Overview of Microgrids in Asia

Fort Collins 2019
Symposium on Microgrids
9-12 August 2019

Saad Sayeef
saad.sayeef@csiro.au

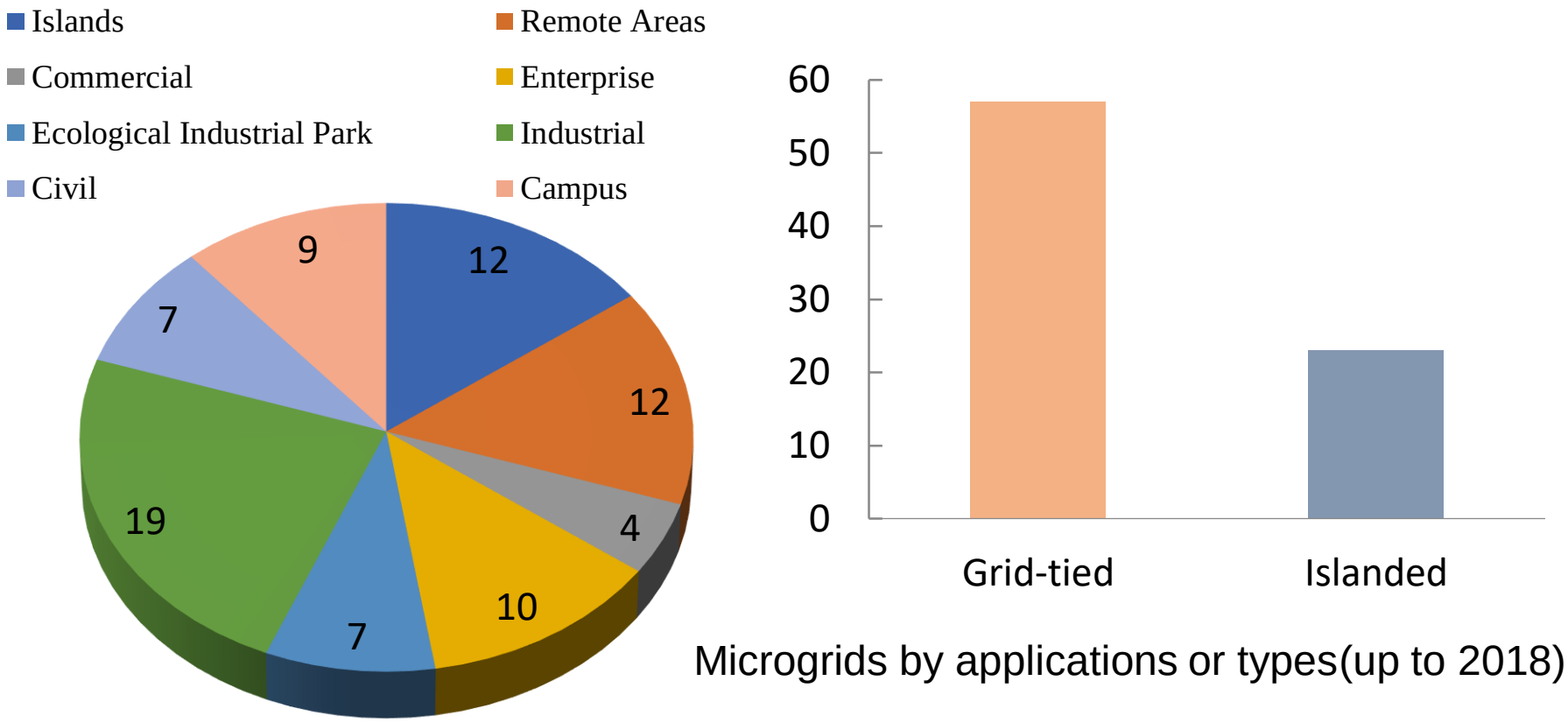
CSIRO

Key Contributors

Country	Name	Organisation
China	Meiqin MAO	Hefei University of Technology
Korea	Dongjun WON	Inha University
Japan	Ryoichi HARA	Hokkaido University
Singapore	Alex CHONG	Experimental Power Grid Centre, A*STAR
Australia	Pierluigi MANCARELLA Saad SAYEEF	University of Melbourne CSIRO

Microgrid Activities in China

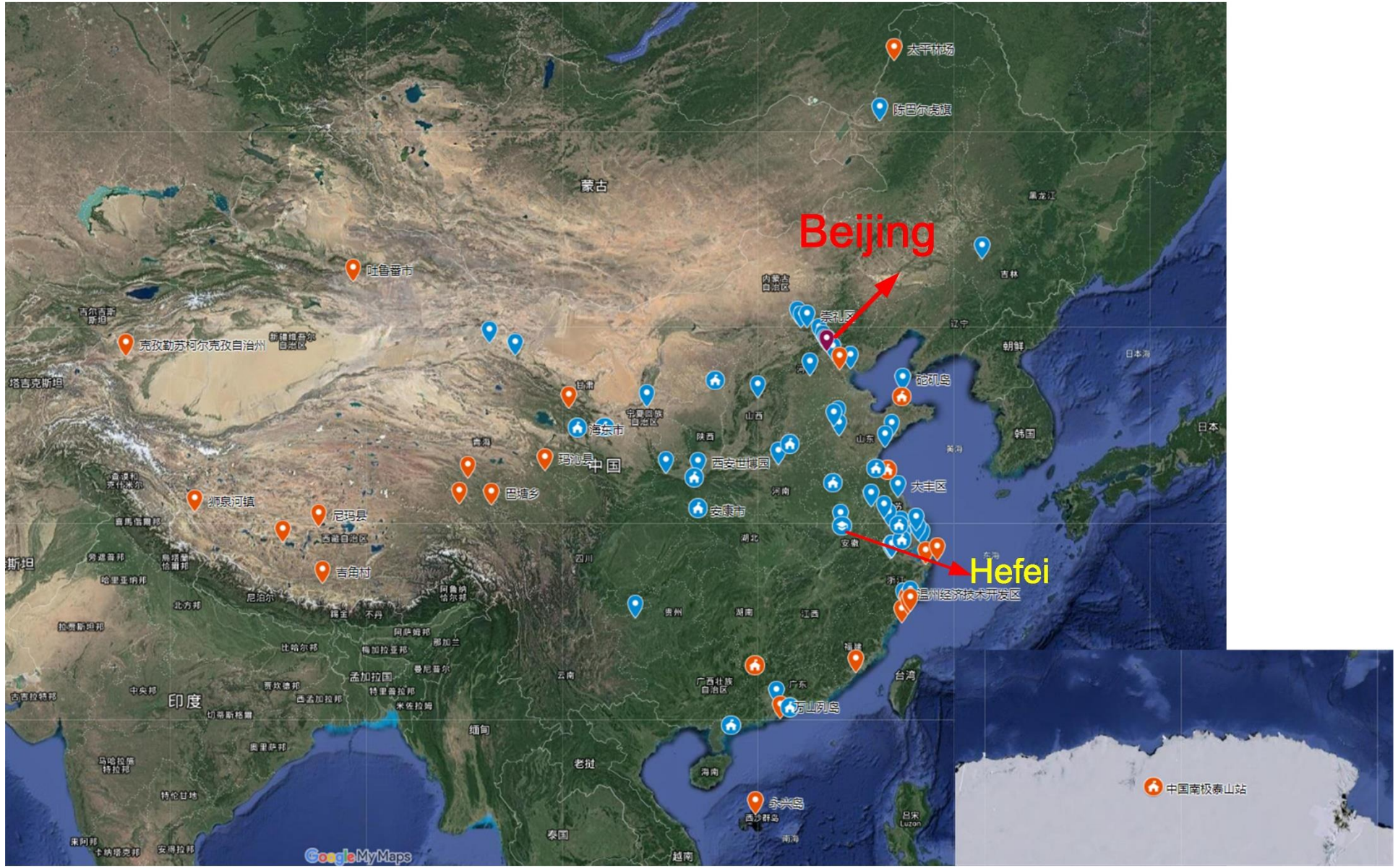
• It is estimated that there are over **80** demonstration microgrids or multi-microgrid groups built in China up to **the middle of 2018**, **28** were identified as “the first batch of new-energy demonstration microgrids” by NDRC and NEA.



Microgrids by applications or types(up to 2018)

• 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

Grid-tied Islanded

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

Microgrid in TaiShan Antarctic Research Station

Basic Information

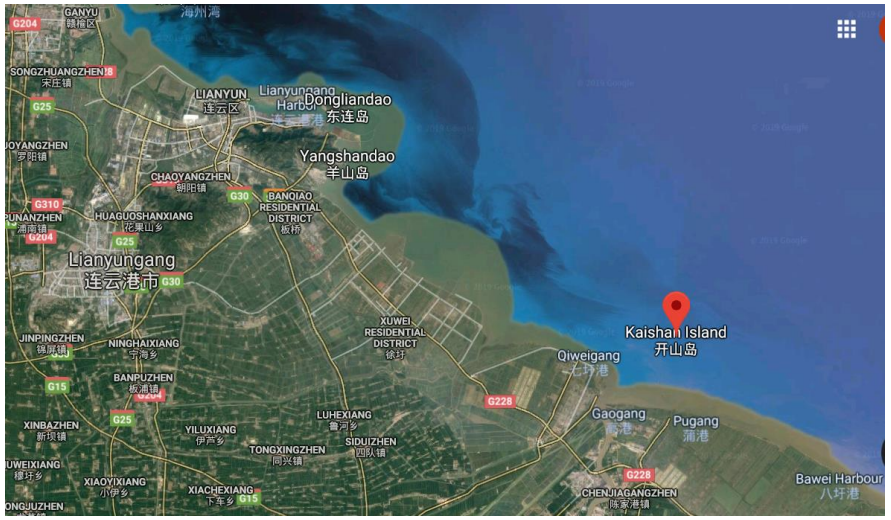
- Completed around Feb. 2019
- China's first Wind/PV/diesel /battery MG deployed in Antarctic area.
- Most of demands, even in the polar nights, are provided by Wind and PV generation, extra electricity could be stored in the battery units as backup.
- In extreme situations, diesel generators will be 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.china-nengyuan.com/news/136504.html
http://www.sohu.com/a/303797031_100016667

Microgrid in Kaishan island(开山岛)

Basic Information



Location of Kaishan island (In the Yellow sea)

Overall scenery of Kaishan island

- **0.0013km²** 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

http://zoceanc.zju.edu.cn/redir.php?catalog_id=291&object_id=2396

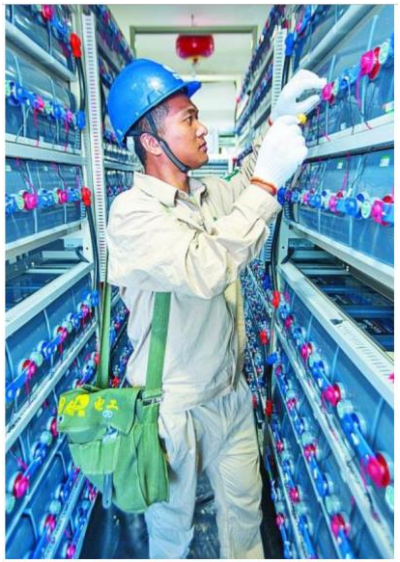
Microgrid in Kaishan island(开山岛)

Some field Photos

Panorama of the Kaishan microgrid

Desalination system

Roof PV panels

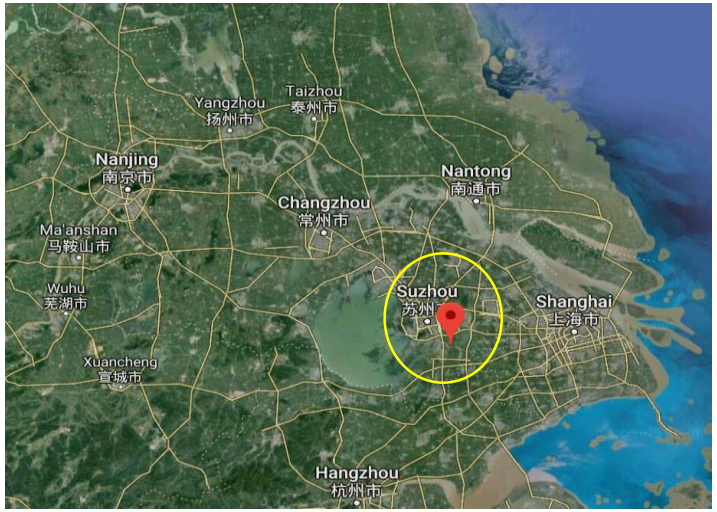


Battery system

http://www.nengyuanjie.net/article/27617.html
http://www.sasac.gov.cn/n2588025/n2588124/c11531011/content.html
http://energy.people.com.cn/n1/2019/0620/c71661-31170134.html

New-energy town in Tongli, Suzhou

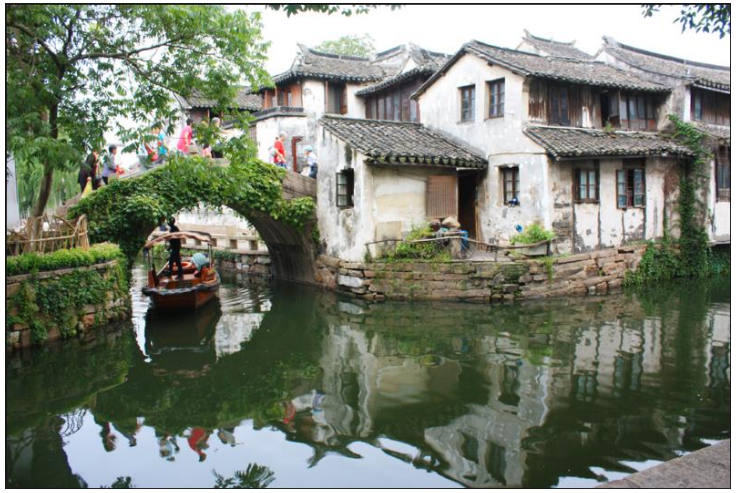
Basic Information



Location of Tongli Town

Sceneries in Tongli

- 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

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

- High-temperature phase change photothermal power generation

solar conversion efficiency reaches up to 43.5%

- Prefabricated-cabin energy storage system

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

- High temperature phase change heat storage

- 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)

Multi voltage levels conversion and AC/DC or DC/AC

- Low-voltage DC ring distribution network

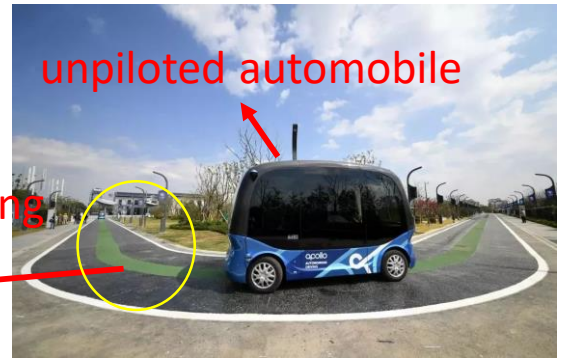
±750V DC ring structure, allowing bidirectional energy flow

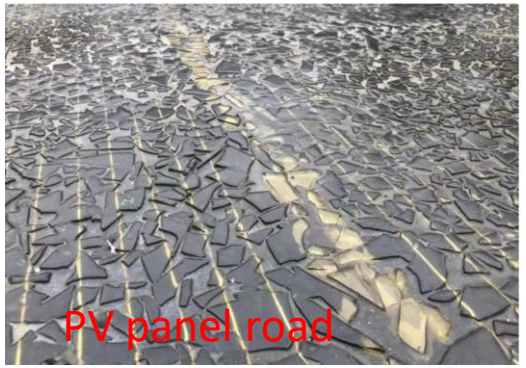
- Supply/grid/storage/load coordinated control system

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

Wireless Charging

https://www.nengapp.com/news/detail/1805502

http://www.its114.com/html/news/urbanits/2018_10_97794.html

New-energy town in Tongli, Suzhou

Highlights and innovative technologies demonstrated inside the Town

- Virtual Synchronous Generator

- Intelligent “passive” house

➢ 20.31 kW, 677 pc * 30w Hantile

➢ 407 m^2 area Hanwall

➢ Media’s coverage

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

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

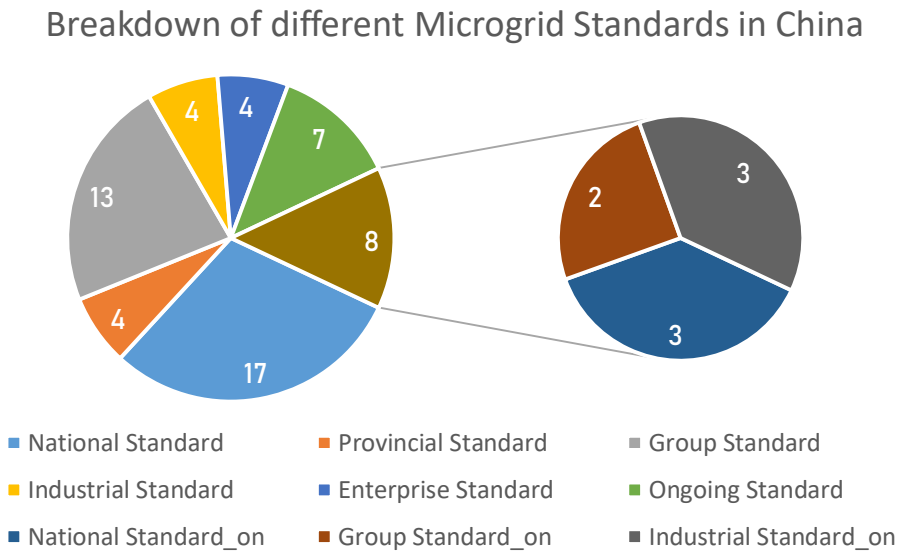
❑ Xiong' an New District

- "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 microgird to Hybrid microgrid, etc.
- According to incomplete statistics, there are nearly 50 implemented and ongoing microgrid standards in China up to 10th July, 2019.



Related Microgrid Standards (In force) in China

Title	Serial No.	Publish Date	Published by	type
Standard for Microgrid Projects Design	GB/T 51341-2018	Dec. 2018	MOHURD SAMR	National
Technical Specification for Energy Management of Microgrid	GB/T 36274-2018	Jun. 2018	SAMR SAC	National
Calculation of Technical Designing Indexes for Multi-energy Microgrid	DB13/T 2503-2017	Mar. 2017	He Bei	Provincial
Technical Guide for Microgrid Groups	DB45/T 1277-2016	May. 2017	Guang XI	Provincial
Specification for Operation and Management of Islanded Microgrid	DL/T 1863-2018	Jun. 2018	NEA	Industrial
Technical Specification for Monitoring and Control of Islanded Microgrid	DL/T 1864-2018	Jun. 2018	NEA	Industrial
Design Code for Microgrid Connecting to Power System	T/CEC 5006-2018	Jan. 2018	CEC	Group
Design Code for Microgrid	T/CEC 5005-2018	Jan. 2018	CEC	Group
Standard of operation and maintenance management for Microgrids	Q/JSFE0001-2019	Jan. 2019	Fortune-energy	Enterprise
Technical Specification for Data Access in Microgrid Cloud Platform	Q/LYWW.J.01.01-2017	Sep. 2017	LINYANG Electronics Co., Ltd.	Enterprise
……				

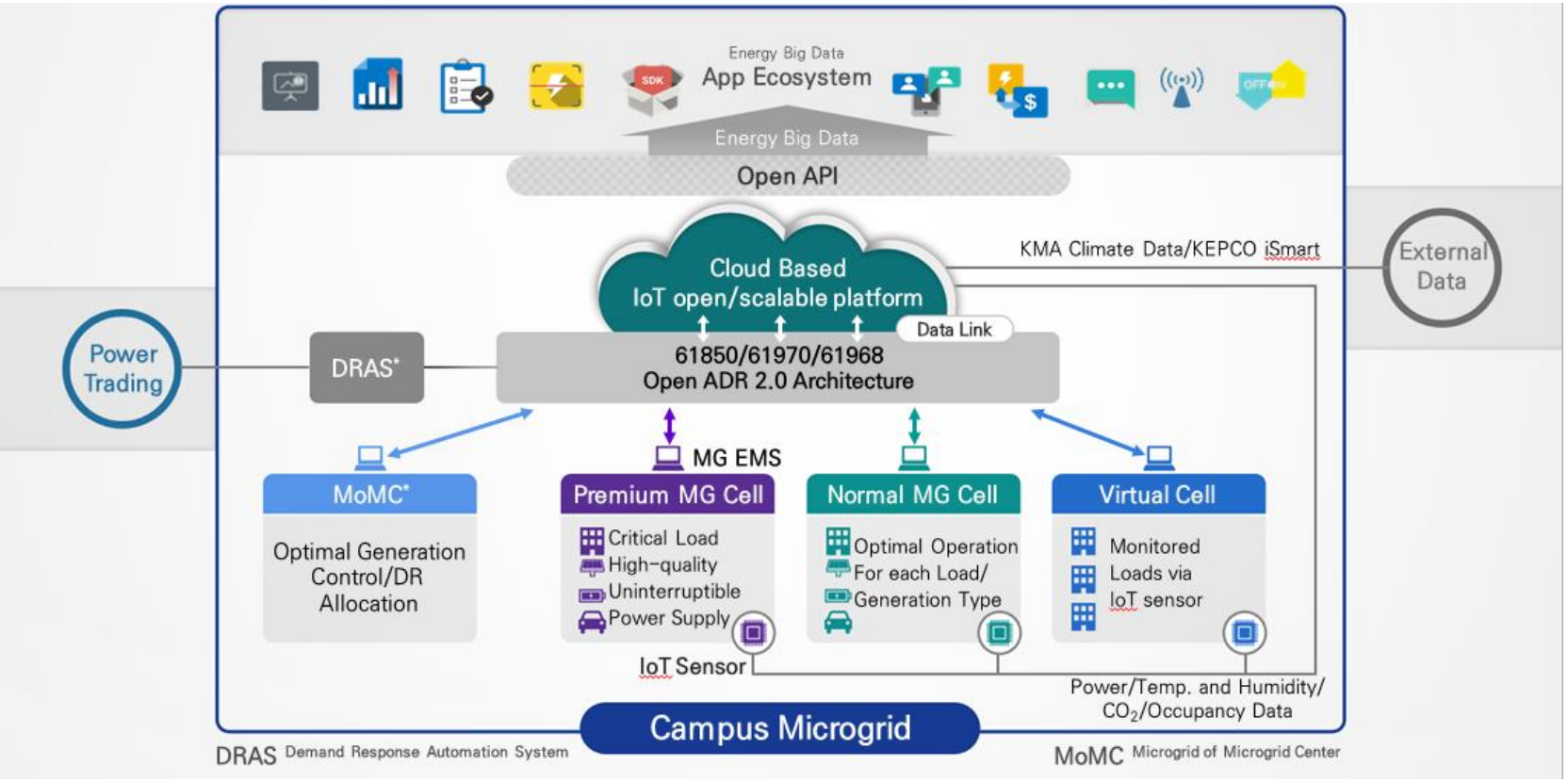
SAC: Standardization administration of China **NEA**: national environment agency **CEC**: China Electricity Council

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

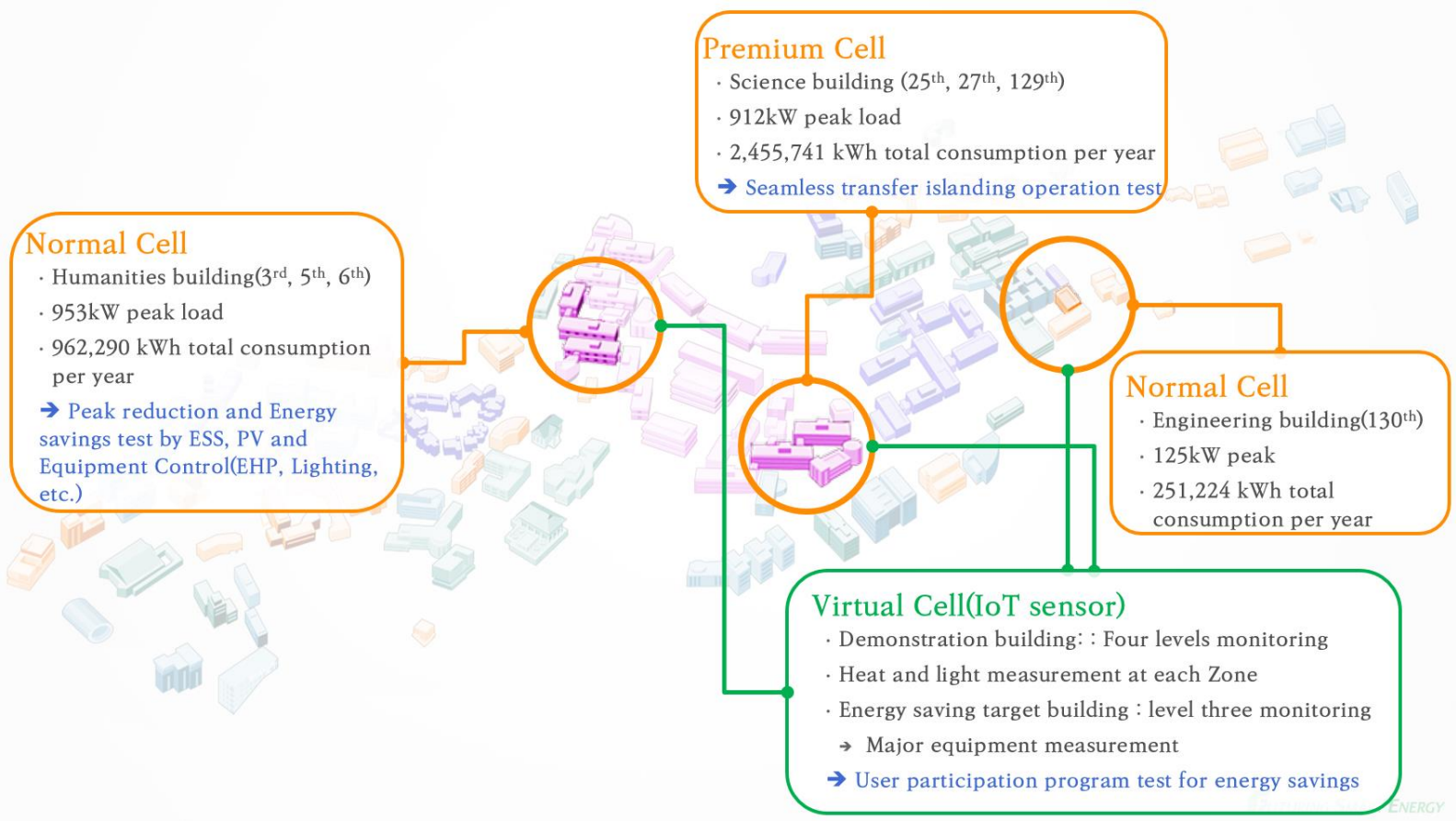
Seoul National University Campus Microgrid, LSIS

- 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

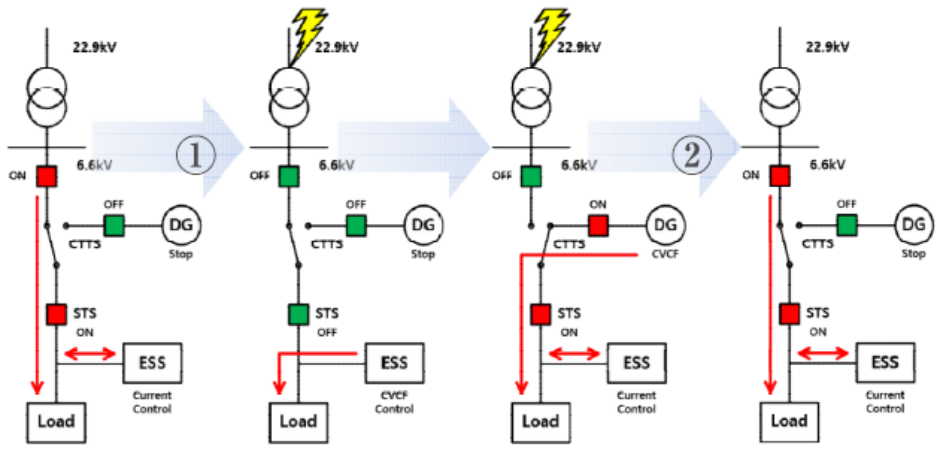
- SNU System for Demonstration
  - Premium Cell : Critical load with seamless transfer islanding operation and high power quality
  - Normal Cell : Normal load with DERs(PV and ESS)
  - Virtual Cell : Normal load with IoT Sensor(without DERs)

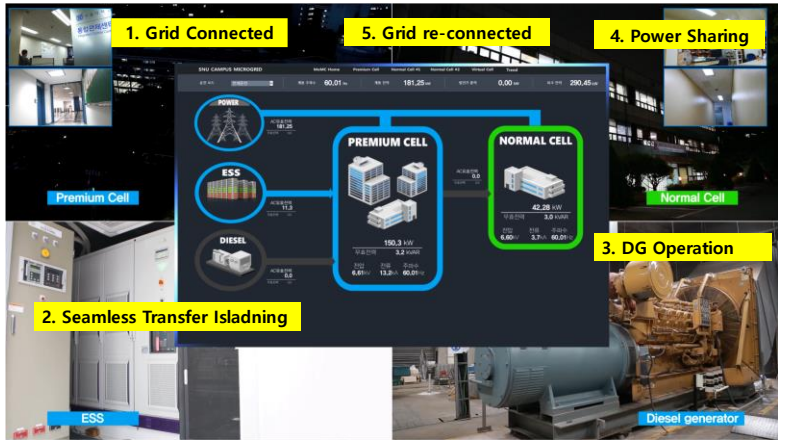


Seoul National University Campus Microgrid, LSIS

[Microgrid of Microgrid Center(MoMC)]

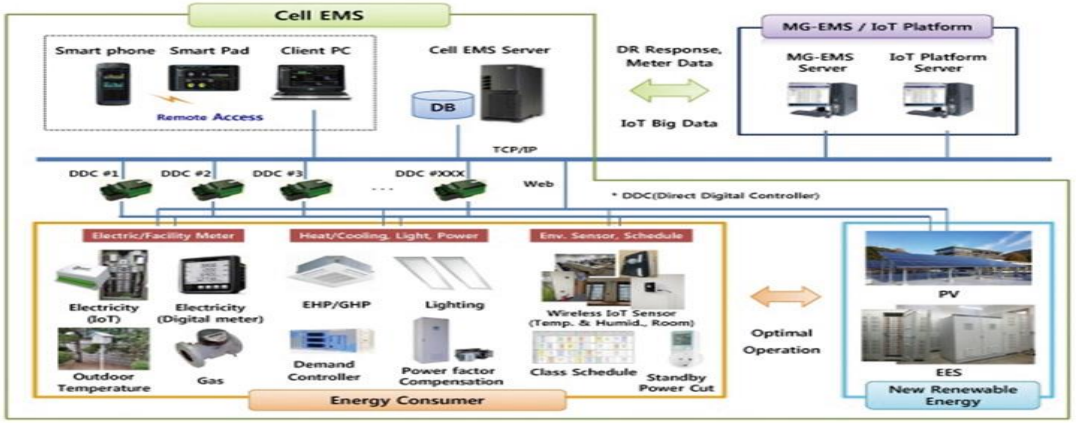
[Seamless transfer Islanding operation for Premium Cell]



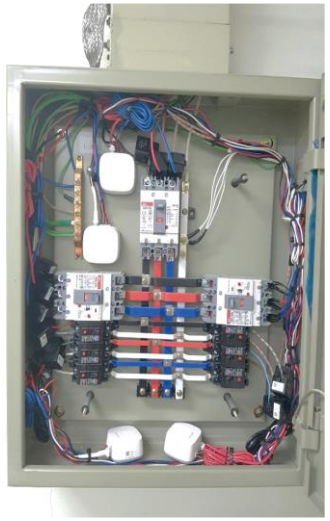


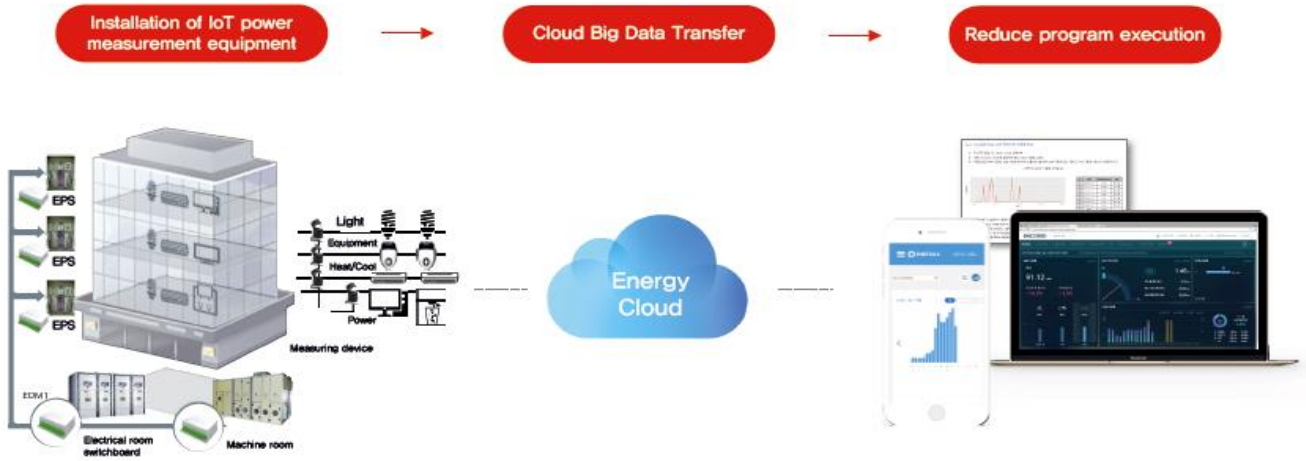
Seoul National University Campus Microgrid, LSIS

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



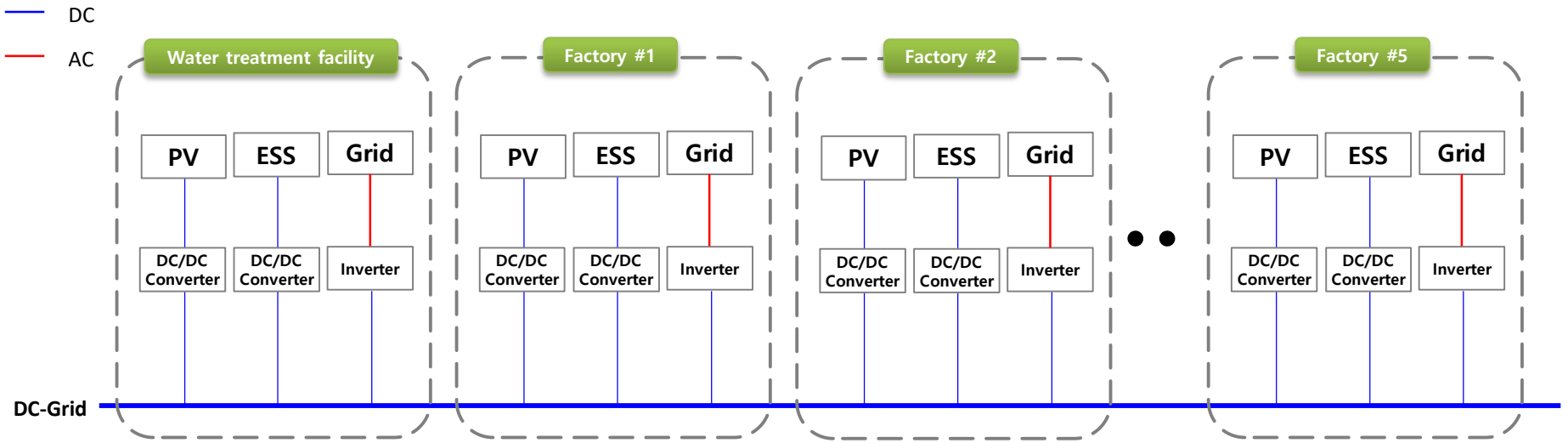
[Consumer participative energy-saving services for Virtual Cell]





DC Microgrid :
Dongsoo Agricultural and Industrial Complex

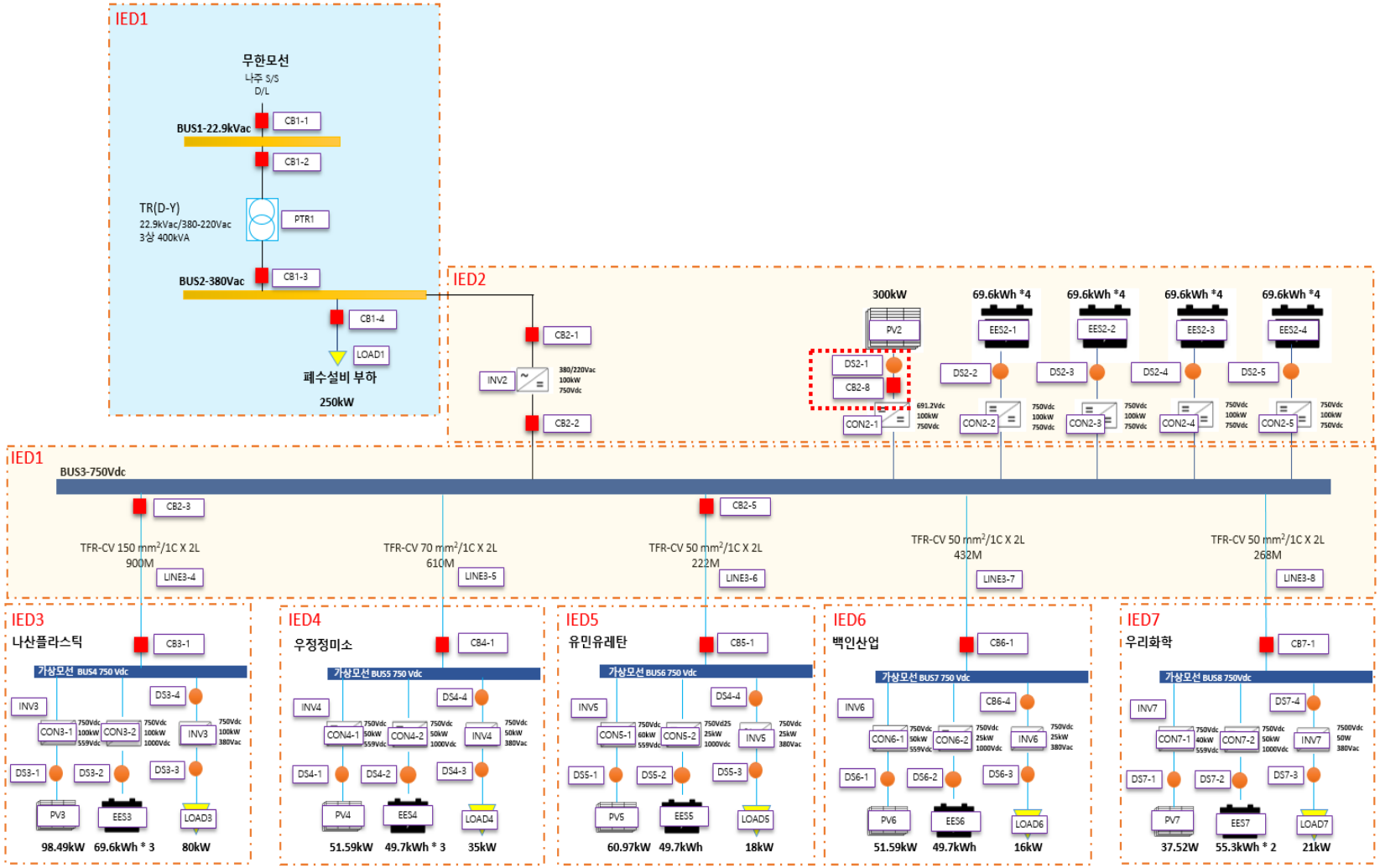
[DC microgrid configuration]



- 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]

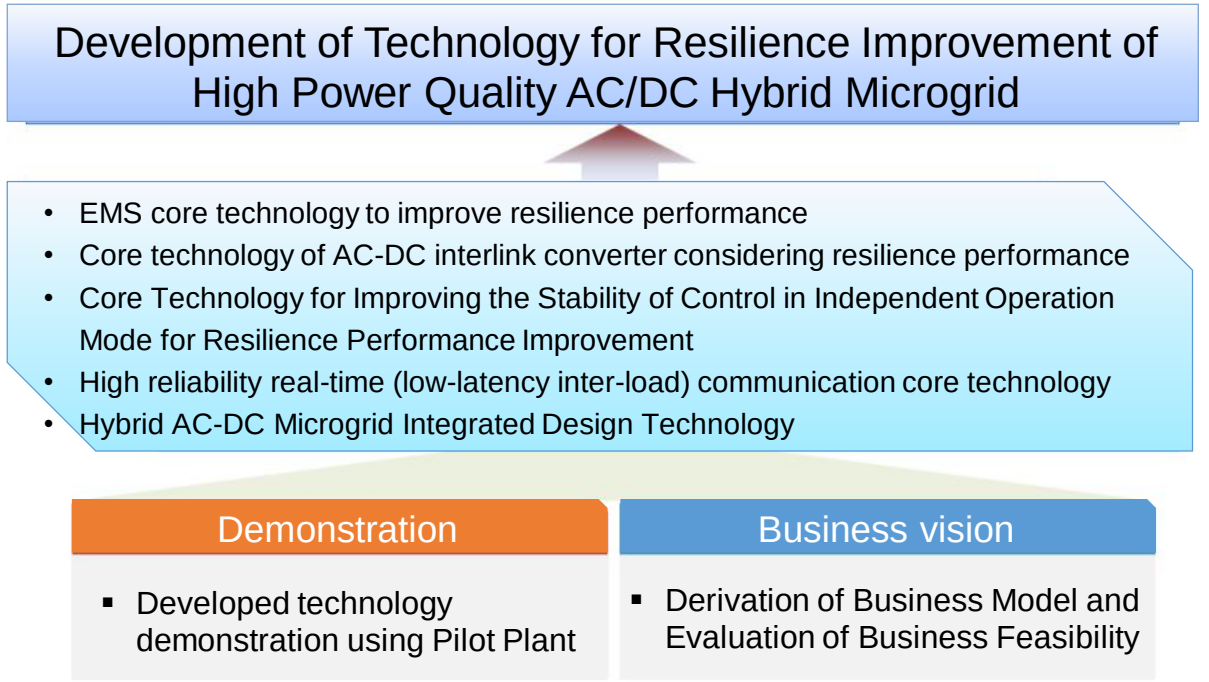
[CHP]

[TOC]

[Factory PV]

[E-House]

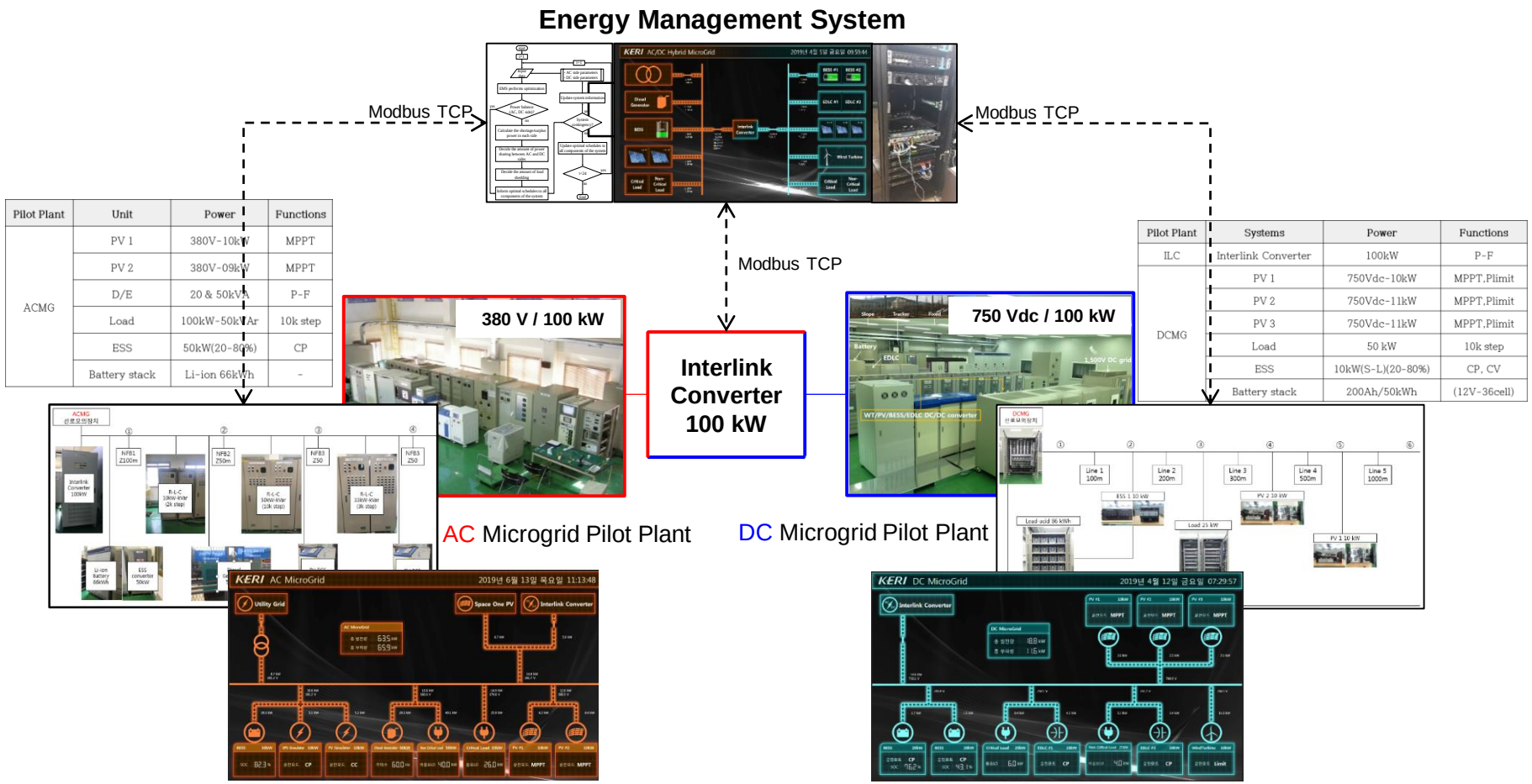
RHYTHM (Korea/UK Collaboration Project)



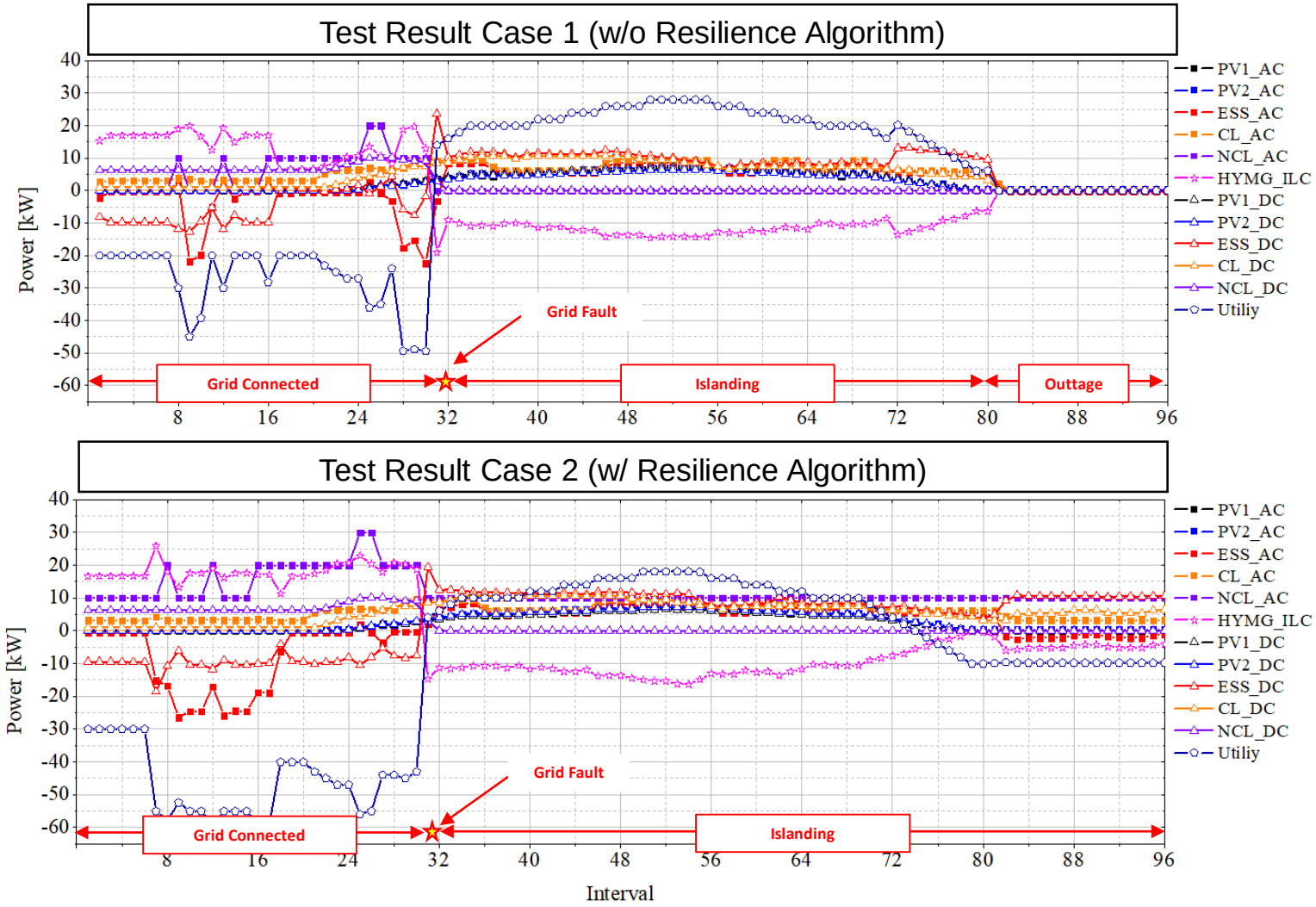
- Project Title
  - Development of Resilient HYbrid Technology for High-value Microgrids (RHYTHM)
- Leading Institutions
  - Incheon University(Hakman Kim), Imperial College of London (Tim Green)
- Project period
  - 04/01/2016 ~03/31/2019 (36 months)

RHYTHM (Korea/UK Collaboration Project)

[AC-DC Hybrid Microgrid Pilot Plant]

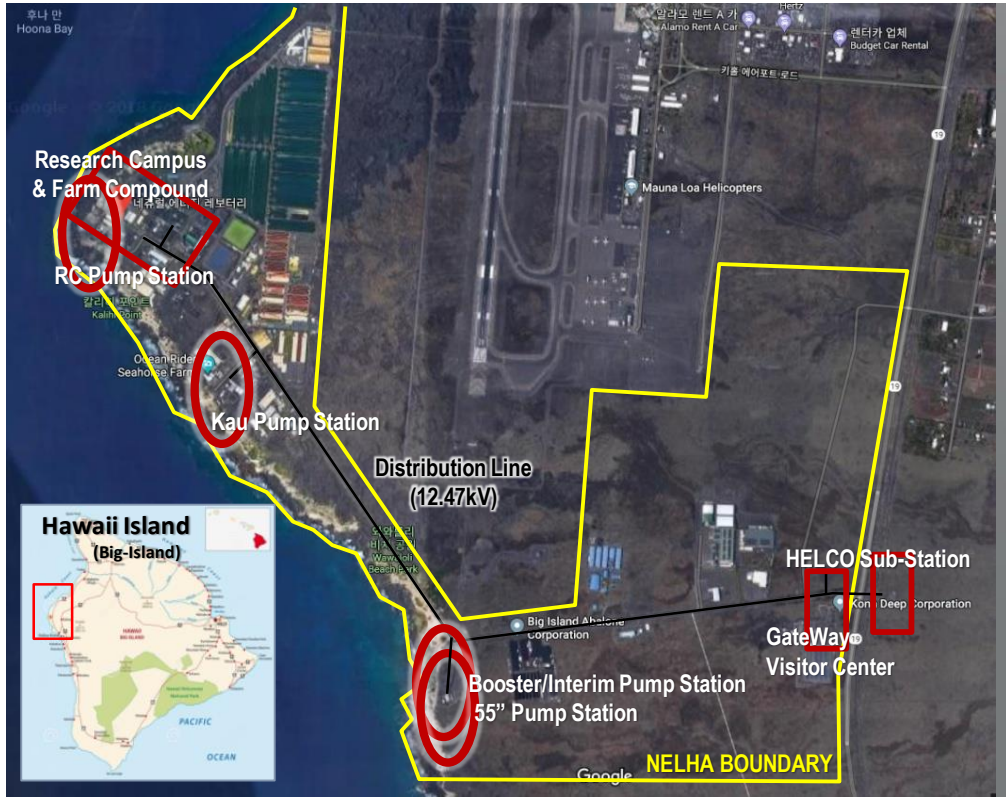


RHYTHM (Korea/UK Collaboration Project)



AI-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

AI-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

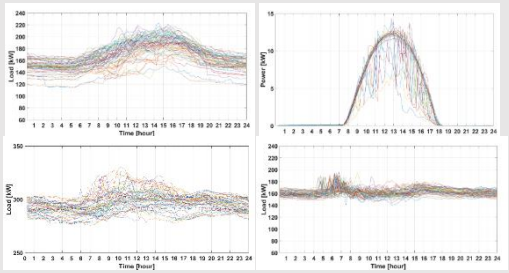
- Investigation of Hawaii state law/regulation and risk
- Establish of microgrid business model guideline
- Seek a new energy service model

AI-based Microgrid in Hawaii

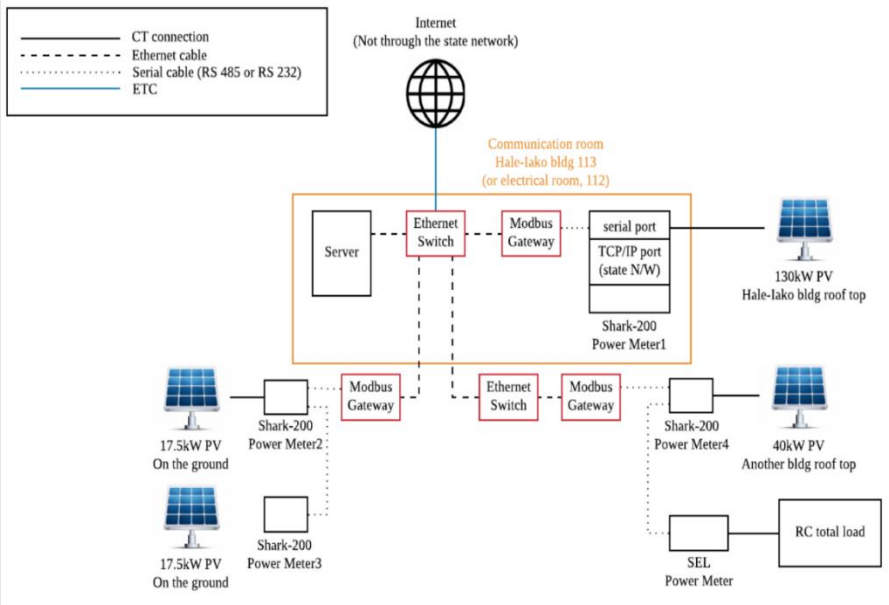
- Project Achievements

Data Collection

<Shark-200 / SEL-735 meter front panel>

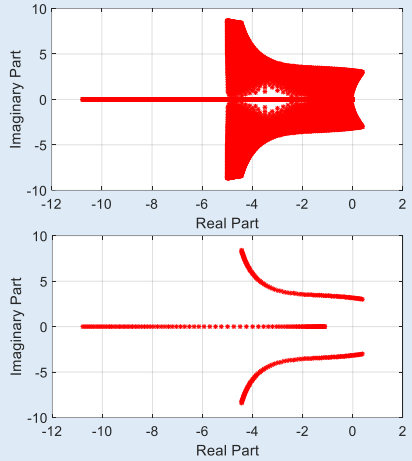


<Load and PV pattern data>



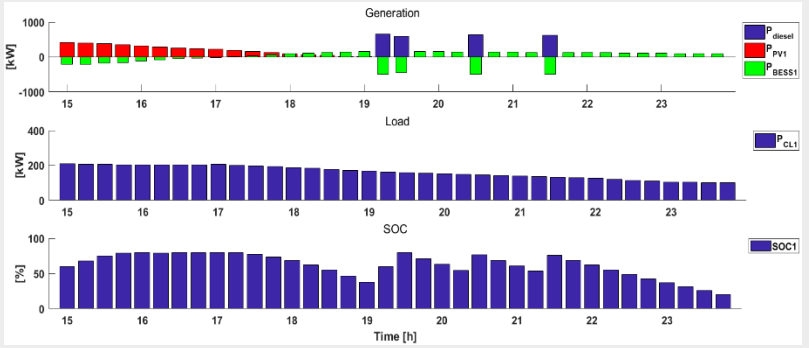
<Local data collection system configuration>

Stability Analysis



<Eigenvalue analysis>

Island mode algorithm

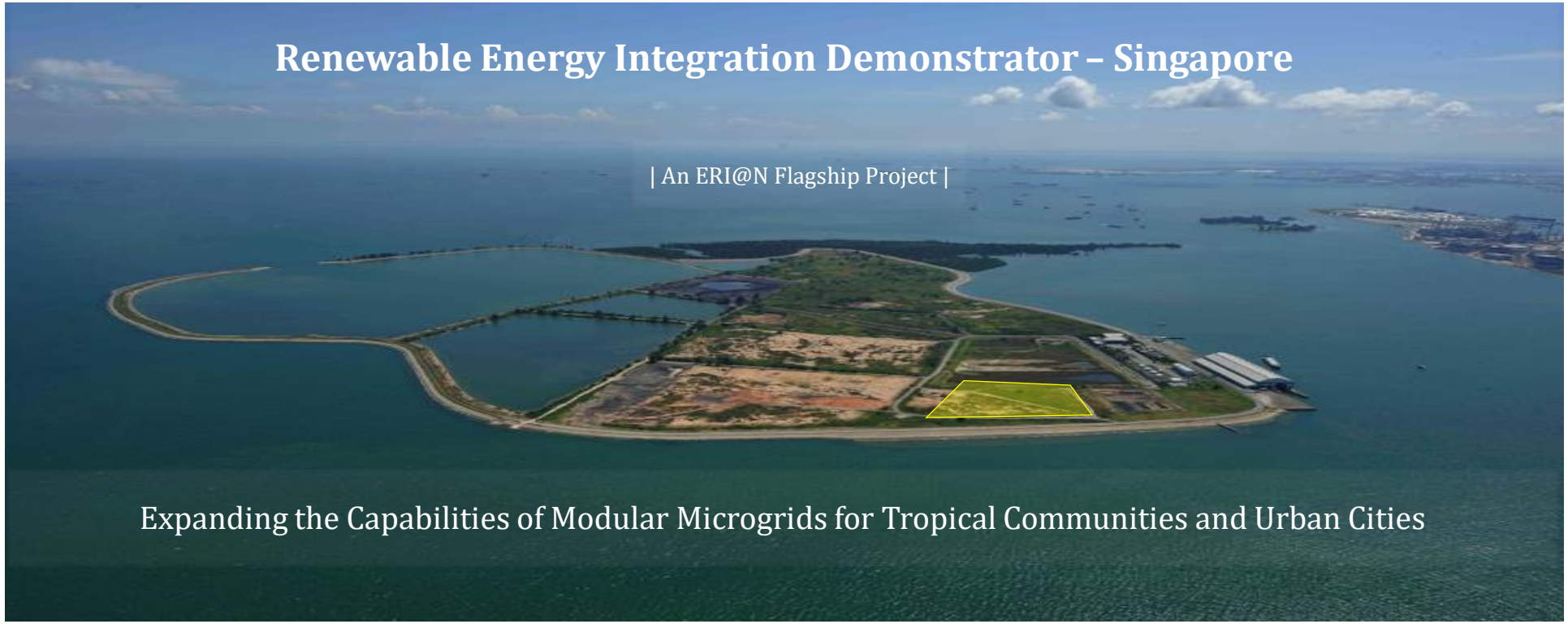


<Island mode optimal scheduling results>

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)

REIDS



Renewable Energy Integration Demonstrator – Singapore

| An ERI@N Flagship Project |

Expanding the Capabilities of Modular Microgrids for Tropical Communities and Urban Cities

Research Leader

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE | Energy Research Institute @ NTU

Supporting Agencies

EDB singapore · National Environment Agency (Safeguard · Nurture · Cherish) · Energy Market Authority (Smart Energy, Sustainable Future) · National Research Foundation

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

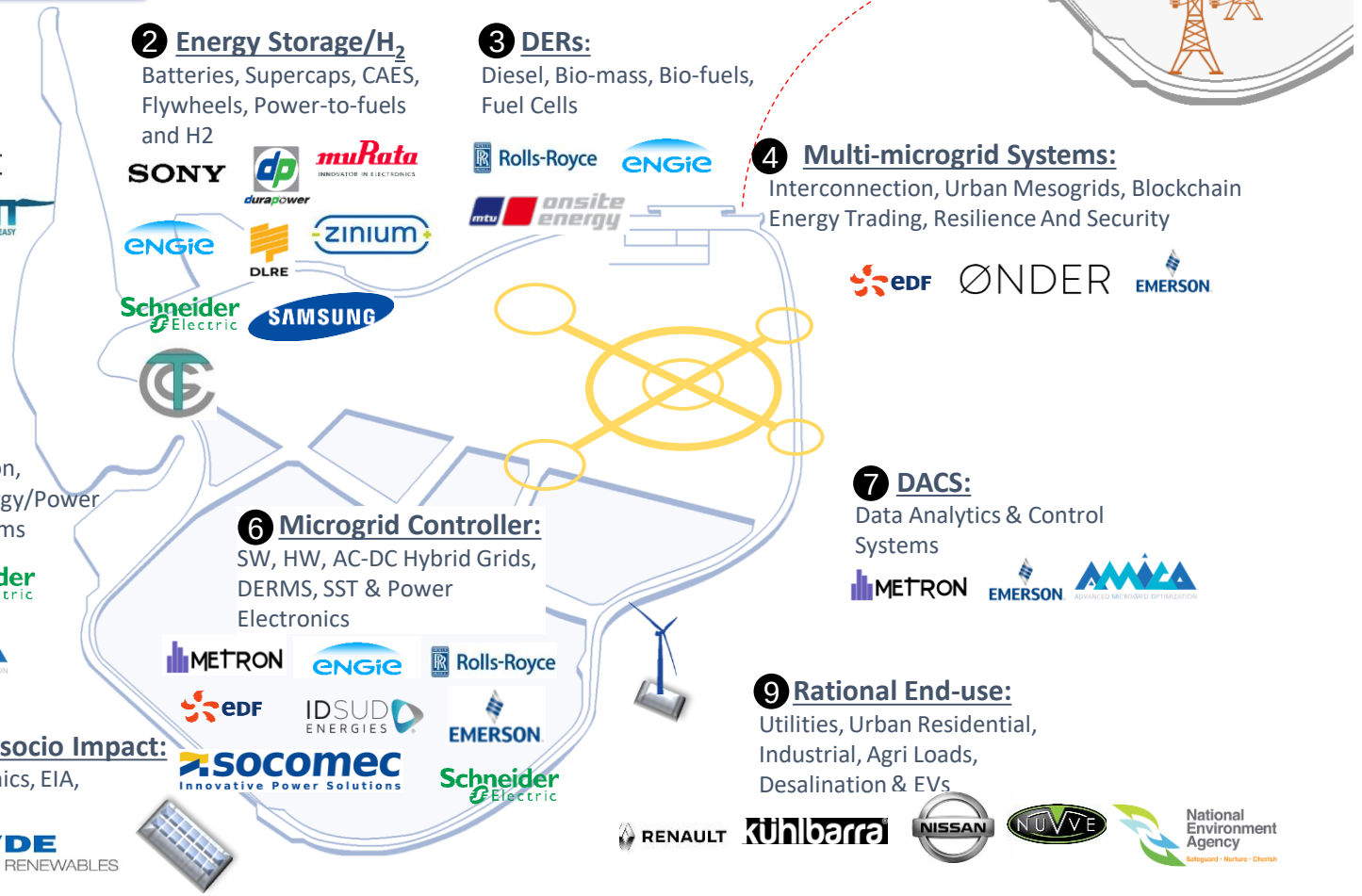
Low Voltage Microgrid Cluster (LVMGC) – Industry Partner Microgrids & Core Infrastructure

- 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/H_2
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

Sustainable Powering Off-grid Regions (SPORE)

- **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

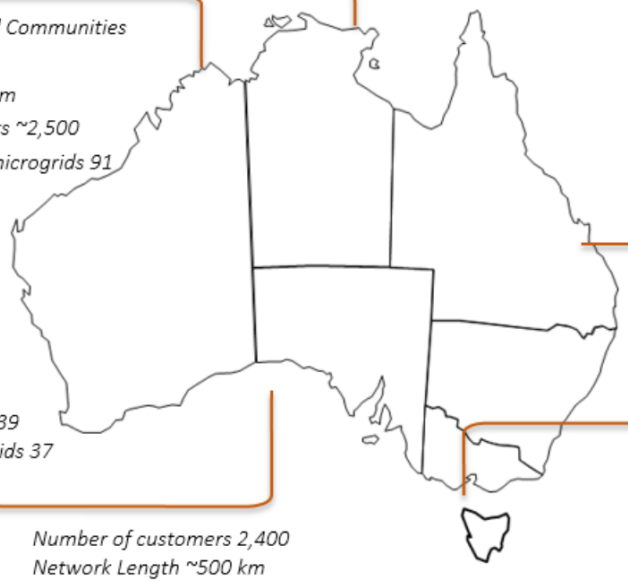
Microgrid for Affordable & Sustainable Electricity in Remote Areas (MASERA)

- **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



WA

Water

- *Total Assets $450m*
- *Mains Length 2,150 km*
- *Number of customers 30,039*
- *Number of remote microgrids 37*
- *Water Produced 21,544 ML*

Larger Remote Aboriginal Communities

- *Total Assets $770m*
- *Mains Length ~325km*
- *Number of customers ~2,500*
- *Number of remote microgrids 91*

Other

- *Standalone water schemes ~100*
- *Other Small community systems > 150 (<50 population)*

Horizon Power Microgrids

- *Total Assets $1,200m*
- *Network Length 6,300 km*
- *Number of customers 30,039*
- *Number of remote microgrids 37*

NT

- *Total Assets $830m*
- *Network Length 3,000 km*
- *Mains Length 1,164 km*
- *Number of Customers ~25,000*
- *Remote Power Networks ~13*
- *Remote Water Networks ~18*
- *IES Community Systems (power and water) 72*

QLD

- *Total Assets $2702[3]*
- *Remote Power Networks 33*
- *Large number of standalone municipal water Schemes*
- *Number of Customers ~7,500[2]*

TAS

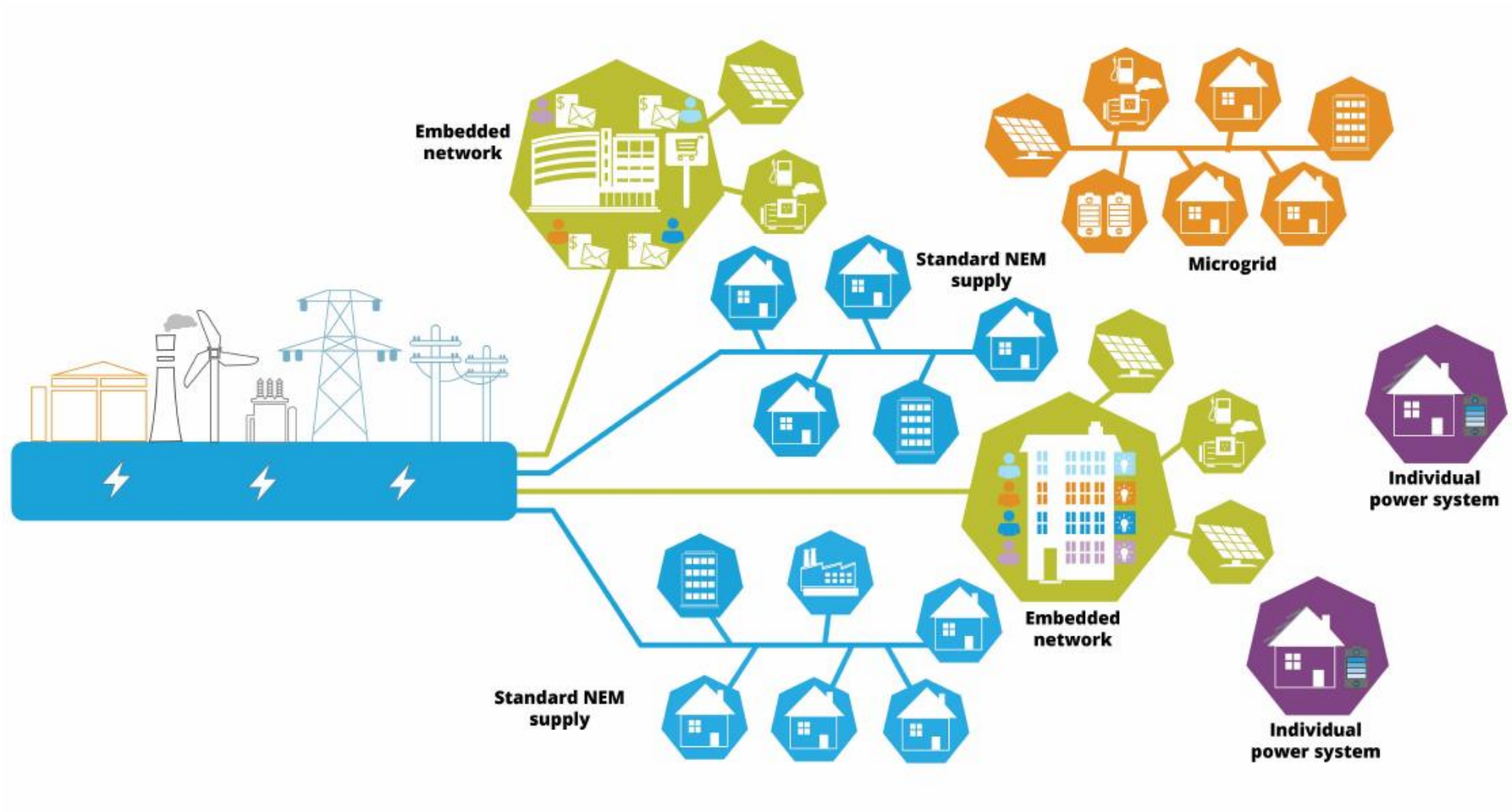
- *Total Assets ~$25m[4]*
- *Network Length ~727 km*
- *Remote Power Networks 2*
- *Number of customers ~2,000*

SA

- *Remote Power systems 13*
- *Remote Aboriginal communities 16*
- *Number of customers 2,400*
- *Network Length ~500 km*


Thursday Island, QLD
Thursday island, QLD
Diesel and wind microgrid
Timor Sea
Darwin
Broome North, WA
Broome North, WA
Solar-powered microgrid
Doomadgee, QLD
Diesel and solar microgrid
Thevenard island, WA
Mackerel islands
standalone power station
Pilbara, WA
Remote aboriginal community standalone
power station
NORTHERN
TERRITORY
Townsville
Daintree, QLD
Solar to hydrogen microgrid
Mackay
Birdsville, QLD
Diesel and geothermal microgrid
QUEENSLAND
Alice Springs
Australia
Murchison, WA
CISRO standalone power station
Kalbarri, WA
Kalbarri microgrid
Murchison, WA
WESTERN
AUSTRALIA
Windorah, QLD
Diesel and solar (concentrated
photovoltaic dishes) microgrid
Brisbane
Toowoomba
Gold Coast
Geraldton
White Gum Valley, WA
White gum valley energy sharing
trial
SOUTH
AUSTRALIA
Northern Adelaide, SA
Solar PV and battery microgrid
Garden Island, WA
Mandurah
Bunbury
Garden island, WA
Garden island microgrid
Jandakot, WA
ATCO hydrogen microgrid
NEW SOUTH
Newcastle
Sydney
Adelaide
North Adelaide, SA
The Mooroolbark, VIC
The Mooroolbark mini grid
Great
Australian
Bight
VICTOR
Ballarat
Melbourne
Latrobe Valley, VIC
Bruny island
The Bruny island microgrid
TASMANIA
The Bruny Island, TAS

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 stand-alone power systems over the next ten years.

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.

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

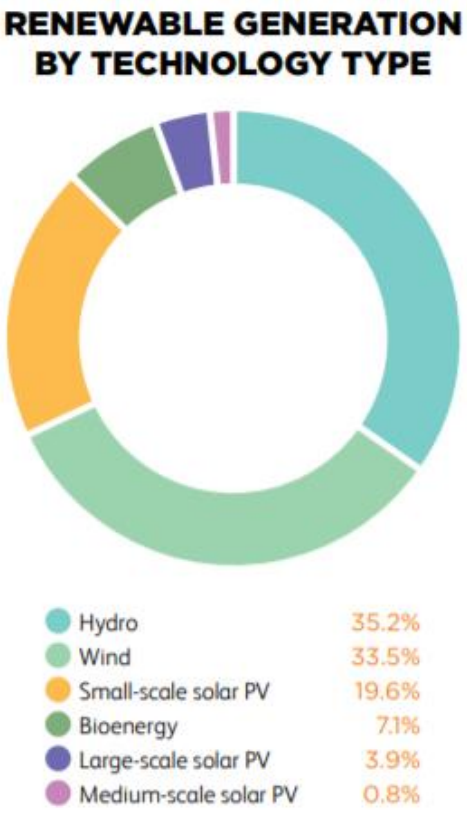
AusNet Services' initial, high-level assessment is that it may be economic to deploy SAPS solutions for between **300-400** of its customers in bushfire prone areas.

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

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

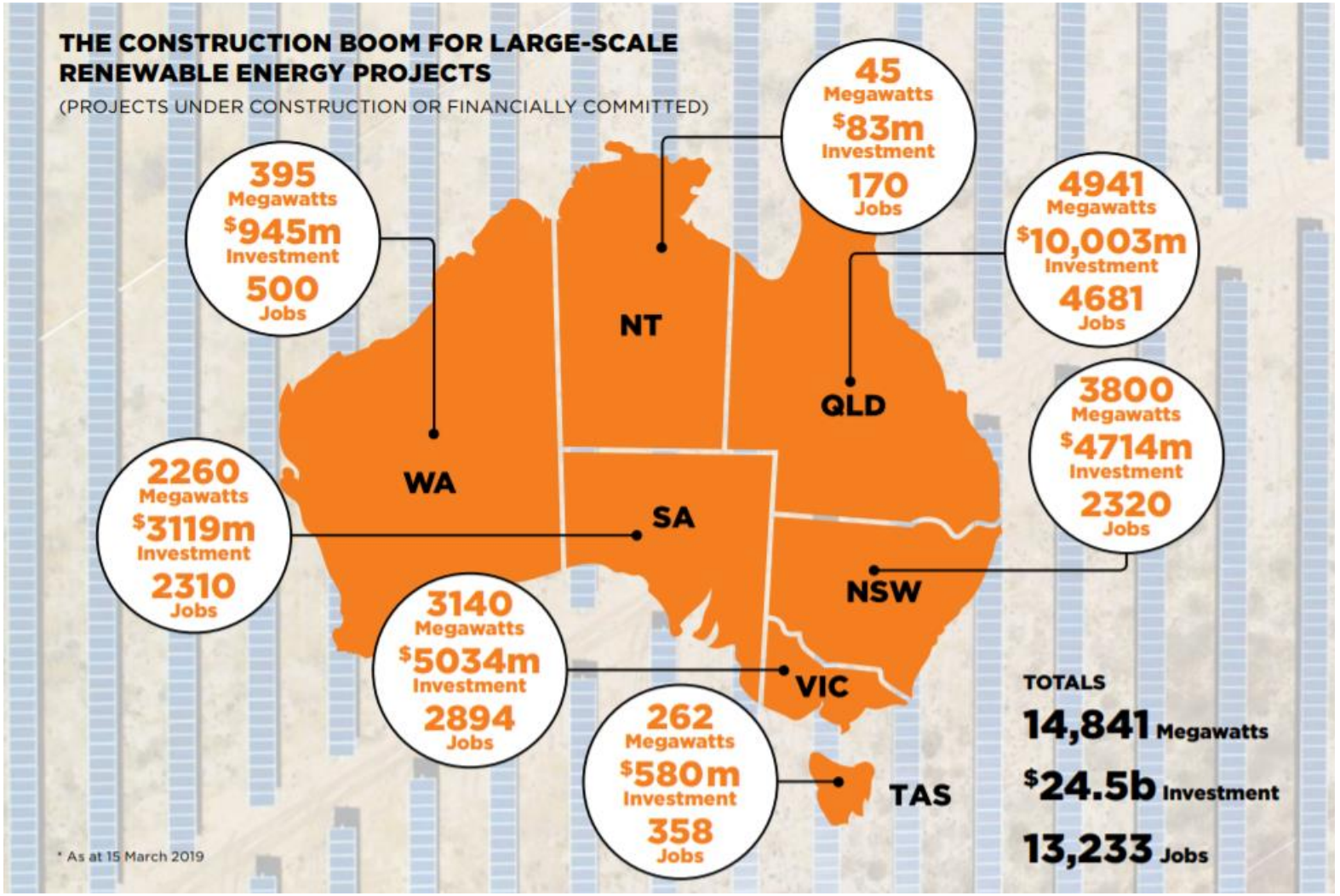
Source: AEMC

Renewables in Australia



Source: Clean Energy Australia Report 2019

Renewables in Australia



Source: Clean Energy Australia Report 2019


thank you
рахмат
danke
謝謝
ngiyabonga
teşekkür ederim
Баярлалаа
mersi
barka
welalin
tack
spas
kia ora
спасибо
faafetai lava
vinaka
спасибі
blagodaram
dank je
misaotra
matondo
paldies
grazzi
mahalo
gracias
tapadh leat
хвала
asante
manana
obrigada
tenki
kiitos
dankie
nanni
nandri
dhanyavad
bedankt
hvala
maururu
köszönöm
gracie
bayarlalaa
enkosi
dziękuję
akun
dankon
aciú
djiere dieuf
tau
mochchakkeram
murakoze
дякую
mamnun
chokrane
chnorakaloutioun
gratias ago
gracies
sulpay
go raibh maith agat
sobodi
dėkuji
sagolun
sukriya
kop khun krap
taiku
arigatô
takk
dakujem
trugarez
obrigado
mèsi
didi madloba
najis tuke
ありがとう
tanemirt
grazie
terima kasih
rahmet
kam sah hamnida
rahmat
ευχαριστώ
diolch
dhanyavadagalu
shukriya
merce
мерси
xièxie
merci
감사합니다