiple GFM Units Test (Jan. 2025 in ESS lab, Bangalore)

- Grid-connected GFM test
- Off-grid GFM test
  - Parallel operation of 3 inverters
  - Loss of mains test
- Validate the tests which were carried out at Fraunhofer



THANK YOU FOR LISTENING