Overview of Microgrids in Asia

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# Key Contributors

<table>
<thead>
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<th>Country</th>
<th>Name</th>
<th>Organisation</th>
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<td>China</td>
<td>Meiqin MAO</td>
<td>Hefei University of Technology</td>
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<td>Dongjun WON</td>
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<td>CSIRO</td>
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Microgrid Activities in China

• It is estimated that there are over 80 demonstration microgrids or multi-microgrid groups built in China up to the middle of 2018, 28 were identified as “the first batch of new-energy demonstration microgrids” by NDRC and NEA.

![Microgrids by applications or types (up to 2018)](chart)

• It is supposed that at least 15 microgrid-related projects covering campus- to enterprise-type microgrid have been newly-announced from then on, making the number of MGs in China approach to 100.
Locations of Part Microgrids in China

- Grid-tied
- Islanded

Existed MGs up to June, 2018

Newly-reported MGs from July, 2018 to July, 2019
Microgrid in TaiShan Antarctic Research Station

Basic Information

- Completed around Feb. 2019
- China’s first Wind/PV/diesel/battery MG deployed in Antarctic area.
- Most of demands, even in the polar nights, are provided by Wind and PV generation, extra electricity could be stored in the battery units as backup.
- In extreme situations, diesel generators will be activated autonomously to supply the loads.
- Equipped with a set of unattended operation system, could be remote-monitored and remote-operated via Iridium Satellite Communications.

http://www.sohu.com/a/302186630_764234
http://www.sohu.com/a/303797031_100016667
Microgrid in Kaishan island (开山岛)

Basic Information

- **0.0013 km²** area, islanded intelligent microgrid, accomplished in **June, 2019**
- **Configuration**: 110kW PV, 30kW wind generator, 50kW backup diesel generator and 660 kwh battery. 32 solar-energy road lamps and one set of 10t/d Desalination system
- **150 MWh electricity** and **3650 t fresh water** could be provided per year to totally fulfill the demand on the island
- **Three-day** uninterrupted electricity supply could be achieved by the backup supply and batteries

http://www.sohu.com/a/141329757_708433  
Microgrid in Kaishan island (开山岛)

Some field Photos

Panorama of the Kaishan microgrid

Desalination system

Battery system

Roof PV panels

http://www.sasac.gov.cn/n2588025/n2588124/c11531011/content.html
http://www.nengyuanjie.net/article/27617.html
New-energy town in Tongli, Suzhou

Basic Information

- Located in Wujiang, Suzhou, Jiangsu,
- A renowned typical ancient water town in southern Yangtze River,
- Having picturesque “Bridges, Rivers and Architectures”,
- Permitted to establish “New-energy” town by NEA in Nov, 2016; Permanent venue of The International Forum on Energy Transitions,
- Comprehensive energy service centre was put into use in Oct, 2018.
New-energy town in Tongli, Suzhou

Highlights and innovative technologies demonstrated inside the Town

- Multi-energy complementary utilization
- High-temperature phase change photothermal power generation

PV, wind energy, terrestrial heat, tide energy are used

- Prefabricated-cabin energy storage system
- High temperature phase change heat storage

- Hybrid energy storage
- Modular
- Easy to install, transport and maintain

- 20kW*15s SC & 200kW*2h lithium battery connected with ±375V DC bus
- 80kW*15s SC & 400kW*2h lithium battery connected with ±750V DC bus

http://www.cnenergy.org/xny_183/cn/201811/t20181128_744030.html
New-energy town in Tongli, Suzhou

Highlights and innovative technologies demonstrated inside the Town

- Compressed-air energy storage
- Energy router (Power electronics Transformer)
- Low-voltage DC ring distribution network
- Supply/grid/storage/load coordinated control system

±750V DC ring structure, allowing bidirectional energy flow
New-energy town in Tongli, Suzhou

Highlights and innovative technologies demonstrated inside the Town

- 3 in 1 “electronic road”: unpiloted driving + wireless charging + PV generation

- Green charging and swapping station

Robot-assistant Bus battery swapping station
Cascade utilization of Retired batteries

https://www.nengapp.com/news/detail/1805502
New-energy town in Tongli, Suzhou

Highlights and innovative technologies demonstrated inside the Town

- Virtual Synchronous Generator

- Intelligent “passive” house

- "Han” tile (汉瓦)
  - 20.31 kW, 677 pc * 30w Hantile

- "Han” wall (汉墙)
  - 407 m² area Hanwall

Jiayuan building in Tongli is the first “passive house” in China, certificated by MOHURD China & DENA German. It is “Zero emission” and other features.

Media’s coverage

https://www.sohu.com/a/270561709_289078
Microgrid in China Urban-Rural and Energy Planning

Beijing

➢ “The 13th five-year electricity and renewable energy development planning for Beijing” states, “...promote 3 new-energy microgrid projects’ construction by 2020...”,

➢ “...explore novel technologies, management and operation modes for microgrids...”,

➢ “…built ‘7+1’ grid-tied microgrid group(7 main grid, 1 loop grid) to achieve advanced energy-physical network which features multi-energy complementary, autonomous control of each sub-grid and coordinated operation among the sub-grids...”,

➢ “…establish distributed PV, microgrid standards to enrich the standard system of new-energy...”,

➢ “…explore user-centric novel energy services and novel market subjects, such as virtual power plant, load aggregator, etc...”
Microgrid in China Urban-Rural and Energy Planning

❖ Xiong’an New District

➢ “Specialized planning of electricity and grid for Xiong’an new district” states, …reliability of power supply will reach 99.999%, 99.9999% for the key areas. And it will achieve 100% local clean-energy consumption and 100% clean-electricity provision…”,

➢ “Hybrid AC/DC microgrid and DC microgrid will be explored and implemented, centralized and distributed energy storage system will be reasonably employed to achieve bidirectional energy flow…”.

➢ “Application scheme of DC microgrid for Xiong’an” has been completed.

As it estimated incompletely, more than 70% provinces in China have identified the microgrid related technologies or demonstrations as the key objectives in their energy plannings.
Related Microgrid Standards in China

- Microgrid-related standard have gained rapid and fruitful developments in China since 2016;
- The microgrid standard system in China consists of National Standard, Provincial Standard, Industrial Standard, Group Standard and Enterprise Standard, and the scope of microgrid standard system covers most applied technologies for both grid-tied and islanded microgrid, from distributed generator control to microgrid planning and designing, from monitoring and control system to protection equipment, from DC microgrid to Hybrid microgrid, etc.
- According to incomplete statistics, there are nearly 50 implemented and ongoing microgrid standards in China up to 10th July, 2019.

Breakdown of different Microgrid Standards in China
## Related Microgrid Standards (In force) in China

<table>
<thead>
<tr>
<th>Title</th>
<th>Serial No.</th>
<th>Publish Date</th>
<th>Published by</th>
<th>type</th>
</tr>
</thead>
</table>

SAC: Standardization administration of China  
NEA: national environment agency  
CEC: China Electricity Council
Microgrid Activities in Korea

• Domestic MG Projects
  • Campus Microgrid: Seoul National University, Chonnam National University, Dongshin University (Finished in 2019)
  • DC microgrid: Geocha island (Finished in 2019)
  • Industry Complex microgrid: Daegu, Dongsoo

• International MG Collaboration Projects
  • Incheon National University & Imperial College of London (UK): Resilient HYbrid Technology for High-value Microgrids (RHYTHM)
  • Doosan Heavy Industry & Texas, USA: DERMS(Distributed Energy Resource Management System)
  • Encored Technologies & NELHA (Hawaii, USA): AI based microgrid
Seoul National University Campus Microgrid, LSIS

- Project Goal
  - 4 hour islanding operation to critical loads
  - 20% peak load reduction and energy cost saving based on campus operating model
  - Consumer participative energy saving services by employing big-data platform
Seoul National University Campus Microgrid, LSIS

- **SNU System for Demonstration**
  - **Premium Cell**: Critical load with seamless transfer islanding operation and high power quality
  - **Normal Cell**: Normal load with DERs (PV and ESS)
  - **Virtual Cell**: Normal load with IoT Sensor (without DERs)
Seoul National University Campus Microgrid, LSIS

[Microgrid of Microgrid Center (MoMC)]

[Seamless transfer Islanding operation for Premium Cell]

1. Grid Connected
2. Seamless Transfer Islanding
3. DG Operation
4. Power Sharing
5. Grid re-connected
Seoul National University Campus Microgrid, LSIS

[20% peak load reduction and energy cost savings for Normal Cell]

[Consumer participative energy-saving services for Virtual Cell]
DC Microgrid: Dongsoo Agricultural and Industrial Complex

[DC microgrid configuration]

- Multi-microgrid operation
- DC Microgrid operation
- Enhancement of energy efficiency
- ESS energy sharing and CHP operation
DC Microgrid: Dongsoo Agricultural and Industrial Complex

[MG Measurement points]
DC Microgrid: Dongsoo Agricultural and Industrial Complex

[DC Microgrid with ESS Energy Sharing in the Complex]

[Wastewater treatment plant PV]  [ESS]  [CHP]

[TOC]  [Factory PV]  [E-House]
RHYTHM (Korea/UK Collaboration Project)

Development of Technology for Resilience Improvement of High Power Quality AC/DC Hybrid Microgrid

- EMS core technology to improve resilience performance
- Core technology of AC-DC interlink converter considering resilience performance
- Core Technology for Improving the Stability of Control in Independent Operation Mode for Resilience Performance Improvement
- High reliability real-time (low-latency inter-load) communication core technology
- Hybrid AC-DC Microgrid Integrated Design Technology

• Project Title
  – Development of Resilient HYbrid Technology for High-value Microgrids (RHYTHM)

• Leading Institutions
  – Incheon University(Hakman Kim), Imperial College of London (Tim Green)

• Project period
  – 04/01/2016 ~03/31/2019 (36 months)
**RHYTHM (Korea/UK Collaboration Project)**

**[AC-DC Hybrid Microgrid Pilot Plant]**

**Energy Management System**

- **380 V / 100 kW**
- **750 Vdc / 100 kW**
- **Interlink Converter 100 kW**

**AC Microgrid Pilot Plant**

**DC Microgrid Pilot Plant**

<table>
<thead>
<tr>
<th>Pilot Plant</th>
<th>Unit</th>
<th>Power</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATM3</td>
<td>PV 1</td>
<td>380V-50Hz</td>
<td>MPPT</td>
</tr>
<tr>
<td></td>
<td>PV 2</td>
<td>380V-50Hz</td>
<td>MPPT</td>
</tr>
<tr>
<td></td>
<td>D/E</td>
<td>220/50Hz</td>
<td>P-P</td>
</tr>
<tr>
<td></td>
<td>Load</td>
<td>100kW-50Hz</td>
<td>10kHz sin</td>
</tr>
<tr>
<td></td>
<td>ESS</td>
<td>5kW/30kWh</td>
<td>CP</td>
</tr>
<tr>
<td></td>
<td>Battery stack</td>
<td>Li-conv/90kWh</td>
<td>-</td>
</tr>
</tbody>
</table>

**DCM3**

<table>
<thead>
<tr>
<th>Pilot Plant</th>
<th>System</th>
<th>Power</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCM3</td>
<td>Interlink Converter</td>
<td>750Vdc-100Hz</td>
<td>MPPT, PCC</td>
</tr>
<tr>
<td></td>
<td>PV 1</td>
<td>750Vdc-113M</td>
<td>MPPT, PCC</td>
</tr>
<tr>
<td></td>
<td>PV 2</td>
<td>750Vdc-113M</td>
<td>MPPT, PCC</td>
</tr>
<tr>
<td></td>
<td>PV 3</td>
<td>750Vdc-113M</td>
<td>MPPT, PCC</td>
</tr>
<tr>
<td></td>
<td>Load</td>
<td>100kW</td>
<td>9kHz sin</td>
</tr>
<tr>
<td></td>
<td>ESS</td>
<td>5kW/30kWh</td>
<td>CP, CV</td>
</tr>
<tr>
<td></td>
<td>Battery stack</td>
<td>220V/155kWh</td>
<td>(12V-30ADC)</td>
</tr>
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</table>
Test Result Case 1 (w/o Resilience Algorithm)

Test Result Case 2 (w/ Resilience Algorithm)

RHYTHM (Korea/UK Collaboration Project)
Al-based Microgrid in Hawaii

- **Project Summary**
  - Duration: 2018.11 ~ 2021.04 (30 months)
  - Fund: $5.6M
  - Keywords: Big data, AI, Off-grid
  - Diesel generator (1050kW + 750kW), ESS (500kW/500kWh – planned), PV (200kW, 350kW + 350kW – planned)

- **Site: NELHA**
  - 870 acres of land + 3,290 acres of research site
  - Test-site under operation by more than 40 enterprises
  - Pump station under operation

- **Requirements**
  - Power supply by renewable energy sources
  - Cope with frequent black out
    - Utilization of ESS is necessary for rapid response
  - Stable operation of the system (+PV+ESS+diesel generator) with EMS
Al-based Microgrid in Hawaii

- **Project Goal**
  - Minimization of operation cost
  - Island mode support and reduction of interruption duration
  - Extension of island mode duration

- **AI-based Cloud EMS**
  - Application of big data/reinforcement learning based forecasting and optimization algorithm
  - Development of power transaction model and service

- **Customizing of island mode operation**
  - Maximizing island mode duration
  - Test of algorithm with RTDS
  - Development of optimal microgrid design methodology

- **Field verification of AI-based MG system**
  - PV, ESS, and supervisory control system design
  - AI-based Cloud/On Premise EMS construction and operation
  - Investigation of economic feasibility and system stability

- **Development of business model**
  - Investigation of Hawaii state law/regulation and risk
  - Establish of microgrid business model guideline
  - Seek a new energy service model
AI-based Microgrid in Hawaii

- Project Achievements

Data Collection

- Shark-200 / SEL-735 meter front panel
- Load and PV pattern data

Stability Analysis

- Eigenvalue analysis

Island mode algorithm

- Island mode optimal scheduling results

Local data collection system configuration

Communication room

17.5kW PV
On the ground

17.5kW PV
On the ground

17.5kW PV
On the ground

1L50kW PV
High-take-Mg, roof top

2L50kW PV
High-take-Mg, roof top

1L50kW PV
High-take-Mg, roof top

115kW PV
High-take-Mg, roof top

15kW PV
High-take-Mg, roof top

15kW PV
High-take-Mg, roof top
Regional Microgrid Construction Support Program in Japan

• After the blackout in Hokkaido Island in 2018 (during Bucharest symposium), the Agency for Natural Resources and Energy, METI, started the support program for regional microgrid construction.

• 5 projects out of 11 adopted for master plan creation. Adopted cities are: Kushiro(*), Kamishihoro(*), Ishikari(*), Maniwa, and Ashikita (*: in Hokkaido area)

• Purpose is to enhance the resiliency and business continuity management using more renewables (PV, biomass).

• Usage of existing distribution system is requested (evolution from legacy dist. grid to microgrid)
Renewable Energy Integration Demonstrator – Singapore

| An ERI@N Flagship Project |

Expanding the Capabilities of Modular Microgrids for Tropical Communities and Urban Cities
REIDS – **Facts at a glance**

Grants from EDB - $18 M
Commitment from Industrial partners > $19 M
RCA / RPA with number of companies – 10
Technologies deployed from number of companies > 20

Installed Power Generation – 2.6MW
1.1 MWp PV + 100 kWp Wind + 500 kVA DG + 930kW
Battery
Energy Storage – 930 kWh
Number of micro grids in operation – 6
REIDS & Low Voltage Microgrid Cluster (LVMGC)

- **REIDS**: living lab and demonstration platform
- **Objectives**: solve engineering, economic, environmental and societal energy transition
- **Technologies**: Renewable energy for off-grid and urban microgrids / Smart grid

Low Voltage Microgrid Cluster (LVMGC) – Industry Partner Microgrids & Core Infrastructure

- Microgrid sub-systems – PVs, ESSs, DGs, Switch-gears, Protection, Loads
- 400VAC & 6.6kVAC Distribution System
- Information & Communication Technology (ICT) network

Challenges:

1. Industrial partner engagement
2. Multi-microgrid Plug-and-Play and Interoperability
3. Multi-microgrid operation for urban smart cities (e.g. Singapore).
Technologies in place

1. **Renewables**: Solar, Wind (onshore/offshore) & Tidal
2. **Energy Storage/H2**: Batteries, Supercaps, CAES, Flywheels, Power-to-fuels and H2
3. **DERs**: Diesel, Bio-mass, Bio-fuels, Fuel Cells
4. **Multi-microgrid Systems**: Interconnection, Urban Mesogrids, Blockchain, Energy Trading, Resilience And Security
5. **VOI**: Visualization, Optimization AI, Energy/Power Management Platforms
6. **Microgrid Controller**: SW, HW, AC-DC Hybrid Grids, DERMS, SST & Power Electronics
7. **DACS**: Data Analytics & Control Systems
8. **Techno-enviro-socio Impact**: Techno-socio Economics, EIA, Certification
9. **Rational End-use**: Utilities, Urban Residential, Industrial, Agri Loads, Desalination & EVs
Established by joint efforts from Engie and Schneider

- Solar PV panels (200kWp)
- Diesel Generators (2 x 50kVA + 100kVA)
- Energy Storage Systems (2 x 200kW / 200kWh)
  - Murata and Ineo

Engie

- Xant Wind Turbine (100kWp)
- Hydrogen Facility (70kVA) – partially deployed
- Hydrogen production facility
  - Hydrogen Refuelling Station
  - Fuel Cell based Electric Vehicle
- Energy Management System

Schneider Electric

- SCADA Network & Power Management System
- Low Voltage Switchboard
- Power Management System
Microgrid for Affordable & Sustainable Electricity in Remote Areas (MASERA)

- **Established by Electricite De France (EDF)**
  - Bi-facial Solar PV panels (50 kWp)
  - Diesel Generators (50 kVA)
  - Electric Vehicle (Nissan Leaf)
  - V2G Charger
  - Energy Storage Systems (50 kWh)
    - Li-ion and Zinc air
  - LV Switchboard
Highlights of Microgrids in Australia

• Key projects are associated with:
  • *Fringe of the grid*, typically to:
    • Avoid reinforcement costs due to long and unreliable 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
Broome North, WA
- Solar-powered microgrid

Thevenard Island, WA
- Mackerel islands standalone power station

Pilbara, WA
- Remote aboriginal community standalone power station

Murchison, WA
- CISRO standalone power station

Kalbarri, WA
- Kalbarri microgrid

White Gum Valley, WA
- White gum valley energy sharing trial

Garden Island, WA
- Garden island microgrid

Jandakot, WA
- ATCO hydrogen microgrid

Thursday Island, QLD
- Diesel and wind microgrid

Doomadgee, QLD
- Diesel and solar microgrid

Daintree, QLD
- Solar to hydrogen microgrid

Windorah, QLD
- Diesel and solar (concentrated photovoltaic dishes) microgrid

Northern Adelaide, SA
- Solar PV and battery microgrid

Bruny Island
- The Bruny Island microgrid

The Mooroolbark, VIC
- The Mooroolbark mini grid
Four models of electricity supply

Source: AEMC
Likely uptake of Standalone Power Systems (APS)

| 9,000,000 NEM + 1,000,000 WEM customers |

**Western Power** recently identified more than 15,000 candidate sites on its network where customers could benefit from standalone power systems over the next ten years.

**SAPN** has indicated that it does not have any candidate sites in mind for SAPS at this time.

**AusNet Services’** initial, high-level assessment is that it may be economic to deploy SAPS solutions for between 300-400 of its customers in bushfire prone areas.

**Citipower/Powercor/United Energy** have indicated that they do not have any candidate sites in mind for SAPS.

**Energy Queensland has** indicated a handful of potential candidate sites for SAPS over the next 5-10 years.

**Essential Energy** suggests that over the next 10 years, SAPS could represent the lowest cost to serve technology for over 2,000 of its customers.

**Endeavour Energy and Ausgrid** have indicated that they are each likely to have a handful of potential candidate sites for SAPS over the next 5-10 years.

**TasNetworks** has recently documented a plan to roll out one SAPS per year for the next 5 years.

Source: AEMC
Renewables in Australia

Source: Clean Energy Australia Report 2019
Renewables in Australia

Source: Clean Energy Australia Report 2019
thank you