Overview of Microgrids in Asia

Newcastle 2017 Symposium on Microgrids

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Toshifumi ISE
ise@eei.eng.osaka-u.ac.jp

大阪大学
OSAKA UNIVERSITY

Alex CHONG
alex_chong@epgc.a-star.edu.sg

Experimental
Power Grid Centre
A*STAR

Key Contributors

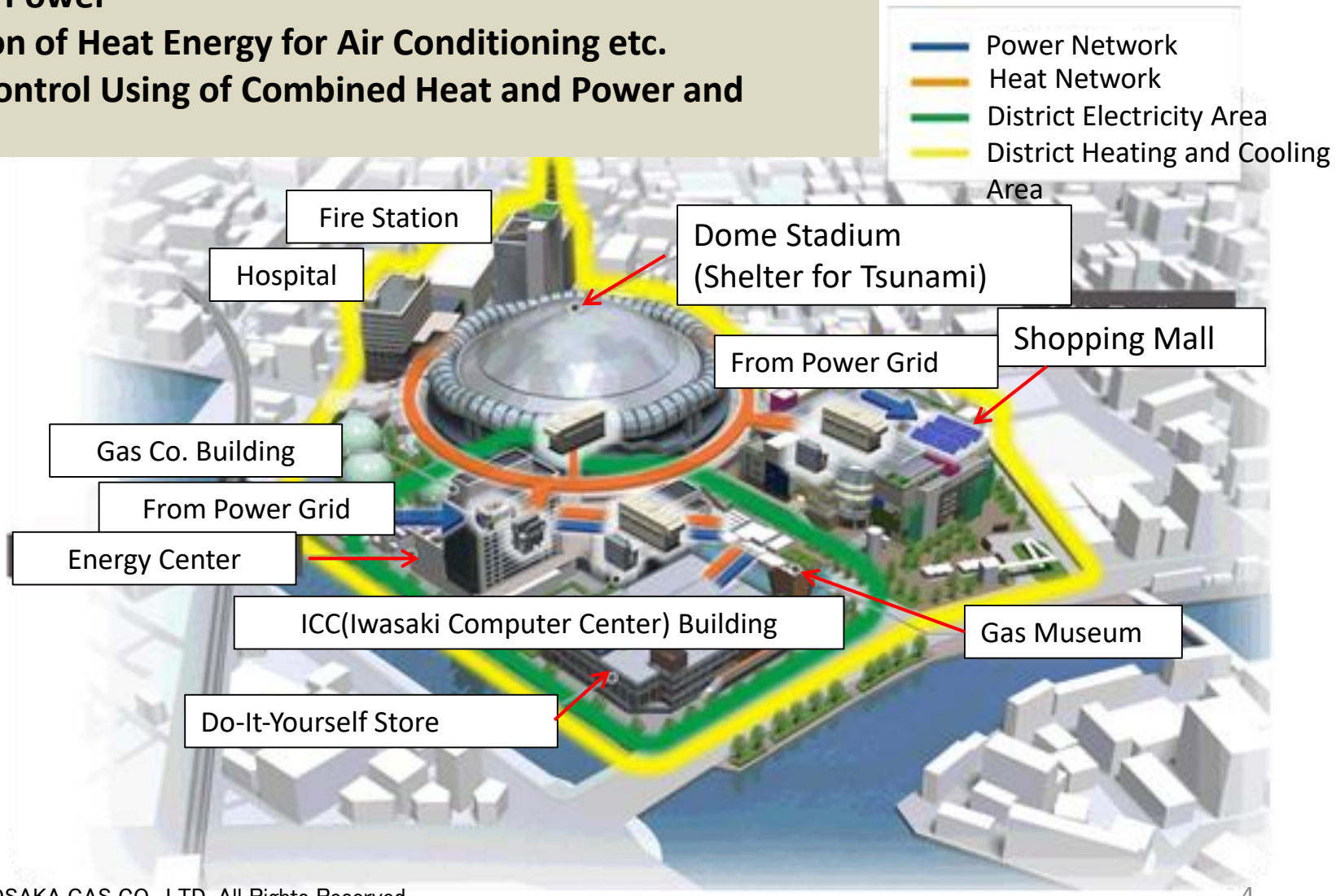
Country	Name	Organisation
Japan	Toshifumi ISE	Osaka University
Korea	Dong Jun WON	Inha University
China	Meiqin MAO	Hefei University of Technology
Taiwan	Raymond Yung-Ruei CHANG, Shyh-Wern SUN	Institute of Nuclear Energy Research
Australia	Saad SAYEEF Pierluigi MANCARELLA	CSIRO University of Melbourne
Singapore	Alex CHONG	Experimental Power Grid Centre, A*STAR

Past Major Demos on Microgrid in Japan

Project / Location	Year(s)	Major Purpose
Aichi-EXPO and Tokoname	2003-2007	Efficiency improvement by co-generation Power supply by multiple inverters
Hachinohe	2003-2007	Power supply by renewables (PV, WT, bio-gas)
Kyotango	2003-2007	30-minutes balancing via commercial power line (virtual microgrid)
Sendai	2004-2007	Different power quality service
Shimizu Construction Company	2006-	Power balancing by gas-engine gen. and batteries
Miyako Island	2009-2013	Power balancing with mega-solar and batteries
Yokohama	2010-2014	Smart community
Toyota	2010-2014	Smart community
Keihanna	2010-2014	Smart community
Kitakyushu	2010-2014	Smart community
Obihiro	2012-2014	DC power supply for office-building
Yamagata	2012-2014	Smart-community consists of DC-microgrids

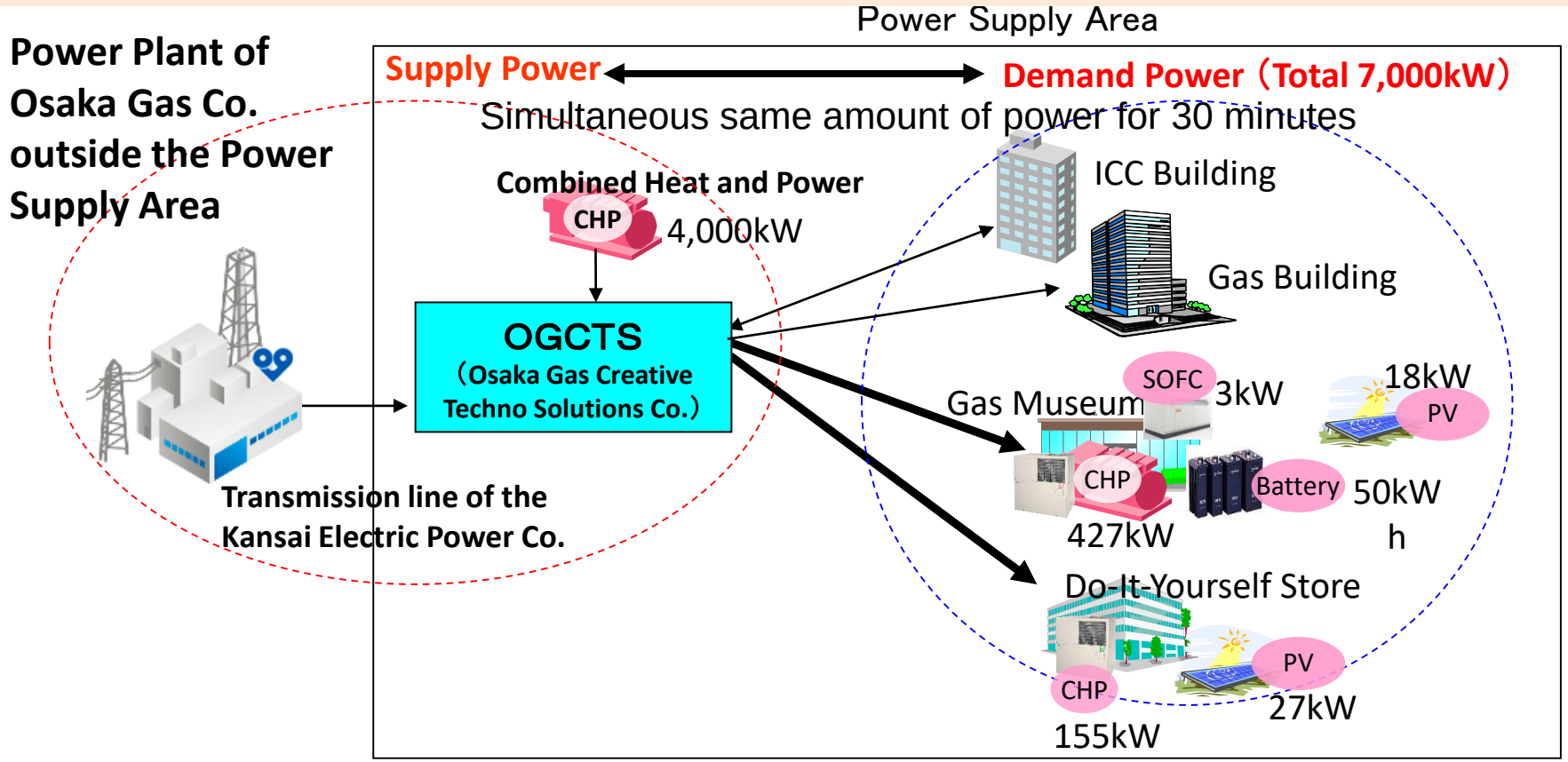
Smart Energy Network by Osaka Gas Co. (Since 2013)

① Enhancement of Resilience by Using Gas Engine Combined Heat and Power
② Utilization of Heat Energy for Air Conditioning etc.
③ Power Control Using of Combined Heat and Power and Batteries



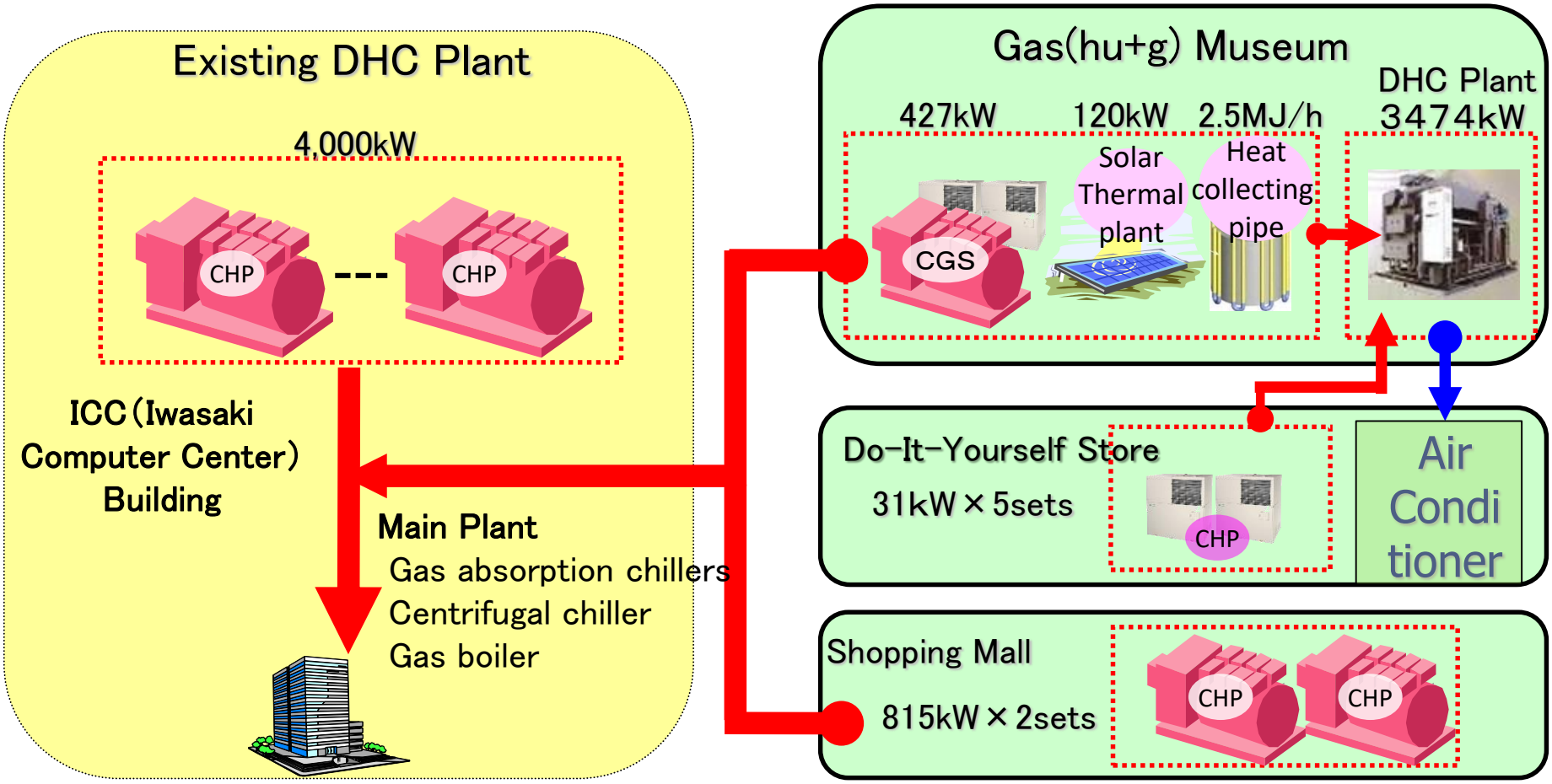
Power Management Using Information and Communication Technologies (ICT)

① Power Management Control Using ICT and Power Supply through Self-Employed Line (Simultaneous same amount of power for 30 minutes)
② Power Control Using of Combined Heat and Power and Batteries



Heat Utilization

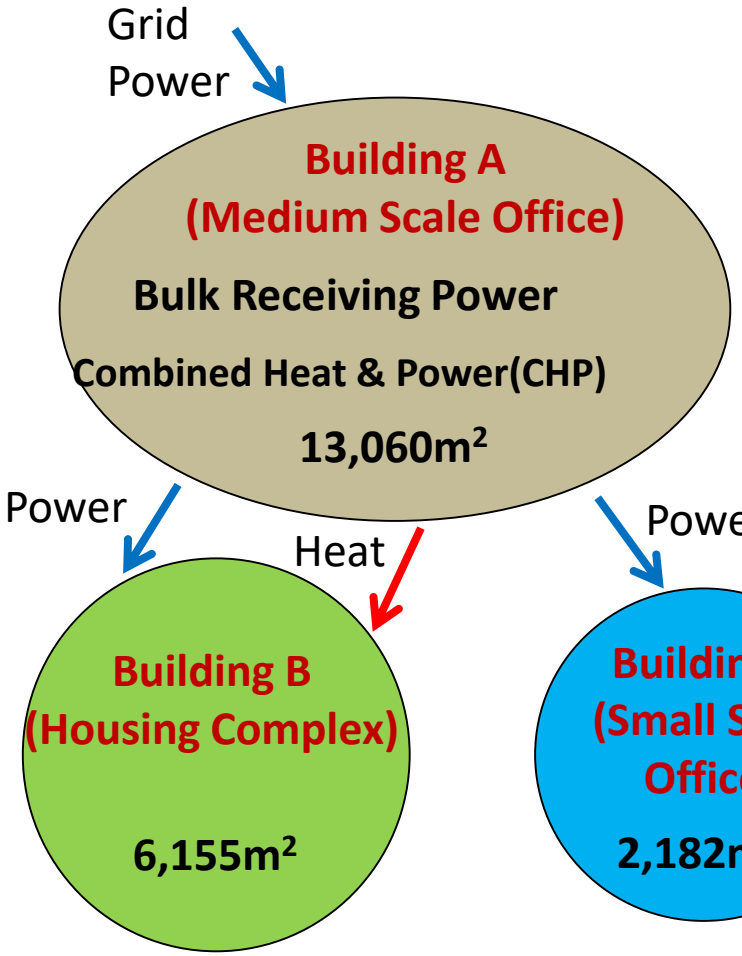
Reduction of Energy Consumption and Emission of CO_2 by using Combined Heat and Power and Solar Thermal Plant

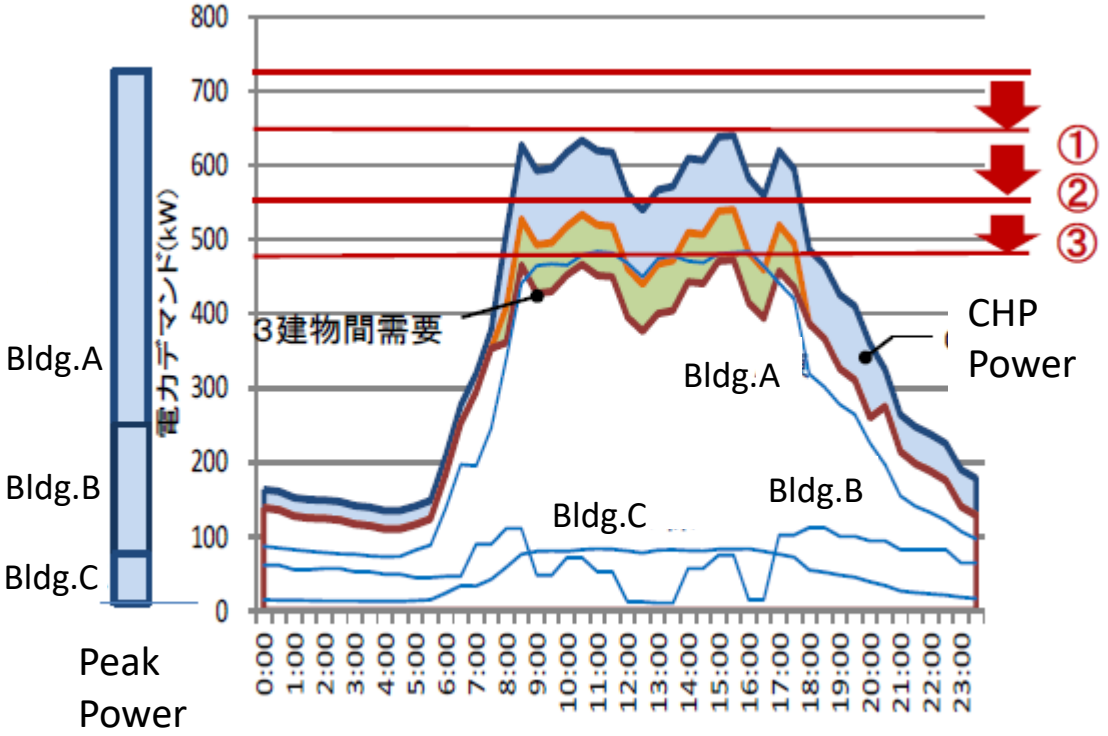


DHC: District Heating and Cooling

Smart Community Project in SHIBAURA, Tokyo

Concept:
Energy and Power Saving in Usual Case and Business Continuity in Emergency Case





Peak Power Reduction

① Effect of combination of different type of building
② Effect of local generation
③ Effect of Community Energy Management System (CEMS)

Emergency Power

Medium pressure gas pipeline and CHP
Power for elevator, water pump, common light etc.

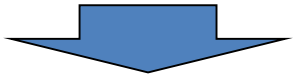
Other Smart Community Projects in Japan

1) KASHIWANOHA Smart City
- **Area development in Kashiwa city in Chiba for 273ha**
- **Power interchange between towns in usual case**
- **Emergency power from PV and batteries**

2) FUJISAWA Sustainable Smart Town
- **Area development in Fujisawa city in Kanagawa for 19ha**
- **Around 1000 houses with PV and batteries in each house**
- **HEMS controls heat pump type water heater, air conditioner**
- **Emergency power from PV and batteries**

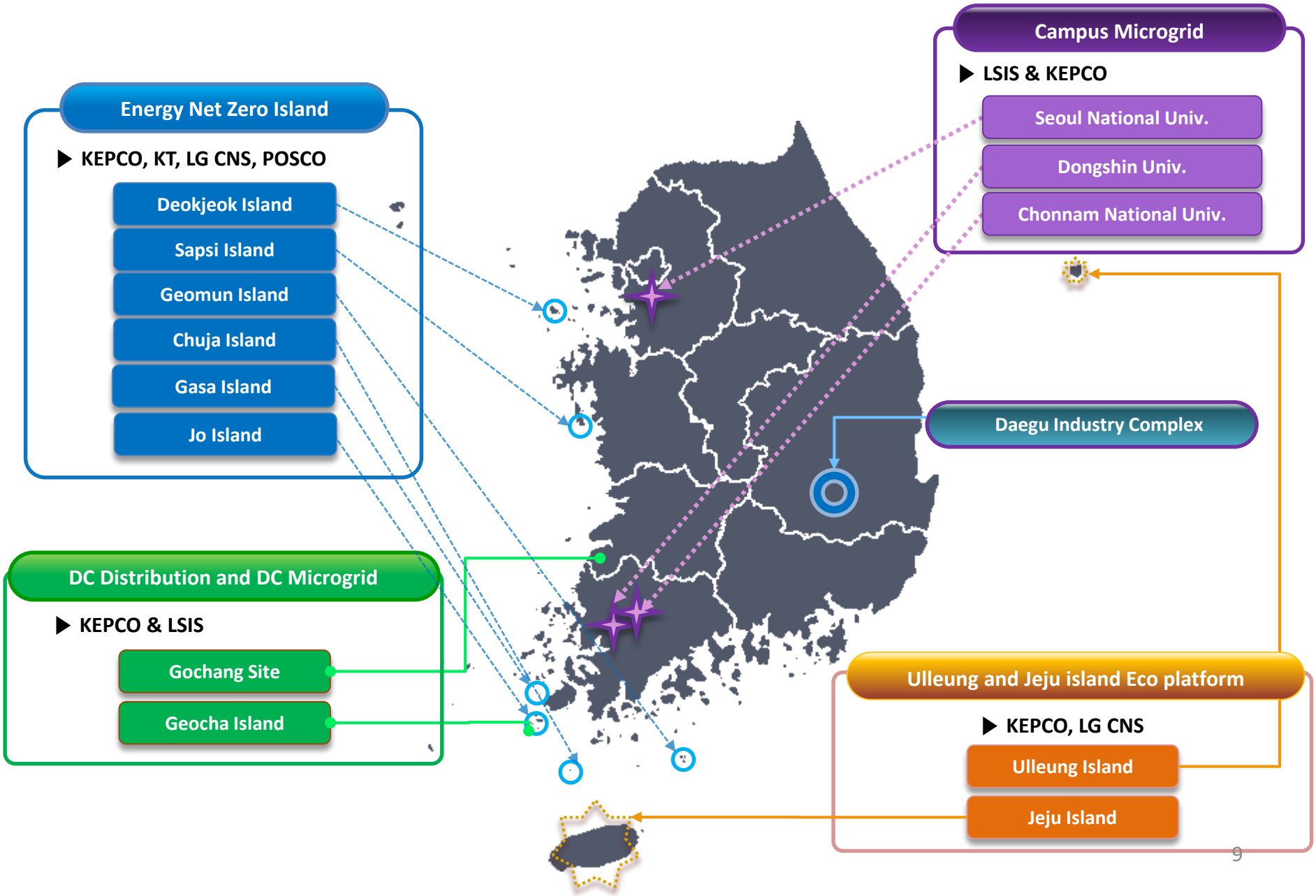
3) F-Grid in Sendai
- **Smart community in industrial park**
- **Generation: 7,800kW CHP, 700kW PV**
- **Storage: 50kWh Reuse batteries for cars and PHV**
- **EMS: CEMS, FEMS, BEMS**

Technology development project supported by government

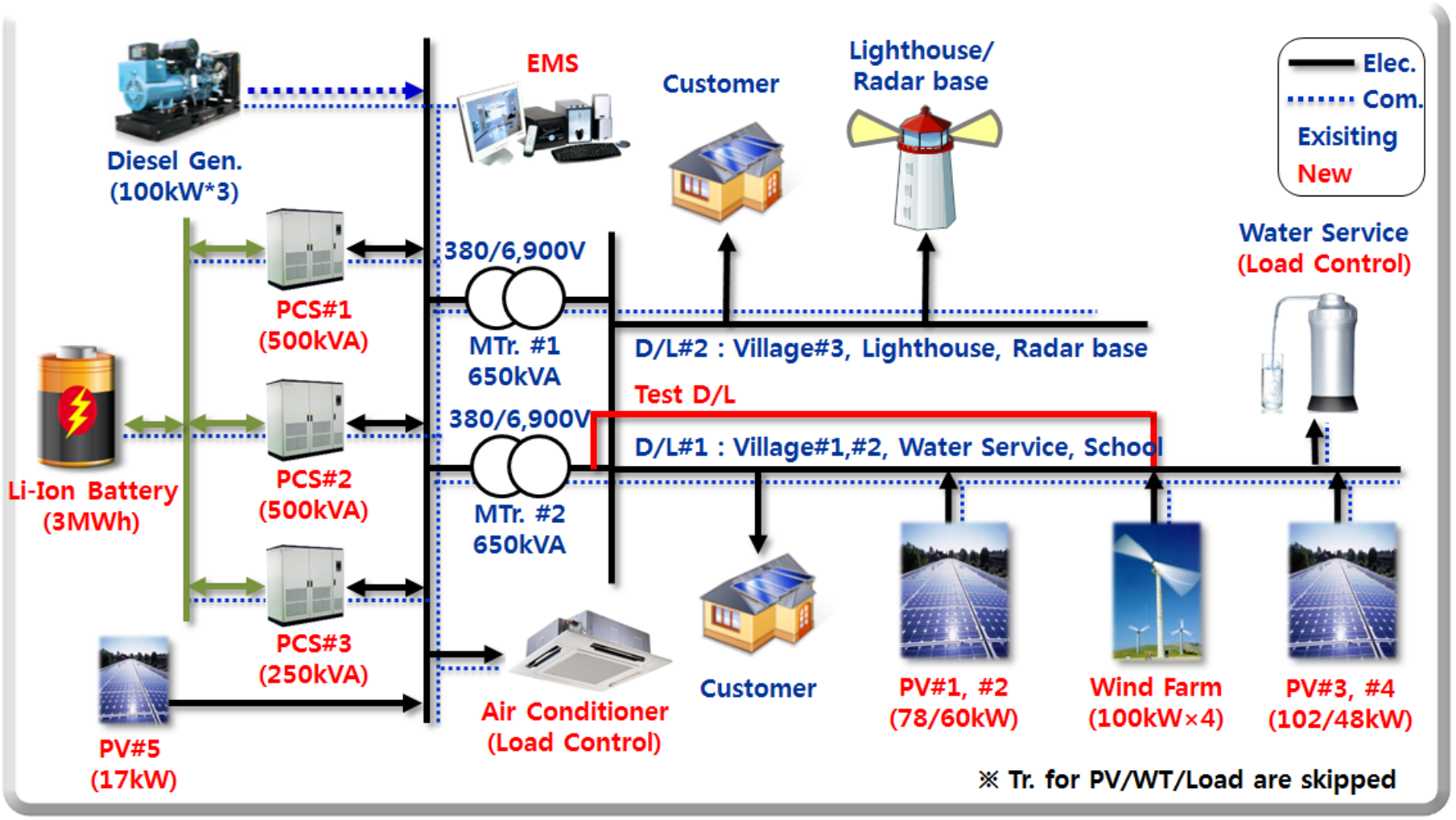


Practical realization as smart communities

Microgrids in Korea



Gasa Island, Korea

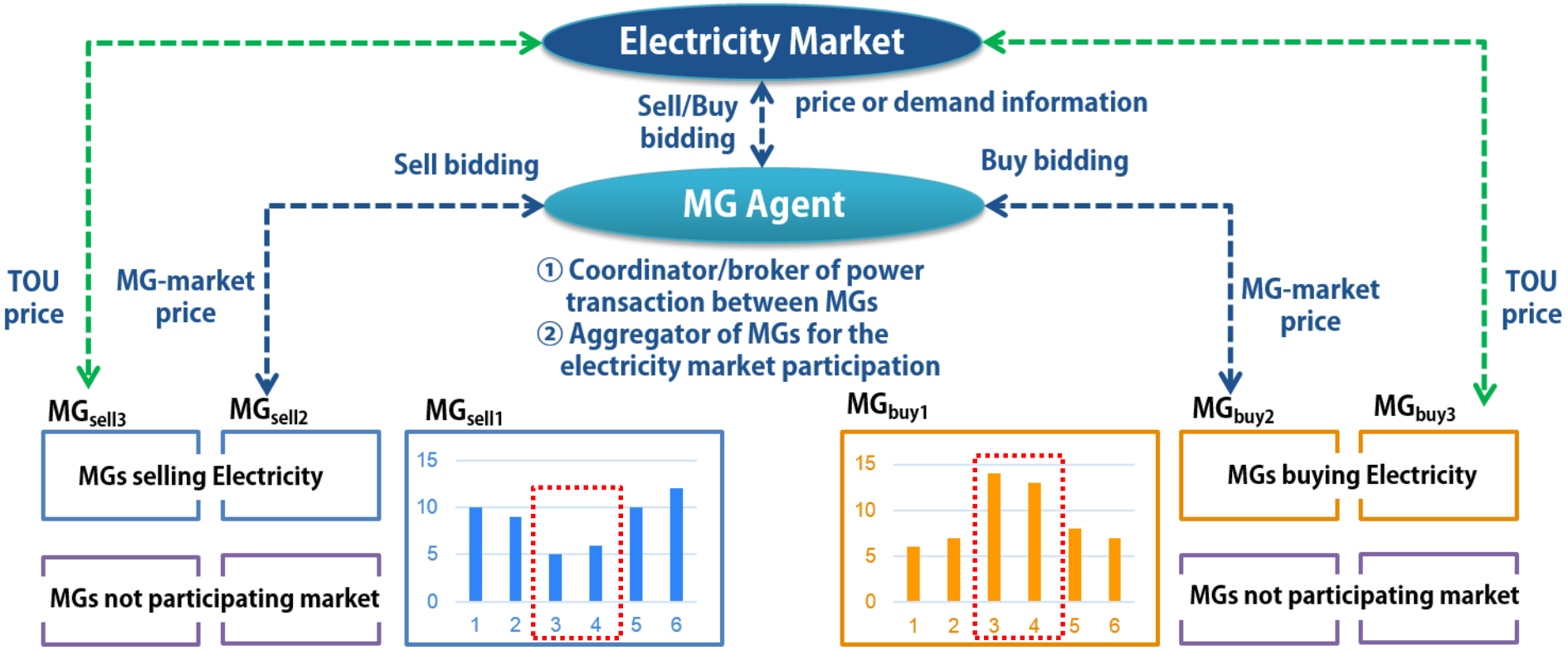


System Architecture

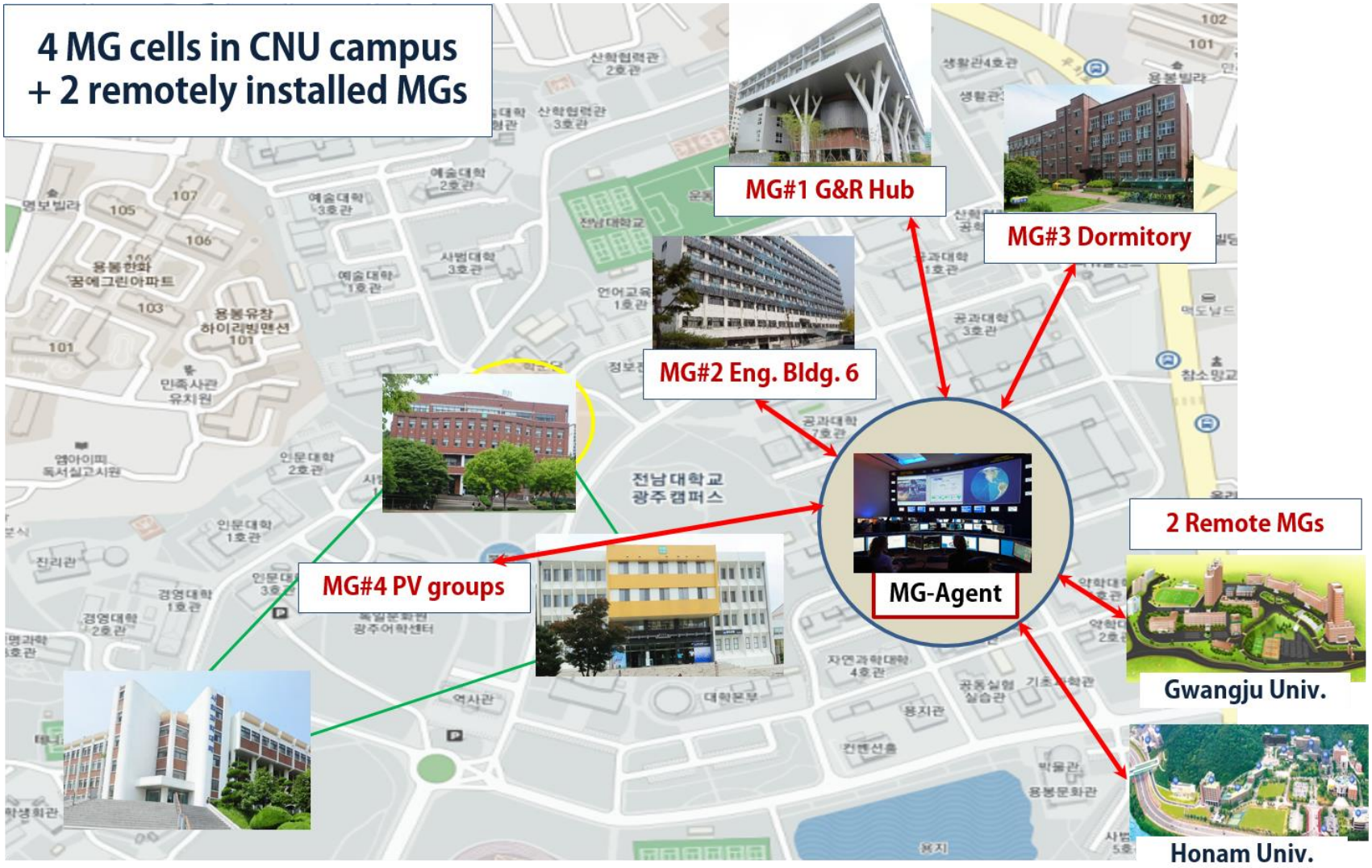
Smart Energy Campus: KEPCO, Korea

Chonnam National University MMG Concept

- Local MG & Agent System → Local MG EMS(Operation), Agent EMS(Transaction)
- Agent provides price info. + MGs bidding → Buy/Sell balancing (price & amount)
- Demonstration system : Market Simulator + MG Agent EMS + Local MG EMSs



Smart Energy Campus: KEPCO, Korea



Geocha Island, Korea

DC Island

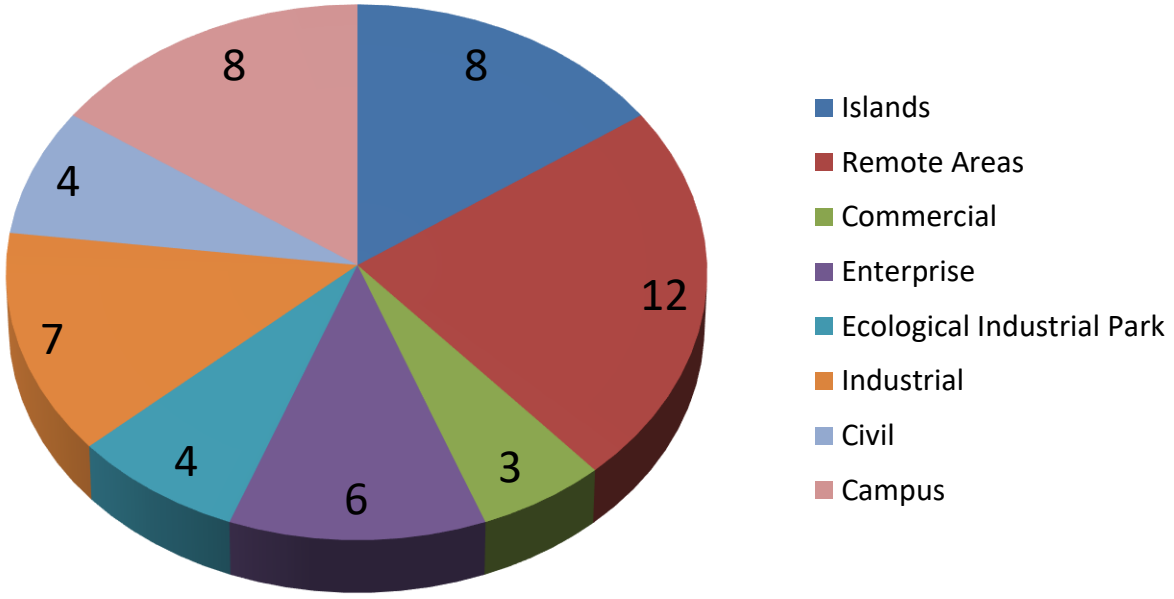
Jeju Carbon Free Island, Korea

- **Goal of Carbon Free Island by the 2030**
  - **Development of renewable generation**
    - **All thermal power plants are replaced to renewable energy**
  - **Acceleration of EV**
    - **All cars are replaced to electric vehicle (EV)**

Microgrid Activities in China

• It is estimated there are over **52** demonstration microgrids built in China up to 2016.

Breakdown of Microgrids by application or type



• On May 5th, 2017, China's National Energy Administration announced that **28** new microgrid demonstration projects will be constructed in the coming years.

Locations of 28 New Microgrid Projects in China

Grid-tied Microgrid

Islanded Microgrid

Highlights of Selected Typical New-Built Microgrids in China

Name	Configuration	Type	Specifications
Yanqing Microgrid	• 25 MWp new-built PV & 6.9 MWp existing PV system; • 2.5 MW solar thermal electric power generation; • 3 MW wind generation system; • 12.8MW CHP; • 12.4 MW electricity storage & 24.4 MW heating storage	Grid-tied	• RES penetration: > 100% • Electricity self-sufficiency: 113% • Power supply reliability: 99.995% • Seamless transfer ability
Hefei Hi-Tech District Microgrid	• 3.9 MWp PV; • 2MW/ 4MWH energy storage; • 11 250kW EV chargers; • 4.1 MWp PV; • 2MW/ 4MWH energy storage; • 11 250kW EV chargers;	Grid-tied	• RES penetration: > 100% • Electricity self-sufficiency: about 100% • Power supply reliability: 99.99% • Islanded operation capability
Beilong Island Microgrid	• 1.355 MWp PV; • 3 MWh energy-type storage & 1 MWh power-type storage • 600 kW diesel generation	Stand alone	• Storage penetration: 42.5% • Electricity self-sufficiency: 90%
Taishan Island Microgrid	• 1.5 MW wind generation & 200kWp PV • 10 kW wave generation & 200 kW diesel generation • 3.2 MWh energy storage	Stand alone	• Storage penetration: 23.4%

Microgrid Projects Supported by China's Government (2014-2017)

Project	Key Objectives	Funds (CNY)	Duration
Key technology & demonstration on customer-side intelligent microgrid based on distributed energy	• Operation modes, planning design, metering, control & protection, energy management and energy saving strategy for customer-side intelligent microgrid; • Develop high-performance microgrid central controller ; • Develop key equipment integrating bidirectional metering, monitoring & energy efficiency management; • Demonstrate obtained technologies on four sites.	--	4 Years (2014)
Key technology & demonstration on intelligent microgrid based on advanced energy efficiency management	• Develop multi-microgrid planning & design, operation & control, energy efficiency management, bidirectional metering technologies for intelligent microgrid; • Novel business model investigation for promoting the development of microgrids; • Demonstrate obtained technologies on four sites.	--	4 Years (2014)

Microgrid Projects Supported by China's Government (2014-2017)

Project	Key Objectives	Funds (CNY)	Duration
Key equipment and control system development & demonstration of PV microgrid	• Advanced PV inverter control technology based on virtual synchronous machine for parallel operation; • High-efficiency and intelligent charging/discharging technology of hybrid PV/battery system; • Seamless switching of PV microgrid; • Project demonstration.	--	(2015)
Key technology & demonstration on flexible integration of the distributed energy storage and PV system	• Planning & design of distributed energy generation systems with high-penetration renewable energy; • Advanced plug & play inverter technology and bidirectional power control of energy storage system; • Regulation & control of regional distributed generation systems in group; • Real-time simulation & measuring and testing techniques for distributed generation systems; • Project demonstration.	18 million	3 Years (2016)

Microgrid Projects Supported by China's Government (2014-2017)

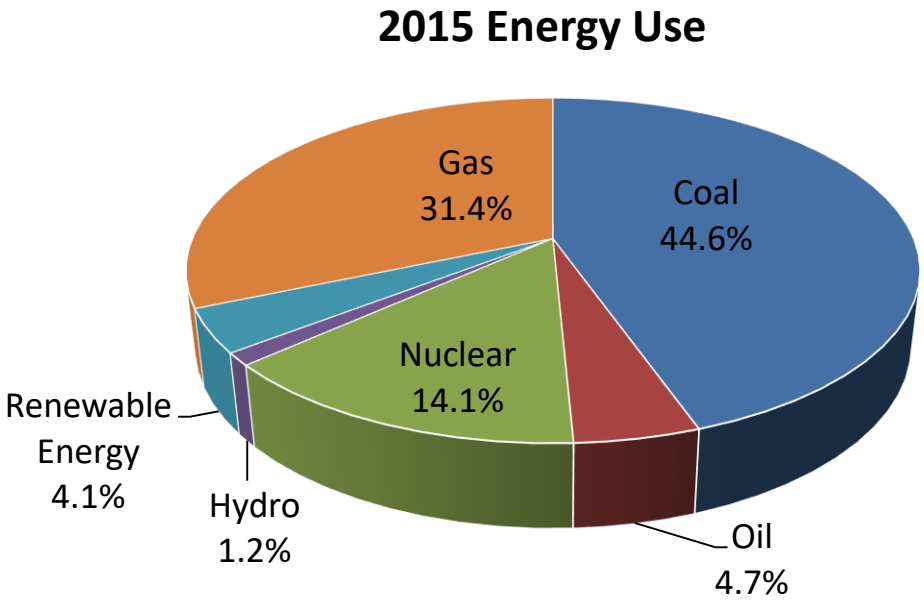
Project	Key Objectives	Funds (CNY)	Duration
Integrated utilization of multi-carrier distributed energy system	• Source-side energy storage mechanism of multi-carrier distributed energy system with renewable & fossil energy; • Off-design performance enhancement of multi-carrier distributed energy system; • Coupling mechanism of different energy with different energy level; • Active Control method of distributed generation system in all operating states.	27 million	5 Years (2016)
Demonstration of multi-energy complement & optimal integration of distributed energy system	• Homogeneous coupling modeling and analysis techniques for heterogeneous energy resources; • Complementary characteristics analysis of different types of power sources in multi-energy systems; • Planning & design method and optimize operation strategy of multi-energy system; • Project demonstration.	20.31 million	4 Years (2017)

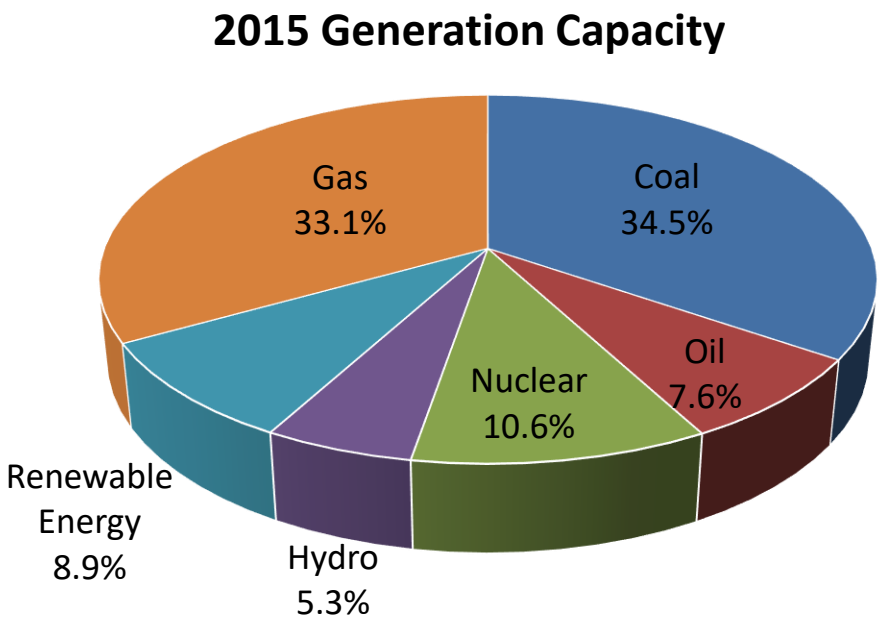
Developments on Related Energy Policies and Standards for Microgrids in China

Title	Date	Status
National standard on specification for test of microgrid connected to distribution network	2017 Aug	In force
Trial measurement to promote grid-tied microgrid construction	2017 Jul	In force
National standard on technical requirements for connecting microgrid to power system	2017May	In force
National standard on technical requirements for grid connection of distributed resources	2017May	In force
The 13th five-year plan for energy development	2016 Dec	In force
The 13th five-year plan for renewable energy development	2016 Dec	In force
Outline of the 13th five-year plan for national economic and social development of the People's Republic of China	2016 Mar	In force
Made in China 2025	2015 Jul	In force
Guidance on promoting the construction of new energy microgrid demonstration projects	2015 Jul	In force
Plan for transformation of power distribution network construction (2015-2020)	2015 Jul	In force
Strategic action plan for energy development (2014-2020)	2014 Nov	In force
Energy saving and new energy automotive industry development plan 2012–2020	2012 Jul	In force

Energy Use and Generation Capacity in Taiwan

- **In 2015, the total amount of energy use was 258 billion kWh.**
- **About 80% energy was supplied by fossil based power plants, which contributed 59% CO_2 emission nationwide.**



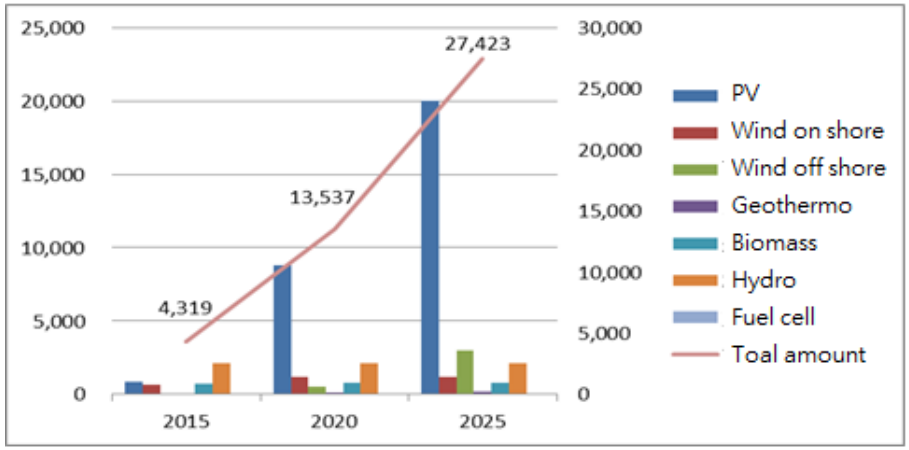


Source: Bureau of Energy (2016)

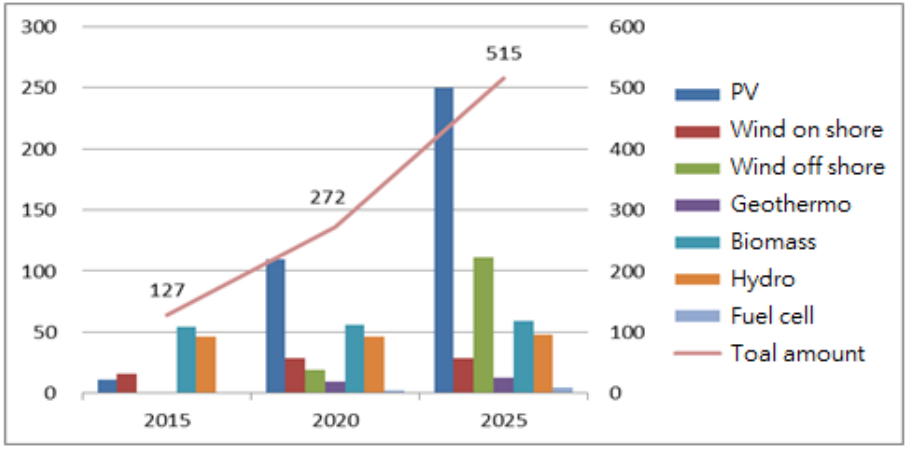
Framework of Taiwan's Renewable Energy Development

Ensure balanced development in energy security, green economy, environmental sustainability, and social equity so that the target of nuclear-free homeland can be achieved and the 20% share of renewable energy in the electricity system can be reached by 2025.

Renewable Energy Generation Capacty by 2025 (MW)



Renewable Energy Generation by 2025 ($x10^9$ kWh)



Source: Ministry of Economic Affairs (2016)

Smart Grid Demonstration Sites in Taiwan

1 Smart Grid Control Center and Smart Home Demo Room

Location: Tatung University
Exhibitors:
Tatung, Ministry of Educatio
National Science Council

2 Demonstration of Smart Meter Reading in a Metropolitan Setting

Location: Min-Shen Community in Tapei
Exhibitors:
Tatung, Acbel, DS2, Renesas

3 Micro-grid and Electric Vehicle Demonstration Site

Location: No. 3, Section 3, Zhongxing Rd, Xindian District, New Taipei City 231
Exhibitors: Haitec,Institute of Nuclear Energy Research

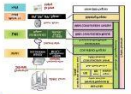
4 Advanced Distribution Automation Demo System

Location: Taipower Shulin TPRI Lab
Exhibitors: Allis Electric Company, Controlnet Technology, Fortune Electric Company, Hsiang Cheng Electric Corp.

5 Smart AC / DC Hybrid Micro-Grid Demonstration System

Location: CHEM Linkou (Taoyuan, Kwei Shan)
Exhibitors:
CHEM,INER, CAEC, Power General Corp.

6 Smart Meter Reading & Demand Response System

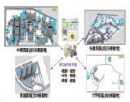


Location: National Central University in Zhong-li
Exhibitors:
Acbel, Tatung, Archmeter, Joseph Technology Co.

7 100 kW Autonomous Microgrid Demonstration System

Location: Institute of Nuclear Energy Research, Atomic Energy Council, Executive Yuan (Longtan)
Exhibitors: Chung Hsin Electric & Machinery, Delta Electronics, Yulon Energy Service

8 Smart Building Energy Conservation Demonstration Area

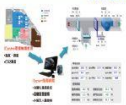


Location: Zhongxing campus, Industrial Technology Research Institute (ITRI), Zhudong Township, Hsinchu County
Exhibitors:
Archmeter, Sensing TEK

9 Wastewater Treatment Plant Power Equipment Monitoring and Energy Conservation Management System

Location: Hsinchu Science Park wastewater treatment plant
Exhibitors:
Axiom Environmental Engineering

10 Hypermarket Energy Conservation Management System



Location:
RT-Mart's Toufen store

11 Furnace Optimized Operation Demonstration System

Location: Toufen plant, China Petrochemical Development Corp

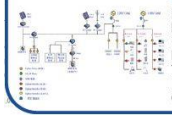
12 Optimizing Control System For a High-tech Plant Ice Water System

Location: Zhongke Rd., Central Taiwan Science Park, Taichung
Exhibitors:
AU Optronics

13 Smart DC Power System Educational Demonstration House

Location: Room 337, College of Education Building 2, National Chung Cheng University
Exhibitors: Sampo, Teco, Fu Feng Sheng, Fujitsu, Leader Electronics, Eulife Technology, E-ton Power

14 Smart Home (Building) Energy Management System



Location: 8th floor, Chi Mei Building, National Cheng Kung University
Exhibitors: ABB Taiwan, Netvox Technology, Tatung, Institute for Information Industry, Microtime Computer, Fontal Technology

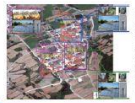
15 Smart Meter System and Home Energy Management System Demonstration Area

Location: Renjian Qingjing Community in Tainan, Bureau of Energy, MOEA
Exhibitors: eMeter,Institute for Information Industry,Acbel Polytech, Delta Networks, Archmeter,Tatung, Secom, Acbel Polytech, Shihlin, Top Tower, Taiwan Power Co., Bureau of Energy, MOEA, Tainan City Government, ITRI

16 Penghu Smart Grid Demonstration Site

Location: Main island of Penghu
Exhibitors: Bureau of Energy, MOEA, Taiwan Power Co., National Science Council

17 Dongkeng Smart Grid Demonstration Project



Location: Dongkeng community, Lieyu, Kinmen, Taiwan
Exhibitors: Chung Hsin Electric & Machinery, Emerald Battery, Amita Tech, Cybernet, Toplus Energy, RAC Electric Vehicles,Power General, Uniergy Engineering

18 Convenience Store Energy Conservation Management System

Location: FamilyMart stores throughout Taiwan
Exhibitors:
FamilyaMart Convenience Stores

Source: Taiwan Smart Grid Industry Association (2016)

Highlights of Selected Microgrids in Taiwan

Project	Key Objectives	Timeline
Microgrid and Electric Vehicle Demonstration Site (Xindian District, New Taipei City)	• Demonstrate energy management technologies; • Promote the smart EV industry, and hope to create a green energy golden value chain through the development of microgrid and EV, energy storage, and community energy industries.	2014 - Present
Smart AC / DC Hybrid Microgrid Demonstration System (CHEM Linkou, Taoyuan)	• 380 VDC/AC hybrid model microgrid system which can operate in grid-tied mode and islanded mode; • Energy management system controller which utilizes intelligent energy scheduling to maximize energy efficiency use. • Verify completion of CHEM's development on 10kW ~ 50kW bi-directional power converter, embedded power management systems and micro-grid energy management systems.	2013 - Present

Highlights of Selected Microgrids in Taiwan

Project	Key Objectives	Timeline
100 kW Autonomous Microgrid Demonstration System (INER, Longtan)	• Taiwan's first national-level 100 kW level microgrid test field; • Develop and implement core microgrid technologies; • Microgrid testing platform for industrial equipment and technology testing area to help firms enter the smart grid industry chain.	2012 - Present
Penghu Smart Grid Demonstration Site (Penghu Island)	• Demonstration area employing smart grid technologies, testing ground for industry; • Achieve the goals of increasing usage of renewable energy, enhancing the grid's troubleshooting ability, and boosting interaction between users and the grid.	2013 - Present
Dongkeng Smart Grid Demonstration Project (Kinmen)	• Promote green energy resources , develop energy management technologies; • Investigate the feasibility of the smart grid system, adjust and expand the scale for more communities, and fulfill the scope of zero carbon Kinmen island.	2013 - 2016

Microgrid Activities in Singapore

Singapore Institute of Technology
Multi-Energy Urban Microgrid

Pulau Ubin Microgrid Test-Bed

Experimental
Power Grid @
EPGC, A*STAR

Renewable Energy Integration
Demonstrator - Singapore (REIDS)

Four main Microgrid sites or facilities in Singapore supported by government funding.

Highlights of Microgrids in Singapore

Project	Key Objectives	Timeline
Pulau Ubin Microgrid Test-Bed (Ubin Island)	• Assess reliability of electricity supply within a microgrid infrastructure using renewable energy sources such as solar PV; • Platform for local companies and research institutions to develop and pilot energy-related technologies and solutions; • Showcase microgrid technologies and solutions for adoption for off-grid communities in the region.	2013 - Present
Experimental Power Grid @ EPGC, A*STAR (Jurong Island)	• Configurable microgrid for research & development, testing & validation of microgrid systems or equipment; • Pre-deployment test-bedding of grid solutions; • Platform for development of technologies to address national challenges; • Support industries' development of microgrid solutions for local and overseas markets.	2011 - Present

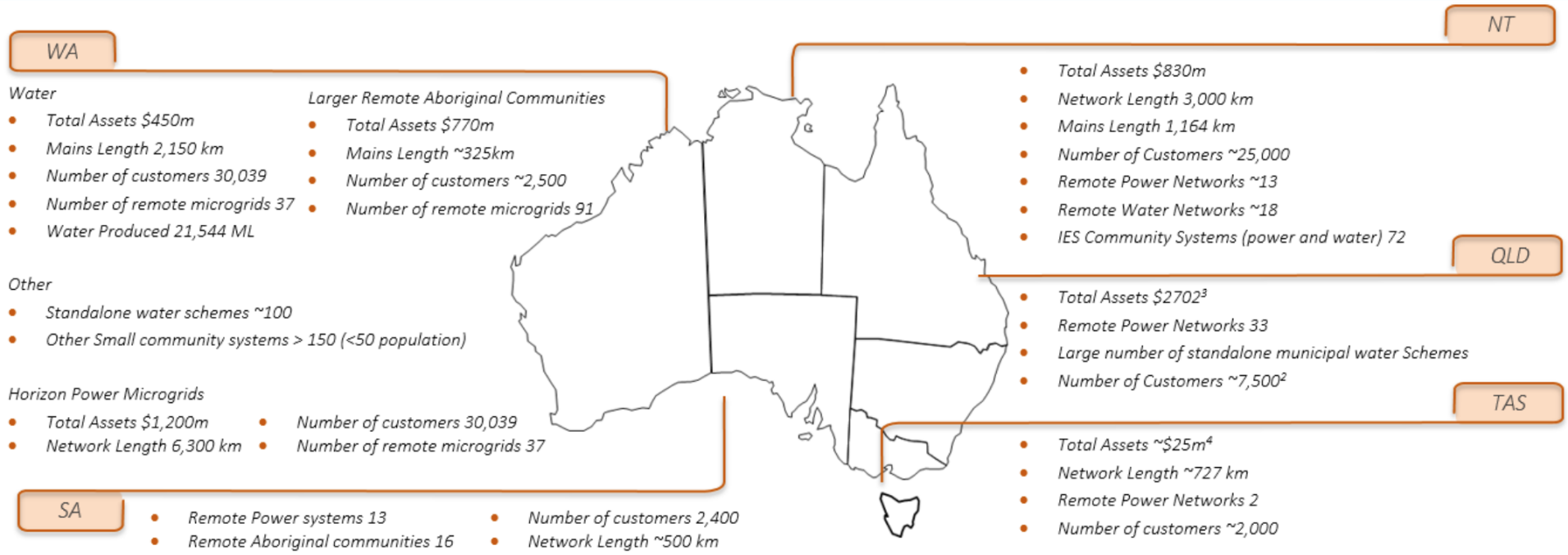
Highlights of Microgrids in Singapore

Project	Key Objectives	Timeline
Renewable Energy Integration Demonstrator – Singapore (REIDS) (Semakau Island)	• RD&D platform dedicated to demonstration and testing of solutions for sustainable multi-activity off-grid communities in Southeast Asia; • Targeting islands, remote applications, emergency situations, fringe networks, military bases.	2016 - Present
Singapore Institute of Technology (SIT) Multi-Energy Urban Microgrid (Punggol Campus)	• Currently in planning, targeted completion in 2023; • Southeast Asia's first university campus microgrid; • Support the research, development and test-bedding of distributed energy systems; • Support training and manpower development for industry (hands-on experience for university students).	Target completion in 2023

Highlights of Microgrids in Australia

- Key projects are associated with:
  - *Fringe of the grid*, typically to:
    - Avoid reinforcement costs due to long and network connection
    - Improve reliability, again especially in those cases of long, unreliable network connections
  - *Isolated communities* and *islands*, where network connection may be too costly or infeasible
  - *Community energy systems*, especially based on solar PV and batteries
  - *Demonstration projects* to test new technologies, equipment and control strategies

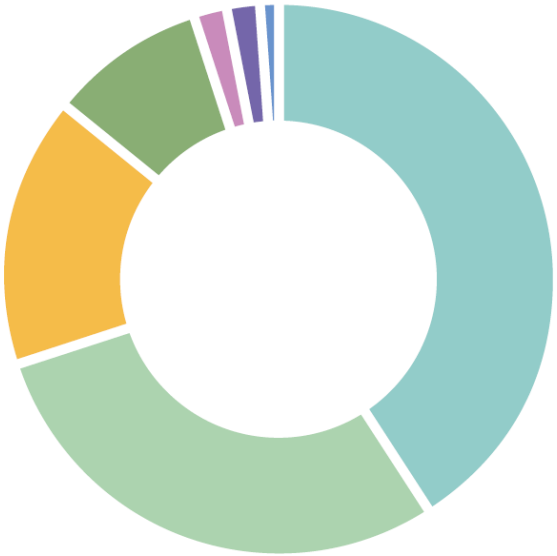
Highlights of Microgrids in Australia



Various examples will be presented throughout the Symposium

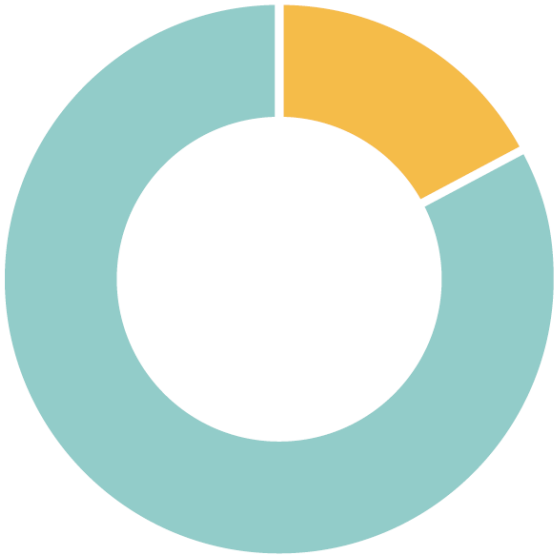
Renewables in Australia

RENEWABLE GENERATION BY TECHNOLOGY TYPE



Hydro	42.3%
Wind	30.8%
Small-scale solar PV	16.0%
Bioenergy	8.6%
Large-scale solar PV	1.2%
Medium-scale solar PV	1.1%
Solar thermal	0.1%

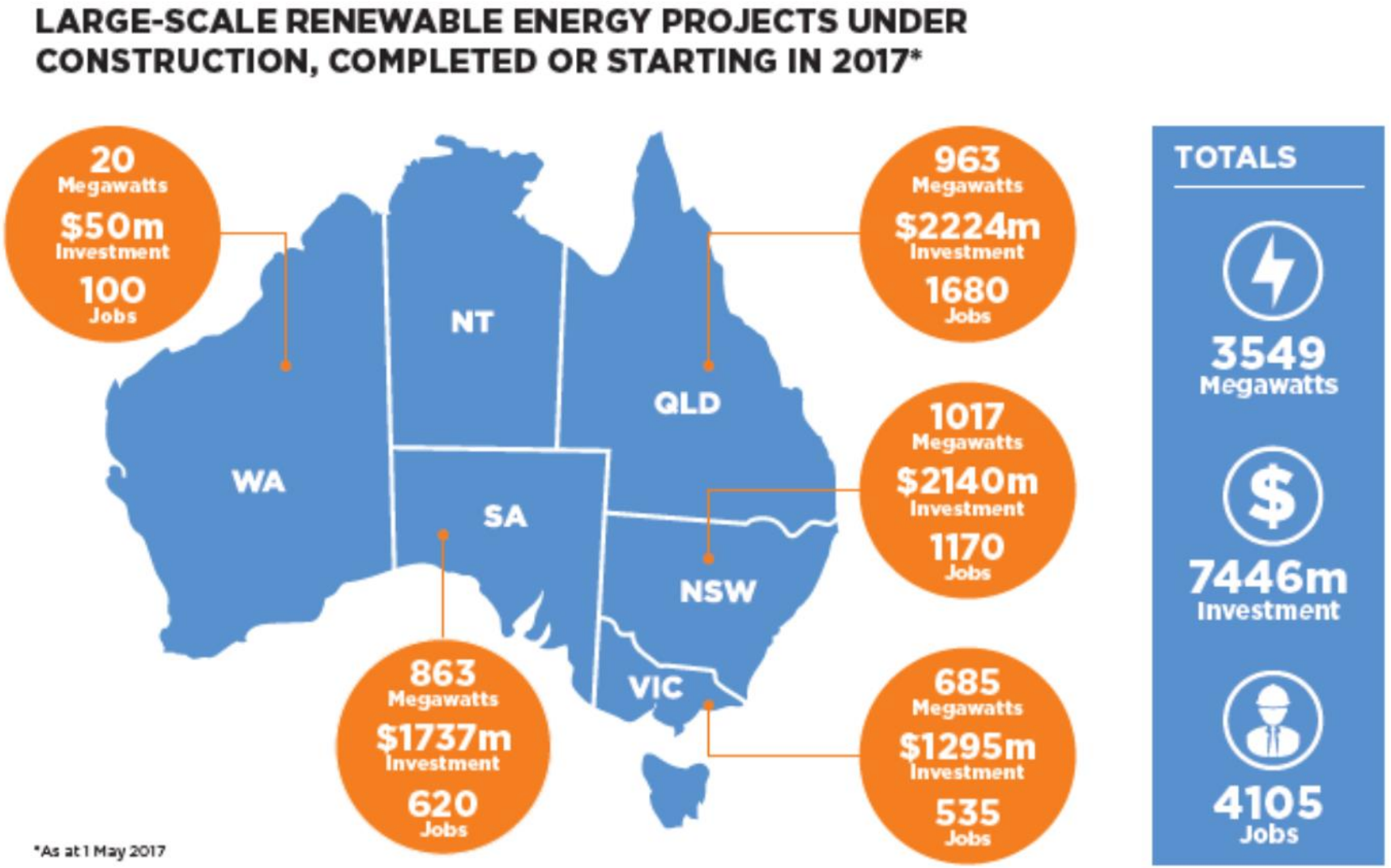
ANNUAL ELECTRICITY GENERATION IN 2016



Renewables	17.3%
Fossil fuels	82.7%

Source: Clean Energy Australia Report 2016

Renewables in Australia



Source: Clean Energy Australia Report 2016