# Build the Green Grid

## Development of Smart Grid in Taiwan - 2015

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Chair Professor, Dept. E. E., National Central University, Taiwan

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

Dec. 7, 2015

# 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, Virtual Power Plant Demonstration Project and AC Microgrid Demonstration Site
- 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 |

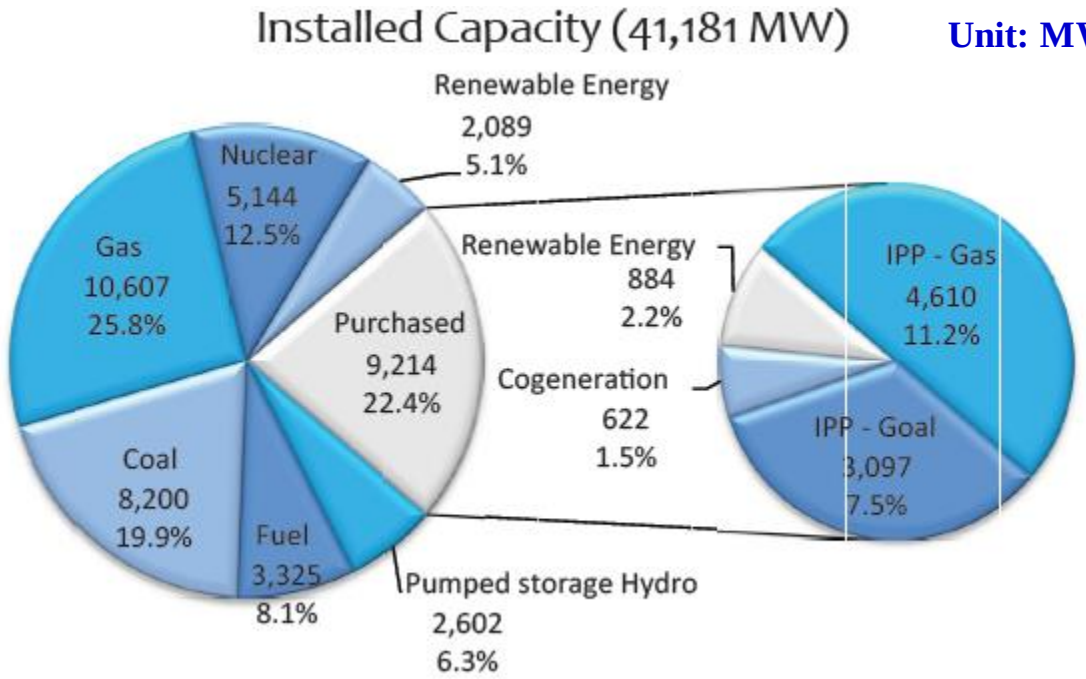
| | ckt-km |
|---|---|
| Transmission Lines | 17,054 |
| Distribution Lines | 351,474 |

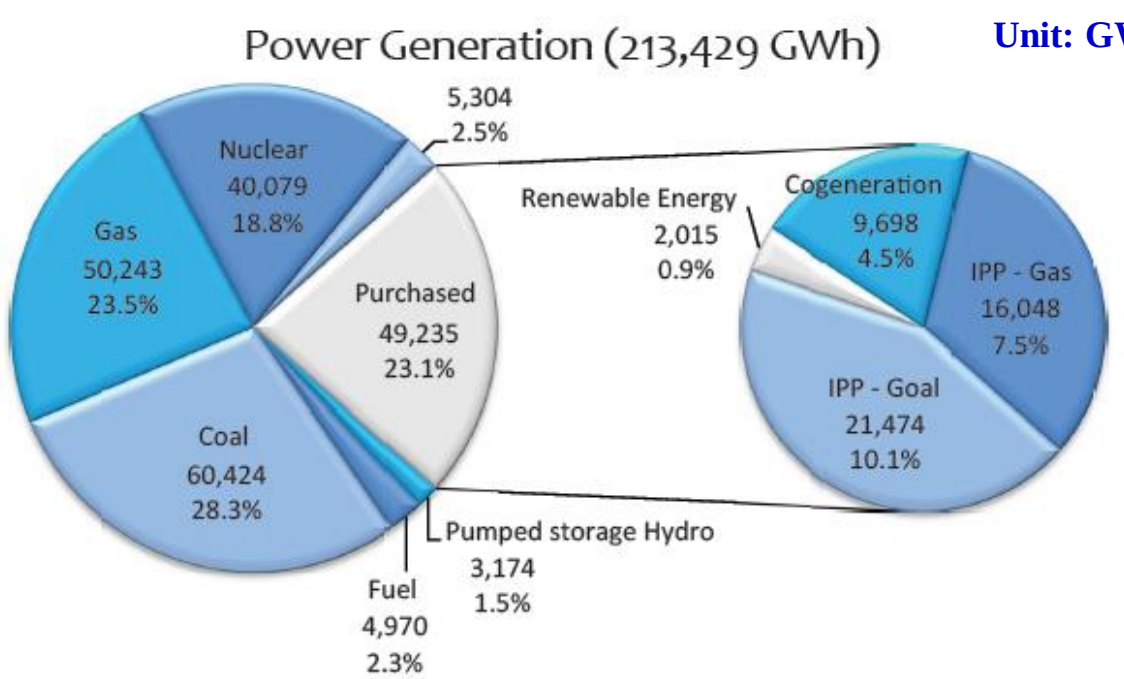
Reference： Taipower www.taipower.com.tw

# Power System in Taiwan

## Taiwan Power Profile

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

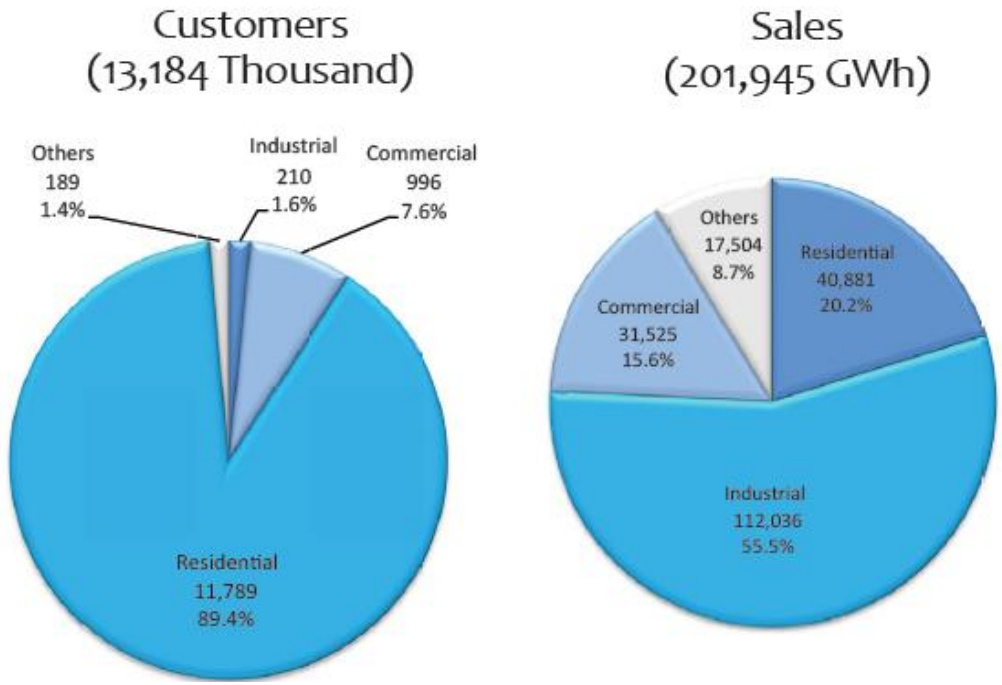



Peak Load in Year **2014**: **34,821MW**

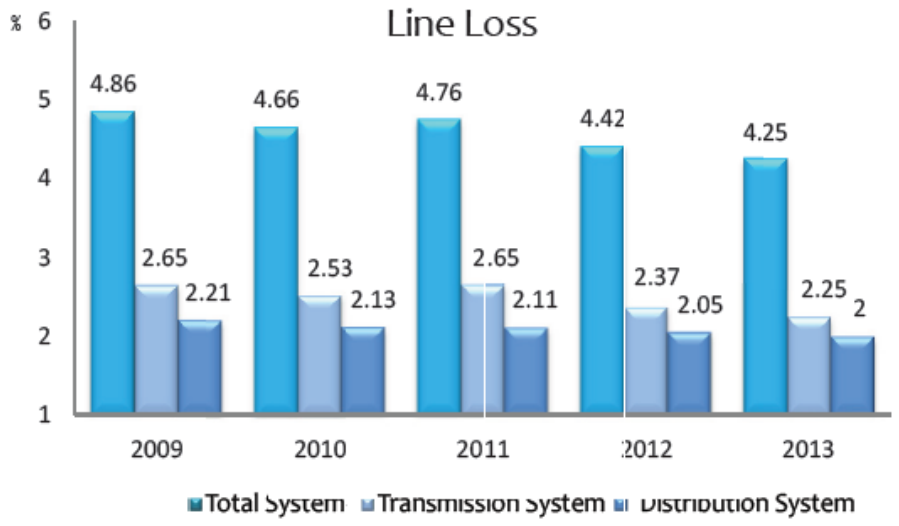
Reference： Taipower www.taipower.com.tw

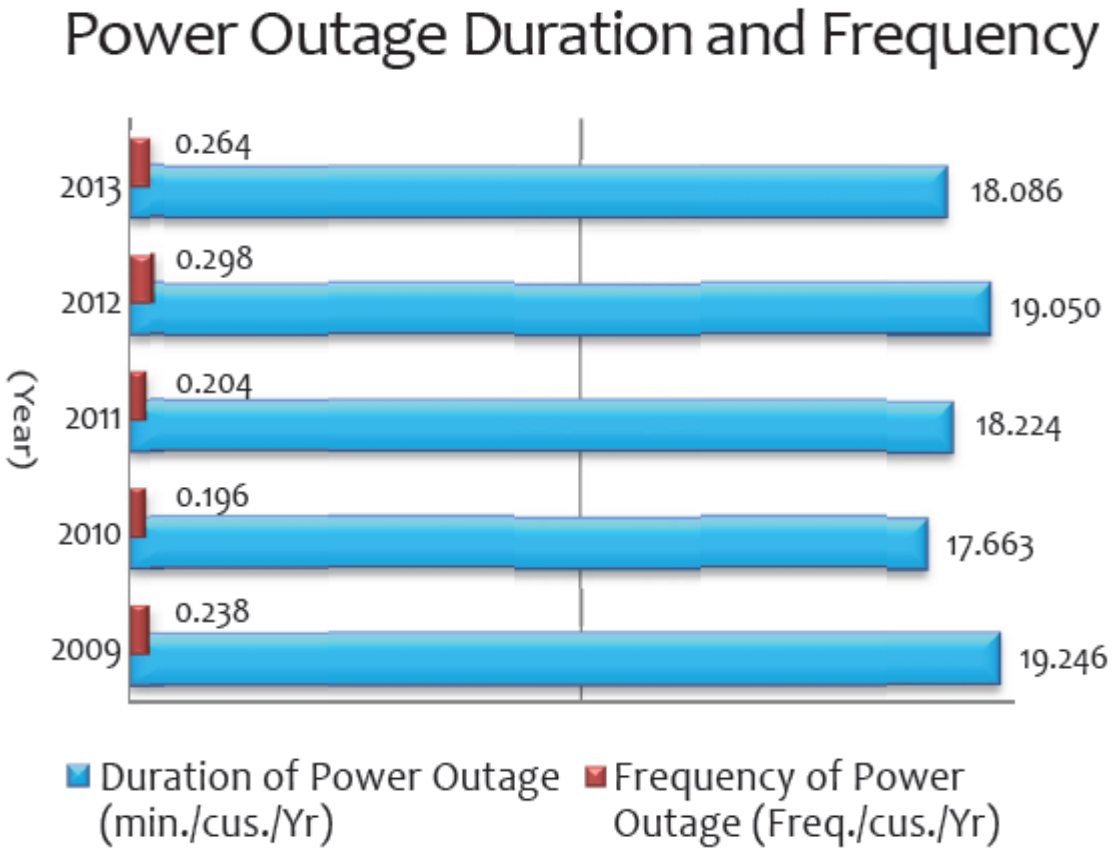
# User Profile of Taipower in 2013









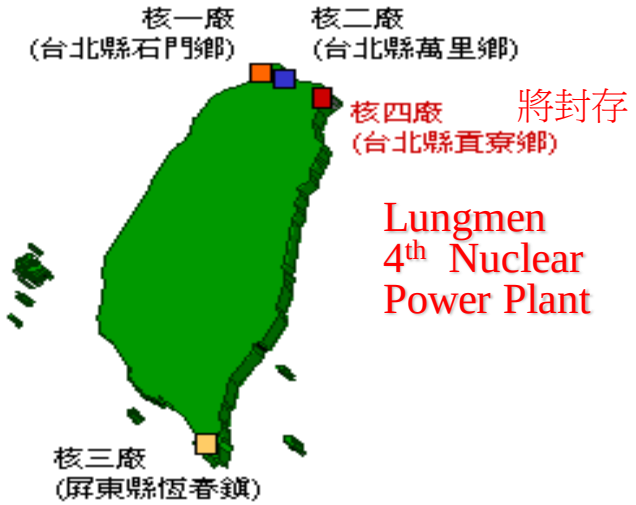
# Nuclear Power Plants in Taiwan

## ■ 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? |

Jinshan
1st Nuclear Power Plant

Kuosheng
2nd Nuclear Power Plant



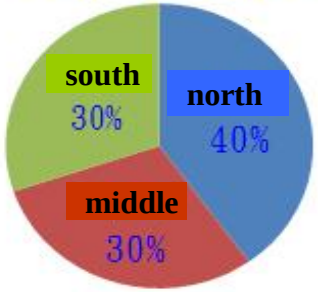

Lungmen
4th Nuclear Power Plant

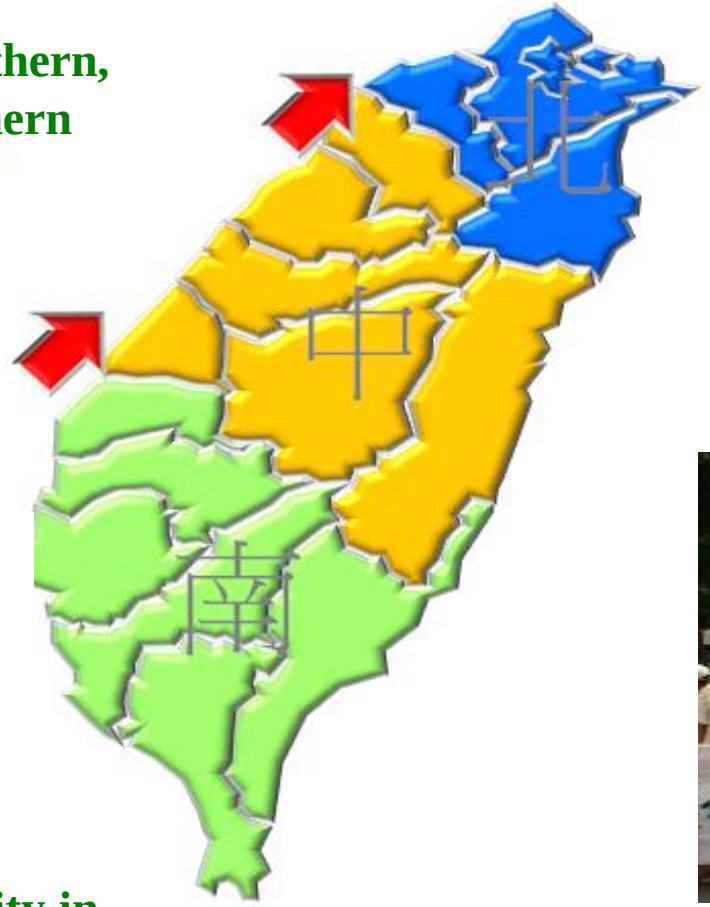
Maanshan
3rd Nuclear Power Plant

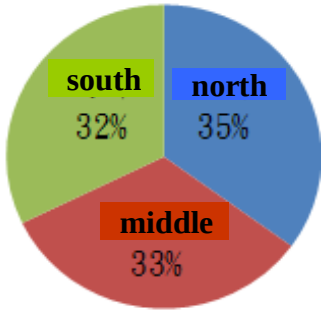
# Regional Power Congestion

## 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


# 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**

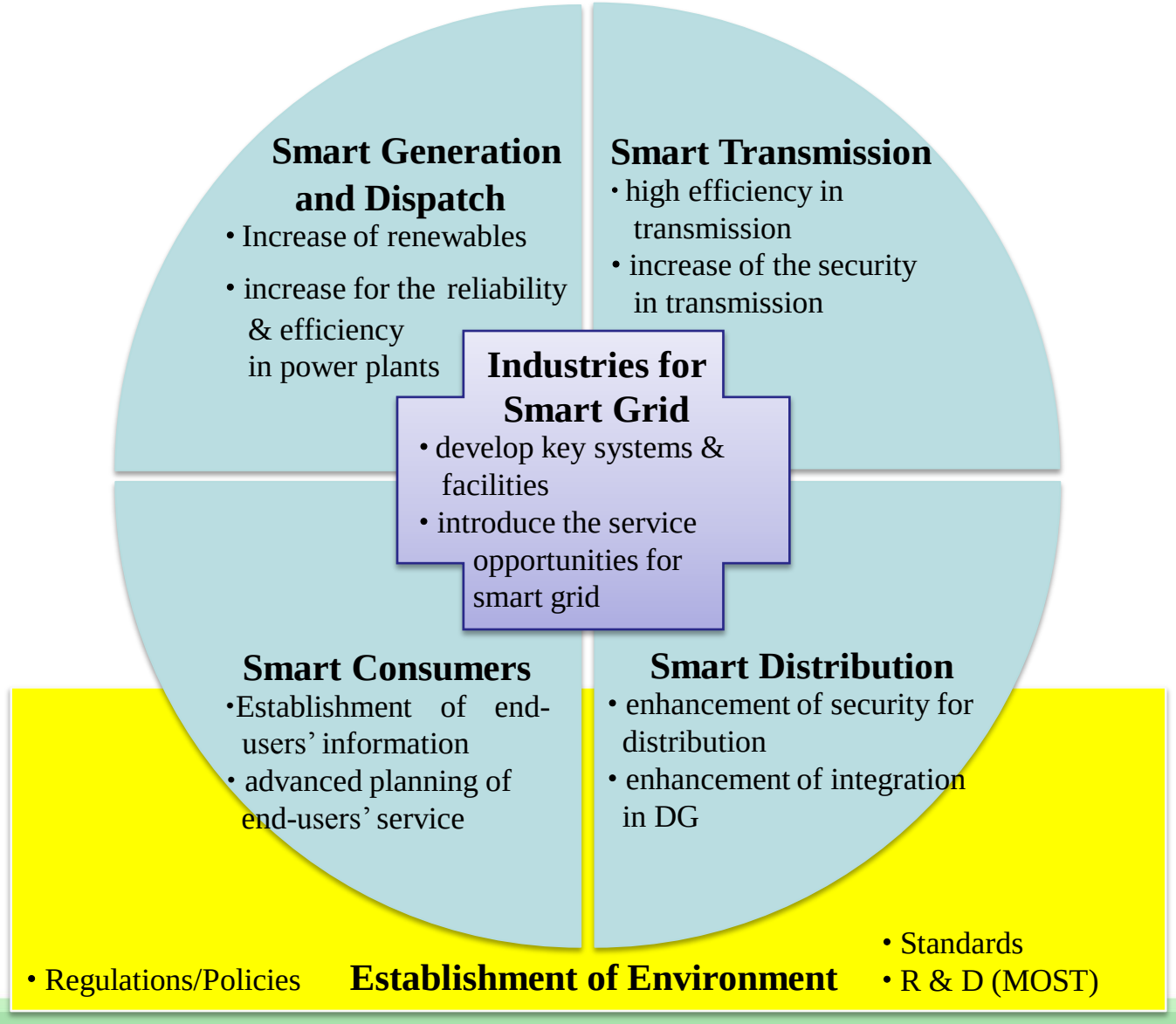
   a) LNG total installation capacity is expected to reach 26,532 MW (accounting for 40% of total capacity of power installations) by 2030.

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 17.25 GW (accounting for 20% of total power installations) by **2030**.

# 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) | 16% (8.3GW) | 26% (17.25GW) |
| Carbon Reduction | Carbon Oxide reduction | (CO2 emission: 276 million tons) | 35.99 million tons | 114.71 million tons |

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

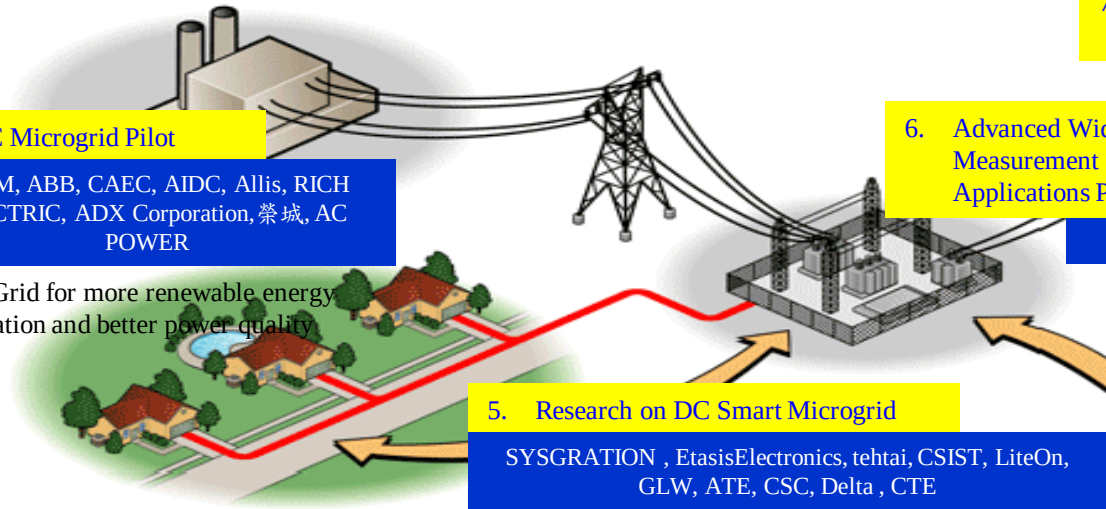
# National Energy Program-Phase I: Smart Grid General Project

**Pilot Projects and Preliminary Collaborating Firms**

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



5. Research on DC Smart Microgrid

SYSGRATION , EtasisElectronics, tehtai, CSIST, LiteOn, GLW, ATE, CSC, Delta , CTE

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

ADX, TATUNG

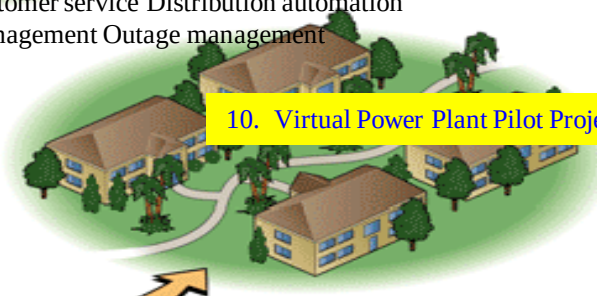
7. Transmission System Power Quality Monitoring and Control Technology Development and Applications Pilot Project

ADX, APPA, TAYA, INER

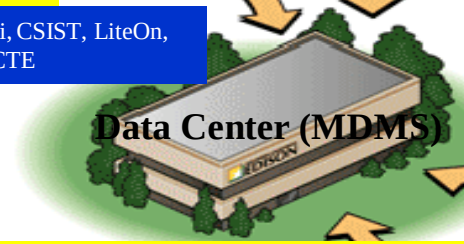
3. Advanced DAS Pilot Project

Hsiang Cheng, Connet, Allis, Ximple

Billing/Customer service Distribution automation
Energy Management Outage management

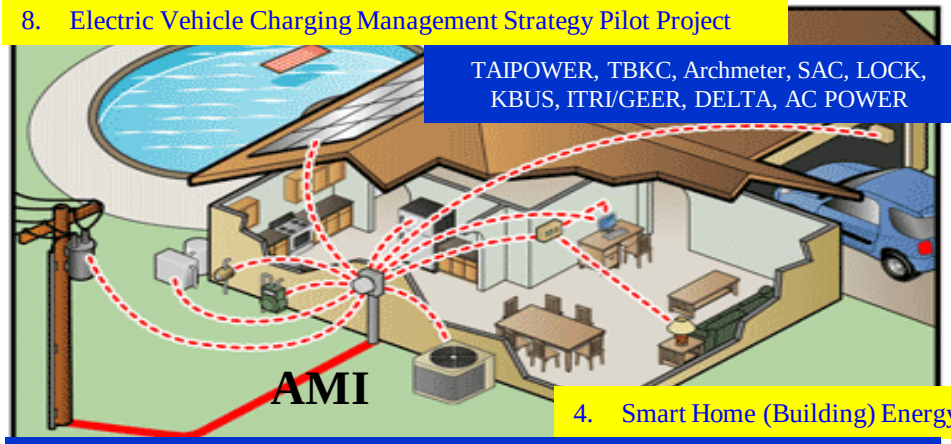


10. Virtual Power Plant Pilot Project




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

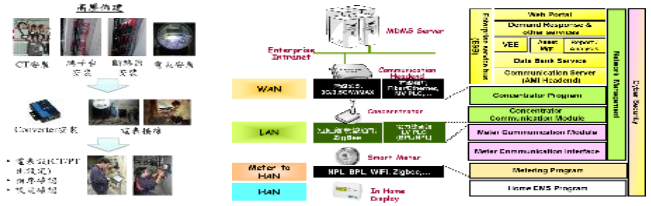
9. Smart Grid And AMI Standard Establishment

CHEM, CHT, DELTA

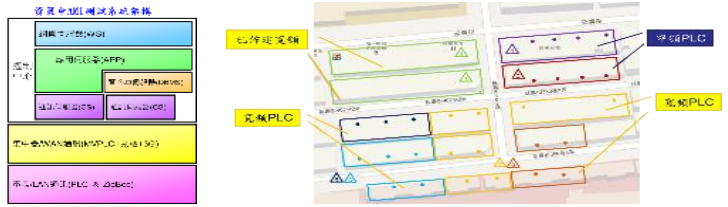
11. Smart Grid Demo Site in Penghu

# Smart Grid Demo Sites in Taiwan-1

## There are currently 18 Smart Grid Demonstration Sites in Taiwan.

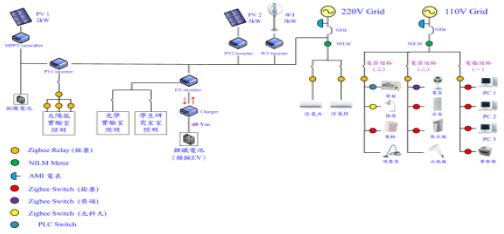


Smart Meter Reading & Demand Response System

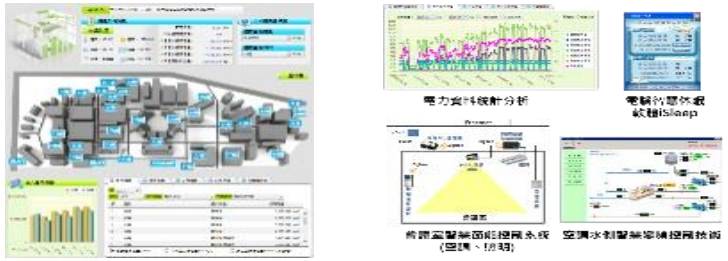


Demonstration of Smart Meter Reading in a Metropolitan Setting

Smart Meter System and Home Energy Management System Demonstration Area



Smart Home (Building) Energy Management System

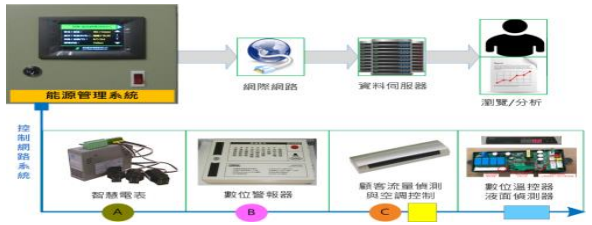


Smart Building Energy Conservation Demonstration Area

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

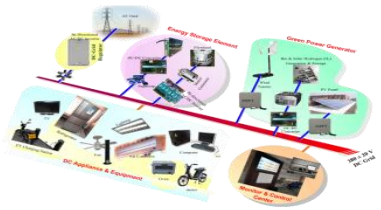


Convenience Store Energy Conservation Management System

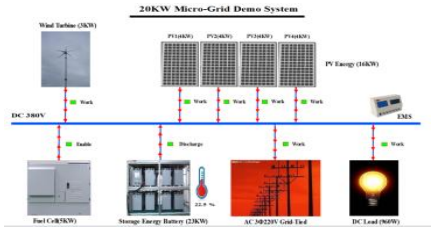
# Smart Grid Demo Sites in Taiwan-2

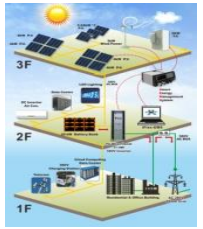

Advanced Distribution Automation Demo System


100 kW Autonomous Micro-grid Demonstration System

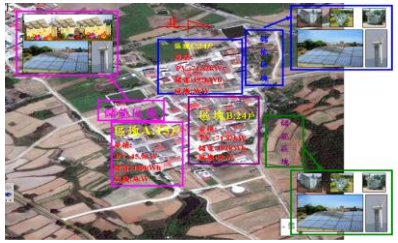
Smart DC Power System Educational Demonstration House



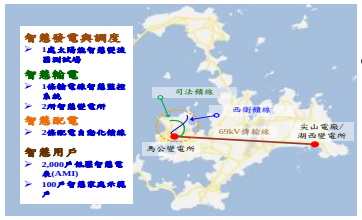


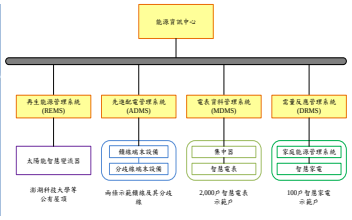

Smart AC/DC Hybrid Micro-Grid Demonstration System


Micro-grid and Electric Vehicle Demonstration Site

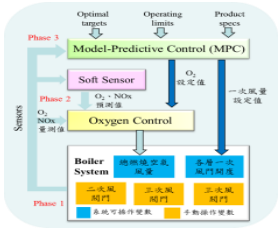



Dongkeng Smart Grid Demonstration Project

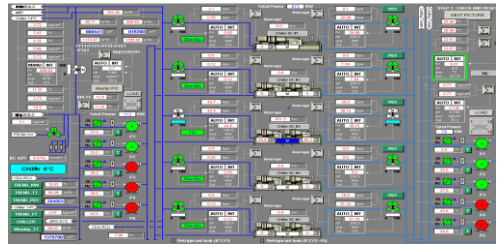





Penghu Smart Grid Demonstration Site


Furnace Optimized Operation Demonstration System



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

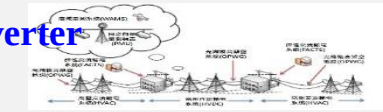
# National Energy Program-Phase II:
# Smart Grid Focus Center Project Framework (2014~ 2018)

sponsored by National Science Council

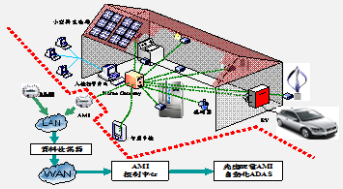
A Smart Energy network and energy saving control Technology

C Distribution Power Control Technology development

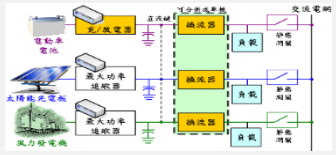
E Grid-connected High Power Converter development



**Equipment and system development**



D Isolated Microgrid Technology development



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

F EV charging station manager strategy

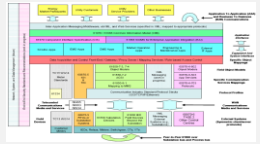
H Transmission System Power Quality improvement and wheeling technology development

B AMI Value-added service and integration technology

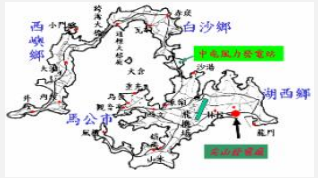
I Smart Grid and AMI Standard Development

**Technology Commercialization**

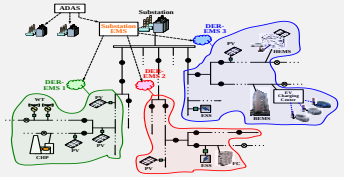
J Smart Gird Industry Development Project



**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

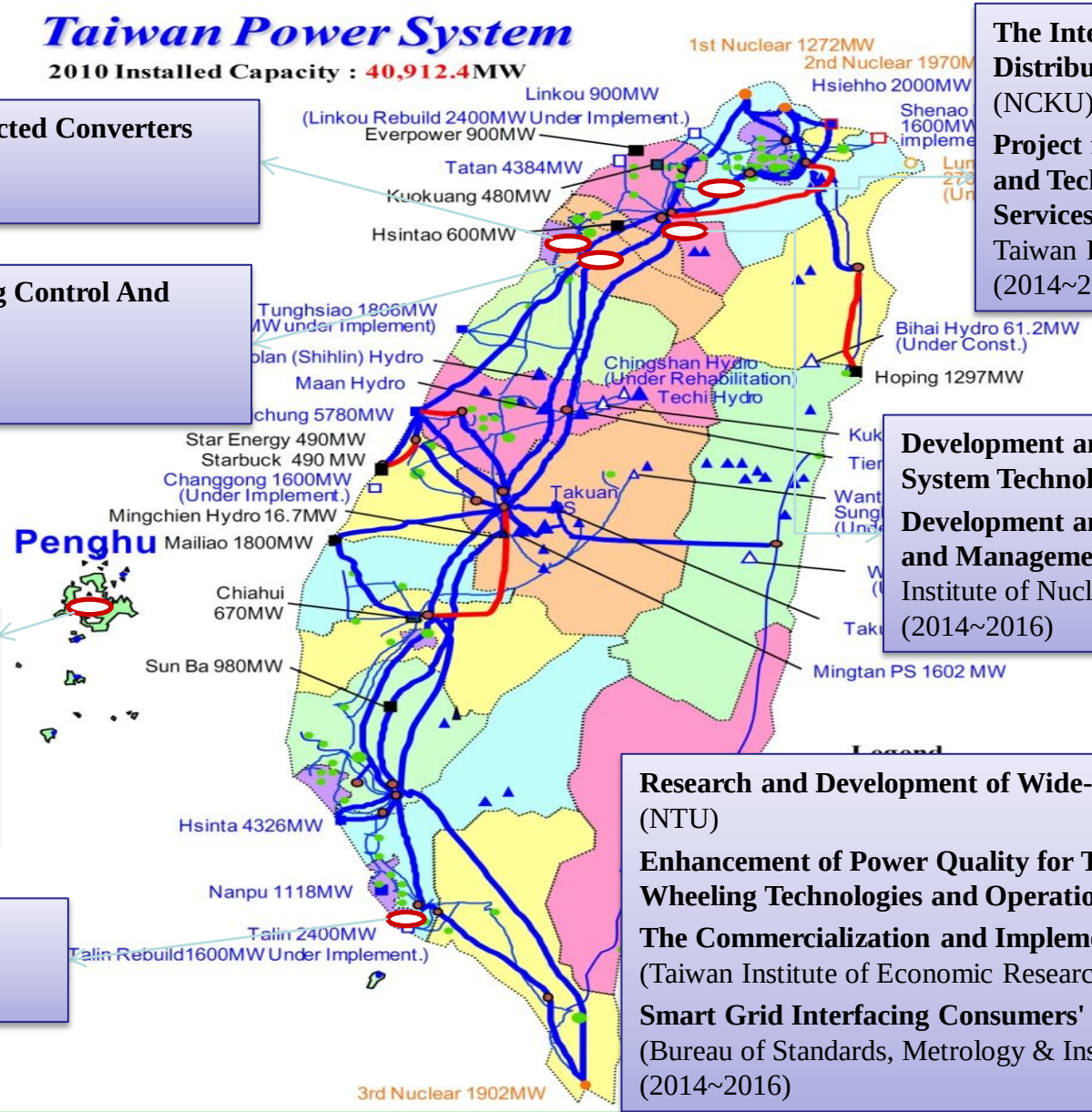
**Development of High Power Grid-Connected Converters**
NTHU, Hsinchu
(2014~2016)

**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)

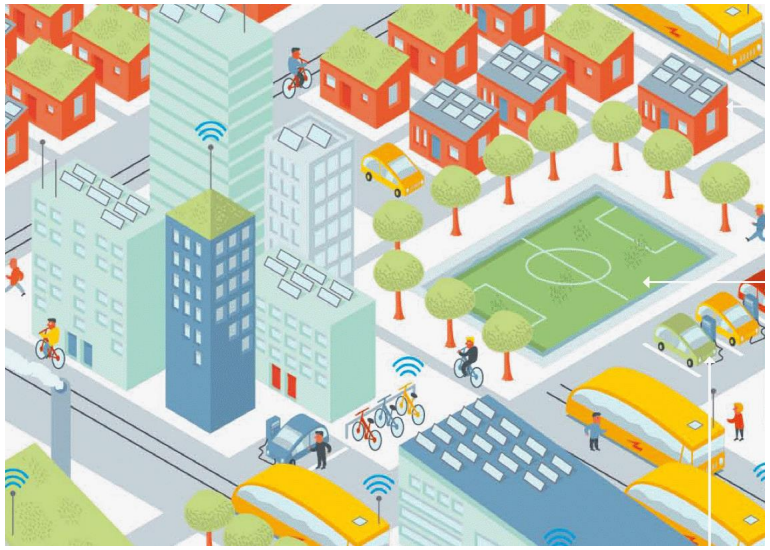
**The Commercialization and Implementation of Smart Grid Technology Project** (Taiwan Institute of Economic Research)

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

# Vision of Smart Grid Promotion in Taipei City

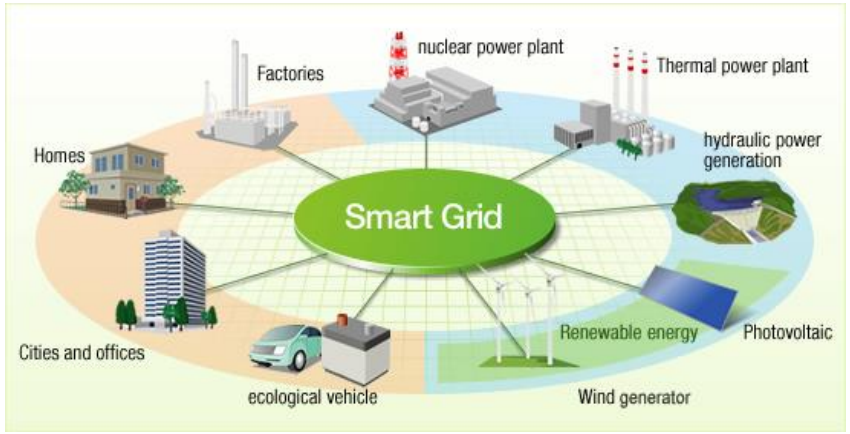
Setting **Smart City, Smart Government, Smart Service and Smart Field** as core, integrate city government's current promotion policies on power saving, power creating and industry, expand the utilization of green energy, enhance power usage efficiency and the willingness to save power, lower the risk of power shortage, invigorate **smart economy**, build the **future energy planning benchmark for the city**.

## Smart City

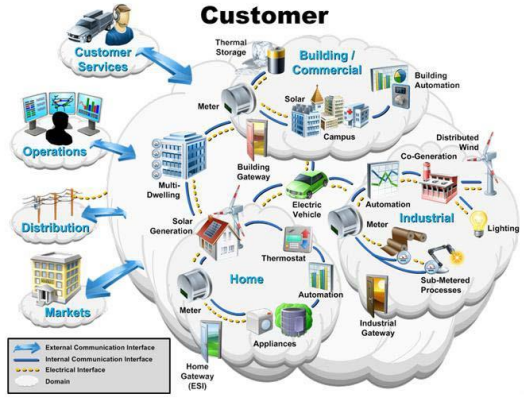


## Smart Energy Economy

### Smart Grid




### Big Data & Cloud

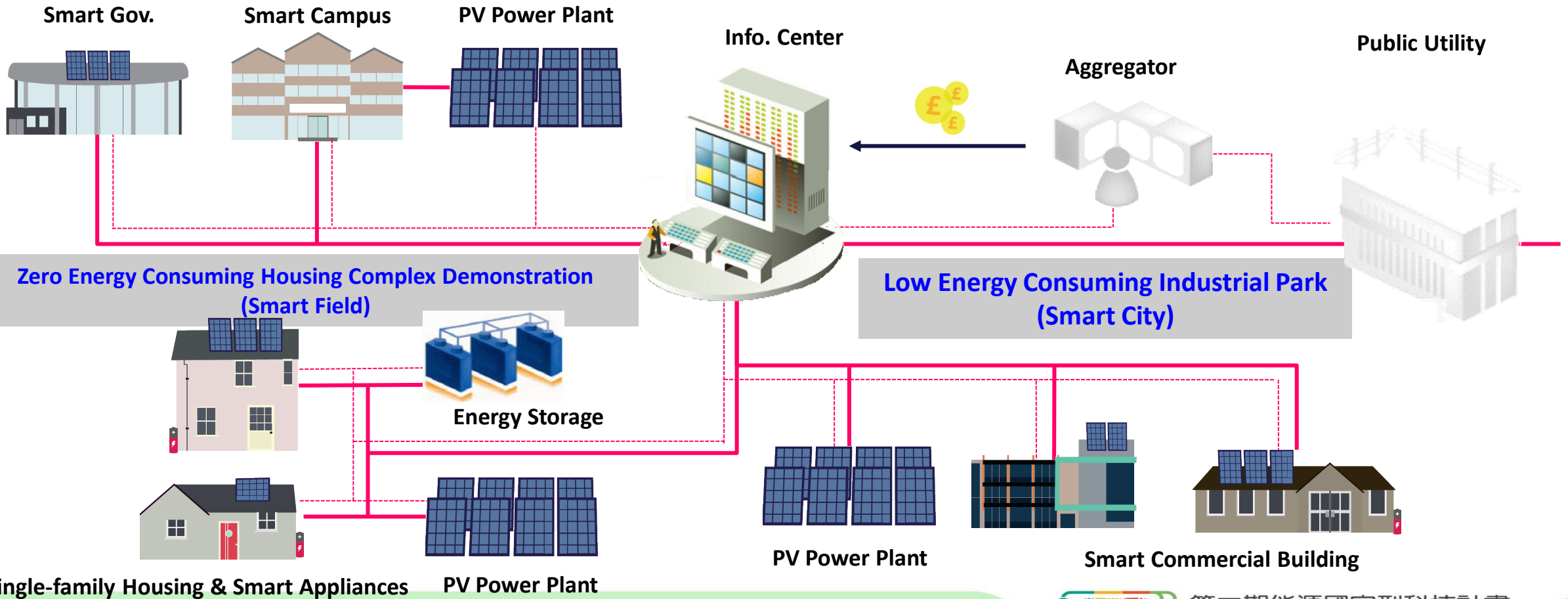


# Structure of Smart Grid Promotion in Taipei City

**Power creating public facilities and Zero Energy Consuming Buildings Demonstration (Smart Government)**

**Energy Information Cloud Center (Smart Service)**

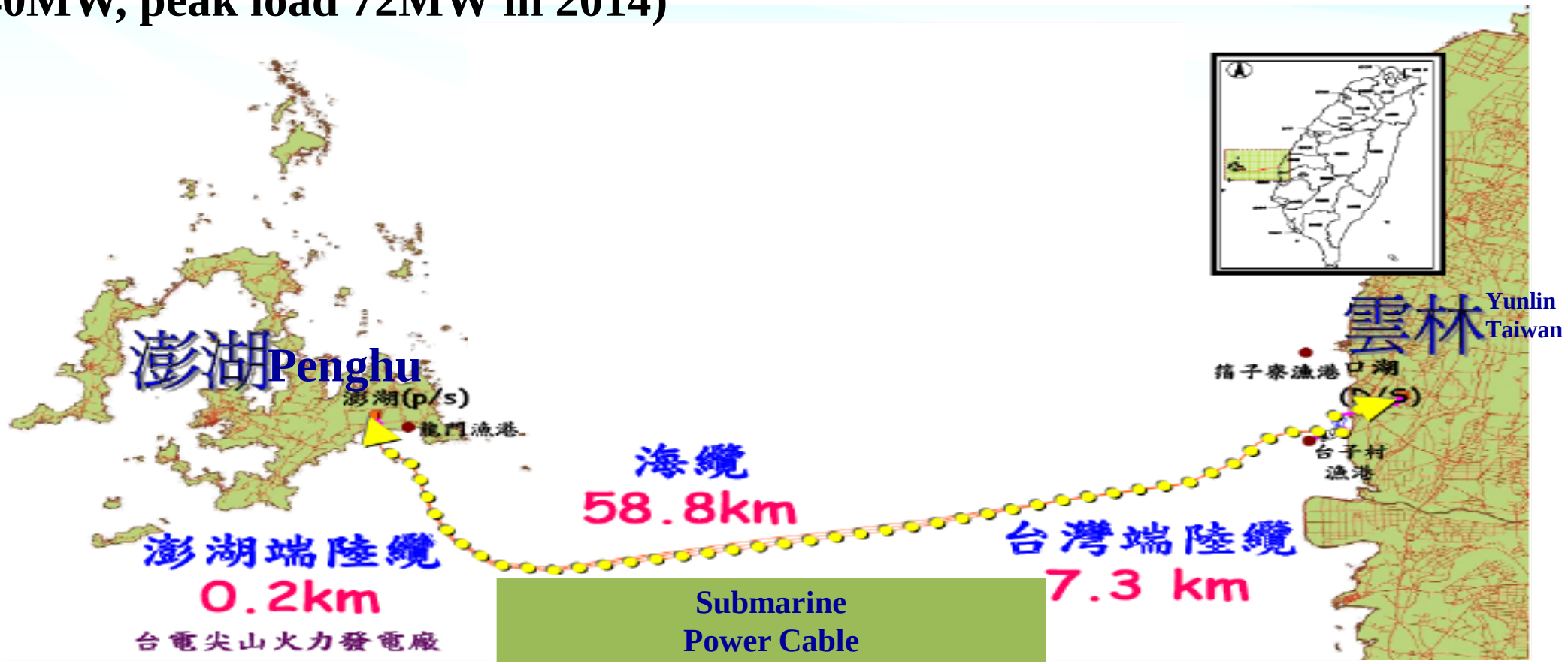
**Power Consumption & Creation Big DATA Aggregator Business Model (Smart Economy)**



# NEP II - Penghu Smart Grid Demonstration Project

# Penghu Smart Grid Demonstration Project

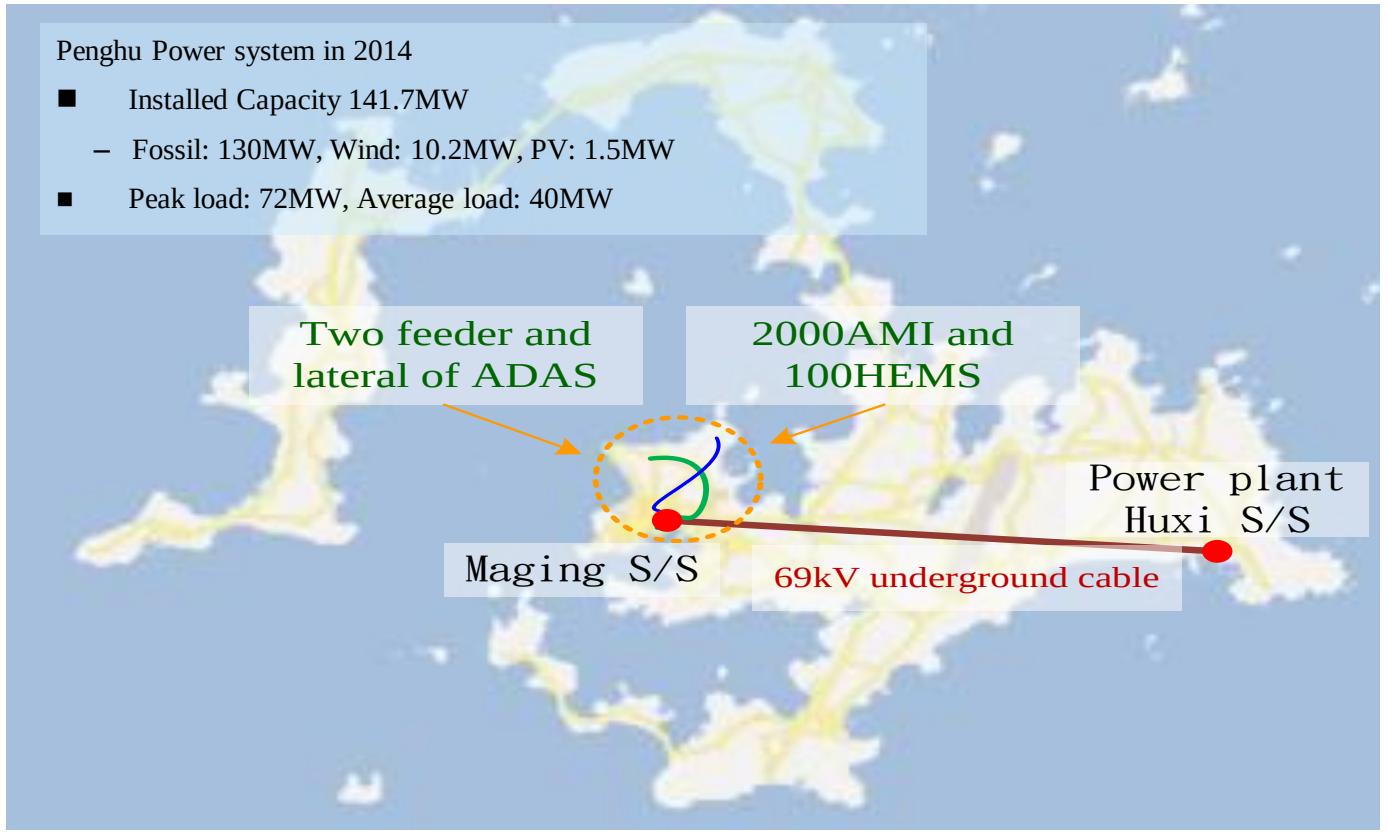
- **Penghu archipelago (48km from Taiwan, inhabitants 100,000, average load 40MW, peak load 72MW in 2014)**




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.

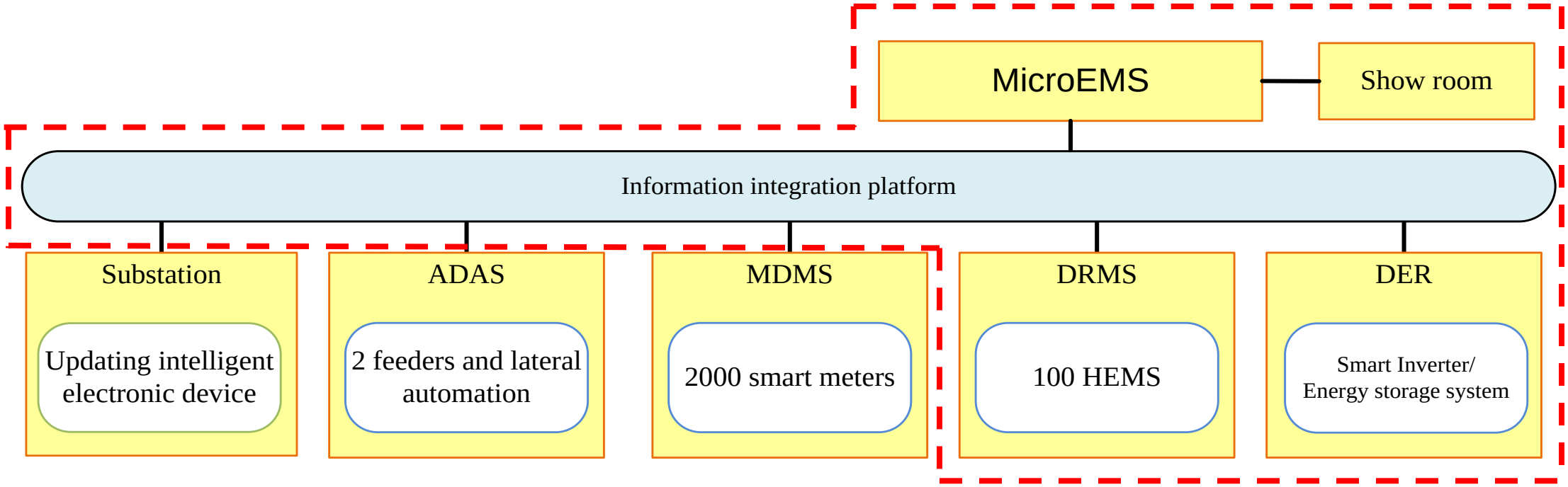



Deployment Items:

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

# NEP II - Virtual Power Plant Demonstration Project

# The Structure of VPP Energy Supply Service Technology

Coal-fired, oil power plants

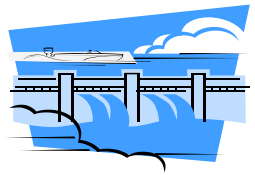
Nuclear Power Plant

Natural Gas Power Plant

Smart transmission technology development

Pumped hydroelectric power

Conventional Hydro Power



The VPP in distribution level can solve the power supply bottleneck problem and to achieve high renewable energy penetration. The VPP can be achieved by the integrated applications of demand response, distributed generator including PV, WTG, micro turbine and diesel generator, and energy storage system.

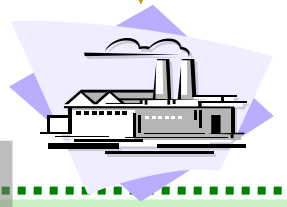
Electricity and communications network systems integration

Two-way exchange of electric power network

Virtual Power Plant (VPP)

Advanced Smart Distribution System Development

Smart user energy management system

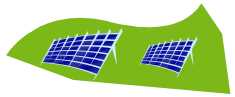


Energy-saving technology

Cogeneration

Wind power

Solar power generation



New energy technology

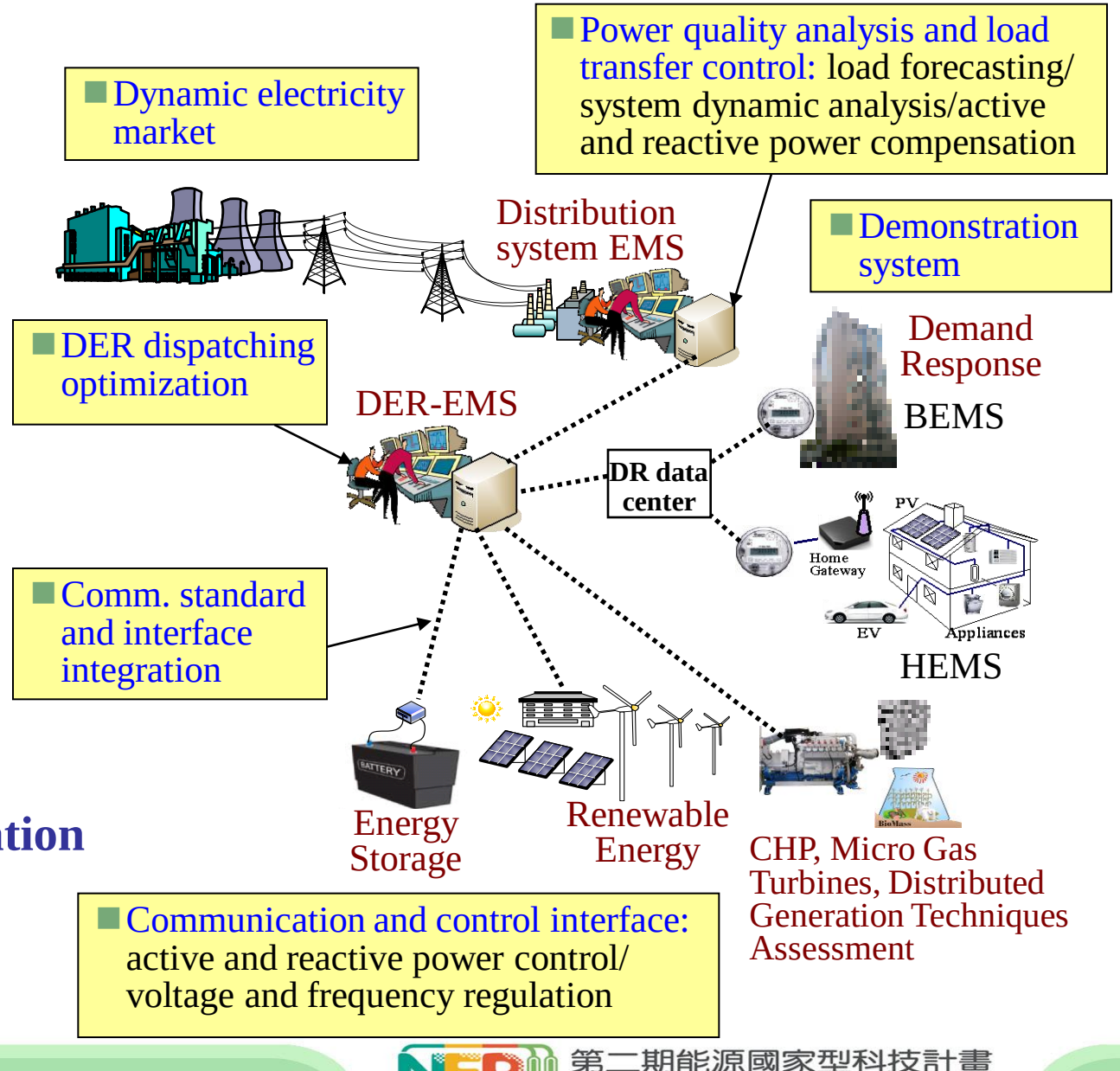
Energy storage systems (including electric vehicles

On-site Production

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

Distributed energy resources

P,Q output control

Power conversion interface

ESS

250kW

Electricity market programs

Substation-EMS economic dispatch decision-making platform

Taipower side

IEC 61850
Advanced DNP

DER-EMS optimal decision-making platform

IEC 61850-7-420
IEEE P2030.2

Power conversion interface

DG

PV, WTG,
Diesel generators,
Steam turbines

IEC 62056
IEC 61968

Automated demand response (ADR)

AMI

OpenADR 2.0 for ADR

H(B)EMS

H(B)EMS

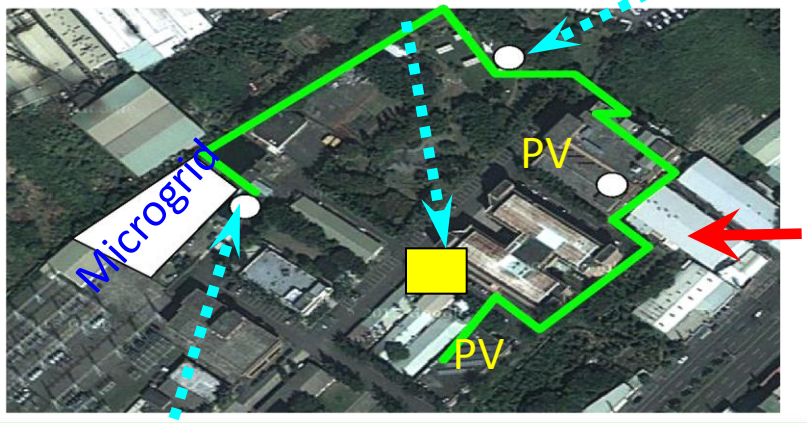
H(B)EMS

DR control
Load saving control

Smart building energy management system

ESS

Wind-turbine

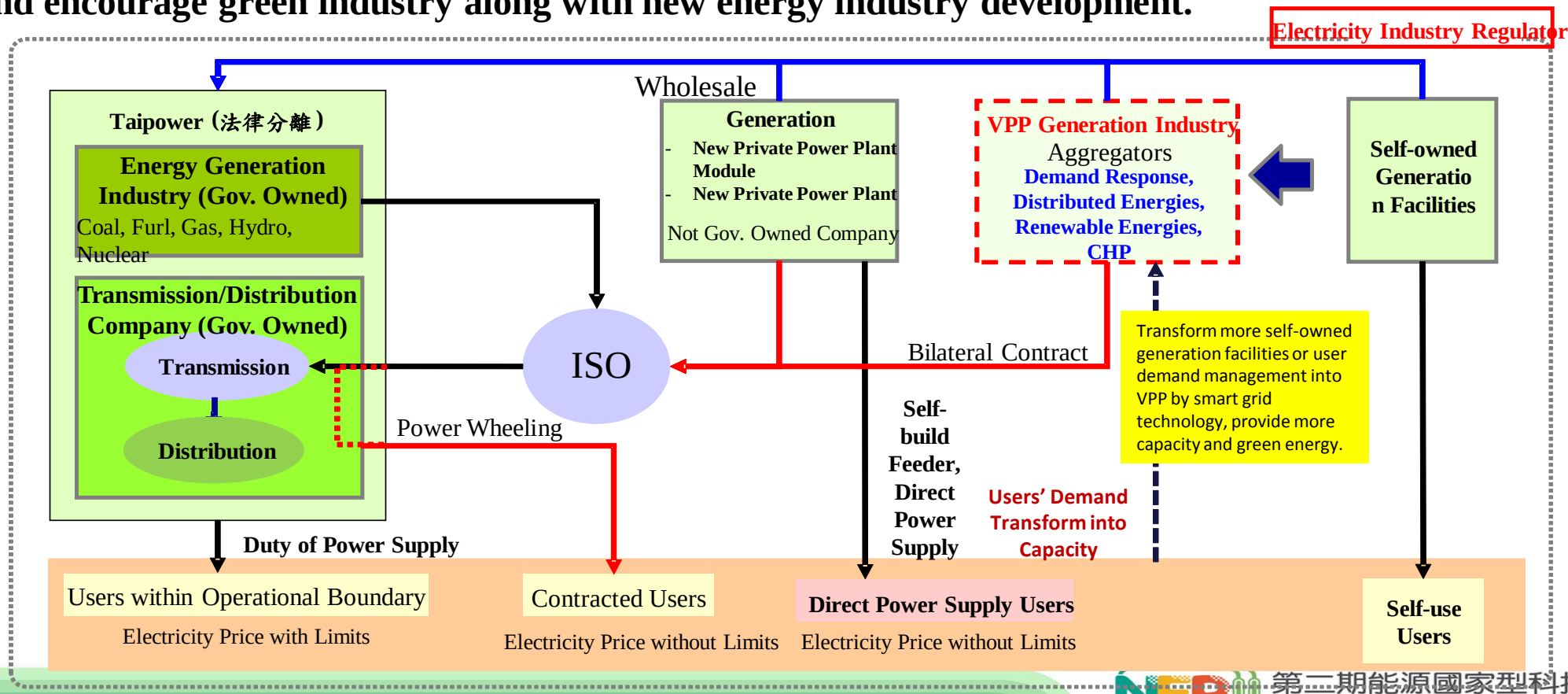



BEMS

Diesel-Engine Generator

# 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.




資料來源：陳彥豪、盧思穎、林法正，虛擬電廠概念與運作模式介紹，電力電子雙月刊,Vol.11, No.4, 46-53頁, 2013年7月。

# 台電綜研所樹林園區–ADR實驗計畫

供電端

① **調度中心**將帶有『卸載等級』的DR Event傳送給需量反應閘道器
② **需量反應閘道器**依據DR event和client類型(simple or smart client)，轉傳event給適當的client
③ **Smart Client**根據DR event及用電狀況做設備控制排程並通知能源管理閘道器
④ **能源管理閘道器**根據排程執行卸載

電力公司調度中心

需量反應伺服器

需量反應事件

**計畫期程：**
103年2月~103年12月

Ethernet

需量反應閘道器

Smart Client
(資訊分析與控制)

儲能併市電系統

用電分析(歷史)

超約預警

需量管理

Ethernet

能源管理閘道器

電力計

負載

後端資料
共通平台

負載端

Dashboard

IHD

Ethernet

AMI與環境感測資訊伺服器

電力線通訊

能源管理閘道器

家庭用戶總表(AMI)

室內溫溼度感測

室外溫溼度感測

$CO_2$感測

環境感測閘道器

# 用戶端大型冰水機ADR自動需量反應實驗計畫

***ADR事件發起人***
綜研所人員 與 DDCC配電調度中心
調度人員

第一層 台電公司
OpenADR 2.0

**汐止-民權饋線範圍內：**
(1) 60台100RT以上冰水機
(2) 參加戶包含高壓與低壓

**VTN**

Internet 公用網路

**VEN**

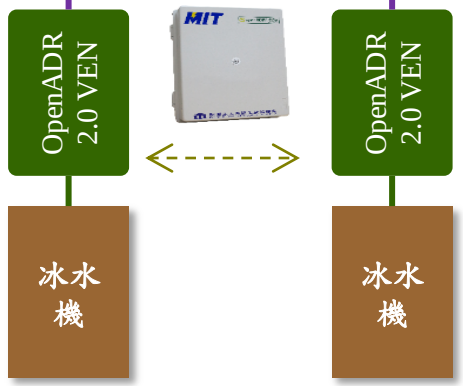
***ADR事件操作人***
用戶群代表Aggregator
調度人員

第二層 用戶群代表 Aggregator (NEP計畫)
OpenADR 2.0

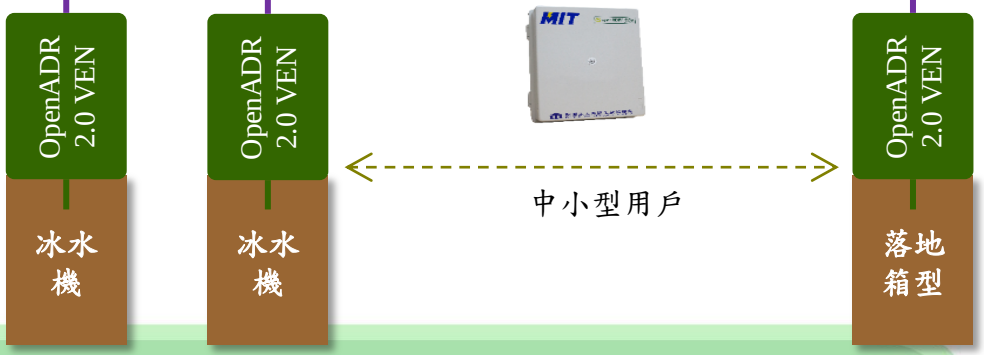
**VTN**

Internet 公用網路

驗證項目：
ADR VEN 與
VTN操作功能
，及Push 與
Pull 混和模式




特高壓用戶



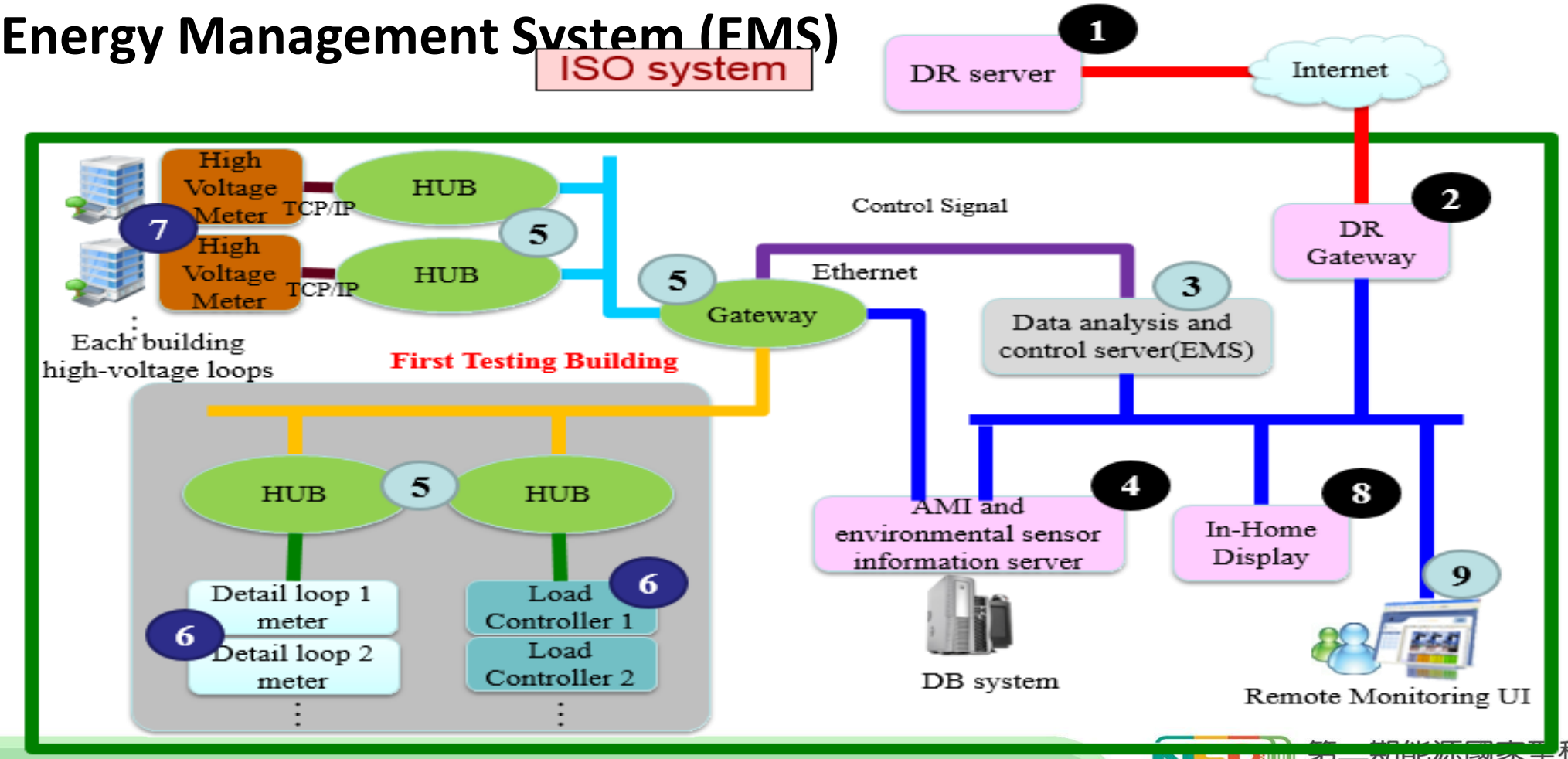

中小型用戶

**計畫重點：**
1. 導入SOP規劃
2. VEN與用戶端整合
3. ADR系統架構驗證
4. ADR效益分析
5. ADR修訂建議

**計畫期程：**
104年2月~106年1月

# AMI and Demand Response Framework Planning

- **Meters installed in Taipower test site**
- **Automated Demand Response Server**
- **Energy Management System (EMS)**



# Development of BEMS Auto-DR System

- **Development of VEN pull-mode system according to Open ADR 2.0**
  - Meet the requirements of Open ADR 2.0 consistency regulation
  - Pass and obtain the VEN pull-mode certification
    - VEN Pull Positive/Negative Test Scenarios
    - VEN Pull Security Test Scenarios
    - Transport Test Cases
- **Interface with BEMS for DR control**
  - Integrated with the developed EMS

DR+ PLUS OUR EARTH
NCKU SMART MANAGER


openADR 2.0a CERTIFIED

*Certificate of System Conformance Awarded to*

National Cheng Kung University

**DR Plus**
(Firmware V1.0)

Certified October 26, 2014 to OpenADR 2.0a Test Plan 1.05

Rolf Bienert
Technical Director

Barry Haaser
Managing Director

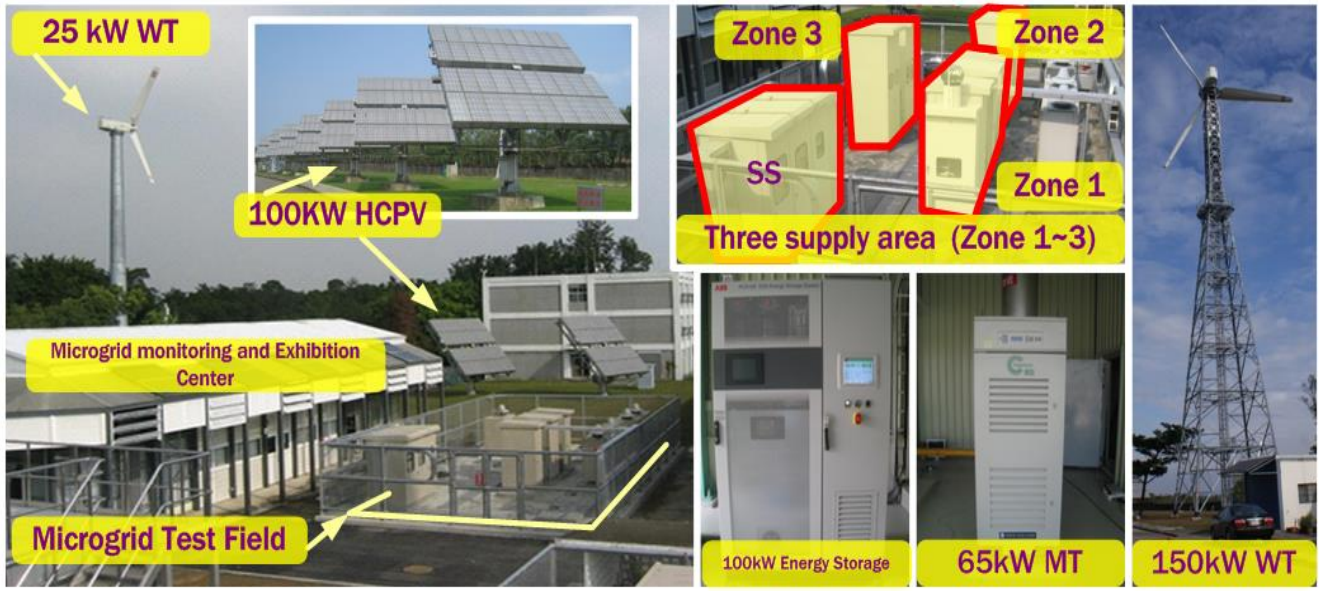
# NEP II - AC Microgrid Demonstration Project

# 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

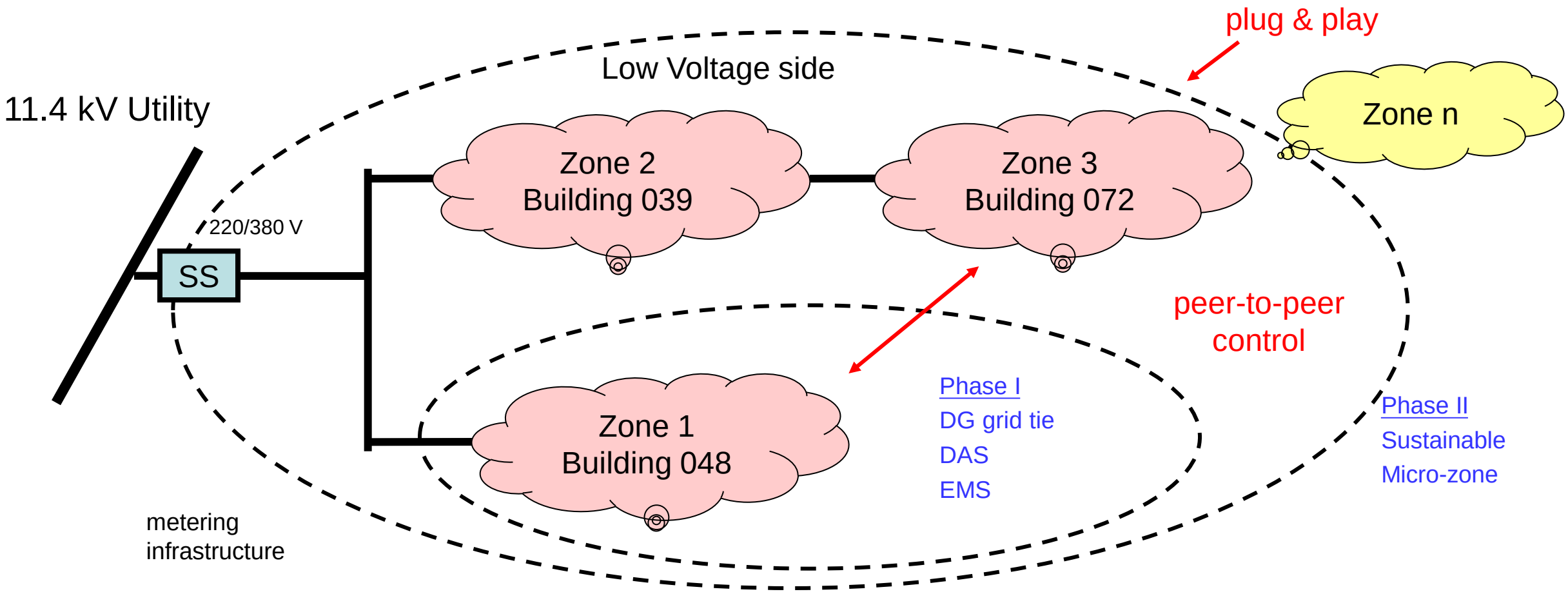
1. Reduce EV charging grid connection impact;
2. Improve the renewable energy usage efficiency
3. Vehicle to Grid (V2G) for Load Shifting




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.



# Microgrid Technology Development

## (1) Power System Technology

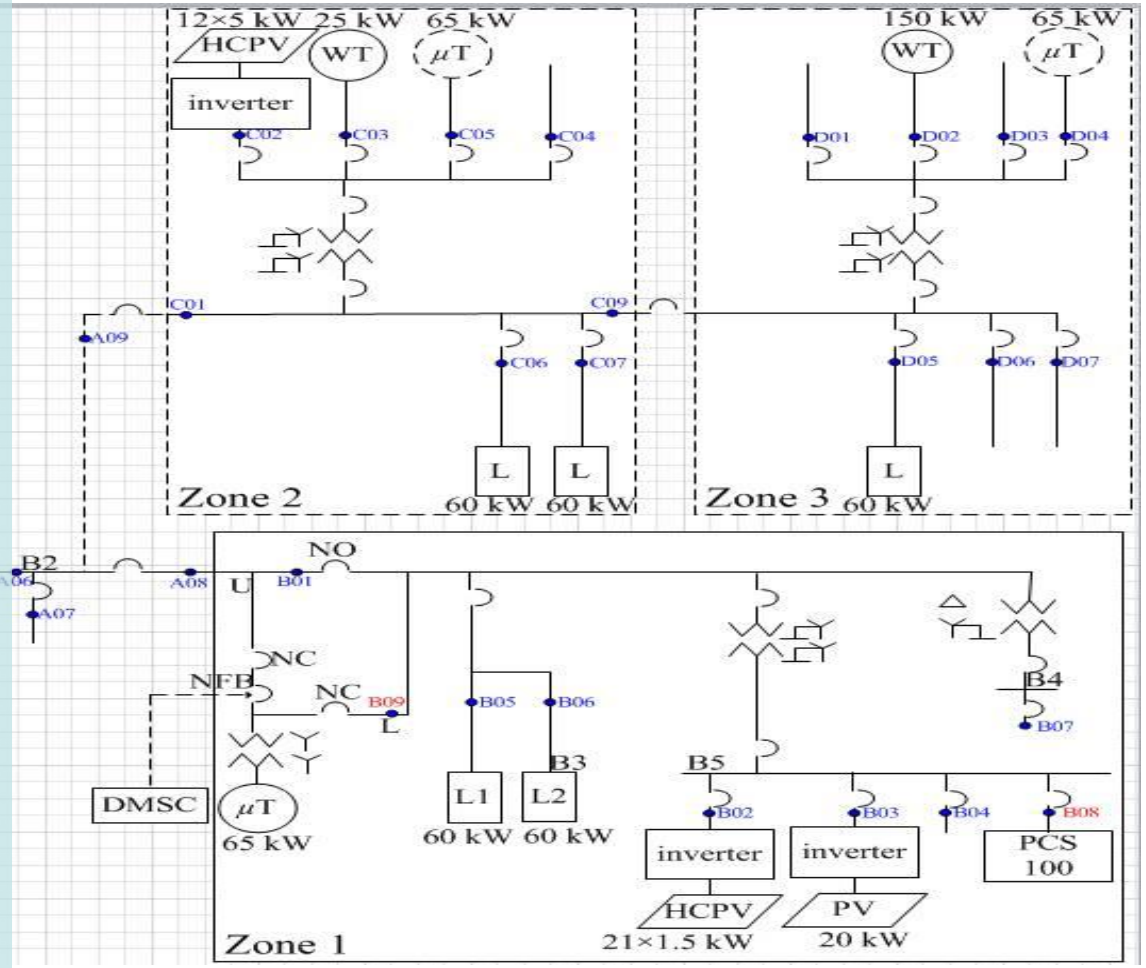
- Operation Scenarios Design & Testing
- System Stability Analysis
- Protection Coordination for MG
- Microgrid Power Quality Analysis

## (2) Power Electronics Technology

- Static Switch and Islanding Detection
- Smooth Switching Inverter
- Active/Reactive Power Control
- Droop Control
- Low Voltage Ride Through

## (3) Intelligent control and EMS

- Energy Management System
- Power Flow Analysis
- Generation & Load Prediction
- DAQ and Time Synchronization



# 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.

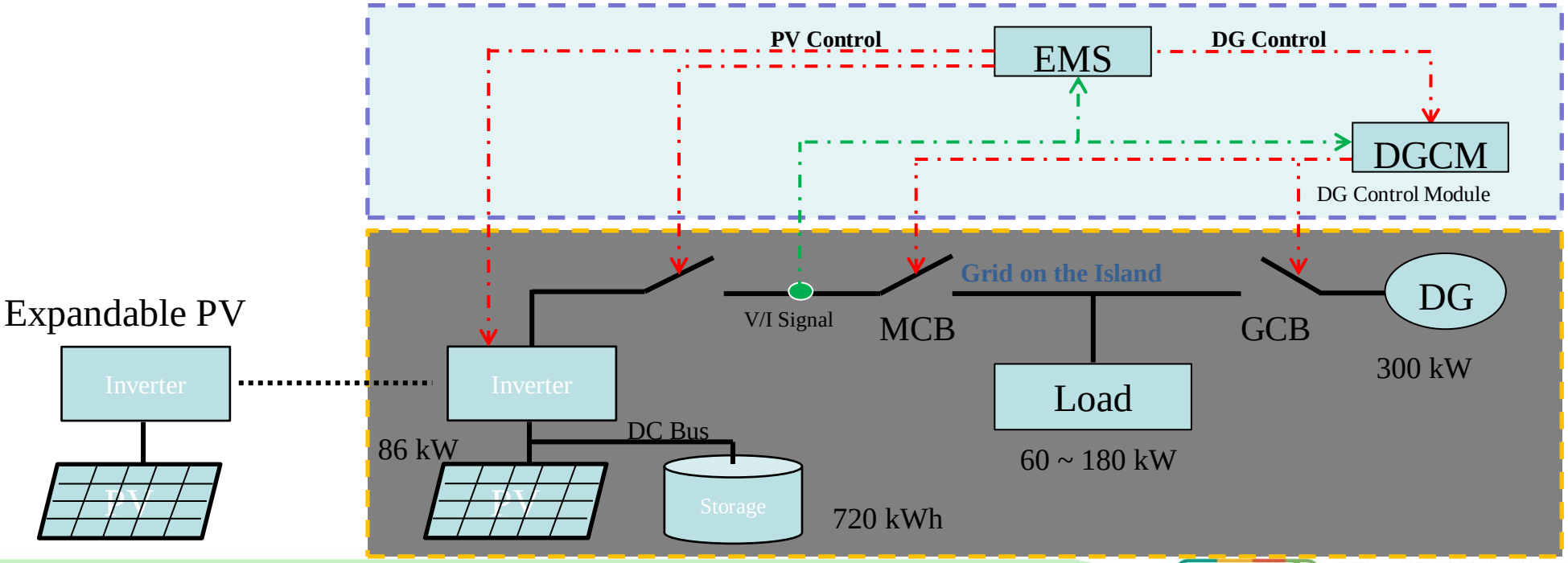
## Functions

- 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.

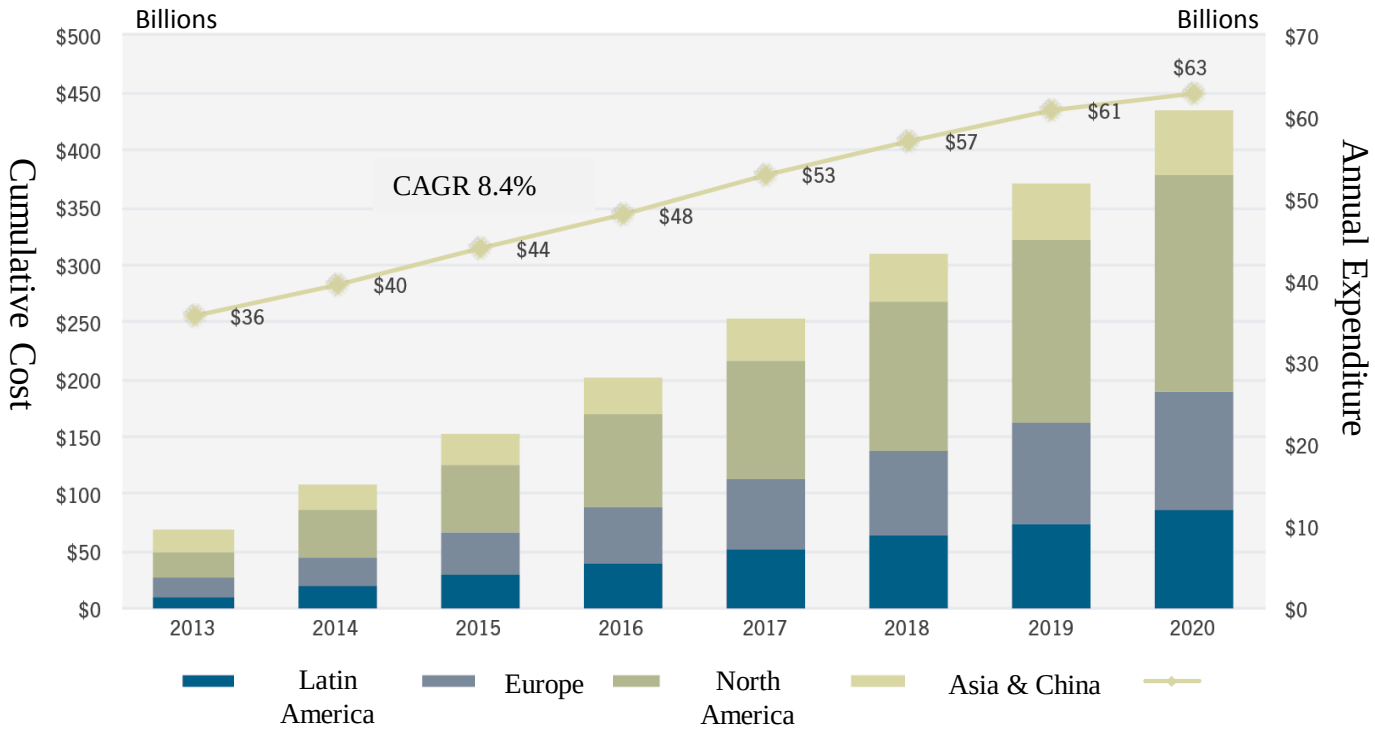


# Development of Smart Grid Industry in Taiwan

# 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)

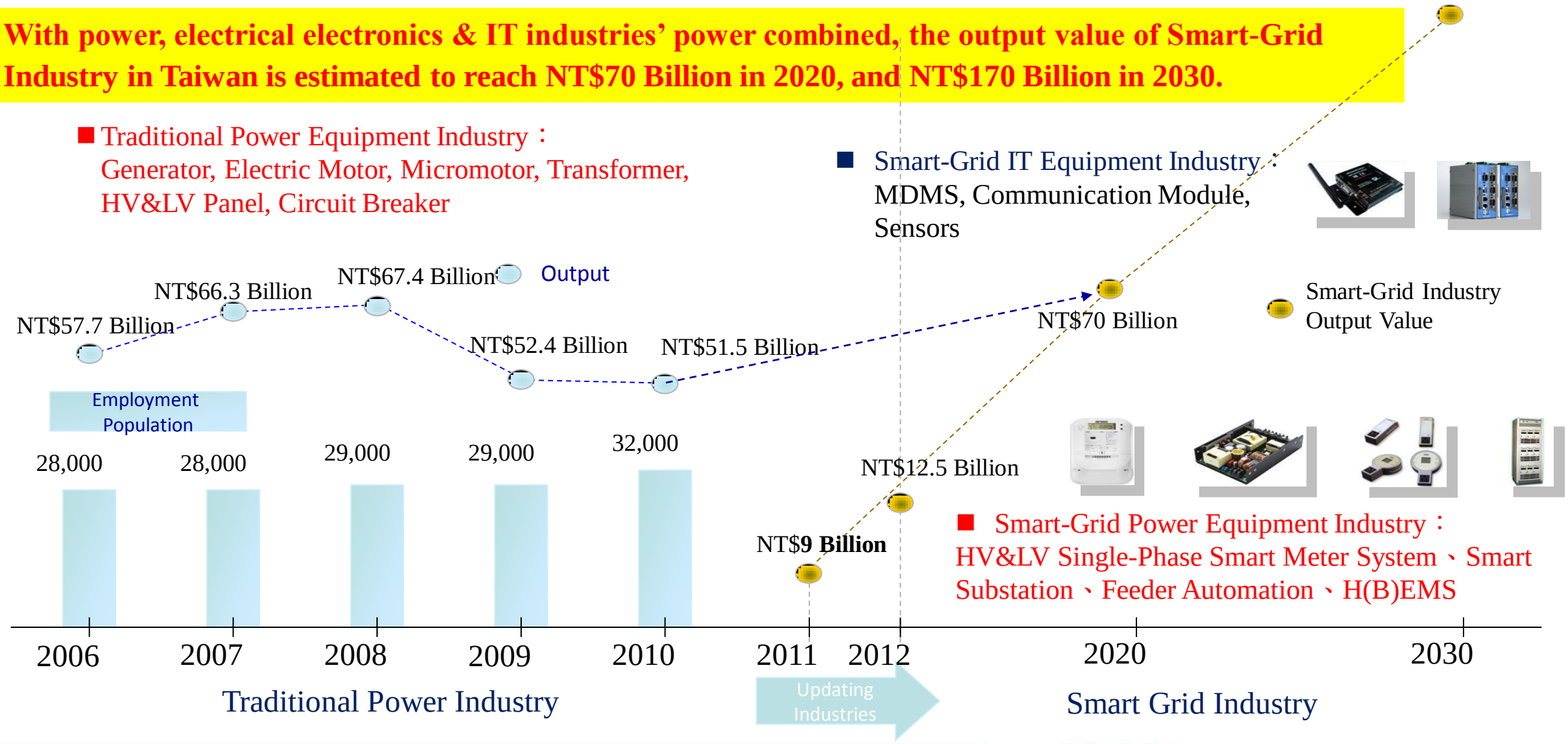
# Vision of Smart Grid Industry in Taiwan

**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.**

■ Traditional Power Equipment Industry：
Generator, Electric Motor, Micromotor, Transformer, HV&LV Panel, Circuit Breaker

■ Smart-Grid IT Equipment Industry：
MDMS, Communication Module, Sensors



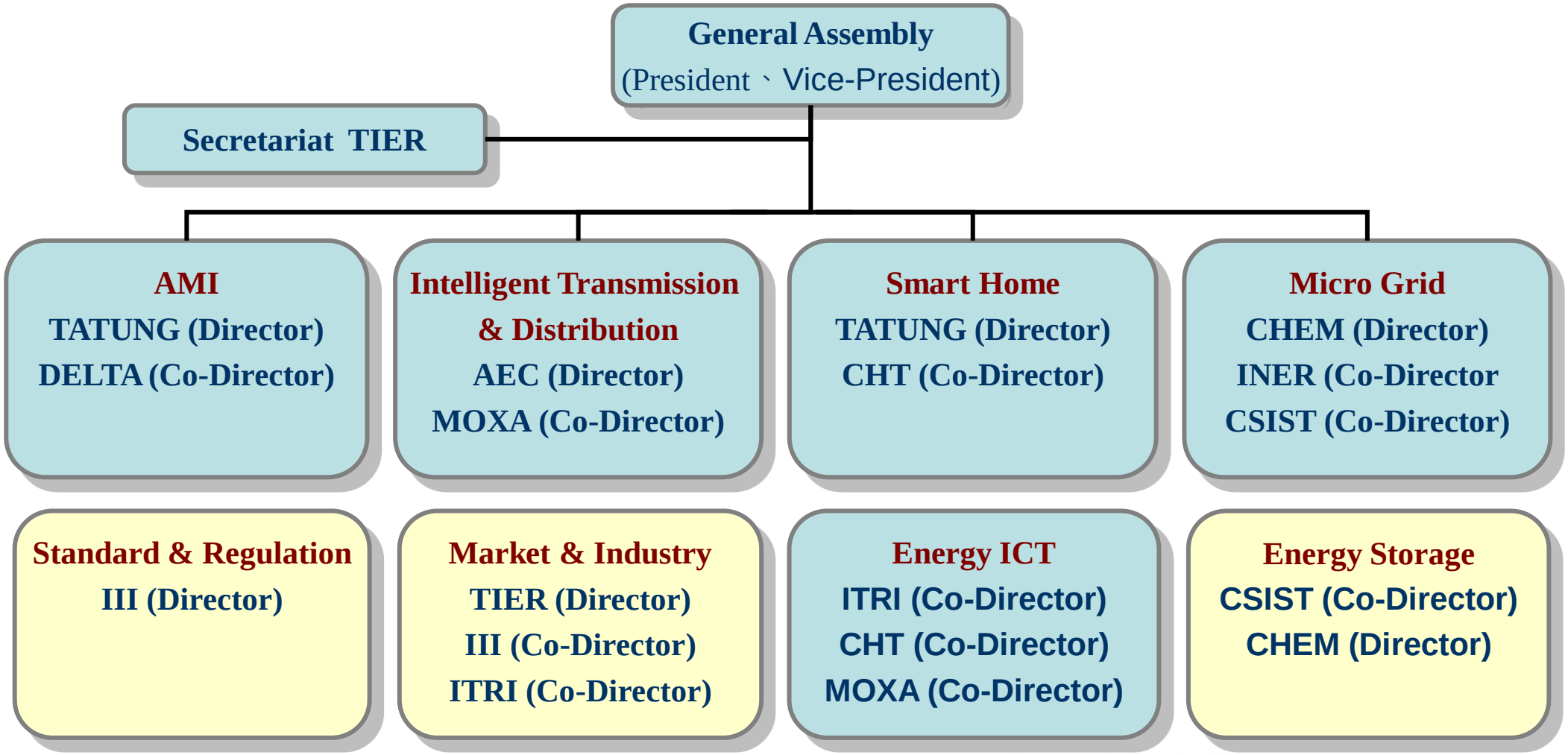





■ Smart-Grid Power Equipment Industry：
HV&LV Single-Phase Smart Meter System、Smart Substation、Feeder Automation、H(B)EMS

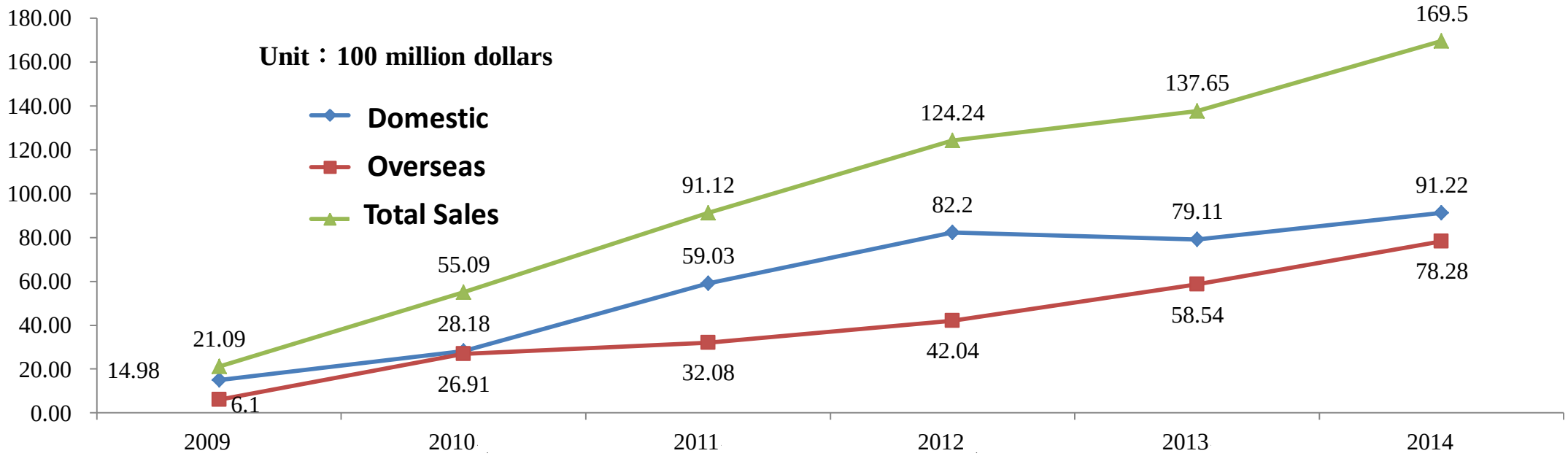
# Structure of Taiwan Smart Grid Industry Association

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



# 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% | |

Unit：NTD in 100 million dollars

# Thank You for Your Listening!