China Microgrid Development Policy, Case Studies, Technology Trends

Wei Feng, Ph.D. Research Scientist
Energy Technologies Area
Lawrence Berkeley National Laboratory

Singapore
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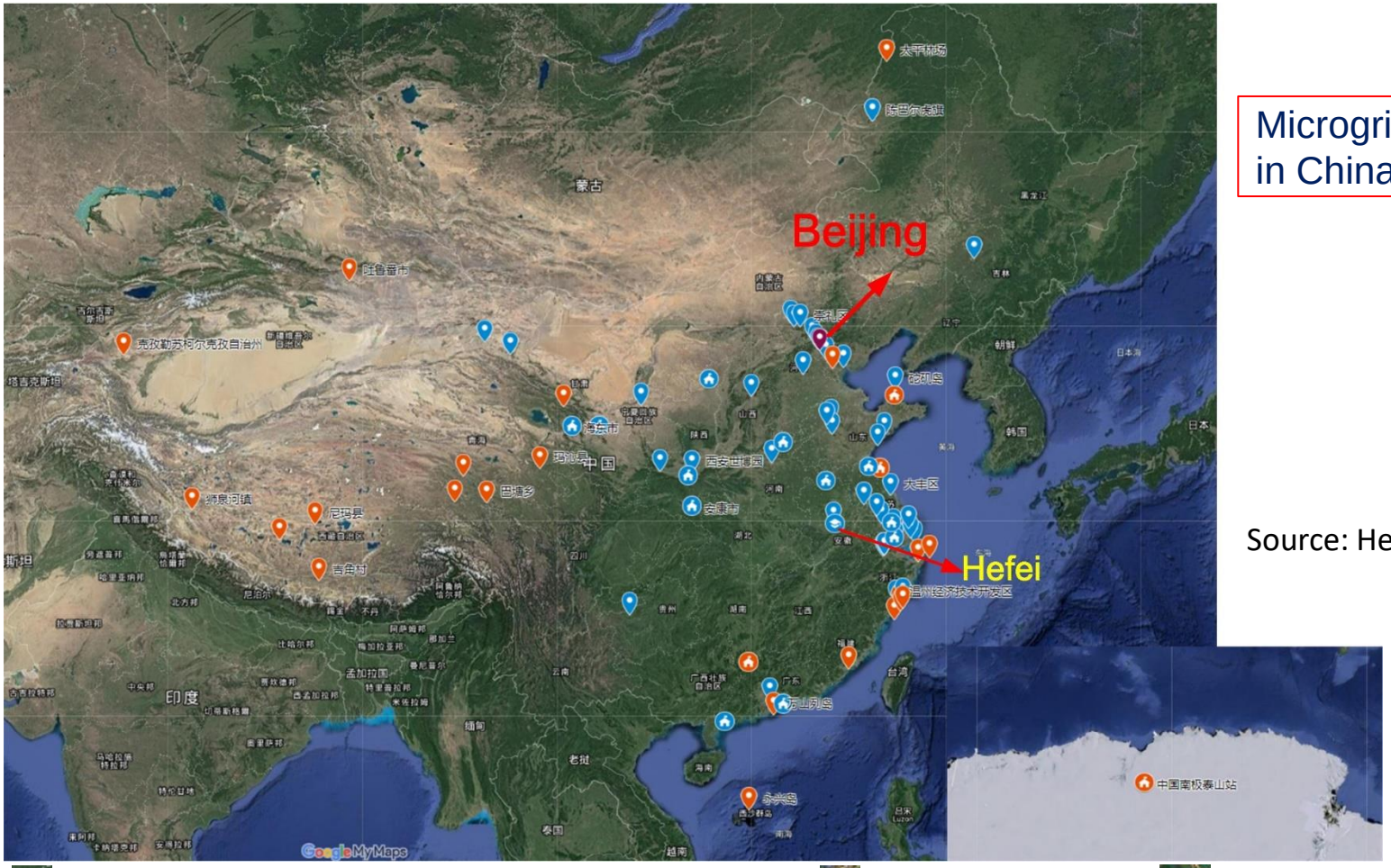
(Slides are also provided by Tianjin University, Hefei Institute of Technology)

Microgrid projects in China

- It is reported about **100** microgrid-related projects have been built up to 2019*. No accurate microgrids demonstration projects were publicly reported in 2020 and 2021, however, at least **20** newly-built microgrids can be found from different public sources.



Microgrids demos in China

Source: Hefei Inst. Tech

Grid-tied Islanded

Existed MGs up to June, 2018

Grid-tied Islanded

Newly-reported MGs from July, 2018 to July, 2019

* https://www.china5e.com/news/news-1075828-1.html

The purpose of microgrid development in China

(1) **help host and distributed energy resources**

Integrated DERs into microgrids, and use control technologies and protection devices to smooth power fluctuation and achieve system stability. Microgrids can balance the local generation with demands, and maintain system voltage and frequency.

(2) **Improve energy efficiency**

Microgrids can host electricity, heating and cooling energy supply and meet different energy demands and improve overall system efficiency.

(3) **Provide electricity supply for remote villages**

Establish village or household-based microgrid systems

(4) **Achieve better power quality**

Using microgrids to improve local distribution system power quality and achieve better reliability.

(5) Provide better resilience to the local power grid and help restore power after disruptive events

Microgrids can operate in island mode during disruptive events. Easy to restore local power supply with black start function.

(6) **Microgrid is a critical part of smart grid**

The island function of microgrids can achieve the resilient operations of the smart grid. And it allows the interconnection of multiple energy technologies.

Overall objectives

- **Achieve high penetration of distributed renewable energy**

  Using microgrid to smooth power quality impact due to high penetration of renewable energy.

- **Provide electricity to island and remote areas**

  Achieve plausible system economics through island microgrid solution.

- **Improve power quality and reliability for special loads**

  Use microgrids to provide better quality and reliability for loads such as factories, and hospitals.

Microgrid policies

Jan 2022, the National Energy Administration issued a policy to encourage power grid companies to provide connection services for clean energy, DERs, storage, microgrid, and distribution power grid.

时间	文件名称	主要内容
2009年	<National R&D plan, MOST>	Establish microgrid research and demo
2015年	<Guidance to clean energy microgrid demo projects>	Mentioned that microgrids represent the future trend of an energy revolution and a meaningful approach to advance energy efficiency and carbon emissions reduction.
2017年	<Policy to promote grid-connected microgrid>	Microgrid clean energy generation project can enjoy RE development subsidy after a microgrid is built. Encourage local government to setup similar supporting policies
2017年	<Clean energy microgrid demo project list>	28 clean energy demo projects were approved to build
2020年	<Promote strategic industry development>	Develop PV+wind, fuel cell, high-performance storage, ocean energy etc. clean technologies; Accelerate smart grid, microgrid, DERs, clean energy storage, H2, fuel cell technology infrastructure construction.
2021年	<Integrated power generation, grid, storage, and demand, a multi-energy development guideline>	Promote the integration of power generation, grid, storage, and demand, and increase system efficiency, reliability, and multi-energy integration.
2022年	<Reply to the 13th people' s congress the 5th meeting, proposal #8711 on industrial carbon peaking>	Promote industrial park green microgrids. Accelerate distributed wind, PV, HP, waste heat utilization, and smart energy management. Enhance multi-energy, and RE local consumption, and green transformation of industry sector.

Microgrid development status

1、Market capacity

Based on 2018 data, China’ s microgrid market has reached 4.37 billion RMB (~620 million USD), with an annual increase of 9.8%. It is estimated the market will reach 7 billion RMB (1 billion USD) in 2023, with key technology advancement, and policy support.

2、Market distribution

Microgrids are mainly built in public entities (government-owned facilities), industrial and commercial parks, and residential communities, with market share in 2021 of 33%、31%、19% respectively; military and island microgrids take 11%, and 6%.

3、DERs status in China

107.5GW distributed PV capacity in 2021, an annual increase of 37.56%. It is forecast that distributed RE will reach to 290GW, 10% of total RE installation capacity; among which 260GW distributed PV, and 30GW distributed wind.

Future development trends

- It is projected more distributed wind and PV installation will happen in the future. After 2030, wind + PV installation capacity will surpass coal, in 2060, clean energy generation will account for 50% of China's total electricity generation.

- Electricity "prosumer" has become more and more common. Grid-demand interaction and demand response have become popular.

- The energy system has developed as the main power grid as the pillar with multiple forms of distribution grid co-existence. The future trend is to integrate with H_2, NG, cooling, and heating inter-connected with the main power grid.

- Microgrid future trends have three directions: 1) the market continues to develop with more DERs applications; 2) commercial and industrial microgrids deployment grow rapidly; 3) Asia becomes the microgrid main market.

Microgrid and demand response

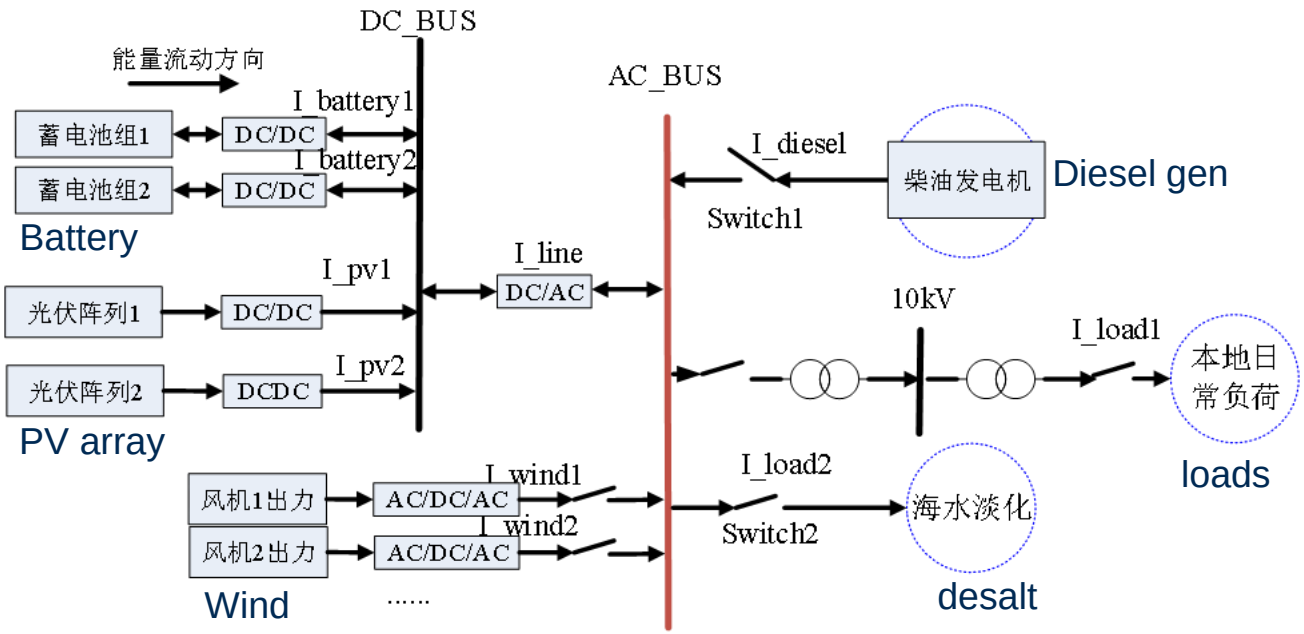
- China has started to build its demand response “market”
- Right now, demand response is conducted at each province or city’s local unity company level. Utility companies use their tariff collection (especially peak tariff) to setup incentive signals for end users.
- Pilot programs are conducted for different users to understand their baseline profiles and DR potentials.
- Encourage microgrid to participate in demand response (virtual power plant) as microgrid has dispatchable DERs.
- Developed a microgrid participating DR standard DL/T 2405-2021

- Challenges:
  - Still missing market-based long-term mechanism for DR.
  - Utility is functioning as a local ISO to manage DR, but there is a wake linkage to prove DR value at both the retail and wholesale levels.
  - The true economic value of DR at the marco level is still unknown.

Island microgrids

Dongfushan island (Zhejiang province)

PV, diesel generation, storage and desalination



System capacity

- 210kW Win-7*30
- 100kW PV
- Lid-Acid Battery 2V/1200Ah 480 units
- 200kW diesel generators
- 24kW seawater desalt
- 300kW PV+battery inverters

The island microgrid is a good demonstration of the island power solution with clean DERs. The key point is to understand multi-energy system operation, interaction, and coordinated control methods to make sure microgrid stable operations.

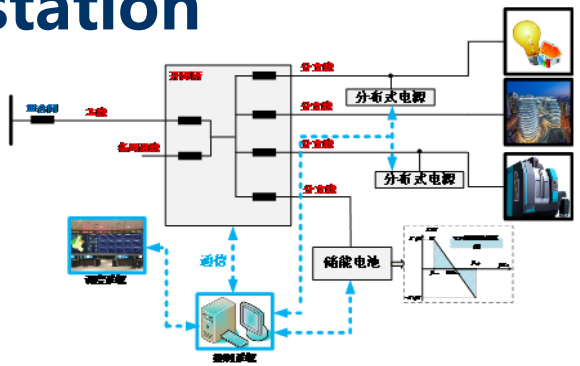
Source: Tianjin University

Microgrid demo projects

Pingshan microgrid – "a virtual substation"

Challenges

- 1500kWp PV grid-connected causing voltage increase at the end of the distribution system
- Voltage increase causes damage to household appliances, therefore PV generation becomes difficult to interconnected



Solutions

- A low-cost solution to solve feeder voltage overshoot
- Add a new 10kV line with a switch station
- Add a 2MWh battery storage, connected with the switch station
- Control the 1.5MWp PV together with the battery and switch station
- Grid-integrated control and disptach

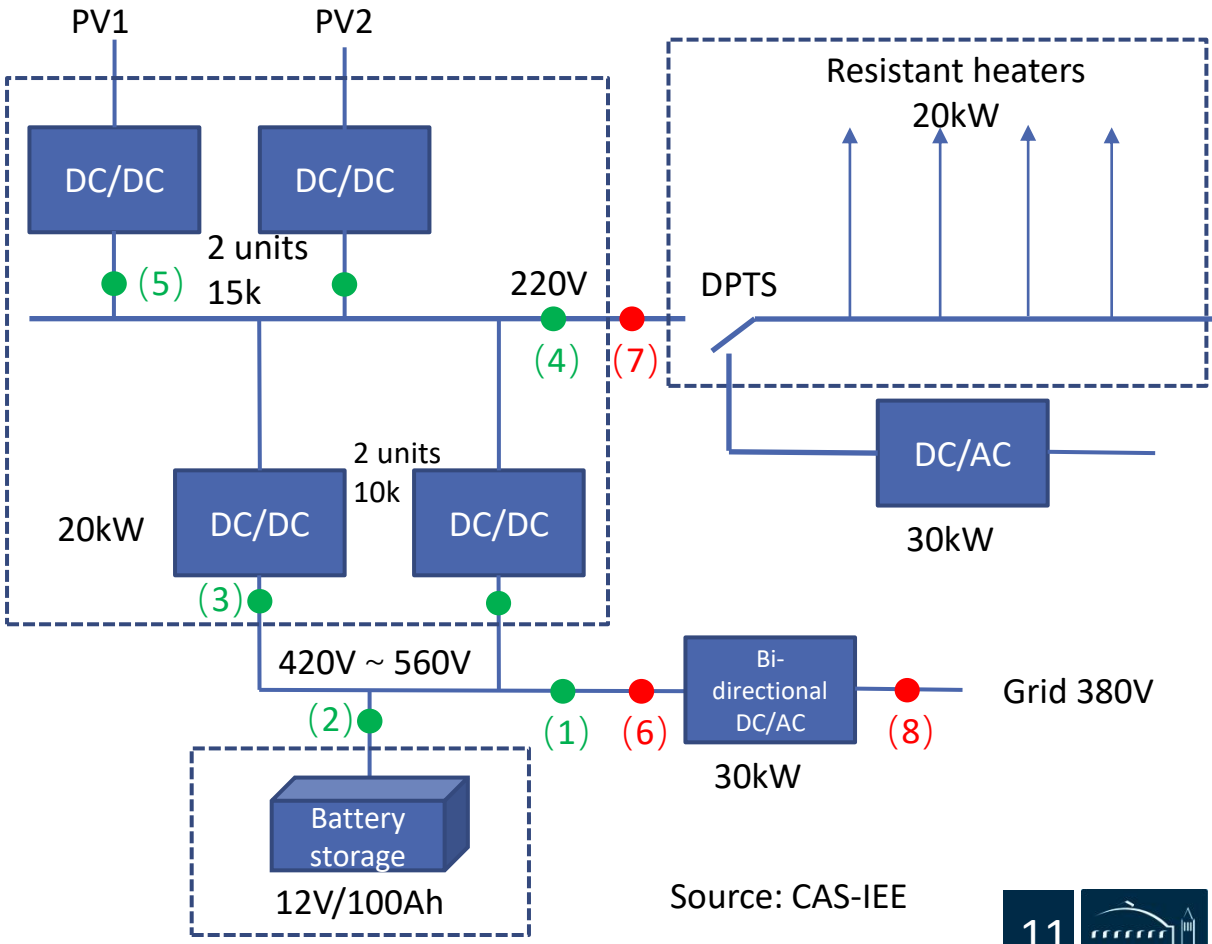
Core control systems

- Battery container controller *3
- Microgrid central controller *1
- Distributed PV controller *5
- Microgrid central controller *1

Source: Tianjin University

Microgrid demo – a partial DC microgrid

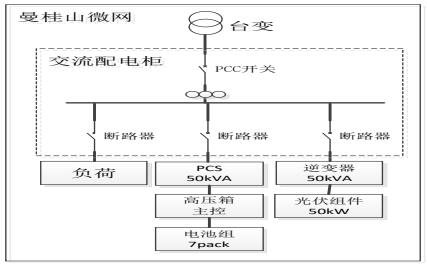
- Located in Qinghai province a remote village.
- residential + hotel, PV + battery DC microgrid
- DC bus for PV + battery, plus DC resistant heaters, the rest of building loads use AC power appliances
- 30kW, 500-700V DC bus



Source: CAS-IEE

Microgrid demo projects

Village microgrid in Xishuangbanna (border close to Laos and Myanmar)



Challenge

- Remote area, low reliability
- Weather and natural disaster can cause power disruption
- If upgrade the local distribution grid, high cost

Solution

- Developing a TRUE grid-connected/island microgrid
- If any distribution network disruption, the microgrid can function as an island mode

Core control systems

- Microgrid central controller*3, one controller per microgrid
- Microgrid controller can smoothly switch between grid-connected mode and island mode
- Provide cloud-based supervision control for monitoring and MMG strategies

Partner: China Southern Grid Yunnan EPRI
Location：Yunnan province, Xishuangbanna
Microgrid type: TRUE microgrid w/ grid-connected and island modes
Project time：2019
System capacity:（PV50kW+ESS100kWh）*3

Source: Tianjin University

Microgrid demo projects

Wangjiazhai microgrid, Hebei Province

Challenge

- Coal to electric clean heating retrofit increases electricity demand and feeder power over capacity;
- Grid distribution system expansion cost is high and not cost-effective

Solution

- Group-control methods to control local HP demand with microgrid, make sure the feeder power quality meet the targets
- Built three community-level microgrids and interconnected them. Total PV installation capacity 920kW; storage 3390kWh

Core control system

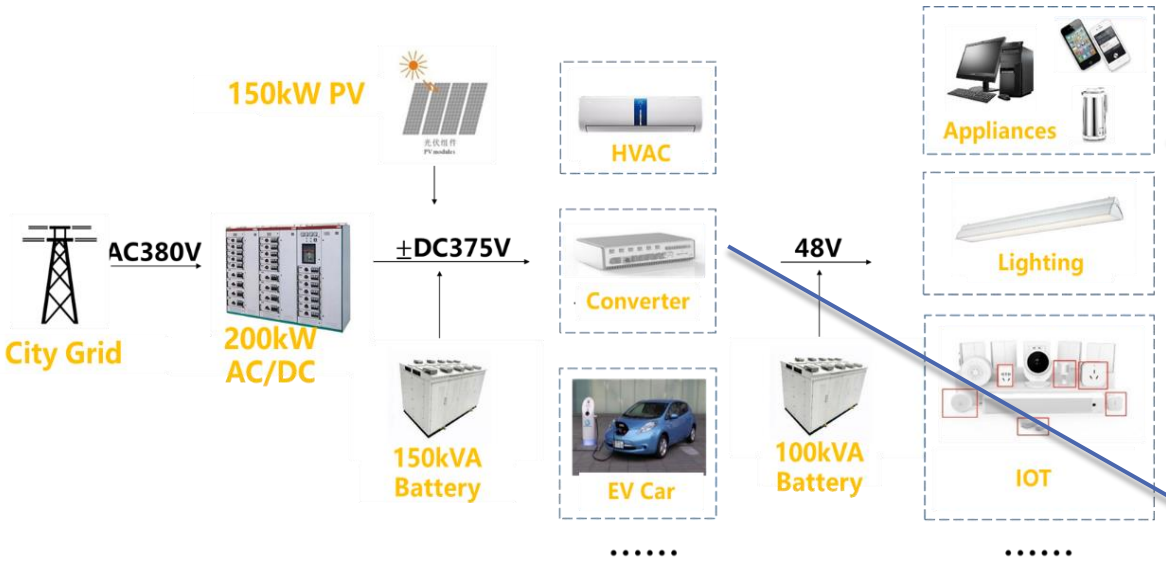
- microgrid central controller, each community microgrid has one controller
- Deploy a multi-microgrid energy management system to optimize the whole village energy dispatch.





Source: Tianjin University

100% DC power microgrid in buildings



Source: Shenzhen IBR

- Features of DC microgrid buildings:
  - +/- 375V bi-polar DC power bus
  - Can combine to 750Vdc for large capacity equipment such as air-conditioners
  - 375V to 48V DC-DC inverters are provided at each floor level, 375/48 converters are installed close to building loads to minimize the wiring distance of 48V equipment
  - 48Vdc converter is provided at each desk to convert to 5V, 20V, 24V for different types of DC electronic plugs.
  - Use of communication cables (e.g. ethernet) for both power and control/pricing signals
  - Battery + controllable flexible load to enable building-to-grid demand response

Summary of China's microgrid practices

The purpose of developing microgrid

- Increase of electricity demand and feeder over capacity, avoid expanding power distribution systems and high investment cost
- Multi-microgrid interconnection to achieve energy and power control coordination
- Using microgrid to
- DC microgrids in buildings to connect local DC IOTs and conduct smart control and demand response
- Island microgrid to provide reliable and clean power solutions

Future trends

- V2G integration in microgrid and related microgrid DR
- Microgrid vs demand response and virtual power plants
- DC microgrids → cost-effective application and demonstration

Thank you!

Questions?

weifeng@lbl.gov