Overview of Microgrids in Asia

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<table>
<thead>
<tr>
<th>Country</th>
<th>Name</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>Toshifumi ISE</td>
<td>Osaka University</td>
</tr>
<tr>
<td>Korea</td>
<td>Dong Jun WON</td>
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<td>Experimental Power Grid Centre, A*STAR</td>
</tr>
</tbody>
</table>
### Past Major Demos on Microgrid in Japan

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

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

Power Plant of Osaka Gas Co. outside the Power Supply Area

Supply Power

Simultaneous same amount of power for 30 minutes

Combined Heat and Power 4,000kW

OGCTS (Osaka Gas Creative Techno Solutions Co.)

Transmission line of the Kansai Electric Power Co.

Demand Power (Total 7,000kW)

ICC Building

Gas Building

Gas Museum

Do-It-Yourself Store

SOFC 3kW

PV 18kW

Battery 50kWh

CHP 427kW

Battery 155kW

PV 27kW

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Heat Utilization

Reduction of Energy Consumption and Emission of CO₂ by using Combined Heat and Power and Solar Thermal Plant

Existing DHC Plant

Gas\( (\text{hu} + g) \) Museum

- GAS \( 427\text{kW} \)
- 120kW Solar Thermal plant
- 2.5MJ/h Heat collecting pipe

DHC Plant \( 3474\text{kW} \)

Do-It-Yourself Store

- 31kW × 5 sets

Shopping Mall

- 815kW × 2 sets

Main Plant

- Gas absorption chillers
- Centrifugal chiller
- Gas boiler

ICC (Iwasaki Computer Center) Building

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Smart Community Project in SHIBAURA, Tokyo

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

Building A
(Medium Scale Office)
Bulk Receiving Power
Combined Heat & Power (CHP)
13,060m²

Building B
(Housing Complex)
6,155m²

Building C
(Small Scale Office)
2,182m²

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

- **Energy Net Zero Island**
  - KEPCO, KT, LG CNS, POSCO
    - Deokjeok Island
    - Sapsi Island
    - Geomun Island
    - Chuja Island
    - Gasa Island
    - Jo Island

- **DC Distribution and DC Microgrid**
  - KEPCO & LSIS
    - Gochang Site
    - Geocha Island

- **Campus Microgrid**
  - LSIS & KEPCO
    - Seoul National Univ.
    - Dongshin Univ.
    - Chonnam National Univ.

- **Ulleung and Jeju island Eco platform**
  - KEPCO, LG CNS
    - Ulleung Island
    - Jeju Island

- **Daegu Industry Complex**
Gasa Island, Korea

System Architecture
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

Chonnam National University MMG Concept

Smart Energy Campus: KEPCO, Korea

Electricity Market

MG Agent

1. Coordinator/broker of power transaction between MGs
2. Aggregator of MGs for the electricity market participation

MGs selling Electricity
MGs not participating market

MGs buying Electricity
MGs not participating market

TOU price
MG-market price

Sell bidding
Buy bidding

Sell/Buy bidding
price or demand information

MG

sell

sell1

sell2

sell3

buy1

buy2

buy3

Table 1: Market Participant Classification

<table>
<thead>
<tr>
<th>MG Type</th>
<th>Selling</th>
<th>Buying</th>
<th>Participating</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGsell1</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>MGsell2</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>MGsell3</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>MGbuy1</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>MGbuy2</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>MGbuy3</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Graph 1: MGs Participation in the Electricity Market

Graph 2: TOU Price and MG-Price Dynamics
Smart Energy Campus: KEPCO, Korea

4 MG cells in CNU campus + 2 remotely installed MGs

- MG#1 G&R Hub
- MG#2 Eng. Bldg. 6
- MG#3 Dormitory
- MG#4 PV groups
- MG-Agent
- 2 Remote MGs
- Gwangju Univ.
- Honam Univ.
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.

• 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
### Highlights of Selected Typical New-Built Microgrids in China

<table>
<thead>
<tr>
<th>Name</th>
<th>Configuration</th>
<th>Type</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yanqing Microgrid</td>
<td>• 25 MWp new-built PV &amp; 6.9 MWp existing PV system;</td>
<td>Grid-tied</td>
<td>• RES penetration: &gt; 100%</td>
</tr>
<tr>
<td></td>
<td>• 2.5 MW solar thermal electric power generation;</td>
<td></td>
<td>• Electricity self-sufficiency: 113%</td>
</tr>
<tr>
<td></td>
<td>• 3 MW wind generation system;</td>
<td></td>
<td>• Power supply reliability: 99.995%</td>
</tr>
<tr>
<td></td>
<td>• 12.8MW CHP;</td>
<td></td>
<td>• Seamless transfer ability</td>
</tr>
<tr>
<td></td>
<td>• 12.4 MW electricity storage &amp; 24.4 MW heating storage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hefei Hi-Tech District Microgrid</td>
<td>• 3.9 MWp PV;</td>
<td>Grid-tied</td>
<td>• RES penetration: &gt; 100%</td>
</tr>
<tr>
<td></td>
<td>• 2MW/ 4MWH energy storage;</td>
<td></td>
<td>• Electricity self-sufficiency: about 100%</td>
</tr>
<tr>
<td></td>
<td>• 11 250kW EV chargers;</td>
<td></td>
<td>• Power supply reliability: 99.99%</td>
</tr>
<tr>
<td></td>
<td>• 4.1 MWp PV;</td>
<td></td>
<td>• Islanded operation capability</td>
</tr>
<tr>
<td></td>
<td>• 2MW/ 4MWH energy storage;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 11 250kW EV chargers;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beilong Island Microgrid</td>
<td>• 1.355 MWp PV;</td>
<td>Stand alone</td>
<td>• Storage penetration: 42.5%</td>
</tr>
<tr>
<td></td>
<td>• 3 MWh energy-type storage &amp; 1 MWh power-type storage</td>
<td></td>
<td>• Electricity self-sufficiency: 90%</td>
</tr>
<tr>
<td></td>
<td>• 600 kW diesel generation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taishan Island Microgrid</td>
<td>• 1.5 MW wind generation &amp; 200kWp PV</td>
<td>Stand alone</td>
<td>• Storage penetration: 23.4%</td>
</tr>
<tr>
<td></td>
<td>• 10 kW wave generation &amp; 200 kW diesel generation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 3.2 MWh energy storage</td>
<td></td>
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<table>
<thead>
<tr>
<th>Project</th>
<th>Key Objectives</th>
<th>Funds (CNY)</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key technology &amp; demonstration on customer-side intelligent microgrid</td>
<td>• Operation modes, planning design, metering, control &amp; protection, energy management and energy saving strategy for customer-side intelligent microgrid;</td>
<td>--</td>
<td>4 Years (2014)</td>
</tr>
<tr>
<td></td>
<td>• Develop high-performance microgrid central controller;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Develop key equipment integrating bidirectional metering, monitoring &amp; energy efficiency management;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Demonstrate obtained technologies on four sites.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Key technology &amp; demonstration on intelligent microgrid based on advanced energy efficiency management</td>
<td>• Develop multi-microgrid planning &amp; design, operation &amp; control, energy efficiency management, bidirectional metering technologies for intelligent microgrid;</td>
<td>--</td>
<td>4 Years (2014)</td>
</tr>
<tr>
<td></td>
<td>• Novel business model investigation for promoting the development of microgrids;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Demonstrate obtained technologies on four sites.</td>
<td></td>
<td></td>
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<tr>
<th>Project</th>
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<th>Funds (CNY)</th>
<th>Duration</th>
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</table>
| **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) |

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<th>Funds (CNY)</th>
<th>Duration</th>
</tr>
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</table>
| 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

<table>
<thead>
<tr>
<th>Title</th>
<th>Date</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>National standard on specification for test of microgrid connected to distribution network</td>
<td>2017 Aug</td>
<td>In force</td>
</tr>
<tr>
<td>Trial measurement to promote grid-tied microgrid construction</td>
<td>2017 Jul</td>
<td>In force</td>
</tr>
<tr>
<td>National standard on technical requirements for connecting microgrid to power system</td>
<td>2017 May</td>
<td>In force</td>
</tr>
<tr>
<td>National standard on technical requirements for grid connection of distributed resources</td>
<td>2017 May</td>
<td>In force</td>
</tr>
<tr>
<td>The 13th five-year plan for energy development</td>
<td>2016 Dec</td>
<td>In force</td>
</tr>
<tr>
<td>The 13th five-year plan for renewable energy development</td>
<td>2016 Dec</td>
<td>In force</td>
</tr>
<tr>
<td>Outline of the 13th five-year plan for national economic and social development of the People's Republic of China</td>
<td>2016 Mar</td>
<td>In force</td>
</tr>
<tr>
<td>Made in China 2025</td>
<td>2015 Jul</td>
<td>In force</td>
</tr>
<tr>
<td>Guidance on promoting the construction of new energy microgrid demonstration projects</td>
<td>2015 Jul</td>
<td>In force</td>
</tr>
<tr>
<td>Strategic action plan for energy development (2014-2020)</td>
<td>2014 Nov</td>
<td>In force</td>
</tr>
<tr>
<td>Energy saving and new energy automotive industry development plan 2012–2020</td>
<td>2012 Jul</td>
<td>In force</td>
</tr>
</tbody>
</table>
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% CO₂ 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.

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 Education, National Science Council

2. **Demonstration of Smart Meter Reading in a Metropolitan Setting**
   - Location: Min-Shen Community in Taipei
   - Exhibitors: Tatung, Acbel, DS2, Renesas

3. **Micro-grid and Electric Vehicle Demonstration Site**
   - Location: No. 3, Section 3, Zhongying Rd, Xinian District, New Taipei City 231
   - Exhibitors: Halcie, Institute of Nuclear Energy Research

4. **Advanced Distribution Automation Demo System**
   - Location: Taipower Shulin TPR Lab

5. **Smart AC/DC Hybrid Micro-Grid Demonstration System**
   - Location: CHEM Linkou (Taiyuan, Kwei Shan)
   - Exhibitors: CHEM.INER, CAEC, Power General Corp.

6. **Smart Meter Reading & Demand Response System**
   - Location: National Central University in Zhongli
   - 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, Yalin Energy Service

8. **Smart Building Energy Conservation Demonstration Area**
   - Location: Zhongying campus, Industrial Technology Research Institute (ITRI), Zhongli 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. **Optimizing Control System for a High-tech Plant Ice Water System**
    - Location: Zhongke Rd., Central Taiwan Science Park, Taichung
    - Exhibitors: AU Optronics

11. **Furnace Optimized Operation Demonstration System**
    - Location: Toufen plant, China Petrochemical Development Corp.

12. **Smart DC Power System Educational Demonstration House**
    - Location: Room 337, College of Education Building 2, National Chung Cheng University
    - Exhibitors: Sampo, Tecso, Fei Feng Sheng, Fujitsu, Leader Electronics, E'life Technology, E-ion Power

13. **Smart Home (Building) Energy Management System**
    - Location: 5th floor, Chi Mei Building, National Cheng Kung University
    - Exhibitors: ABB Taiwan, Nettex Technology, Tatung, Institute for Information Industry, Microtime, Computer, Fenta Technology

14. **Smart Meter System and Home Energy Management System Demonstration Area**

15. **Penghu Smart Grid Demonstration Site**
    - Location: Main island of Penghu
    - Exhibitors: Bureau of Energy, MOEA, Taipower Co., National Science Council

16. **Dongkeng Smart Grid Demonstration Project**
    - Location: Dongkeng community, Lien, Taiwan

17. **Convenience Store Energy Conservation Management System**
    - Location: FamilyMart stores throughout Taiwan
    - Exhibitors: FamilyMart Convenience Stores

Source: Taiwan Smart Grid Industry Association (2016)
## Highlights of Selected Microgrids in Taiwan

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<thead>
<tr>
<th>Project</th>
<th>Key Objectives</th>
<th>Timeline</th>
</tr>
</thead>
</table>
| **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

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<tr>
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</table>
| **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

Four main Microgrid sites or facilities in Singapore supported by government funding.
### Highlights of Microgrids in Singapore

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</thead>
</table>
| **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

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</table>
| **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

Source: Clean Energy Australia Report 2016
Renewables in Australia

LARGE-SCALE RENEWABLE ENERGY PROJECTS UNDER CONSTRUCTION, COMPLETED OR STARTING IN 2017*

- **20 Megawatts**
  - $50m Investment
  - 100 Jobs

- **963 Megawatts**
  - $2224m Investment
  - 1680 Jobs

- **1017 Megawatts**
  - $2140m Investment
  - 1170 Jobs

- **863 Megawatts**
  - $1737m Investment
  - 620 Jobs

- **685 Megawatts**
  - $1295m Investment
  - 535 Jobs

**TOTALS**

- 3549 Megawatts
- $7446m Investment
- 4105 Jobs

*As at 1 May 2017

Source: Clean Energy Australia Report 2016