Development of Smart Grid in Taiwan

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第二期能源國家型科技計畫
National Energy Program-Phase II

Sep. 5, 2016

Outline

- Current Status of Taipower System
- Master Plan of Smart Grid in Taiwan
- National Energy Program - Phases I-II: Smart Grid General Project
- Penghu Smart Grid Demonstration Project
- Automatic Demand Response Demonstration Project
- Virtual Power Plant Demonstration Project
- AC Microgrid Demonstration Project
- Development of Smart Grid Industry in Taiwan

Current Status of Taipower System

Power System in Taiwan

TPC Power System

Installed Capacity in Year 2013: **41,181** MW

	Installed Capacity	MW		%
Taipower	Nuclear	5,144		12.45
	Thermal	22,132		53.80
	Oil		3,325	8.00
	Coal		8,200	21.30
	LNG		10,607	25.60
	Hydro	4,353.60		10.5
	Convential Hydro		1,792	4.20
	Pumped storage Hydro		2,602	6.30
	Wind	287		0.70
	PV	18		0.01
Subtotal of Taipower		32,508.06		78.50
IPP	Thermal	7,707.10		18.60
	Coal		3,097.1	7.50
	LNG		4,610.0	11.20
	Hydro	289.10		0.70
	Wind	236.10		0.57
	PV	350		0.85
	CoGeneration	622.00		1.50
Subtotal of IPP		8,892.60		21.5
Total Installed Capacity		41,181		100

Substation	No.	MVA
EHV	29	56000
Primary	264	68450
Secondary	295	20728

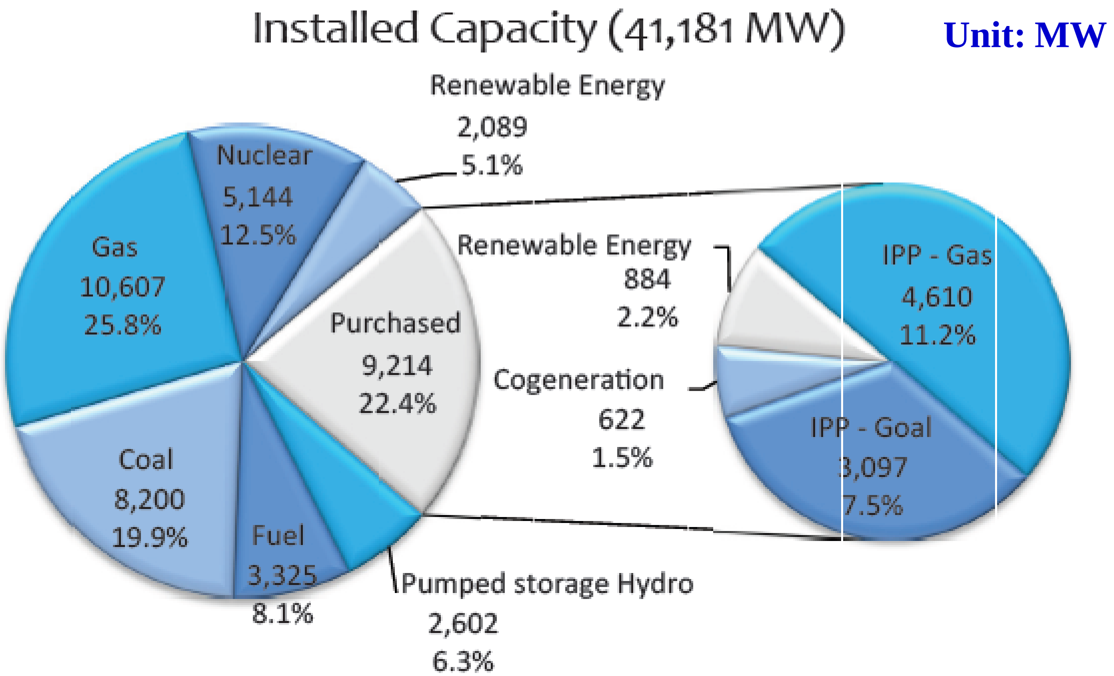
	ckt-km
Transmission Lines	17,054
Distribution Lines	351,474

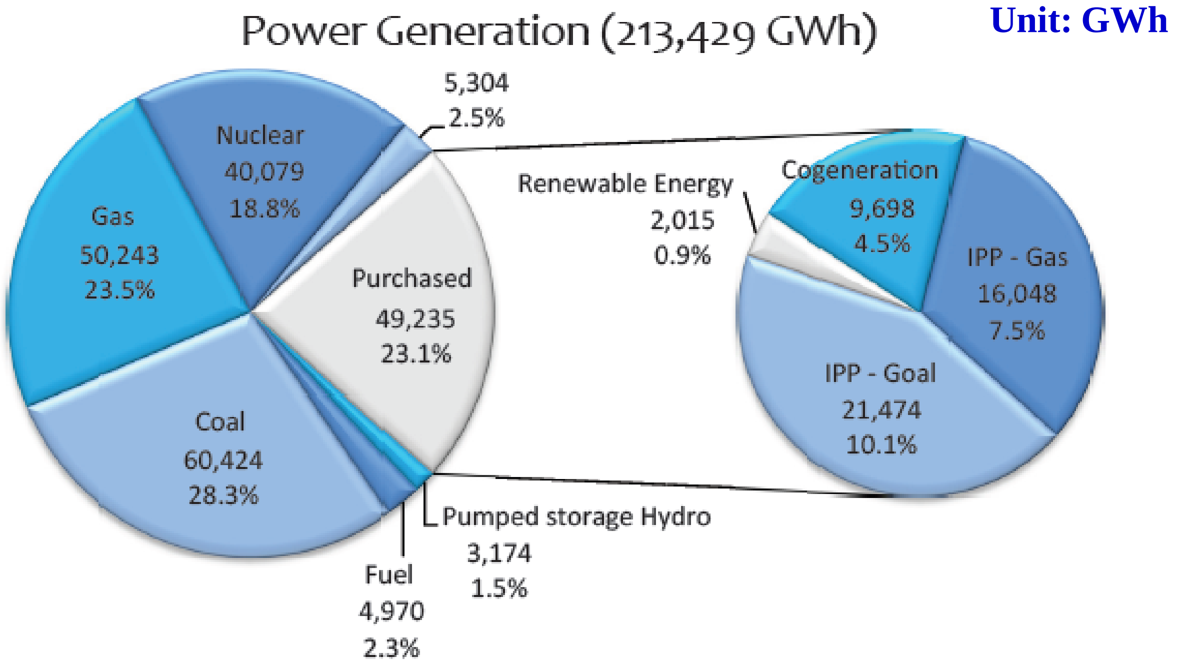
Reference： Taipower www.taipower.com.tw

Power System in Taiwan

Taiwan Power Profile

Installed Capacity and Generation Data as of **2013**

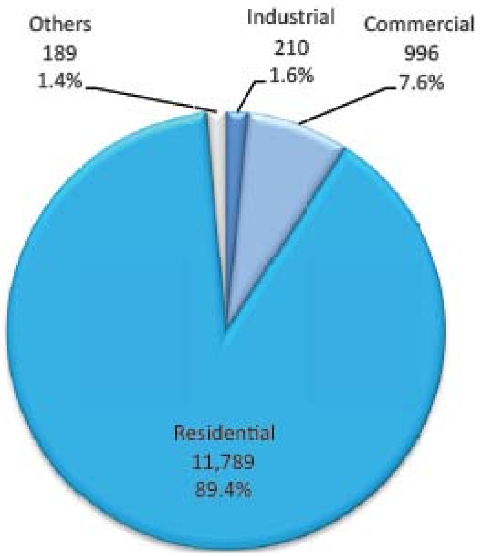




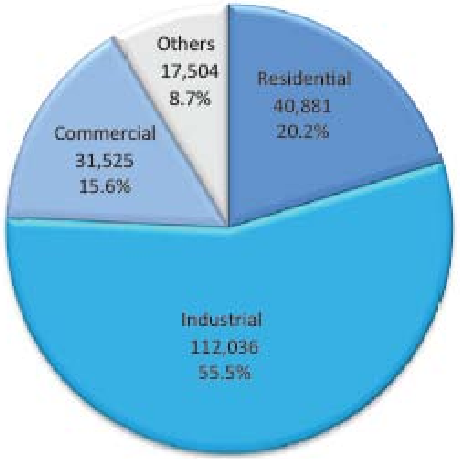
Remark 1: In 2014, peak load is 34,821MW.
Remark 2: In 2015, installed capacity of RE is 3.8GW (9%).
Remark 3: In 2015, power generation is 219,224GWh in which RE is 4%.

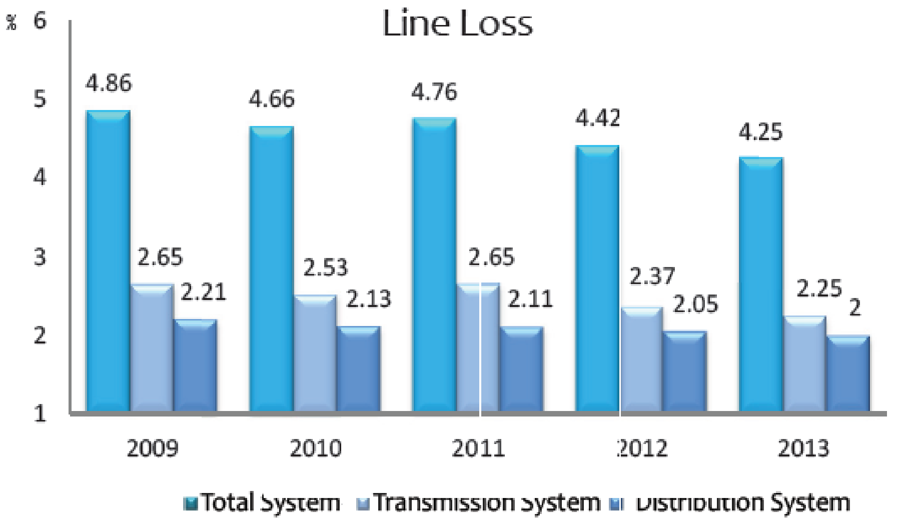
User Profile of Taipower in 2013

Customers
(13,184 Thousand)

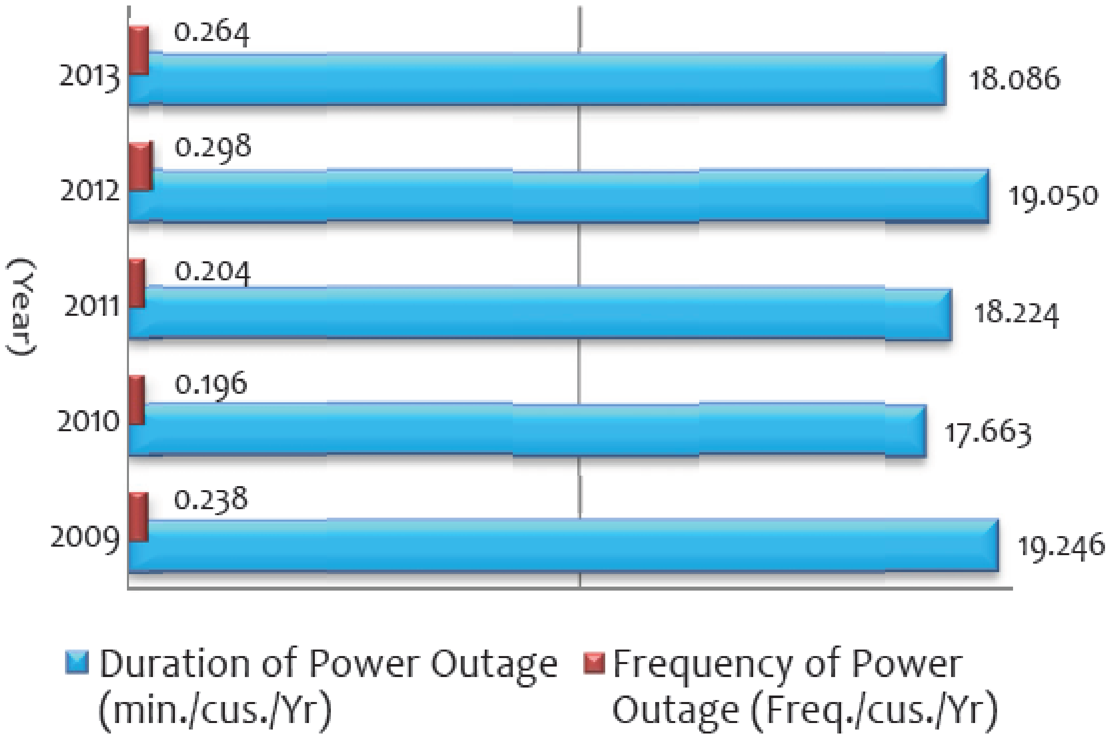


Sales
(201,945 GWh)





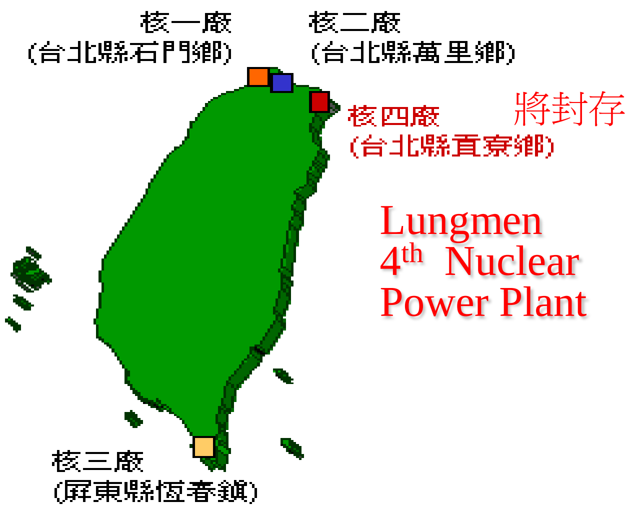
Power Outage Duration and Frequency



Nuclear Power Plants in Taiwan

■ Nuclear Power Plants in Taiwan

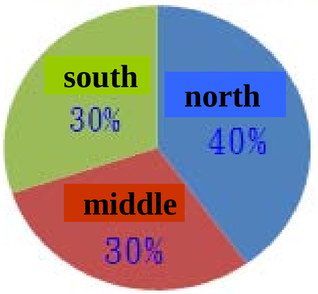
Station	Set	Capacity (MW)	Status
1st Jinshan Nuclear Power Plant	1	636	Retire in 2018
	2	636	Retire in 2019
2nd Kuosheng Nuclear Power Plant	1	985	Retire in 2021
	2	985	Retire in 2023
3rd Maanshan Nuclear Power Plant	1	951	Retire in 2024
	2	951	Retire in 2024
4th Lungmen Nuclear Power Plant	1	1350	Operate after 2017?
	2	1350	Operate after 2018?

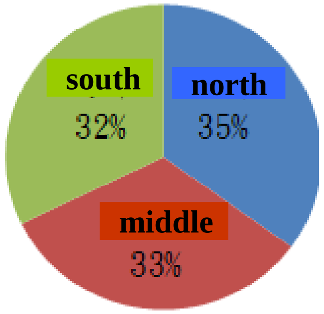


Regional Power Congestion

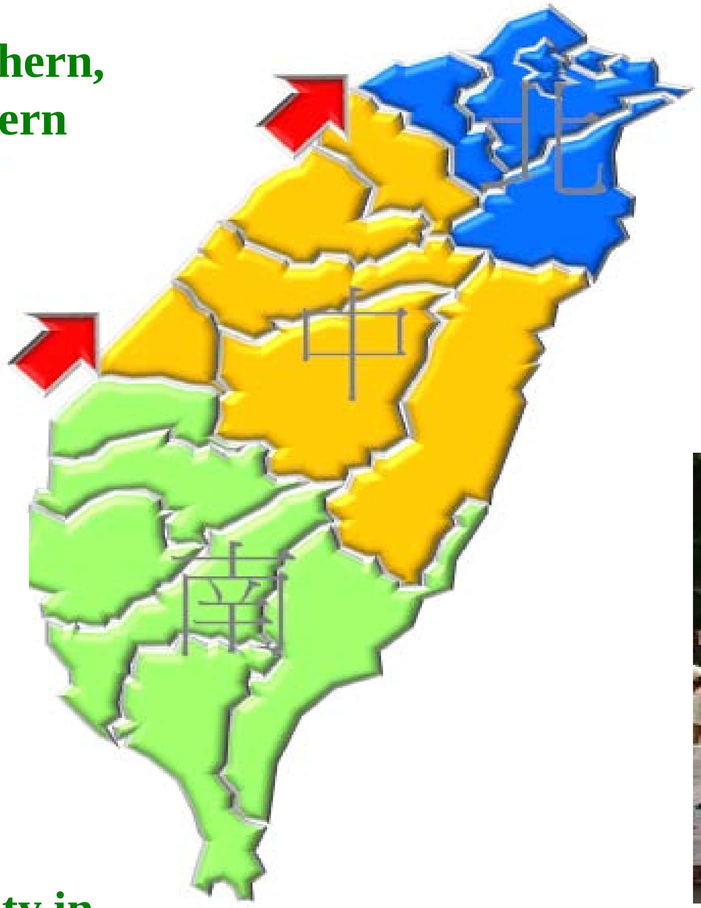
The regional supply capacity and peak load of northern, middle and southern Taiwan in 2013

Peak load in northern, middle and southern



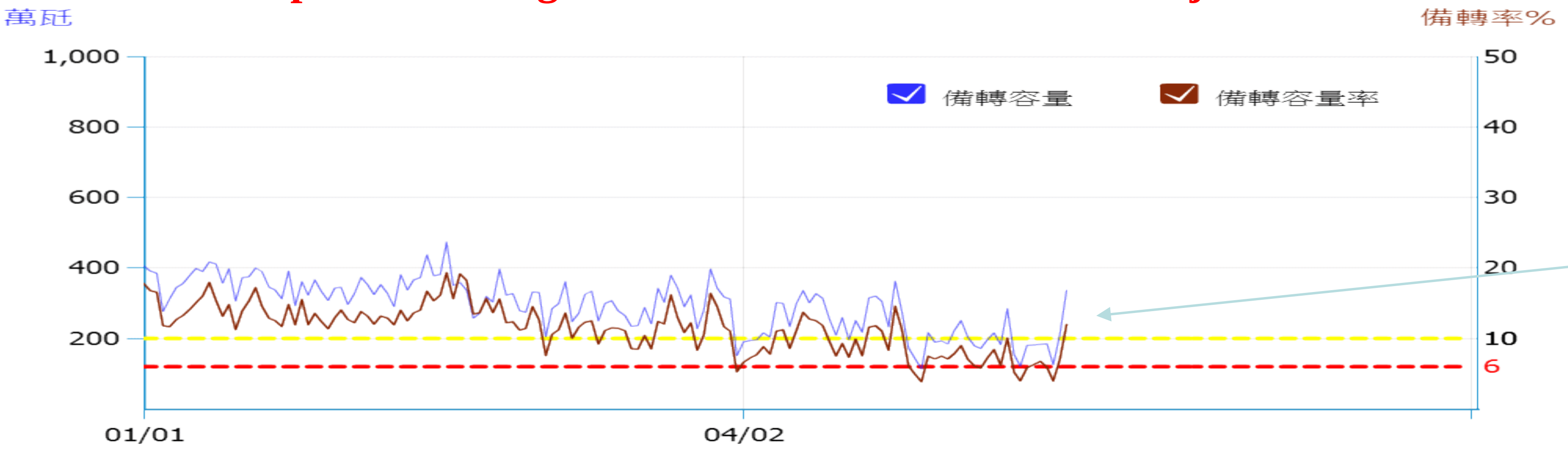


Power supply capacity in northern, middle and southern



The Future Power Supply Environment in Taiwan

- Estimation based on analysis of overall power supply and demand shows that under the circumstances of Nuke 4 came to a halt, Nuke 1, 2 and 3 will decommission on schedule, the newly planned coal-fired and natural gas power generation will be completed on schedule, and the outdated facilities will be eliminated on schedule:
  - Calculation based on normal power consumption scenario (power consumption growth rate is 2%), **starting from 2018, Taiwan will face the risk of power shortage**. (idea case)
  - However, if the renewed coal-fired, natural gas power generation facilities are inoperable and Nuke 1, 2 and 3 can't reconnected to the grid due to any reason, **Taiwan will face the risk of power shortage in 2016** the earliest. (current situation)
  - **The risk of power shortage is a serious and unavoidable subject that all the citizens will face.**



When Electricity reserve rate is lower than 15%, the chance of electricity rationing will increase, it has happened to be lower than 10% multiple times in 2015, and it was 3.88% on April 29th, 2015.

Source：Bureau of Energy, Ministry of Economic Affairs , Taipower Company, 2015.05

Current Status of Taipower and Energy Policy of Taiwan

(1) Current Status of Taipower

a. Due to an extreme lack of indigenous energy resources, Taiwan relies on imported energy resources for 98% of its needs.

b. Fossil fuels play a major role in the energy supply structure, having a tendency of excessive concentration.

c. As an isolated power system, Taiwan Power network has not yet been connected to other power systems.

d. Taipower is owned by the government. Under the government's policy, flat electricity prices have been failing to reasonably reflect the costs.

(2) Energy Policy of Taiwan

a. **Steadily Reducing Nuclear Dependency**

- a) No extension to life spans of existing plants, and the decommissioning plan should be launched as planned.
- b) The security of the 4th Nuclear Power Plant must be ensured prior its commercial operation.

b. **Replacing Nuclear with LNG** for **Base Load**

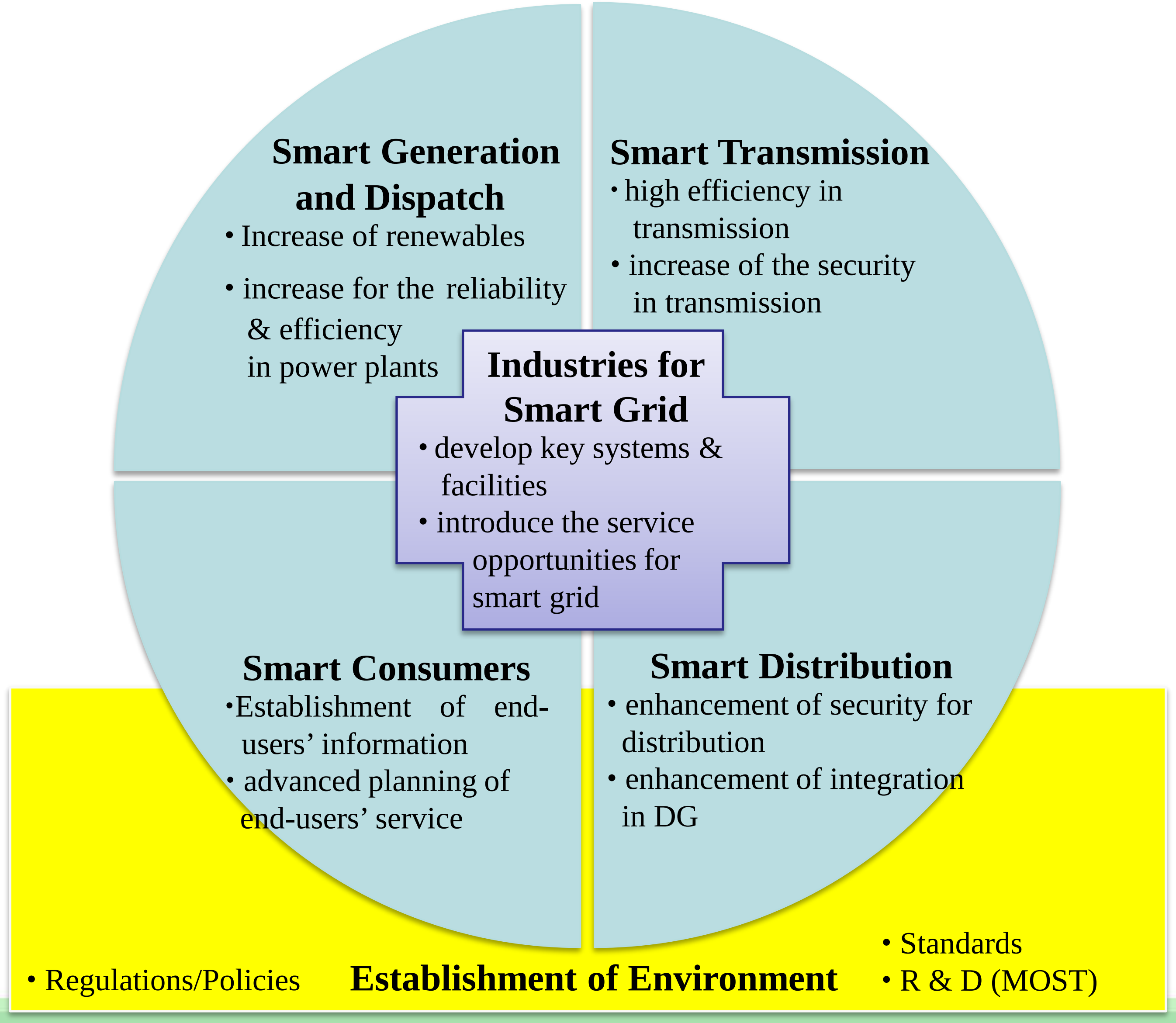
- a) LNG total installation capacity is expected to reach 26,532 MW (accounting for 40% of total capacity of power installations) by 2030.

c. **Promoting Renewable Energy Extensively**

- a) Under the campaign of "one thousand wind mills" and "one million sunshine roofs", the installed capacity of renewable energy is expected to reach **28.5 GW** (PV 20GW, WTG 3GW) by **2025** (accounting for 50% of total power installations).

Master Plan of Smart Grid in Taiwan

Master Plan of Smart Grid in Taiwan (2011~2030)



Task Forces：

- **Ministry of Science and Technology (MOST)**
- **Ministry of Economic Affairs (MOEA)**
  - Bureau of Energy
  - Bureau of Standards
  - Industrial Development Bureau
  - Department of Industrial Technology
- **Taiwan Power Company**
- **Institute for Information Industry**
- **Institute of Nuclear Energy Research**
- **Industrial Technology Research Institute**
- **Taiwan Institute of Economic Research**
- **Taiwan Smart Grid Industry Association**

Objectives of Smart Grid Master Plan

Benefit	Objective	2010	2020	2030
Security & Reliability in Power Grid	System average interruption duration index (SAIDI)	21min/ customer · year	16min/ customer · year	15.5min/ customer · year
Energy Efficiency	Efficiency in thermal power plants	42.52%	44.73%	(2023 44.95%)
Renewable (Including Hydro Power)	Percentage of installed capacities	4.7% (2GW)	(2015 9%, 3.8GW)	(2025 50%, 28.5GW)
Carbon Reduction	Carbon Oxide reduction	(CO_2 emission: 276 million tons, 12 ton per person)	35.99 million tons	114.71 million tons

National Energy Program-Phases I-II:
Smart Grid General Project

National Energy Program-Phase I: Smart Grid General Project

Pilot Projects and Preliminary Collaborating Firms

7. Transmission System Power Quality Monitoring and Control Technology Development and Applications Pilot Project
ADX, APPA, TAYA, INER

1. AC Microgrid Pilot
CHEM, ABB, CAEC, AIDC, Allis, RICH ELECTRIC, ADX Corporation,榮城, AC POWER

MicroGrid for more renewable energy penetration and better power quality

6. Advanced Wide-area Measurement System (WAMS) Applications Pilot Project
ADX, TATUNG

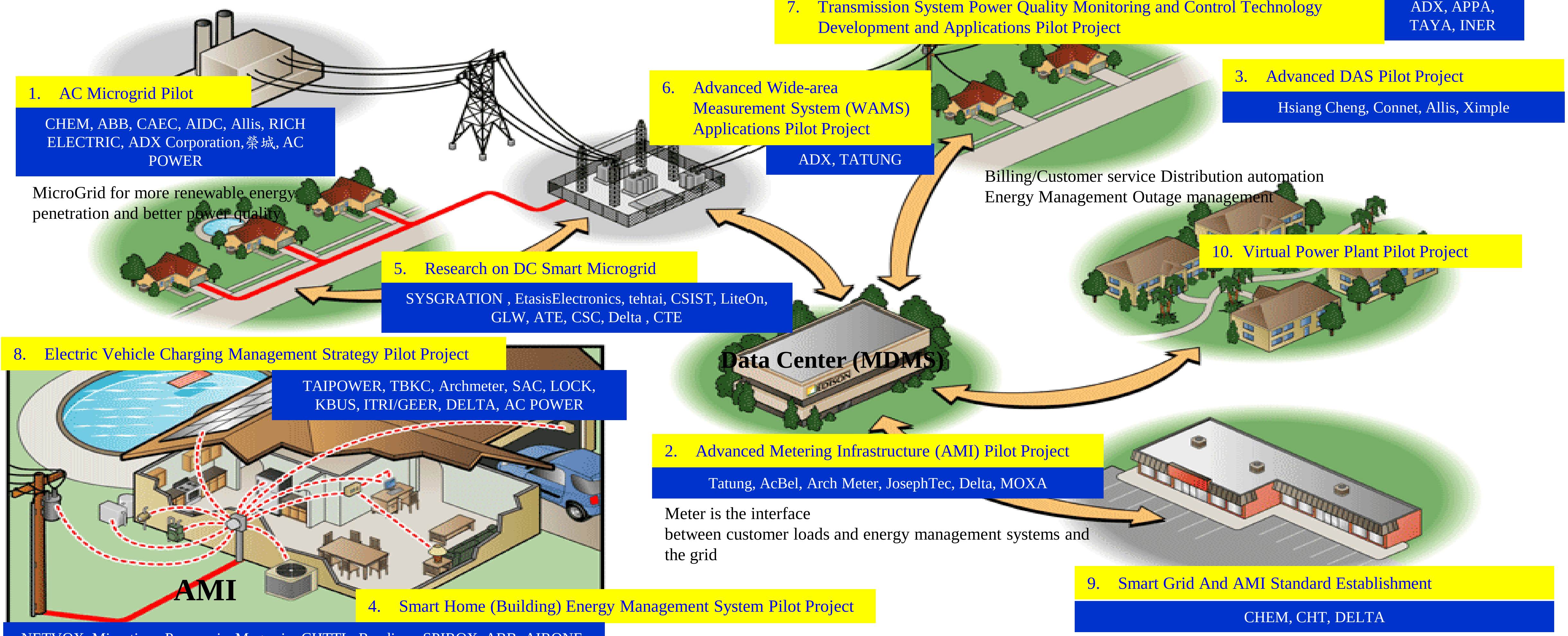
3. Advanced DAS Pilot Project
Hsiang Cheng, Connet, Allis, Ximple

Billing/Customer service Distribution automation
Energy Management Outage management

10. Virtual Power Plant Pilot Project

5. Research on DC Smart Microgrid
SYSGRATION , EtasisElectronics, tehtai, CSIST, LiteOn, GLW, ATE, CSC, Delta , CTE

8. Electric Vehicle Charging Management Strategy Pilot Project
TAIPOWER, TBKC, Archmeter, SAC, LOCK, KBUS, ITRI/GEER, DELTA, AC POWER



2. Advanced Metering Infrastructure (AMI) Pilot Project
Tatung, AcBel, Arch Meter, JosephTec, Delta, MOXA

Meter is the interface between customer loads and energy management systems and the grid

4. Smart Home (Building) Energy Management System Pilot Project
NETVOX, Microtime, Panasonic, Megawin, CHTTL, Raydium, SPIROX, ABB, AIRONE, 源鼎, ITRI/GEER, ITRI/IC, III, TATUNG

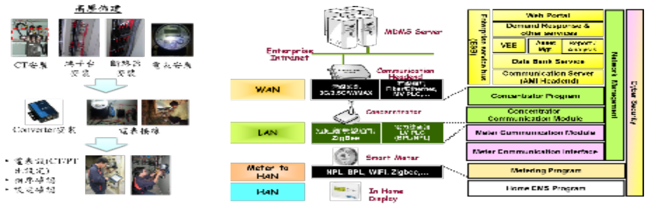
Improve of building energy efficiency and public energy saving conscious

9. Smart Grid And AMI Standard Establishment
CHEM, CHT, DELTA

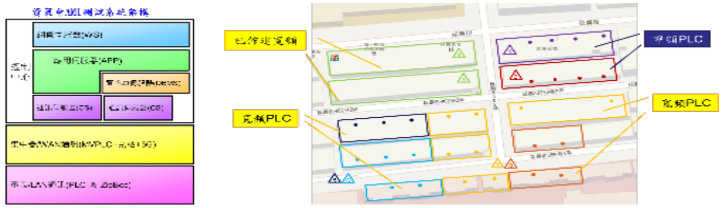
11. Smart Grid Demo Site in Penghu

Smart Grid Demo Sites in Taiwan-1

There are currently 18 Smart Grid Demonstration Sites in Taiwan.

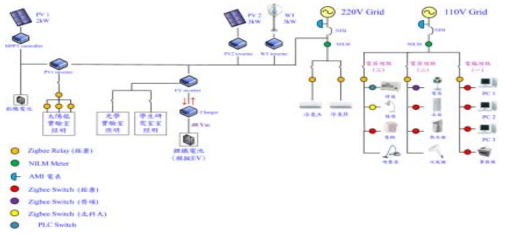


Smart Meter Reading & Demand Response System

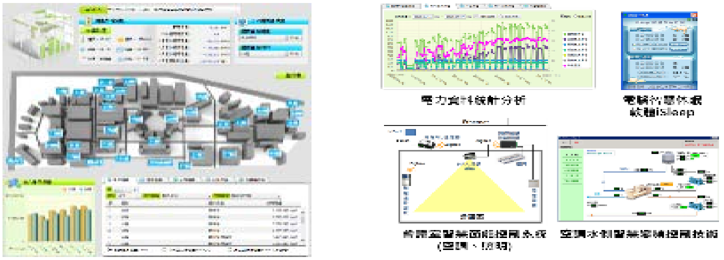


Demonstration of Smart Meter Reading in a Metropolitan Setting

Smart Meter System and Home Energy Management System Demonstration Area



Smart Home (Building) Energy Management System

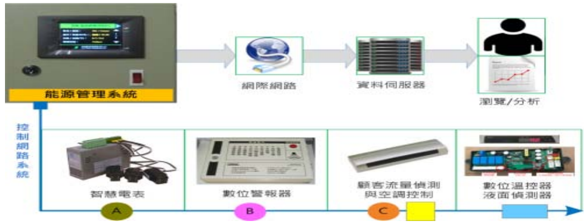


Smart Building Energy Conservation Demonstration Area

Smart Grid Control Center and Smart Home Demo Room

Wastewater Treatment Plant Power Equipment Monitoring and Energy Conservation Management System

Hypermarket Energy Conservation Management System

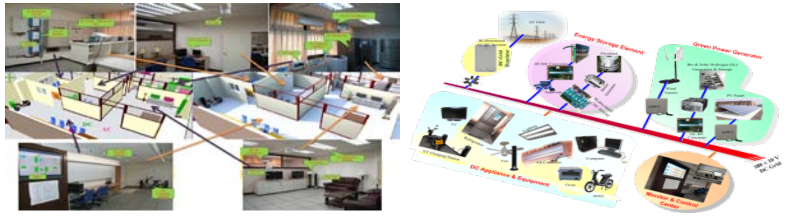


Convenience Store Energy Conservation Management System

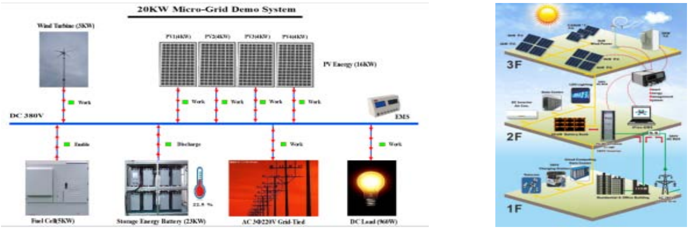
Smart Grid Demo Sites in Taiwan-2

Advanced Distribution Automation Demo System

100 kW Autonomous Micro-grid Demonstration System



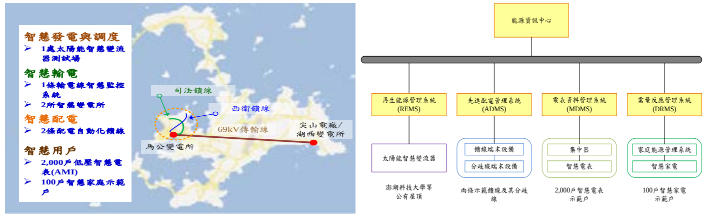
Smart DC Power System Educational Demonstration House



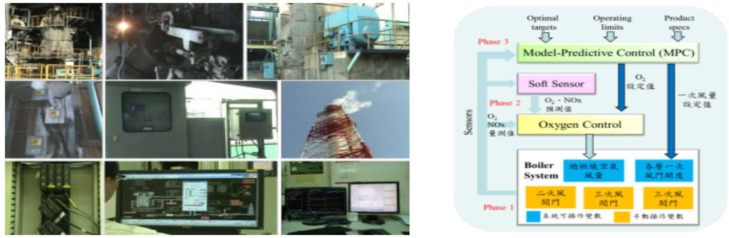
Smart AC/DC Hybrid Micro-Grid Demonstration System

Micro-grid and Electric Vehicle Demonstration Site

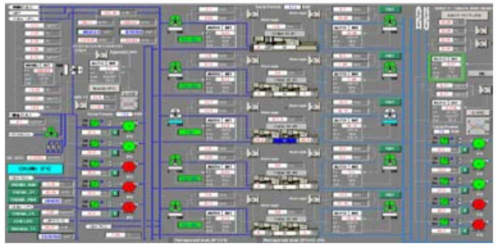
Dongkeng Smart Grid Demonstration Project



Penghu Smart Grid Demonstration Site



Furnace Optimized Operation Demonstration System



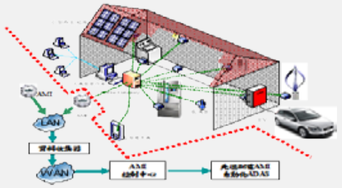
Optimizing Control System for a High-tech Plant Ice Water System

National Energy Program-Phase II: Smart Grid Focus Center Project Framework (2014~ 2018)

sponsored by National Science Council

Equipment and system development

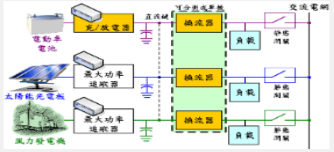
A Smart Energy network and energy saving control Technology



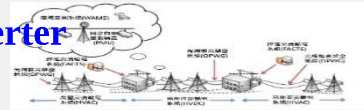
B AMI Value-added service and integration technology

C Distribution Power Control Technology development

D Isolated Microgrid Technology development



E Grid-connected High Power Converter development



F EV charging station manager strategy

G Advanced Wide-area Measurement System (WAMS) and control technology

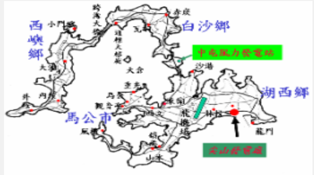
H Transmission System Power Quality improvement and wheeling technology development

I Smart Grid and AMI Standard Development

Technology Commercialization

J Smart Gird Industry Development Project

Demonstration



K Penghu Smart Grid Demon Site Construction (Low Carbon Island)

L Integrated Applications of Demand Response, Distributed Generator, and Energy Storage System (VPP Demo Site)

Implementation

M Taiwan Power Company Smart Grid Installation

NEP-II Smart Grid Focus Center – Research Projects and Test Fields

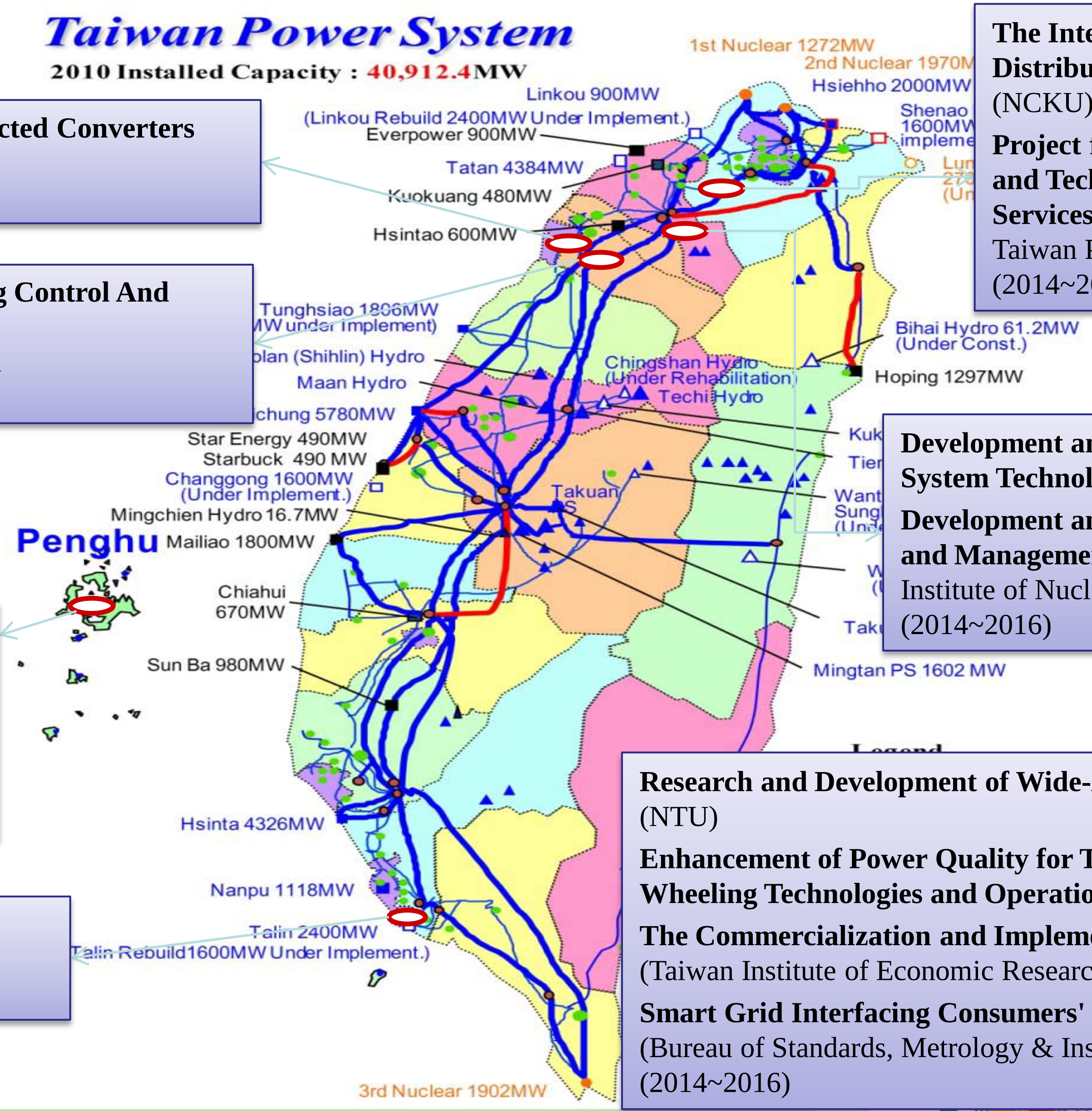
Development of High Power Grid-Connected Converters
NTHU, Hsinchu
(2014~2016)

Key Technology Development of Energy Saving Control And System Integration for Smart Grids
Industrial Technology Research Institute, Hsinchu
(2014~2016)

Penghu Smart Grid Demonstration Project (ITRI)

Integrated demonstration project of Penghu smart grid (ISU)
Penghu archipelago
(2014~2016)

EV charging station manager strategy
NSYSU, Kaohsiung
(2014)



The Integrated Application of Demand Response, Distributed Generator, and Energy Storage System (NCKU)

Project for Research on International Energy Policy and Technologies Development on AMI Value-Added Services (Institute for Information Industry)
Taiwan Power Research Institute, Shulin
(2014~2016)

Development and Application of Standalone Microgrid System Technology

Development and Application of Autonomous Power Control and Management Technology for a Distributed Power System
Institute of Nuclear Energy Research, Longtan
(2014~2016)

Research and Development of Wide-Area Monitoring and Control Technologies (NTU)

Enhancement of Power Quality for Transmission Network and Development of Wheeling Technologies and Operations Planning (NCCU)

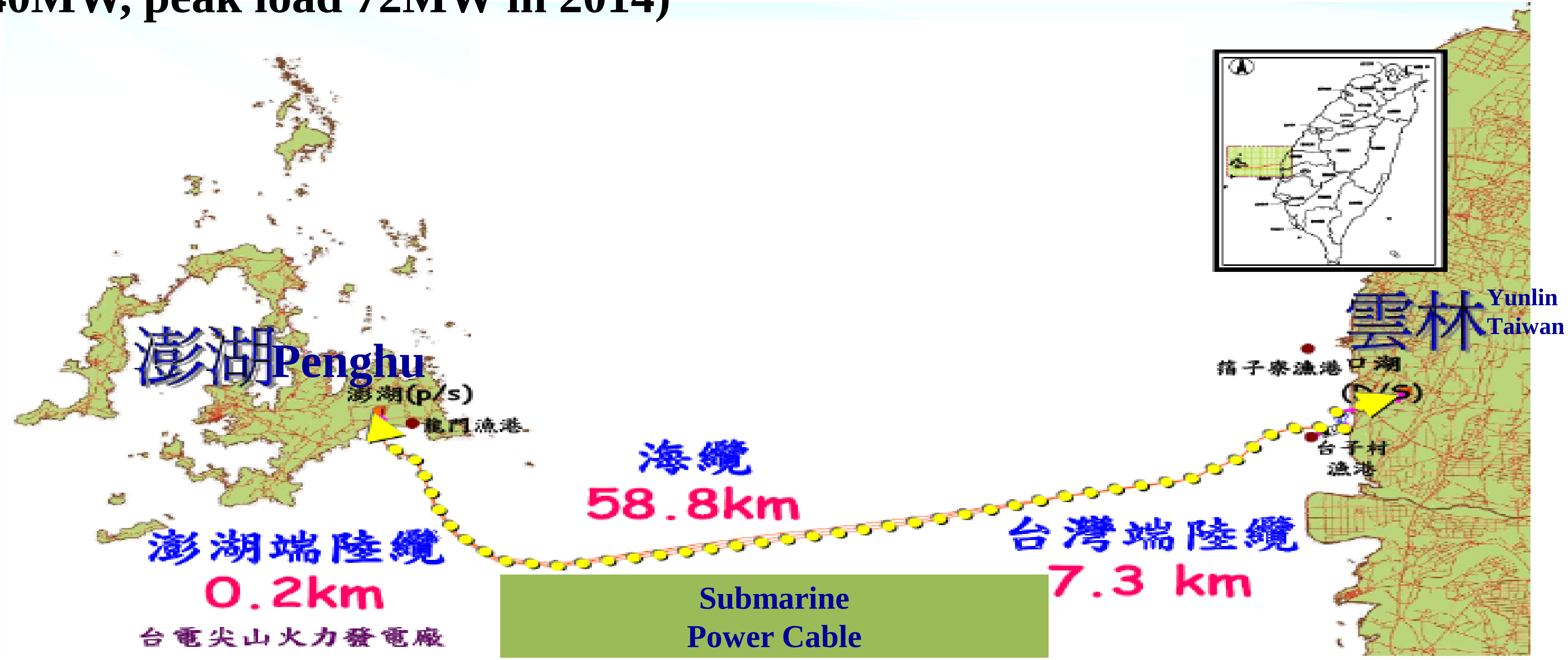
The Commercialization and Implementation of Smart Grid Technology Project (Taiwan Institute of Economic Research)

Smart Grid Interfacing Consumers' Standards and Their Test Specifications (Bureau of Standards, Metrology & Inspection, M.O.E.A.)
(2014~2016)

NEP II - Penghu Smart Grid Demonstration Project

Penghu Smart Grid Demonstration Project

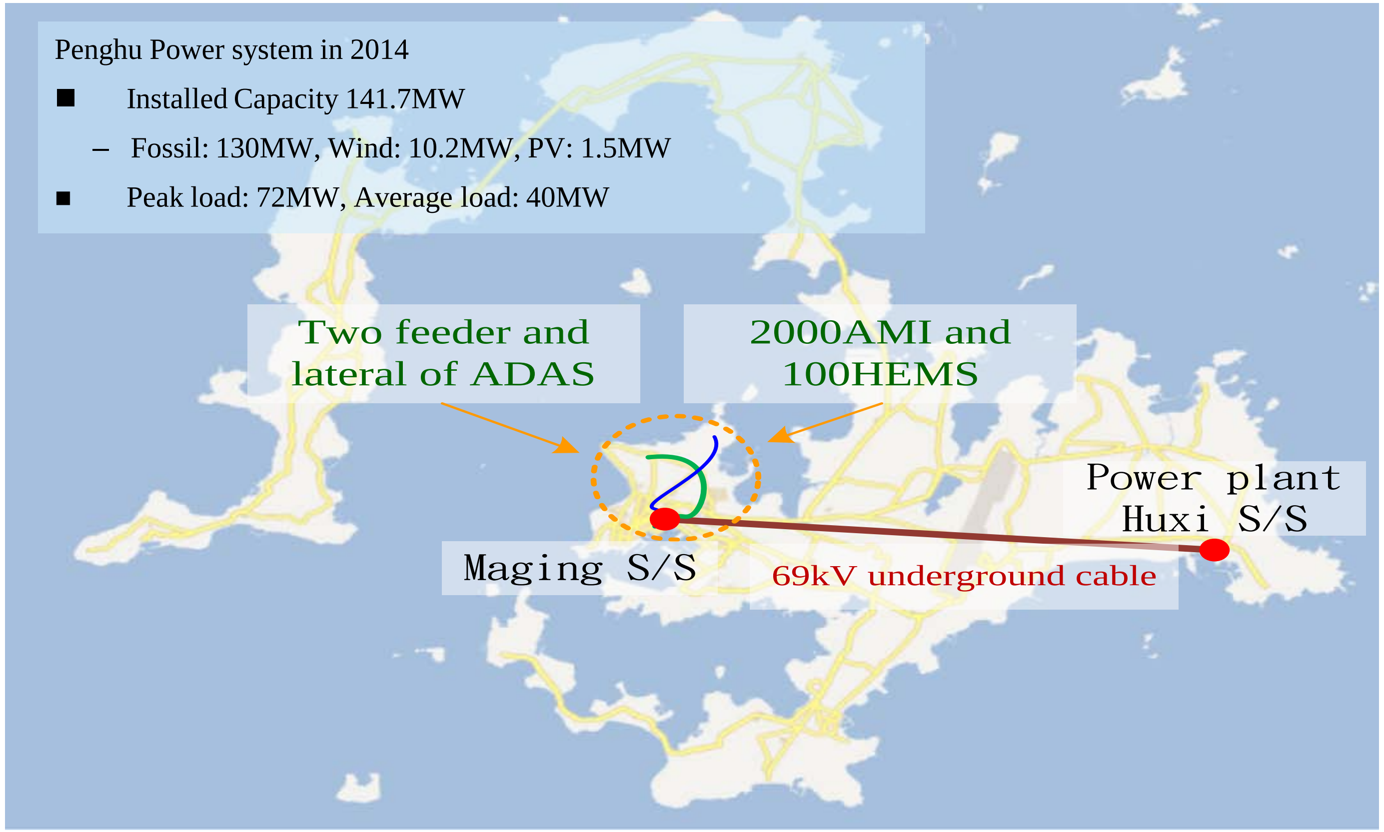
- **Penghu archipelago (48km from Taiwan, inhabitants 100,000, average load 40MW, peak load 72MW in 2014)**



With 161kV/200MW and completed in the end of 2016

Penghu Smart Grid Demonstration Project

- Smart Grid Master Plan was announced in 2012.
- Some technologies need detailed action plans and technology verification.
- Penghu Island is proposed as the demo site of Smart Grids technologies.

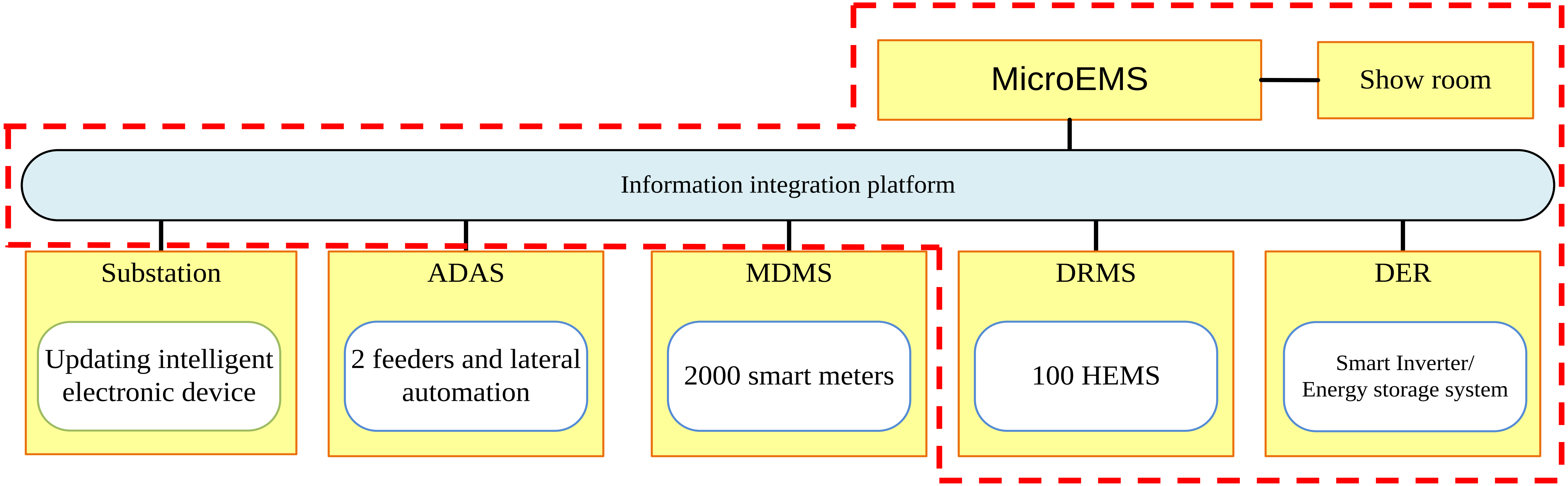


Deployment Items:

1. Smart PV inverter test site
2. Smart Substations (Magong & Huhsi S/S)
3. Advanced DAS with FDIR in two feeders
4. 2,000 smart meters
5. 100 smart users with HEMS
6. Micro-EMS demo system

Penghu Smart Grid Demonstration Project

- An information integration platform accesses data with substation, ADAS, MDMS, DRMS and DER through MicroEMS.



ADAS: advanced distribution automation system
MDMS: metering data management system
DER: distributed energy resource

Penghu Smart Grid Demonstration Project

Show Room of Penghu Smart Grid Demonstration Project

Scenario of smart home, computer room for information integration platform, model of smart grid system, monitoring power generation and transmission of Penghu island

Penghu Smart Grid Demonstration Project

website http://smartgrids.tw

Inverter – Role in PV Plants?

PV inverter converts DC energy from solar modules in to AC energy and interface the PV system with electricity grid

Traditional Inverter

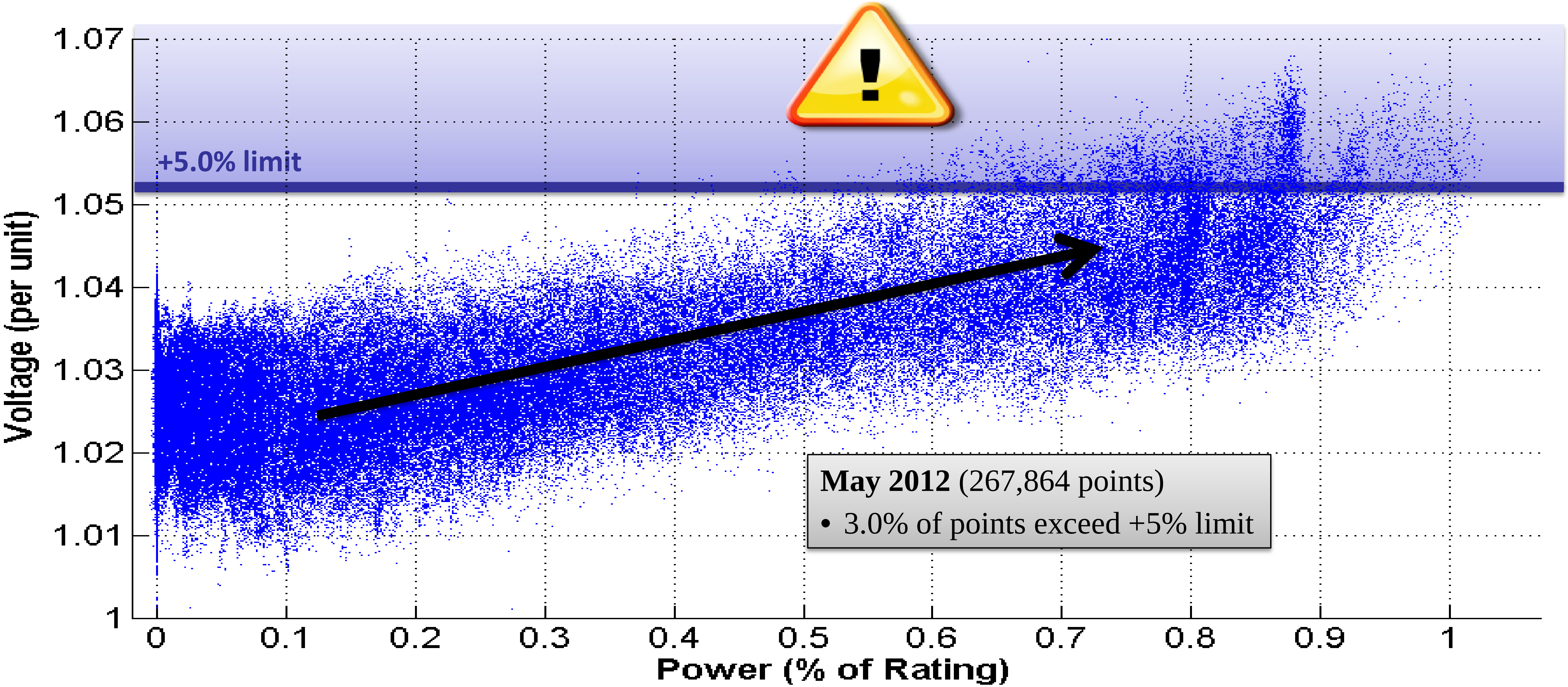
- Harvesting maximum power from PV array
- Matching plant output with grid voltage and frequency
- Providing unintentional islanding protection

What is Smart Inverter?

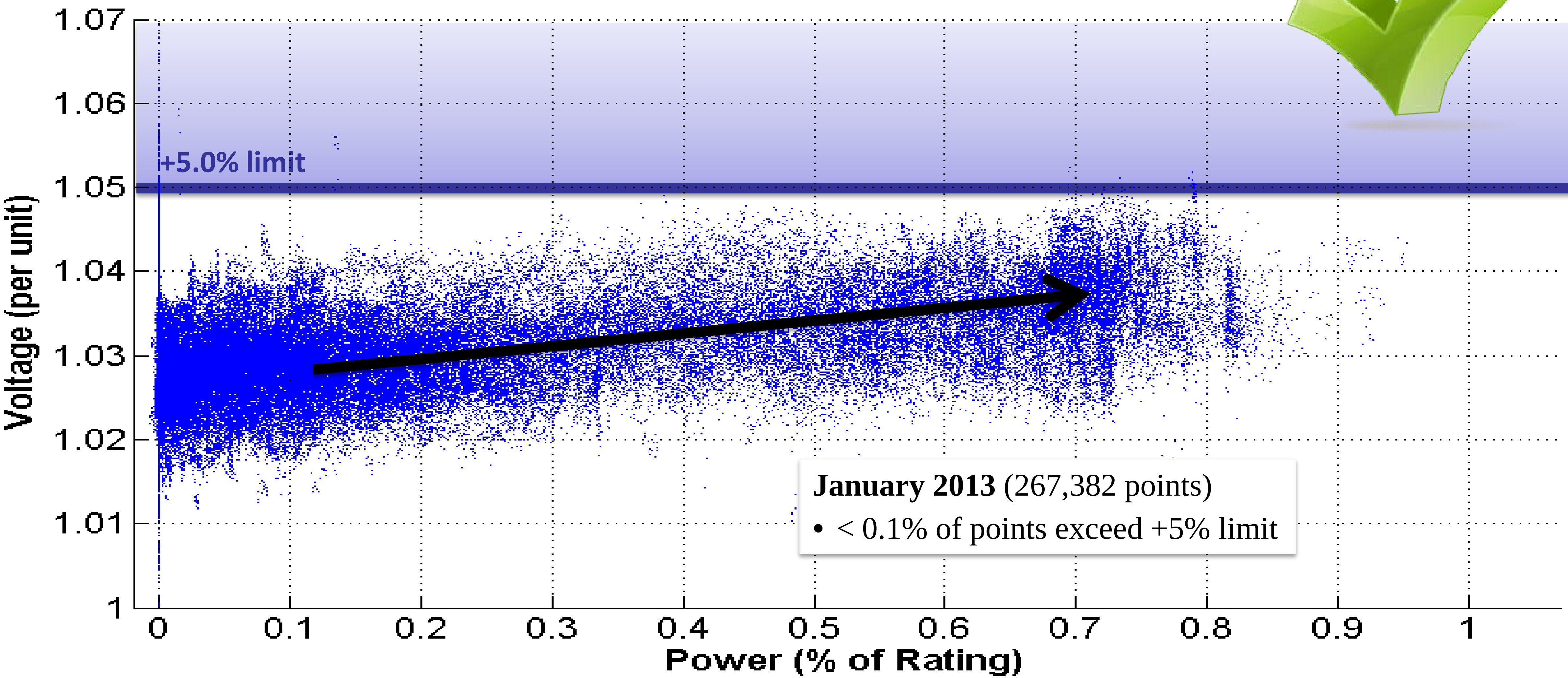
- Inverter that can modify it's real and reactive power output to provide grid support

- Can respond autonomously to V/F changes or can respond to communicated signal

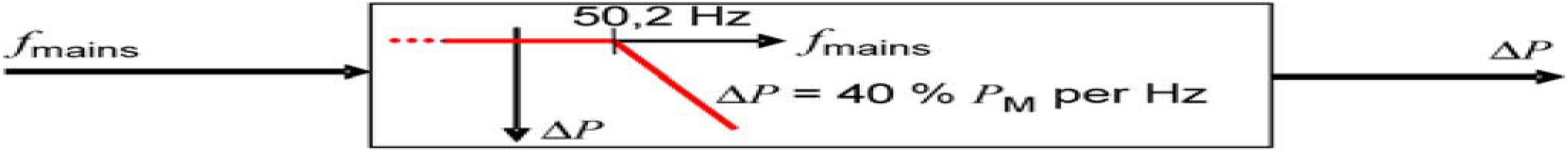
Voltage Violation (w/o smart inverter)



Voltage after Power Factor Adjustment



Active power feed-in control with smart inverter



$$\Delta P = 20\ P_M \frac{50.2Hz - f_{mains}}{50Hz} \qquad \text{for } 50.2\text{ Hz} \le f_{mains} \le 51.5\text{Hz}$$

Where:

P_M : the power generated at the time of exceeding 50.2 Hz;

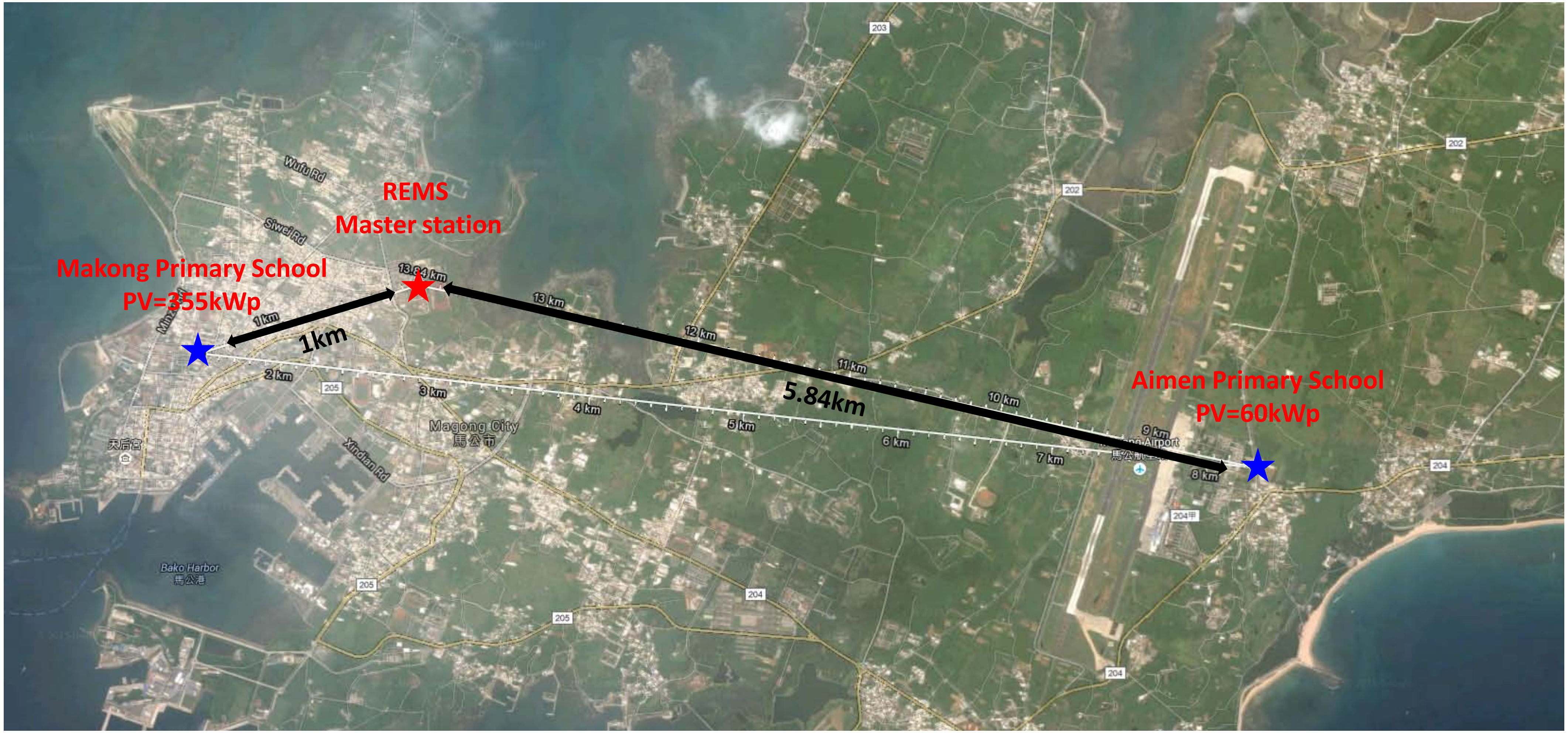
P : the power reduction ;

f_{mains} : the mains frequency.

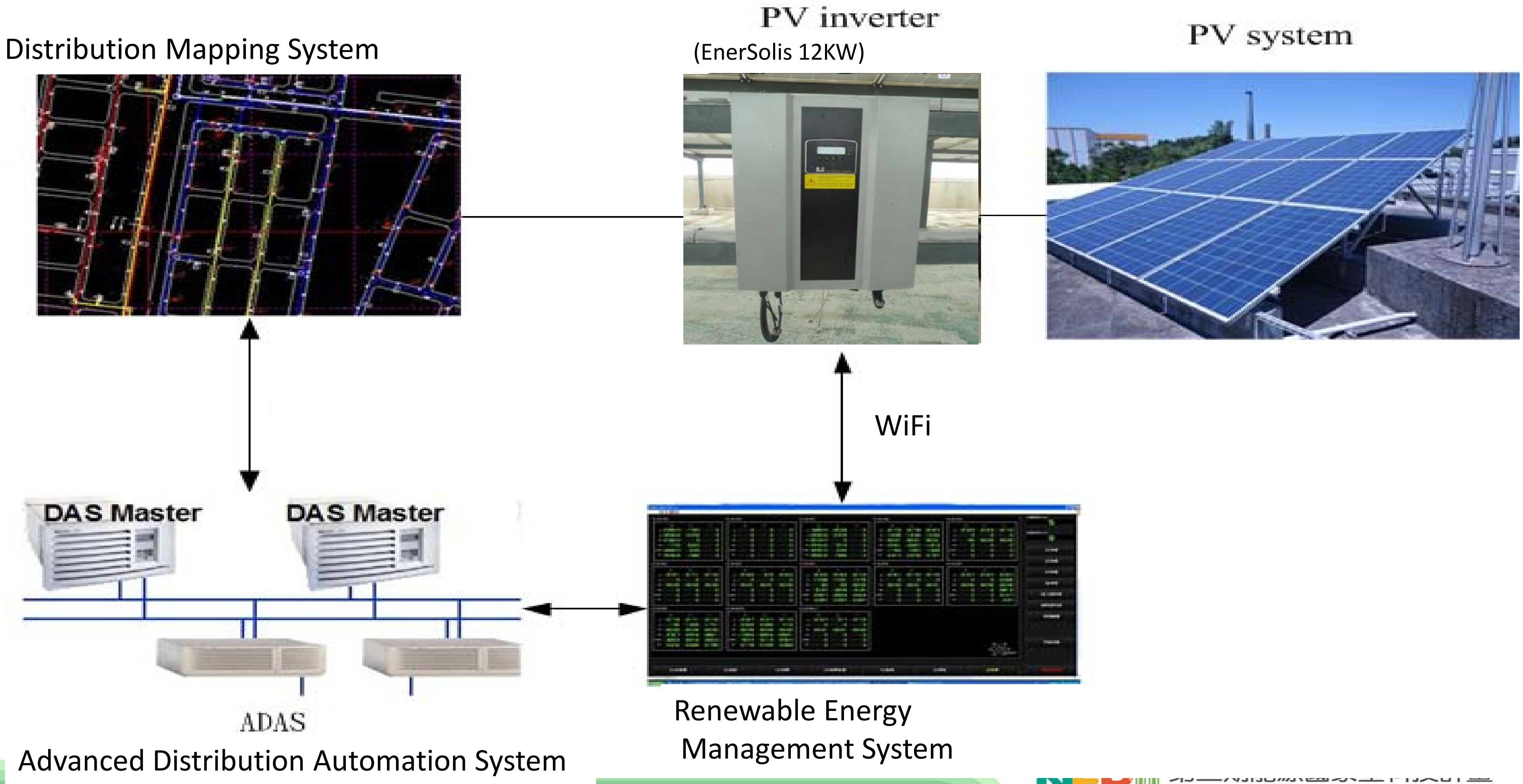
There are no restrictions for frequencies of 47.5 Hz $\le f_{mains} \le$ 50.2 Hz.

Disconnection from the network is required for $f_{mains} \le$47.5 Hz and $f_{mains} \ge$ 51.5 Hz.

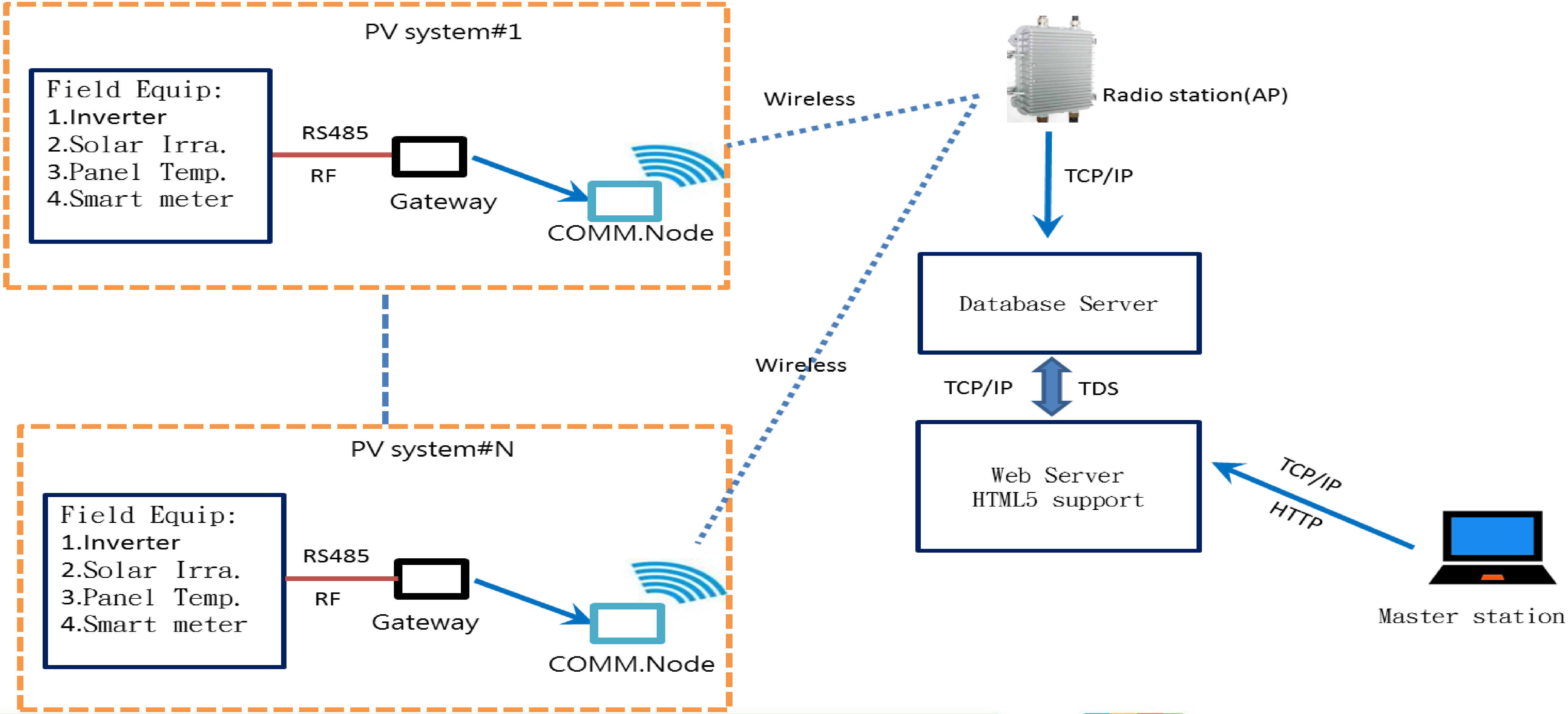
Demonstration of Smart Inverter in Penghu



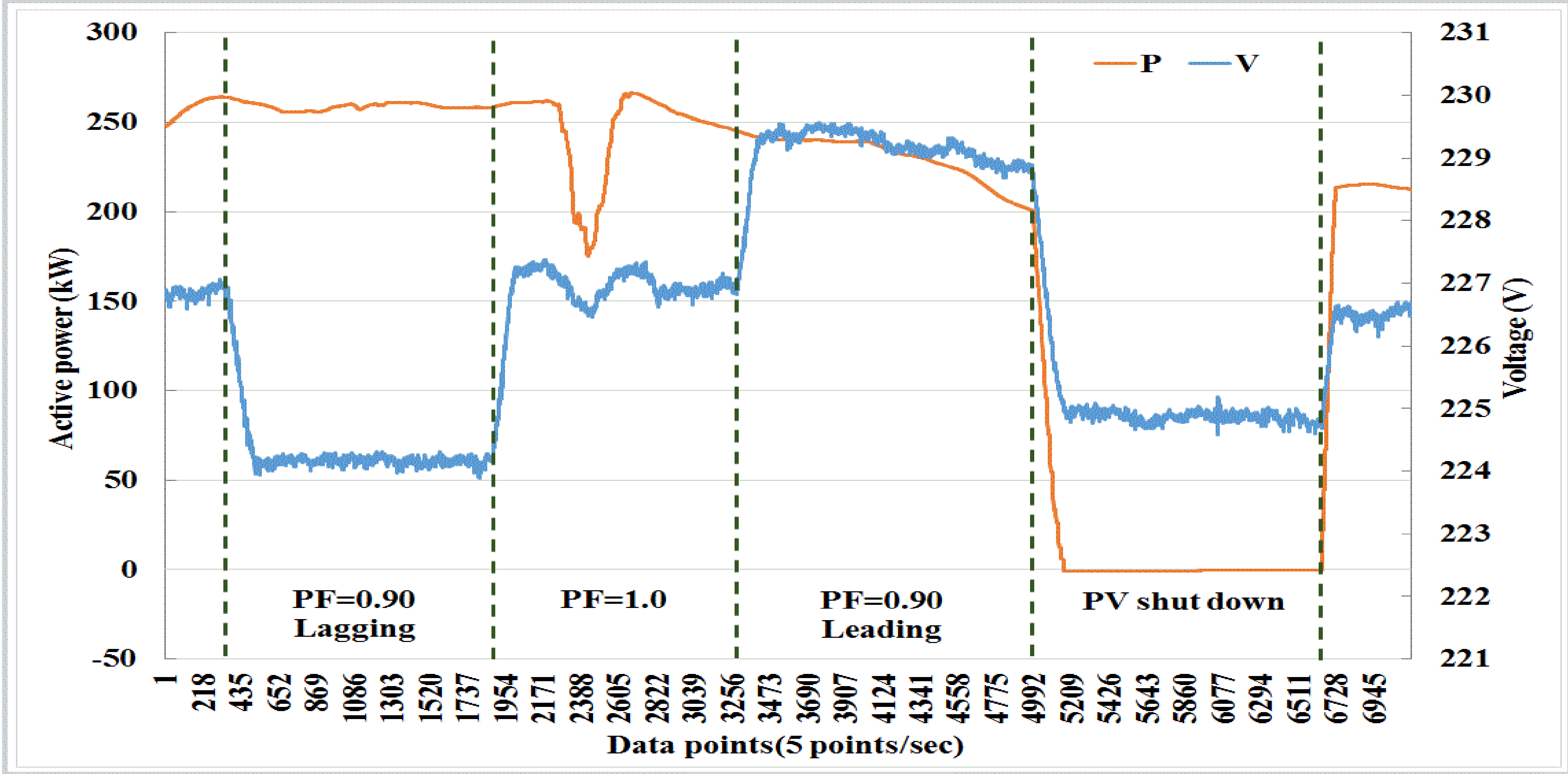
Monitoring and Control of Grid-connected PV System



Communication Architecture of Renewable Energy Management System



Field Test of Smart Inverter
(Makong Primary School, 2015/06/25-10：30AM)



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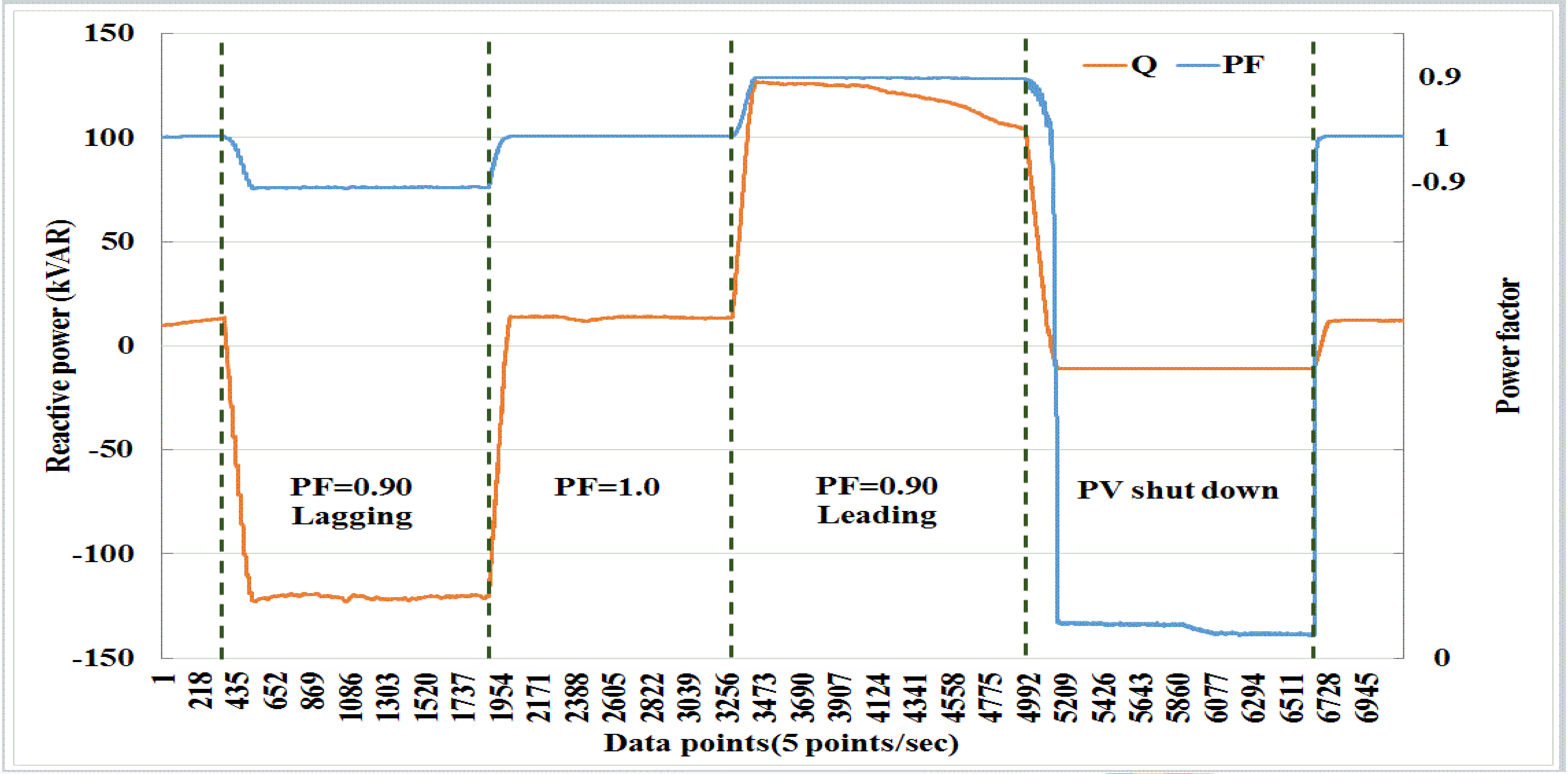
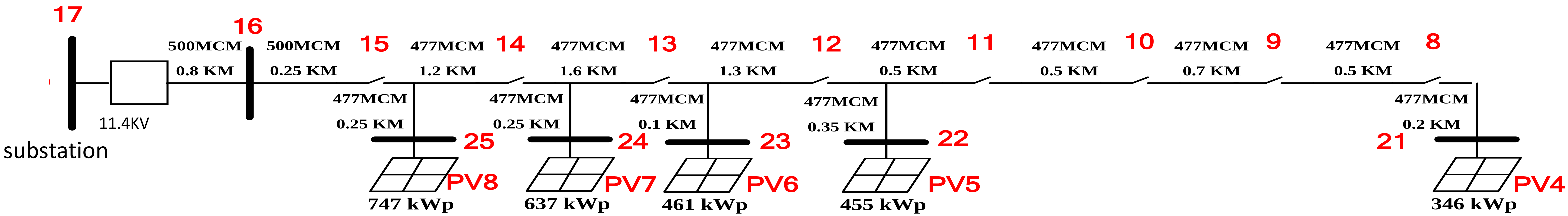


Enhancement of PV penetration by power factor control of smart inverters

- Taipower distribution feeder:
  length=8.5KM
  total existing PV installation=2646KWp
- A new PV installation with smart inverter



Maximum capacity of PV integration (W/O violating the constraint of voltage variation 2.5%)

- **Conventional PV Inverter (PF=1.0)**
  - PV capacity of 3200 KWp (Maximum PV capacity:3200 KWp)
- **Smart Inverter (operating with PF=0.9)**
  - Maximum PV capacity:5434 KWp
- **Conclusion**
  - The maximum capacity of PV integration is increased by 2234 KWp when the smart inverters are applied for the large PV farm.

NEP II – Automatic Demand Response Demonstration Project

Automatic Demand Response (ADR)

Demand Response (DR) is a set of actions taken to reduce load when electric grid contingencies threaten supply-demand balance or market conditions occur that raise electricity costs. Automated demand response consists of fully automated signaling from a utility, ISO/RTO or other appropriate entity to provide automated connectivity to customer end-use control systems and strategies. Open Automated Demand Response (OpenADR) is a research and standards development effort for energy management led by North American research labs and companies. The typical use is to send information and signals to cause electrical power-using devices to be turned off during periods of high demand. OpenADR provides a foundation for interoperable information exchange to facilitate automated demand response.

Taipower Research Institute Test Site – ADR

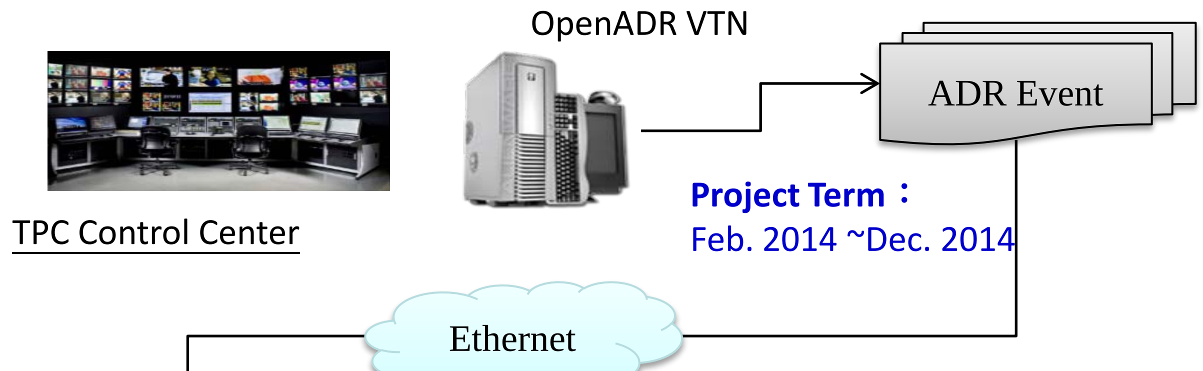
Utility

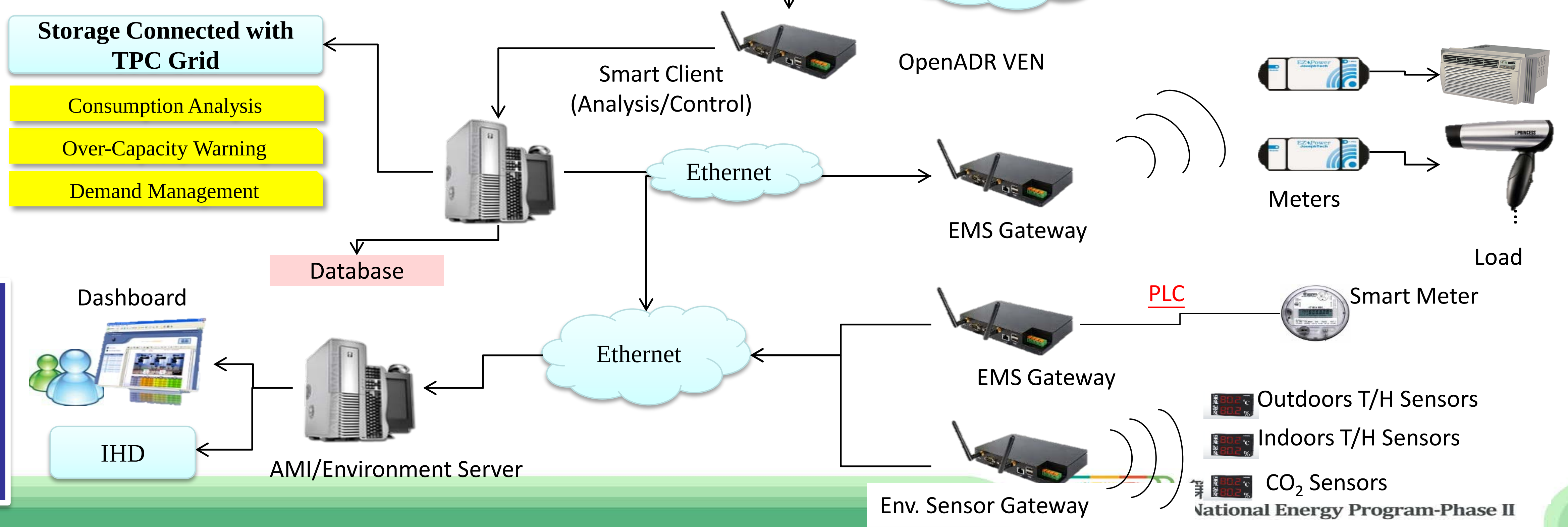
① **Control Center** transmits DR Event with “Reduction Level” to ADR VEN

② **ADR VEN** transmits DR event to responsible client according to DR event and client (simple or smart client)

③ **Smart Client** negotiates EMS system to schedules demand reduction accordingly

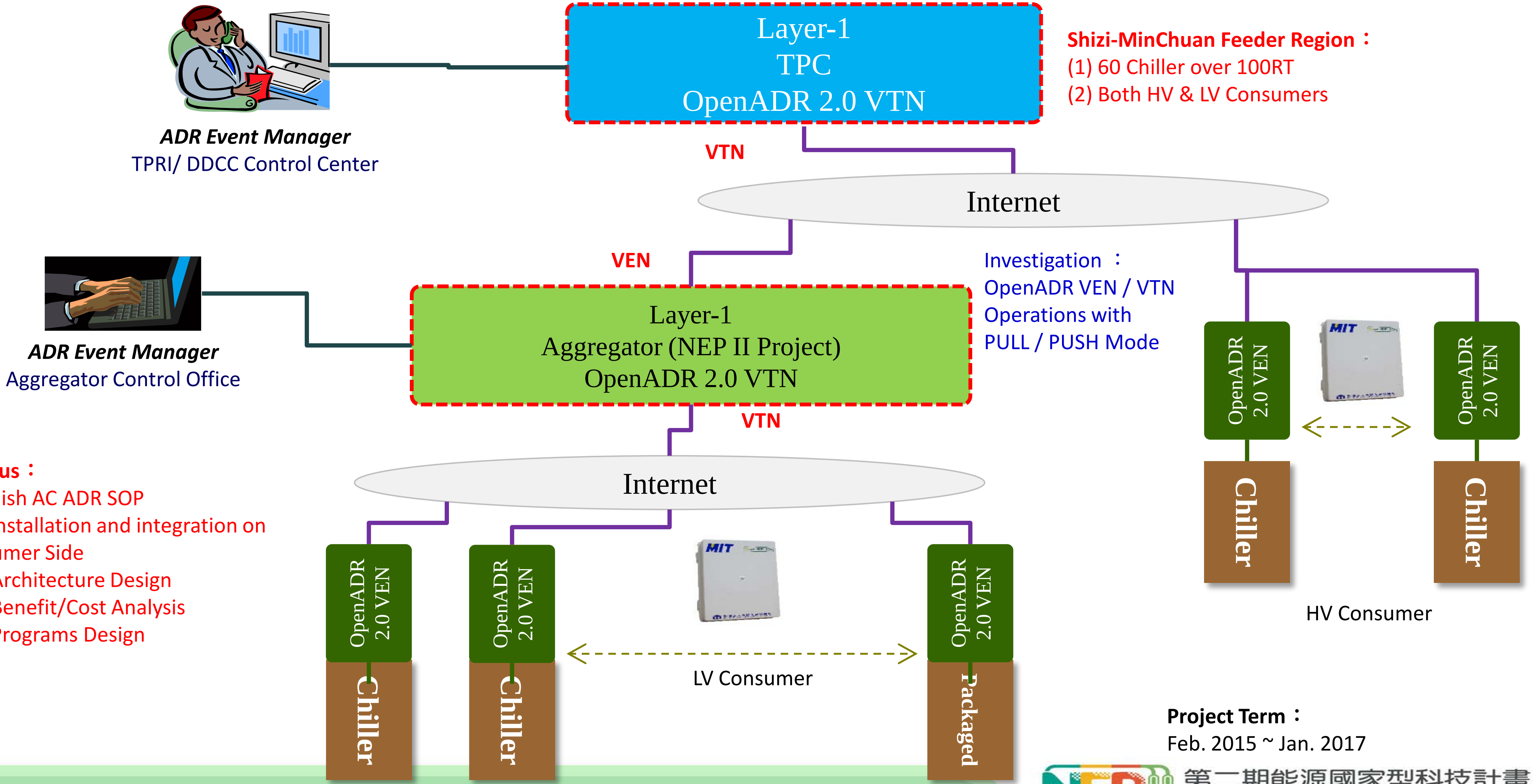
④ **EMS System** manages and controls load according to demand reduction schedule





Consumer

Demonstration of ADR Using Large Chiller



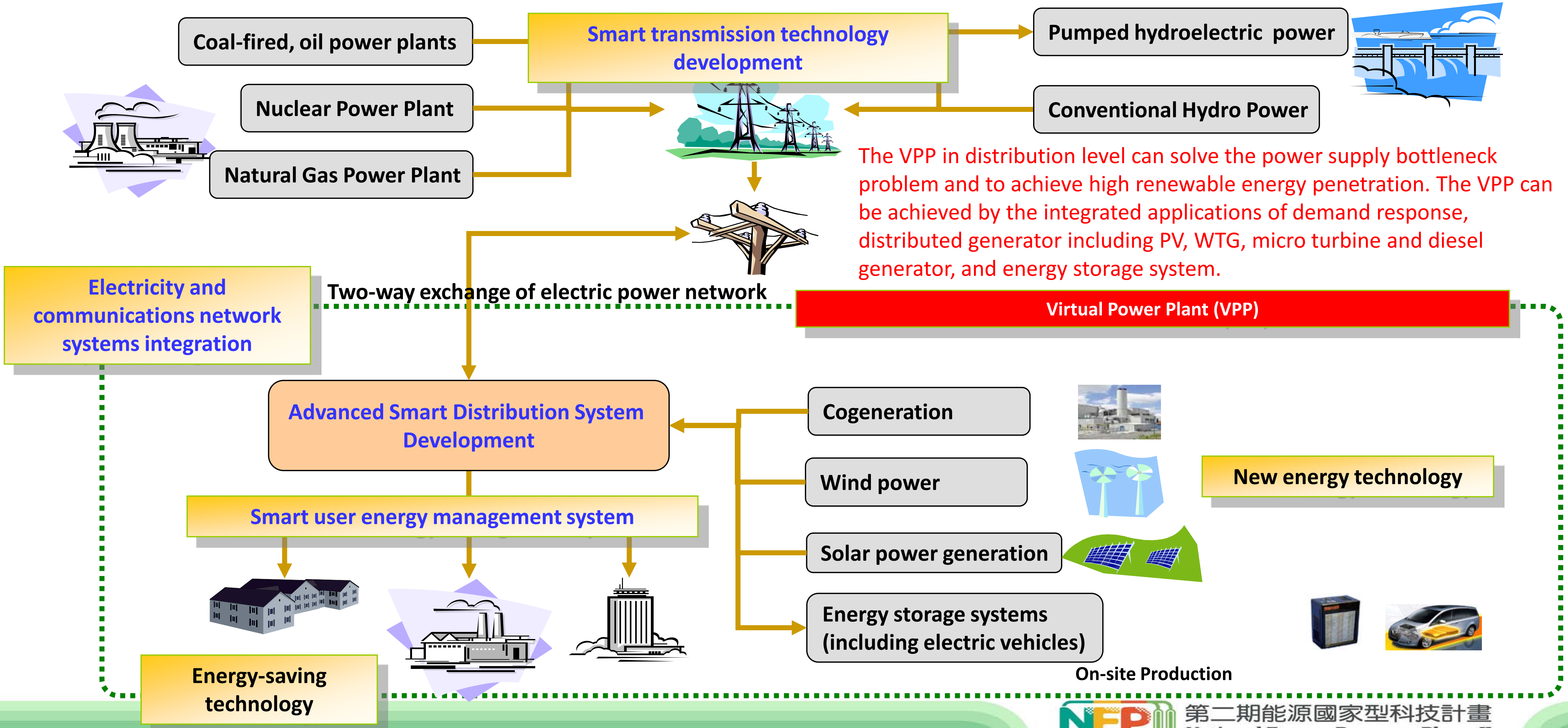
Project Focus：

1. Establish AC ADR SOP
2. VEN installation and integration on Consumer Side
3. ADR Architecture Design
4. ADR Benefit/Cost Analysis
5. ADR Programs Design

Project Term：
Feb. 2015 ~ Jan. 2017

NEP II - Virtual Power Plant Demonstration Project

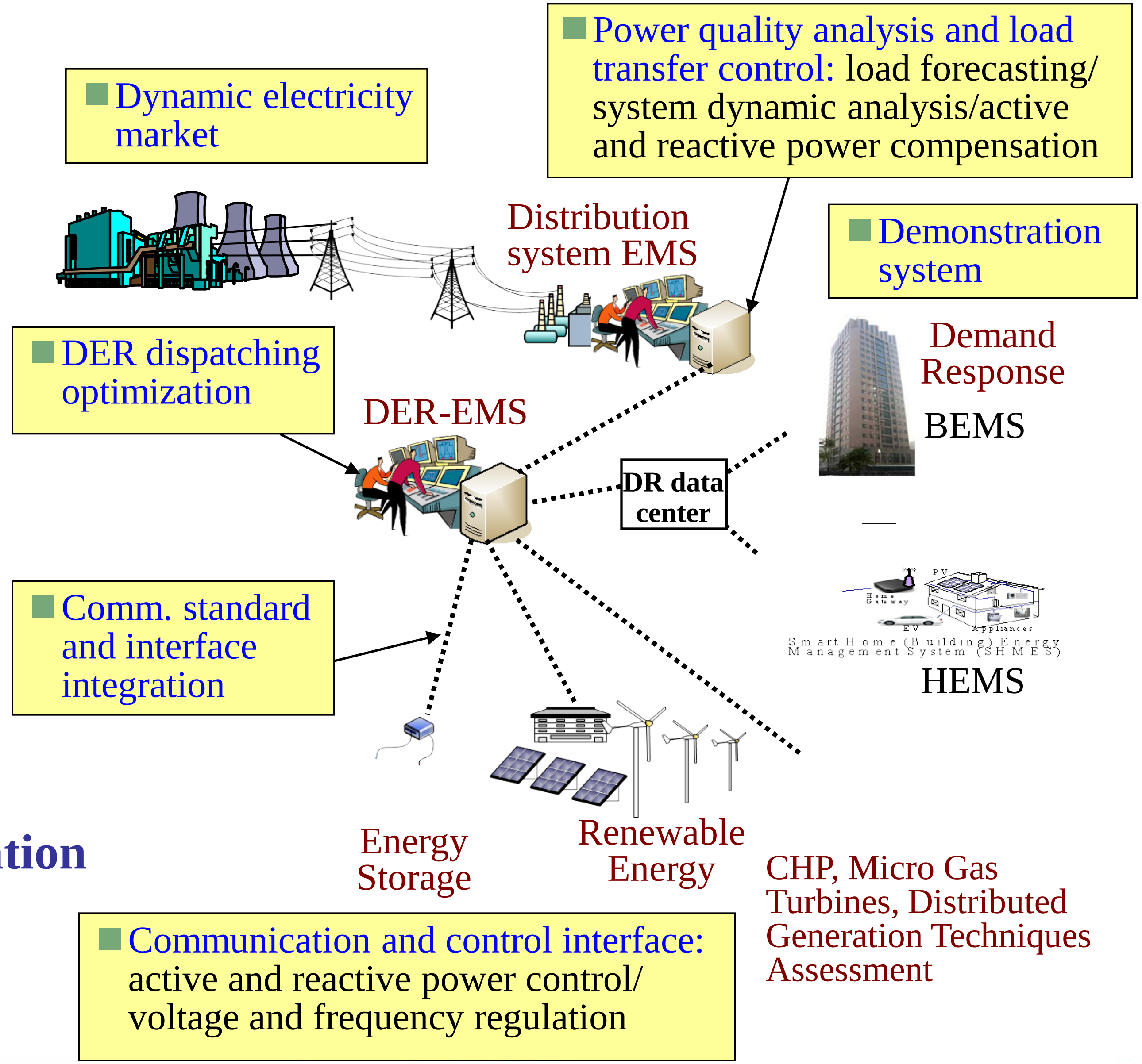
The Structure of VPP Energy Supply Service Technology



Source: Energy National Science and Technology Program－Smart grid and advanced meter reading project NSC 102-3113-P-008-010

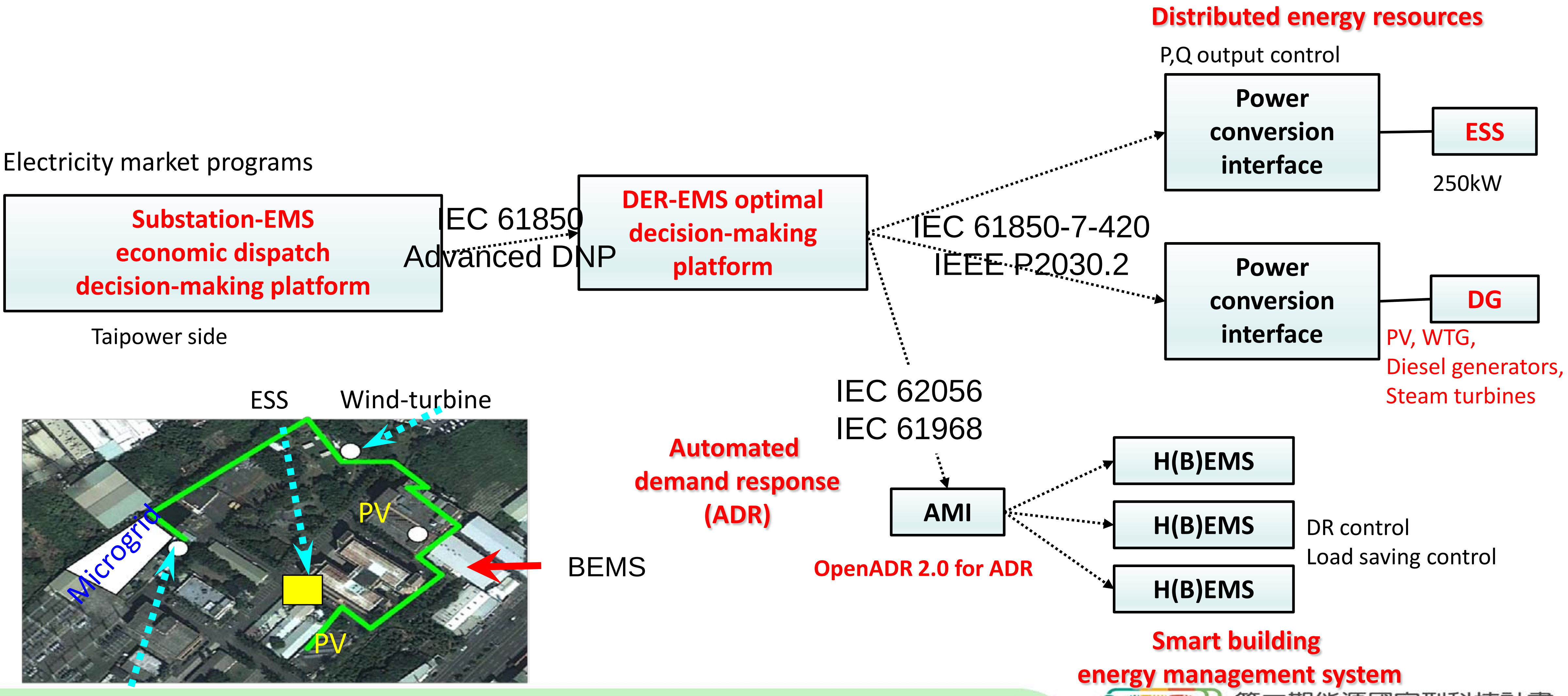
Virtual Power Plant Demonstration Project

- **Dynamic Electricity Market/Ancillary Services Market Mechanisms**
  - Analyze related international VPP and DR experiences, and propose suitable model for Taiwan
- **Comm. Control Interface Standard**
  - Research and development of comm. Interface
  - CAN Bus / DNP3 / IEC 61850
- **Supervisory Control and Data Acquisition (SCADA)**
  - Software and Hardware Developments
  - Human Machine Interface (HMI)
- **DER Energy Management System (DER-EMS)**
  - Forecasting system, optimal EMS algorithms, reactive and real power demand dispatching
- **Comm. and Control Interface of Energy Conversion System**
- **Distribution System Mathematical Model Simulation**
  - Power system and DER models simulation and analysis
- **Testing System Demonstration**
  - Taiwan Power Research Institute
  - BEMS, DER, and DR integration



Taipower Research Institute Test Site

- **To Build DER-EMS System and Technical Verification**



Taipei Residential Policy- New-built Public Housing Project

Taipei's residential policy would like to build 50,000 public residence in 8 years. Public residences will be the permanent assets of Taipei city government, and the government is planning to establish a Taipei real estate company which is responsible for rental, maintenance etc.

- **Shinlong Public Housing, Jiankang Public Housing, Dongming Public Housing and Young-adult Public Housing are currently negotiating with Taipower about AMI implementation.**
- **Public housings are planning PV installation to provide basement and public area lighting. Power charging facilities are reserved for EVs.**

Shinlong Public Housing Area 1

Young-adult Public Housing

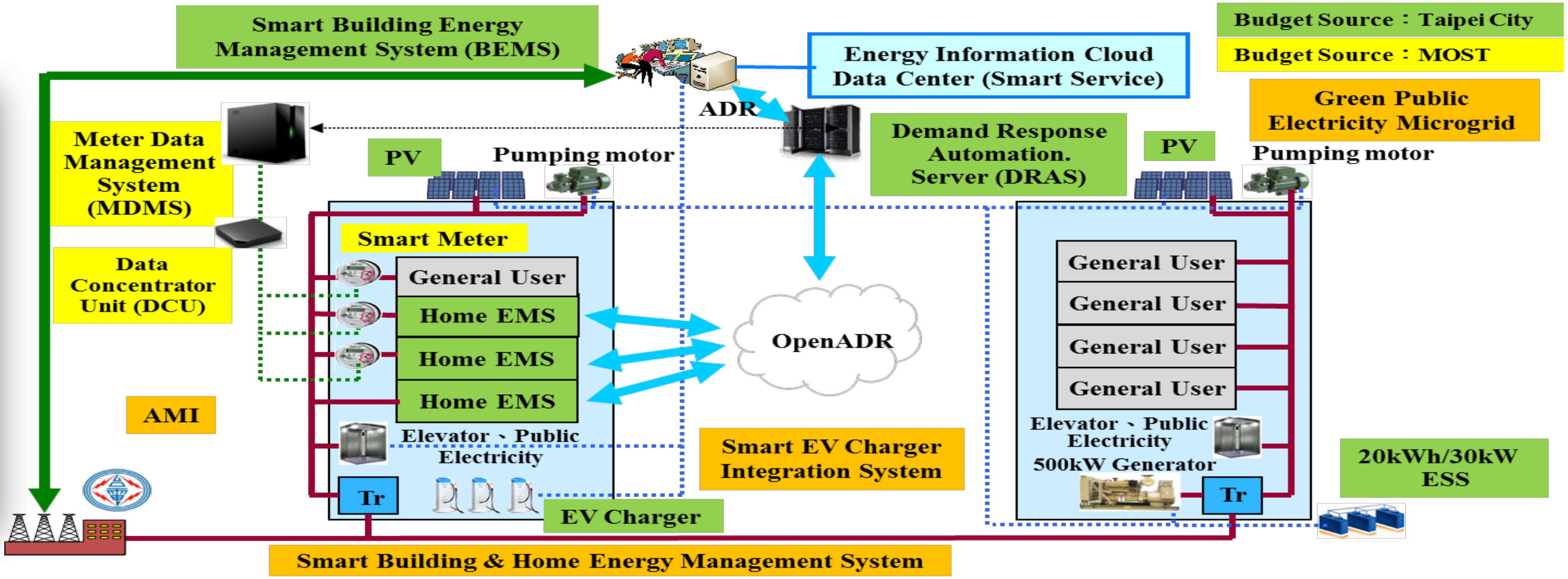
Dongming Public Housing

Jiankang Public Housing Area 1 & 2

Shinlong Public Housing Area 2

Singlong Public Housing 1st Block Smart Grid Phase Zero Project

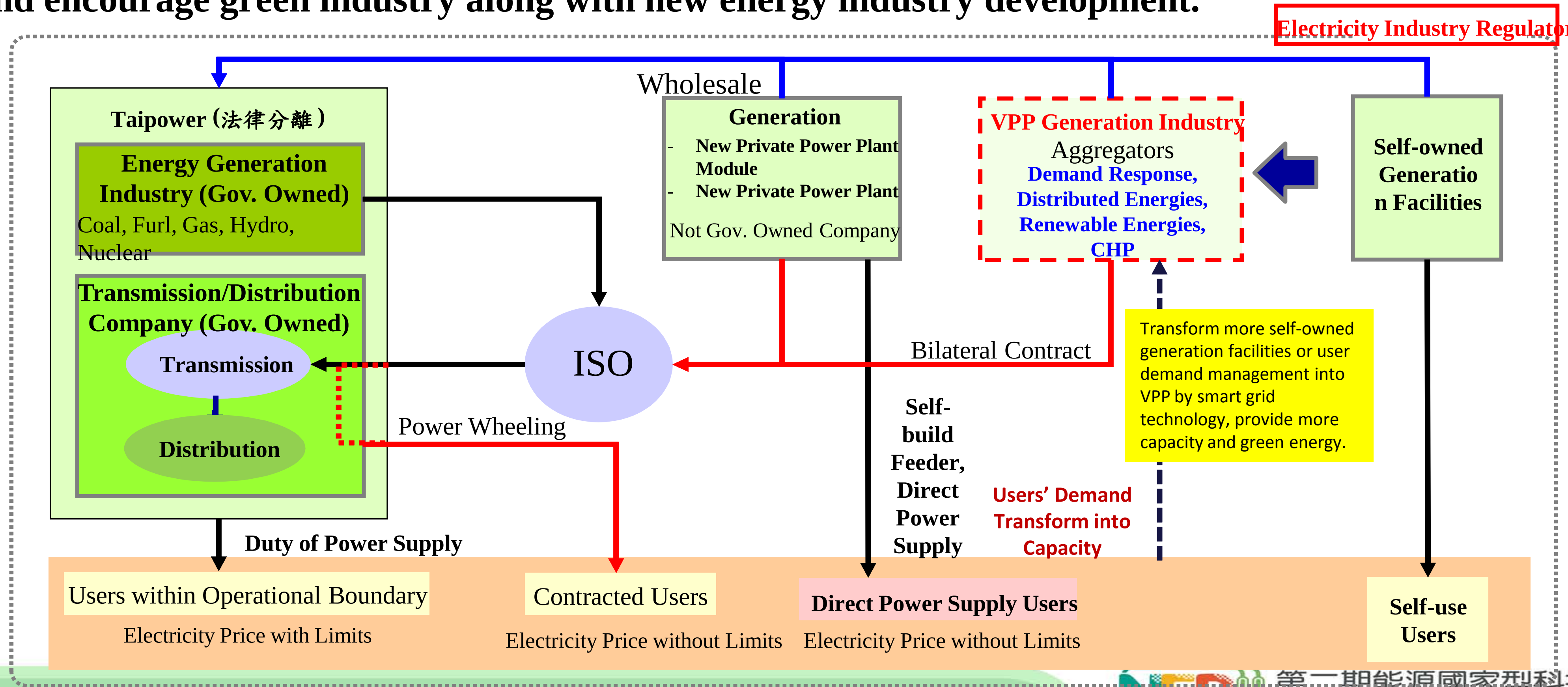
1. **Smart Building/House Energy Management System (B/HEMS)-** Set up monitoring station to integrate the individual HEMS, and be able to reduce energy usage during peak hours through the demand response (DR) program
2. **Green Public Electricity Microgrid –** Install & integrate photovoltaic (PV) system and Energy Storage System (ESS)
3. **Smart EV Charging Integration Management System**
4. **Advanced Metering Infrastructure (AMI)**



Source: Department of Urban Development, Taipei City Government, NCKU, TIER and TaiPower, Suggestions for Smart Grid Promotion in Taipei City - Xing Long ... c Housing, Oct 201...

Connection between Taiwan VPP Promotion and Energy Market

- The concept of VPP enables distributed energies, demand response and others with lower capacity to be part of energy market, despite the limitation of ISO financial model and real facility model.
- The VPP technology coordinating with energy market liberalization attract enterprises to integrate demand response, distributed energies such as solar energy, wind energy, power saving facilities, fuel cells, CHP, etc., to join energy generation industry, make up for the future capacity gap caused by steady decreasing nuclear power usage, and encourage green industry along with new energy industry development.



NEP II - AC Microgrid Demonstration Project

DOE: Definition of a MicroGrid

A group of interconnected loads and distributed energy resources (DER) with clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid and can connect and disconnect from the grid to enable it to operate in both grid connected or island mode.

Typical Microgrid Requirements

- **Grid Connected Capabilities**

– Optimization for Economic Operation

– Support Integration of Renewables

– Support for DER Market Participation

- **Islanding Capabilities**

– Emergency Islanding Support

– Managing Critical/Non-Critical Loads to Available Generation

– Island Operations with High Penetrations of Renewables

– Optimized Island Operation for Longevity (Fuel, Maximizing REs)

- **Secure Operations**

– Cyber Secure Communications Network

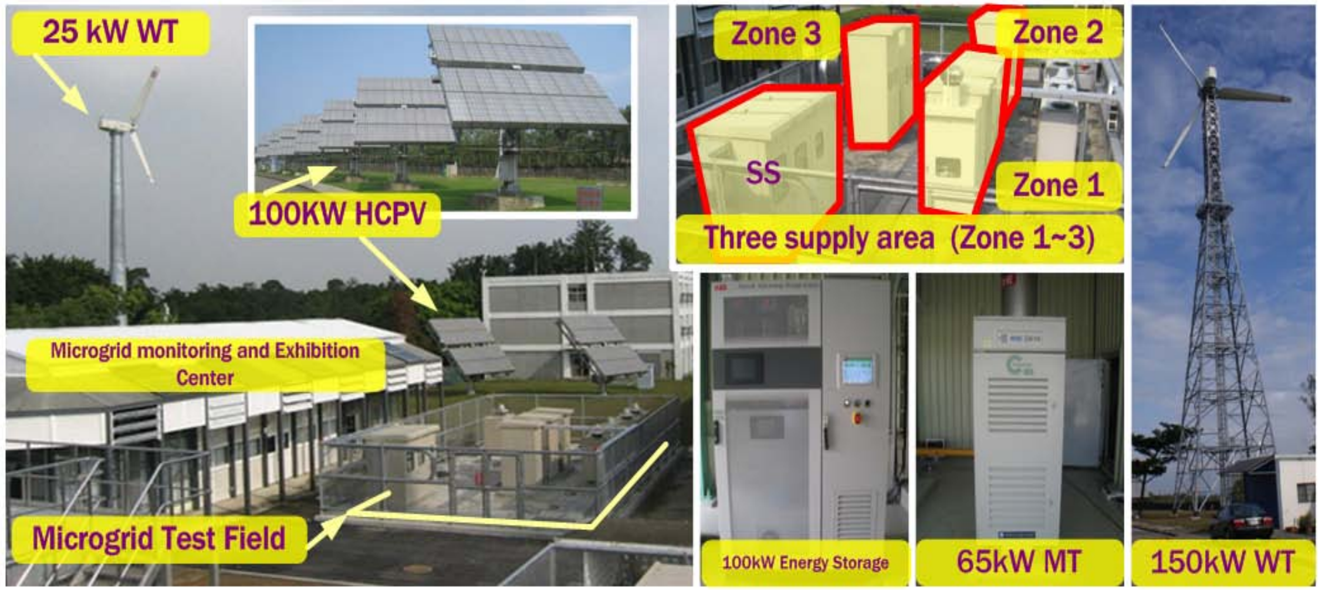
– Distributed and Resilient Architecture

Institute of Nuclear Energy Research Microgrid

- The establishment of an autonomously-controlled microgrid demonstration system, and completion of seamless, stable switching of microgrid between grid-connected and islanding operating modes.

  - INER are developing Microgrid & EV Integration Technology

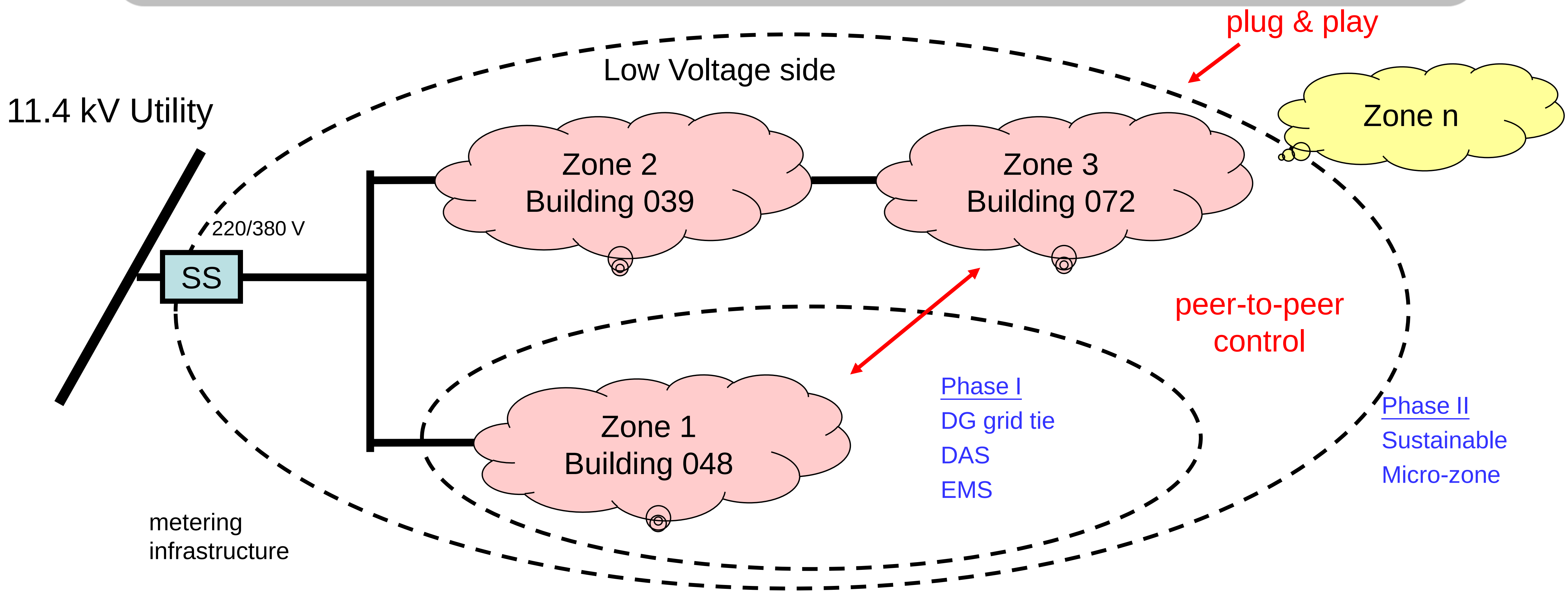
1. Reduce EV charging grid connection impact;
2. Improve the renewable energy usage efficiency
3. Vehicle to Grid (V2G) for Load Shifting



Source: Institute of Nuclear Energy Research for 21st APEC Automotive Dialogue

Target: Developing power control and management technology for low voltage side of microgrid with three zones in which 20% of total energy comes from renewable energy.

Microgrid EMS can be used to perform seamless transition control between grid connected and stand alone operation successfully.



470 kW Microgrid Test Field

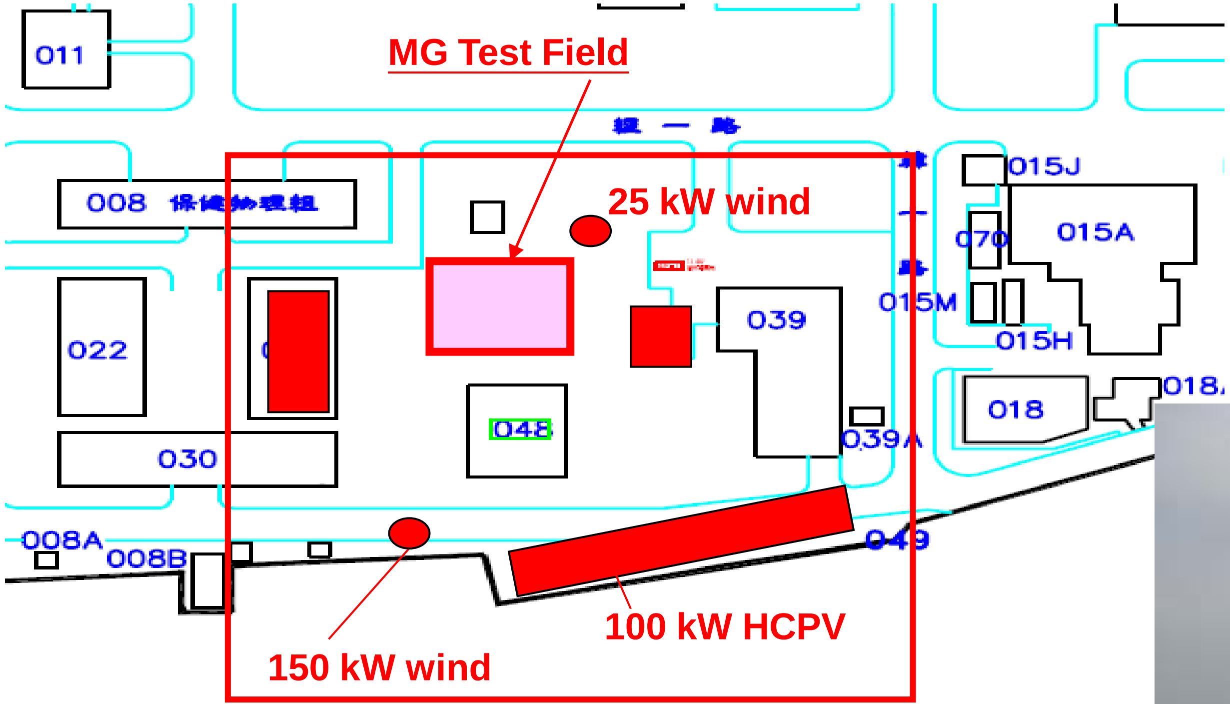
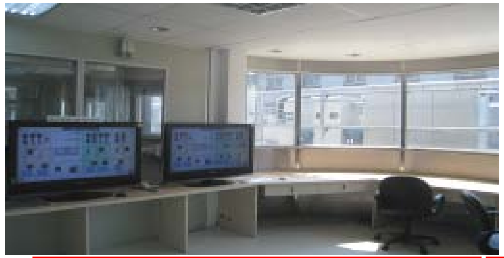


Photo Direction

100 kW HCPV

150 kW wind



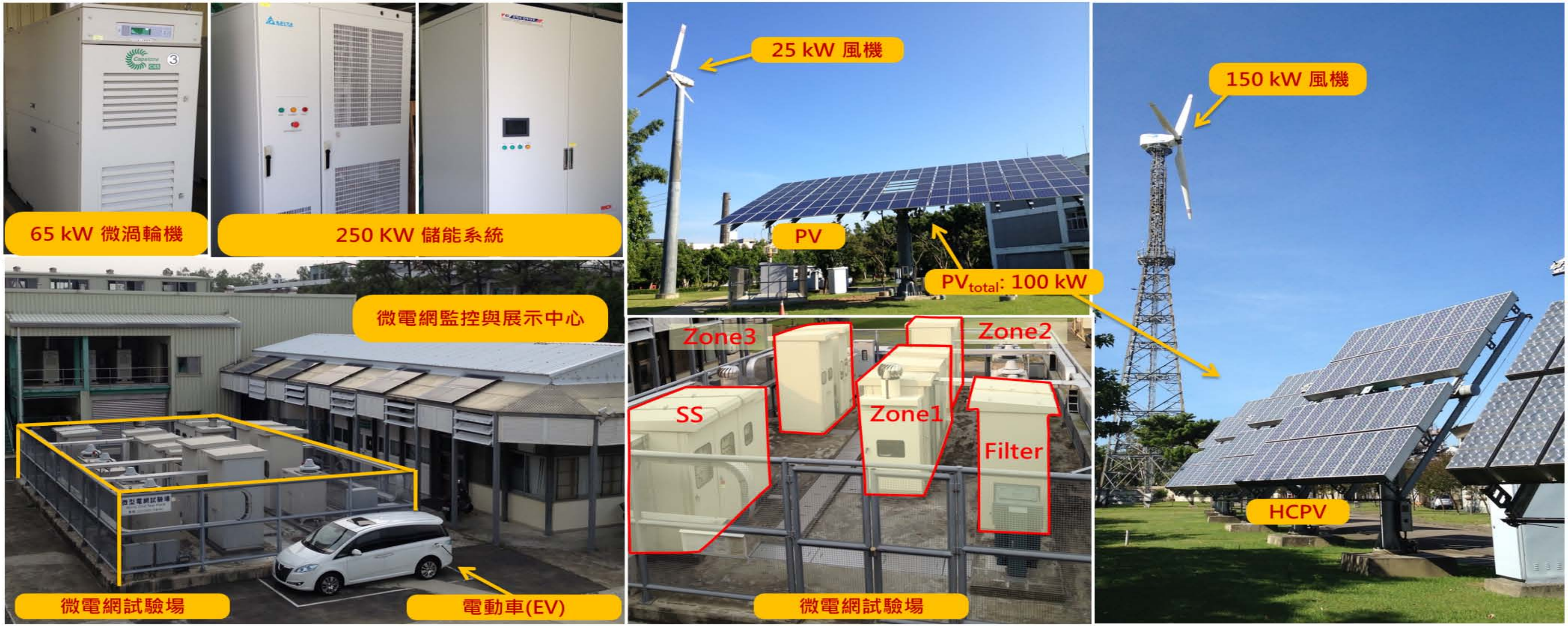
Control Room

250 kW ES

65 kW x3 MT

MG Test Field

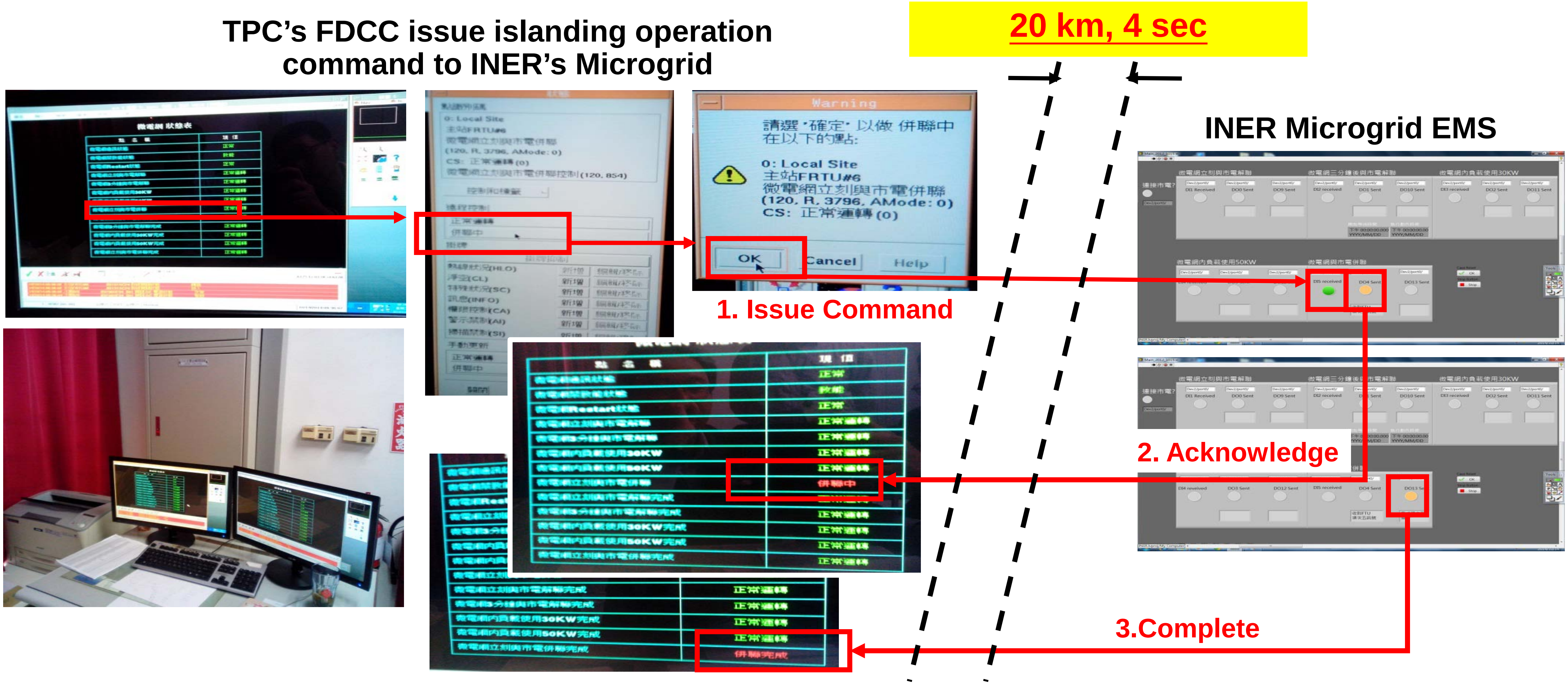
470 kW Microgrid Test Field



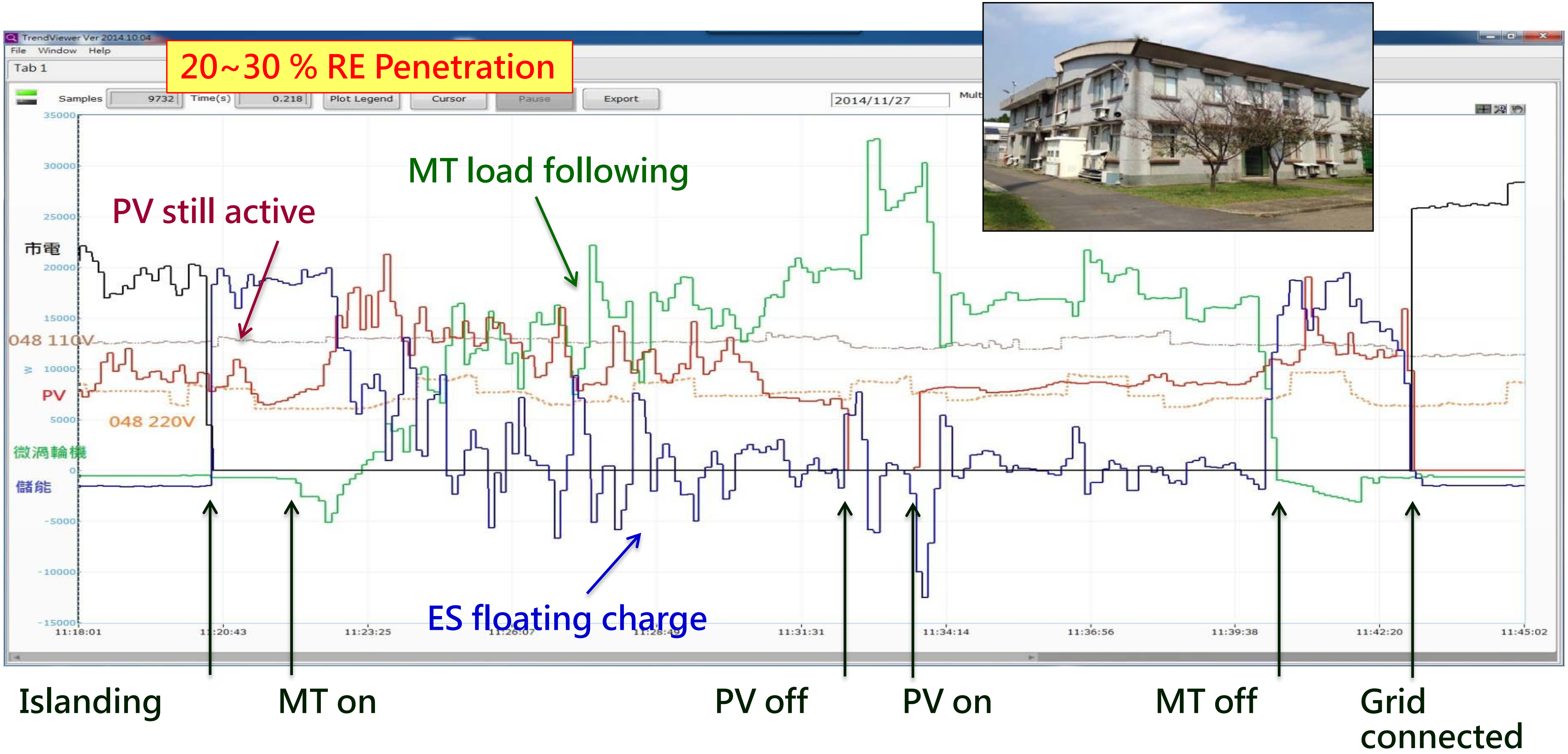

TPC Distribution Feeder
Point of Common Coupling (PCC)
Microgrid Test Field
魚池
Overhead Line (700 m)
Underground Line (35m)

Power Dispatching by TPC

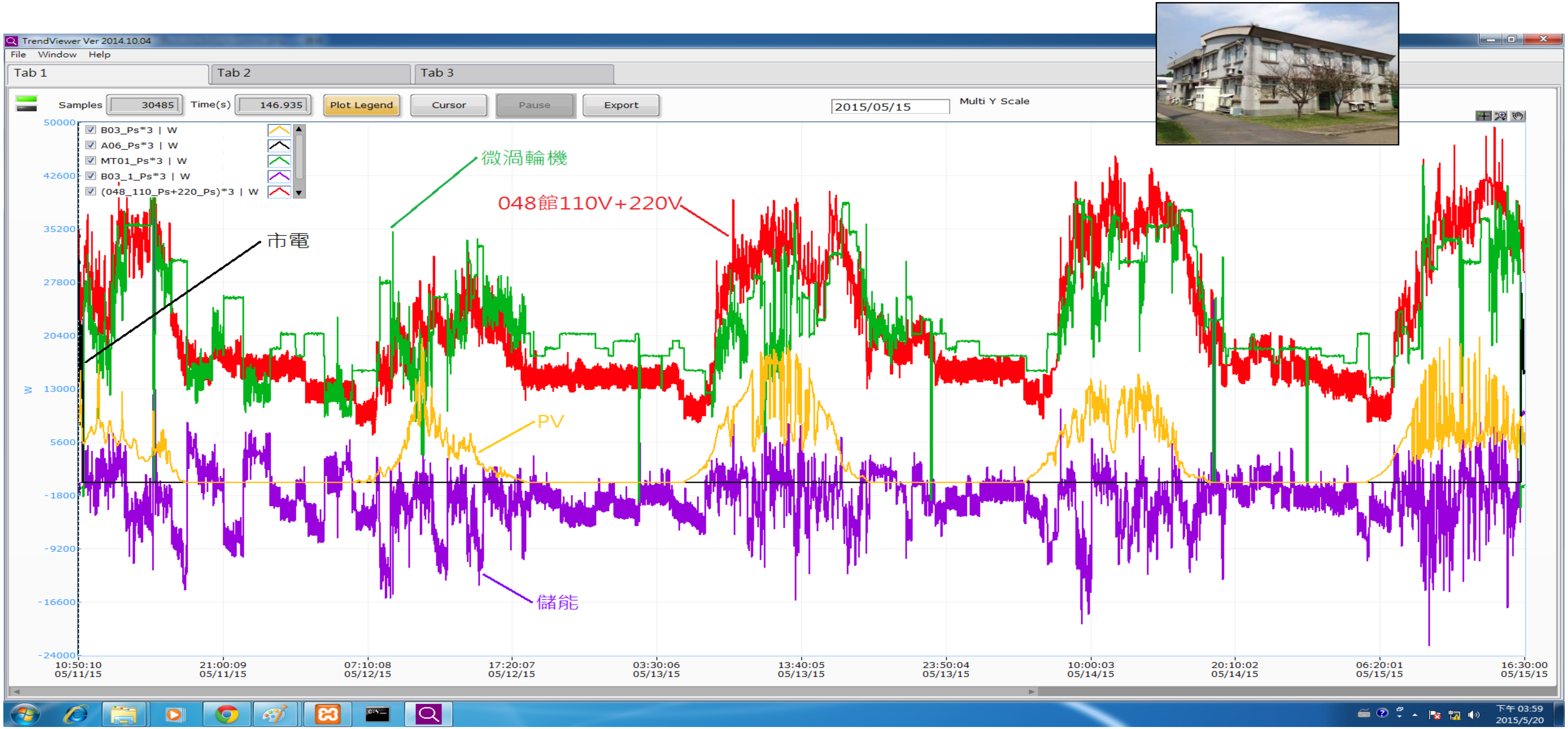
TPC's FDCC issue islanding operation command to INER's Microgrid



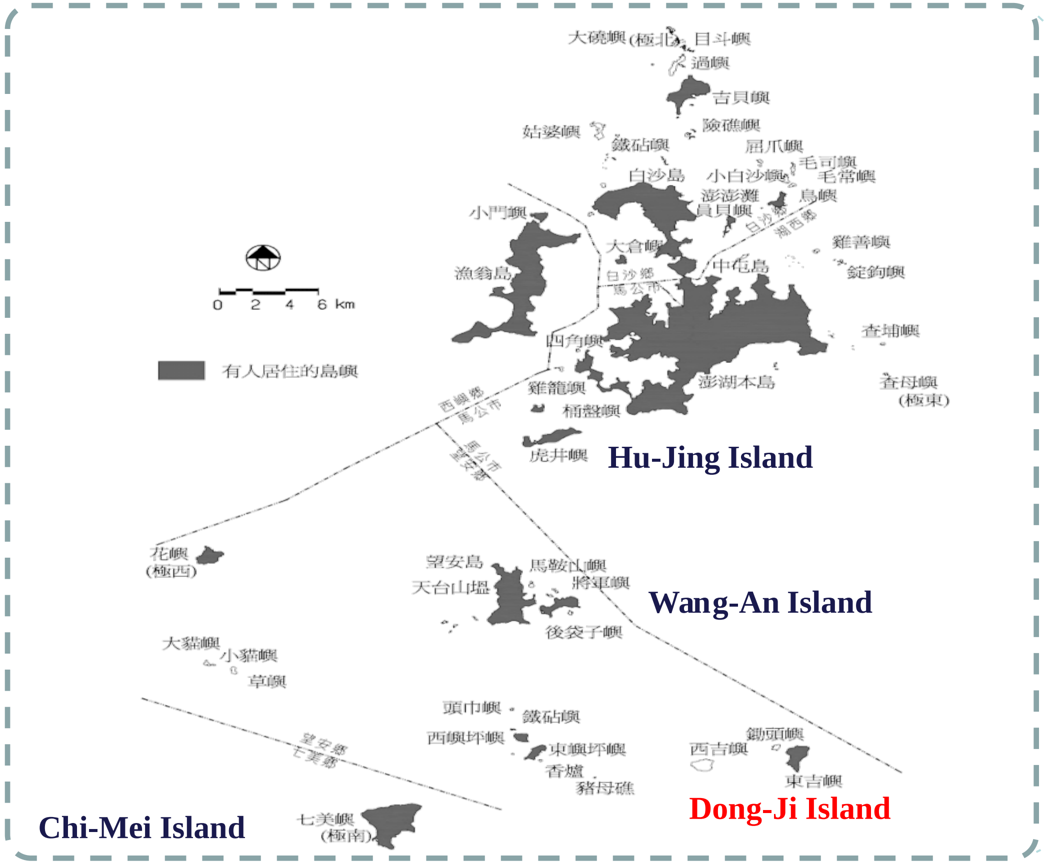
Islanding Operation on Building



100 hrs Islanding Operation



Taiwan’s Remote Islands



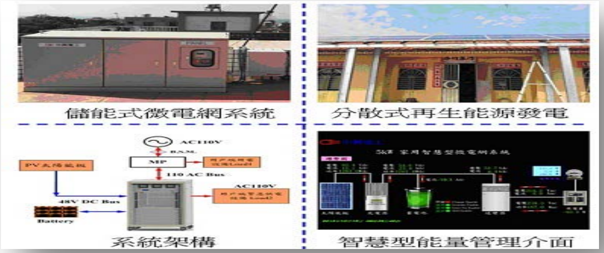
Demonstration of Microgrid Remote Islands

- Microgrid could be divided into two modes, grid-connected and stand-along. In Taiwan, stand-along microgrid is applied to remote islands, for example, Tai-Ping Island, Dong-Keng Community, Kinmen County, and Dong-Ji Island,Penghu County. Grid-connected microgrid is otherwise applied mainly in urban and rural areas, for example, the public housing in Taipei City and Siaolin Village No.2, respectively.
- The function of microgids in remote islands are to increase the penetration of renewable energy and lower cost of power supply.

Microgrid in Tai-Ping Island

With a 40 kWp solar PV system and a 612 kWh energy storage system, the microgrid in Taiping Island could be integrated with the existing 120 kWp solar PV system and 4 diesel generators. It is estimated that the microgrid could generate around 190 thousands kWh per year.

Smart Energy Storage System in Dongkeng Community



With 45.9 kWp solar PV system, 3 kW wind turbine, 5 kW fuel cell, and 140 kWh secondary battery energy storage system, Smart Energy Storage System in Dongkeng Community could generate 200 kWh per day, and provide to 16 households. This is a demonstration site of how to stabilize the power supply in communities by using renewable energy, energy storage system, and load management.

Microgrid in Dong-Ji Island,Penghu County

Dong-Ji Island has existing diesel generatior, solar PV system, and energy storage system, but was unable to be connected together. It is expected to connect these equipment using the microgrid and energy management system, and to enhance the quality and stability of power supply in Dongji Island.

Source: Tatung Company, National Chung-Shan Institute of Science and Technology, Chung Hsin Electric & Machinery Mfg. Corp. Ltd., organized by TIER

Demonstration of Microgrid - Rural and Urban Areas

- Grid connected microgrids are applied to rural and urban areas, we already have related demonstration sites such as Guangtsai Wetland in Pingtung County, Siaolin Village No.2 in Kaohsiung City, and Public Housing in Taipei City.
- While in main island of Taiwan, the function of microgrids is to provide backup power when in emergency.

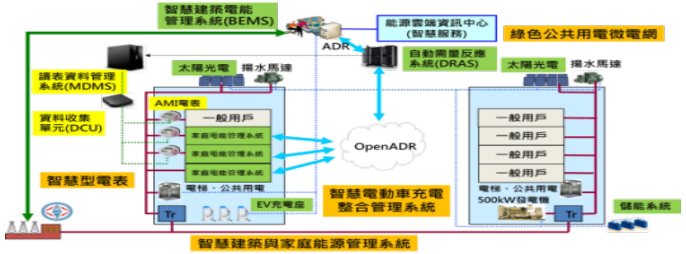
Microgrid in Guangtsai Wetland, Pingtung County

The power supply in Guangtsai Wetland is based on renewable energy, mainly from 78 kW solar PV and 10 kW wind power generation system, along with energy storage system and modern smart energy management system. By using these systems, it is expected to achieve real-time management of power supply and demand, and 100% of self-sufficicncy in power supply.

Smart Energy Storage System in Siaolin Village No.2, Kaohsiung City

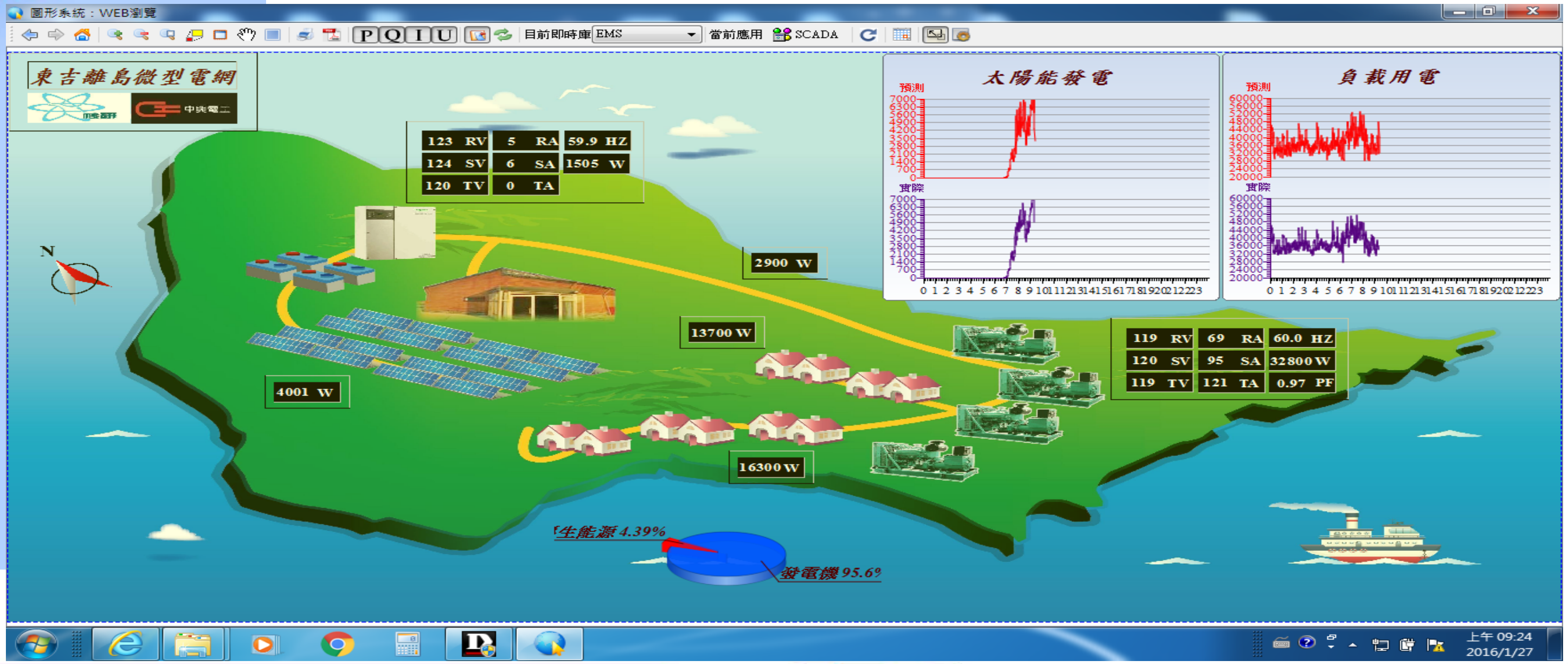
NCSISI has established a Smart Energy Storage System in Siaolin Village No.2, Kaohsiung City in April, 2016. It is expected to promote the system in remote mountains, and further, to overseas.

Green Microgrid for Public Electric Facilities in Taipei City



The concept of this microgrid is to integrate solar PV system, diesel generator, and energy storage system into a mix power supply system. When in emergency, the building could maintain its power supply by activating the energy storage system and diesel generator, therefore increasing the stability of power supply in it. Other than that, the microgrid could also soothing congestion problem by dispatching power supply to nearby loads.

Microgrid on Dongji Island



Microgrid on Dongji Island

Goals

- Increase the electricity generation of renewable energy.
- Reduce electricity generation from fuels.
- Enhance the power supply quality on offshore islands.
- Pave the way for zero-carbon electricity generation.

Method

- Implementation of Microgrid Power Management Systems on Offshore Island.

Functions

- Power generation forecasts
- Load forecasts
- Remote monitoring
- Energy distribution
- Demand control
- Unbalanced three-phase power control

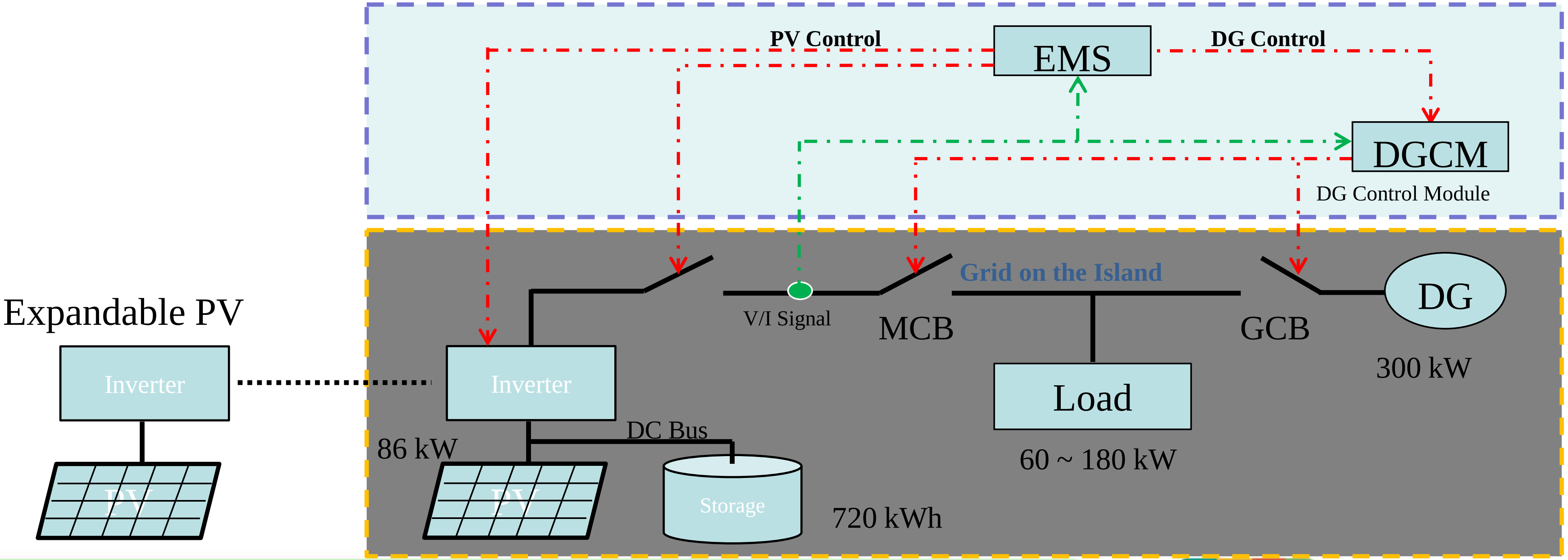
Microgrid on Dongji Island

Achieves the coordinated control of PV and DG：

➢ PV serves as the primary power supply, while DG as the secondary power supply. The target is to generate electricity without fuels.

➢ Achieves the coordinated control of PV and DG to improve the stability of power supply on offshore islands.

➢ Increase Penghu's popularity by establishing international case of offshore island which the power generation is mainly supplied by renewable energy.

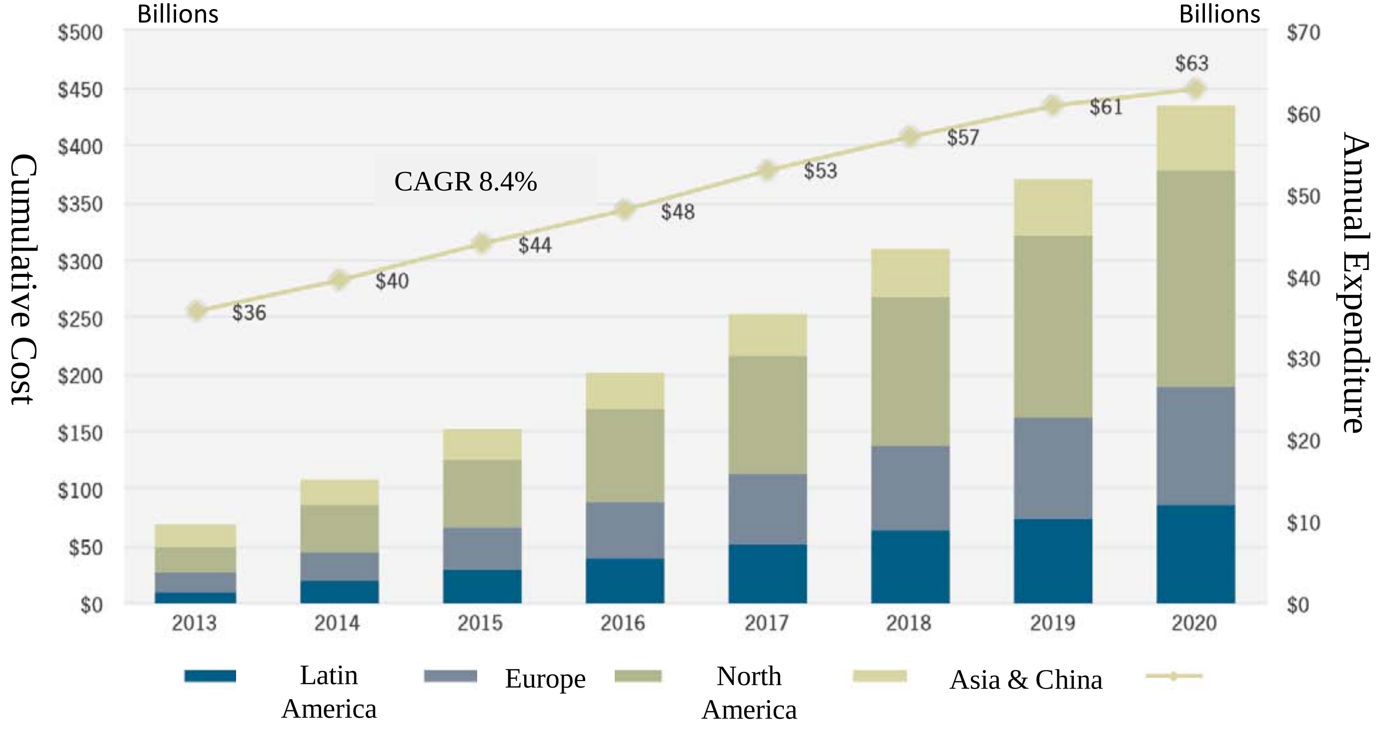


Development of Smart Grid Industry in Taiwan

Global Development of Smart Grid Market

The construction development of smart grid around the world has begun, and the output value of smart grid global market will continue to grow sustainably.

- **Whether grid update projects of developed countries or grid infrastructure installation of developing countries, all will continue over 20 years or more.**
- **According to the analysis done by international research institute GMT, the total output value of smart grid global market will generate over $400 billion with 8% of compound average growth rate (CAGR). It can be expected that the output value of smart grid global market will continue to grow sustainably in the future.**

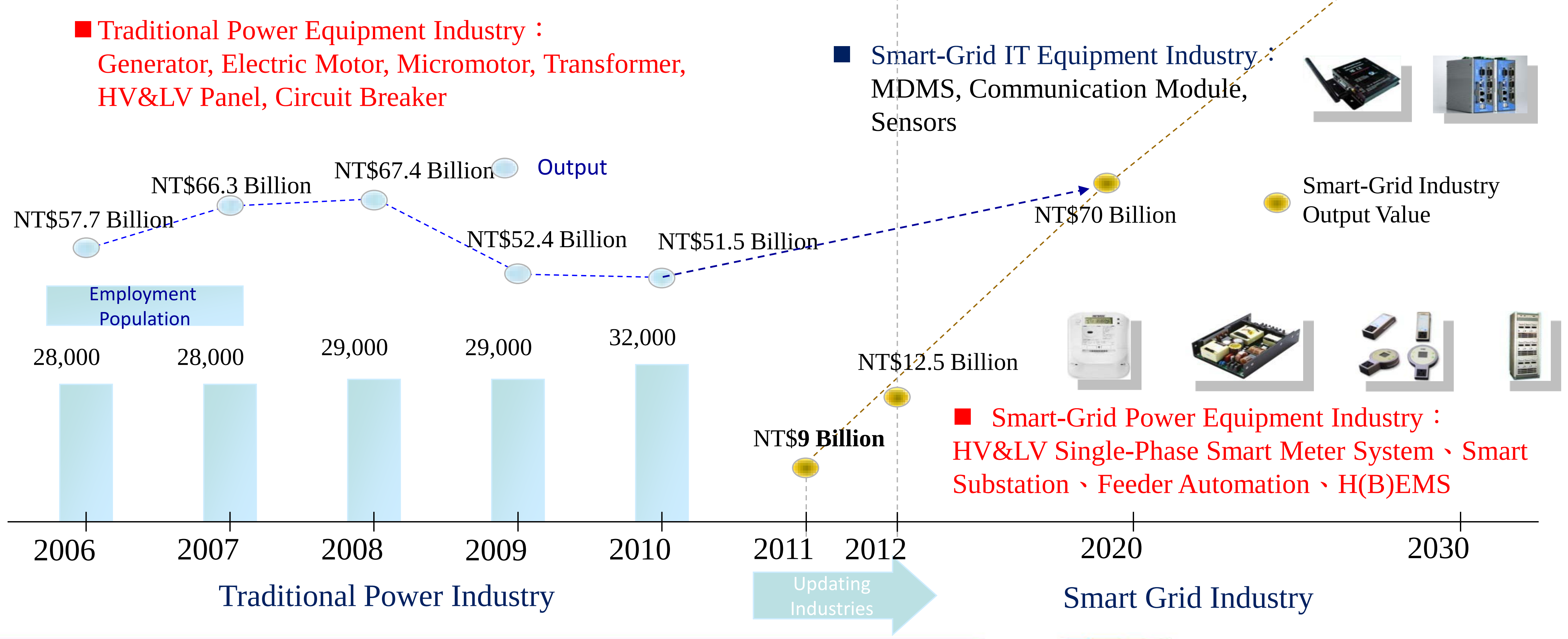


Source：2013 ~ 2020 over output value of smart grid (Source：GTM 2013)

TGIA 台灣智慧型電網產業協會 Taiwan Smart Grid Industry Association

Vision of Smart Grid Industry in Taiwan

With power, electrical electronics & IT industries' power combined, the output value of Smart-Grid Industry in Taiwan is estimated to reach NT$70 Billion in 2020, and NT$170 Billion in 2030.



Structure of Taiwan Smart Grid Industry Association

Taiwan Smart Grid Industry Association（TSGIA）was officially established in September 2009 for the purpose of facilitating the development of the smart grid industry in Taiwan

General Assembly
(President、Vice-President)

Secretariat TIER

AMI
- TATUNG (Director)
- DELTA (Co-Director)

Intelligent Transmission & Distribution
- AEC (Director)
- MOXA (Co-Director)

Smart Home
- TATUNG (Director)
- CHT (Co-Director)

Micro Grid
- CHEM (Director)
- INER (Co-Director
- CSIST (Co-Director)

Standard & Regulation
- III (Director)

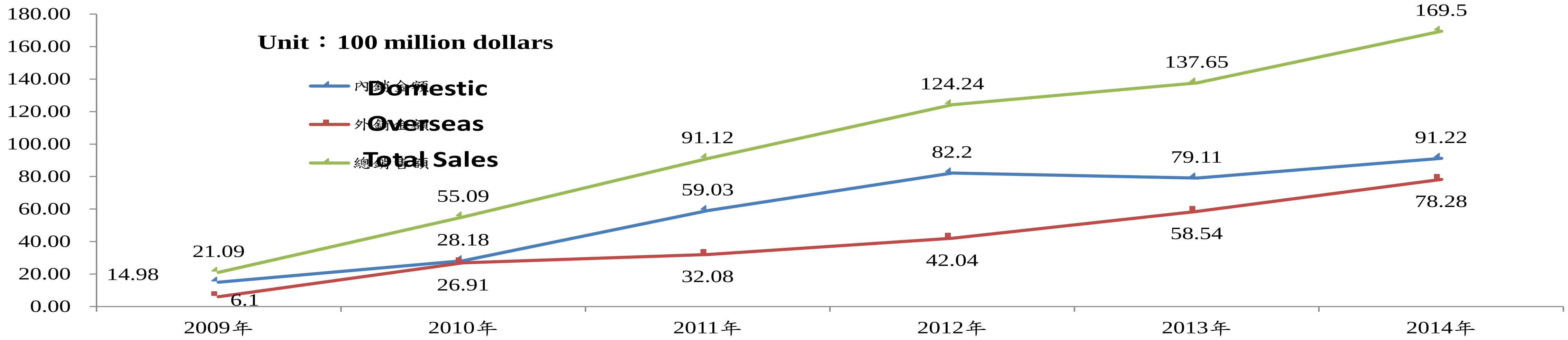
Market & Industry
- TIER (Director)
- III (Co-Director)
- ITRI (Co-Director)

Energy ICT
- ITRI (Co-Director)
- CHT (Co-Director)
- MOXA (Co-Director)

Energy Storage
- CSIST (Co-Director)
- CHEM (Director)

Results of Smart Grid Industry Survey in Taiwan

According to the surveys that were conducted in 2012 and 2014, the result shows that the total sales of Smart Grid related products continue to grow steadily and have a Compound Annual Growth Rate (CAGR) of 51.71%. 2012 , 2013 domestic sales growth lower than expected , mainly due to Taipower's reduce or postpone of investment in transmission and distribution sector, companies more actively developing overseas markets. Overall, nearly six years, domestic and foreign markets showing stable growth trend.



	Domestic	Overseas	Total Sales	Domestic	Overseas	Growth Rate	CAGR
2009	$14.98	$6.10	71.07%	28.93%	$21.09	-	51.71%
2010	$28.18	$26.91	51.15%	48.85%	$55.09	161.25%	
2011	$59.03	$32.08	64.79%	35.21%	$91.12	65.41%	
2012	$82.20	$42.04	66.16%	33.84%	$124.24	36.36%	
2013	$79.11	$58.54	57.47%	42.53%	$137.65	10.79%	
2014	$91.22	$78.28	53.82%	46.18%	$169.5	23.14%	

Thank You for Your Listening!