Bucharest 2018 Symposium on Microgrids

Penghu Dongjiyu Microgrid Enhancement – Stability, Quality and Economic Effectiveness

CHUNG-HSIN Electric & Machinery Mfg. Corp. (CHEM)
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Penghu County Government

Outline

- **Dongjiyu, the remote island**
  - Past & Present
  - Location / Importance
- **Overview of the project**
  - Objective
  - Motivation
  - Approach
  - Achievement
  - Application
  - Suggestion for Upgrade
  - Hybrid ES (Energy Storage)
  - Hybrid ES reference

Background

- Established in **1956**
- Group Capital: **USD 140 Million**
- Group Revenue: **USD 330 M/Yr**
- **Power Equipment, Engineering and Energy Management**
- TSE: **Code 1513, listed since 1994**
- Headquarter: **Linkou, Taiwan**
- ISO 9001/9002/14001/AS 9100
- www.chem.com.tw

CV

Name: Joseph, C.D Chang

Current Positions

1989-Present, Special Assistant at Chairman Office, Chung-Hsin Electric & Machinery MFG. CORP.
2010-Present, Director of Taiwan Smart Grid Industry Association

Academic Qualifications

Air Force Institute of Technology, Electronics Engineering

Related Experiences

1989/6 -Present

1. Process Automation and Computer Integration Manufacturing at Sugar Refinery of Taiwan Sugar Corporation, Kaoshiung
2. The Fifth of Power Distribution Automation Planning-Feeder Automation, TaiPower Company.
3. The Sixth of Power Transmission Automation Planning-Sub-station Automation Establishment.
4. SCADA System of Switch Yard at Dar-tan Thermal Power Plant, TaiPower Company, Guanying.
5. DDCS Back-up System Implementation at Taoyuan and Miaoli DDCC
6. Joint Development of Microgrid Power Management System with INER.

Professional Awards

Golden Quality Medal Award granted by “Public Construction Commission” recently including:

1. The 5th annual award (2004)
2. The 7th annual award (2006)
3. The 8th annual award (2007)
4. The 9th annual award (2008)
5. The 11th annual award (2010)
6. The 12th annual award (2011)
7. The 16th annual award (2016)

8. 2017 Energy Smart Communities Initiative (ESCI) Best Practices Awards Program – Silver Award of Smart Grid

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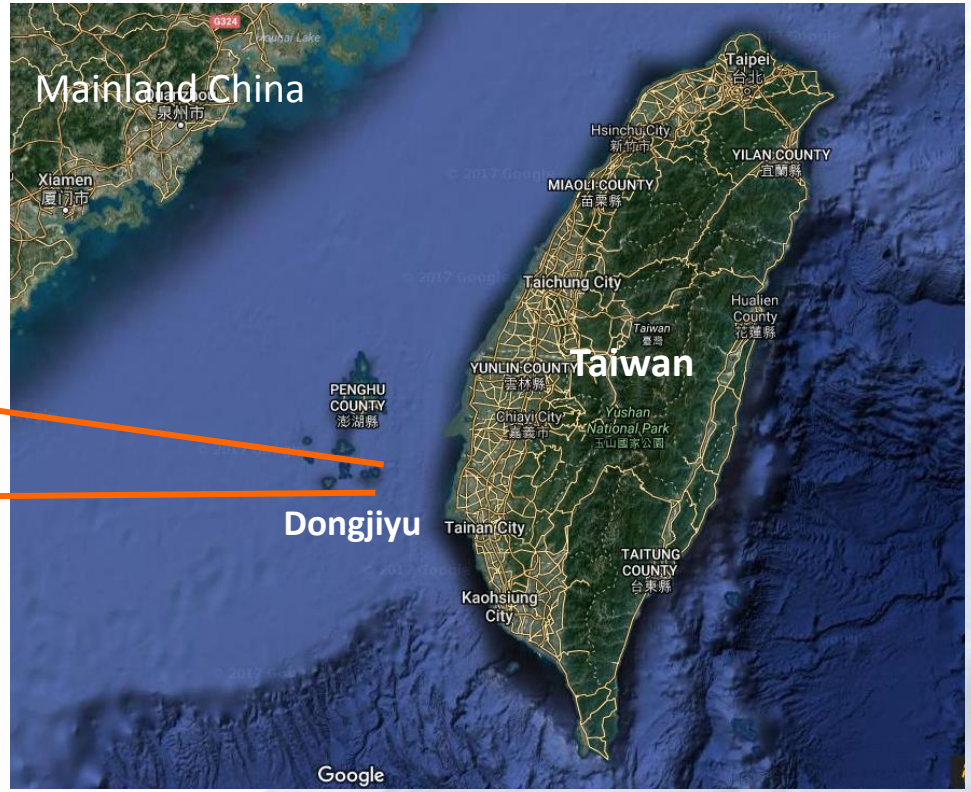
DONGJIYU - The location

- Dongjiyu, connecting Mainland China and Southwest Taiwan, brings the important value in 1900s.



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PAST - Importance

- **100 YEARS AGO as LITTLE SHANGHAI**

Photo courtesy: DaAi TV

PRESENT - Importance

- **The 9th NATIONAL PARK and**
- **The 2nd MARINE NATIONAL PARK**
  - 6 endemic plant species
  - 18 protected wild species, including 3 endemic species
  - The unique location & the important breeding area.

Photo courtesy: National Marine Park

PAST & PRESENT

➢ PAST

– Limited Solution: Diesel Generator as SMALL POWER SUPPLY SYSTEM

– Pollution in Noise, Air, High Opex

➢ PRESENT

– Goal: clean energy for the nature

  – natural resources optimized

  – fuel consumption reduced

  – operating cost reduced

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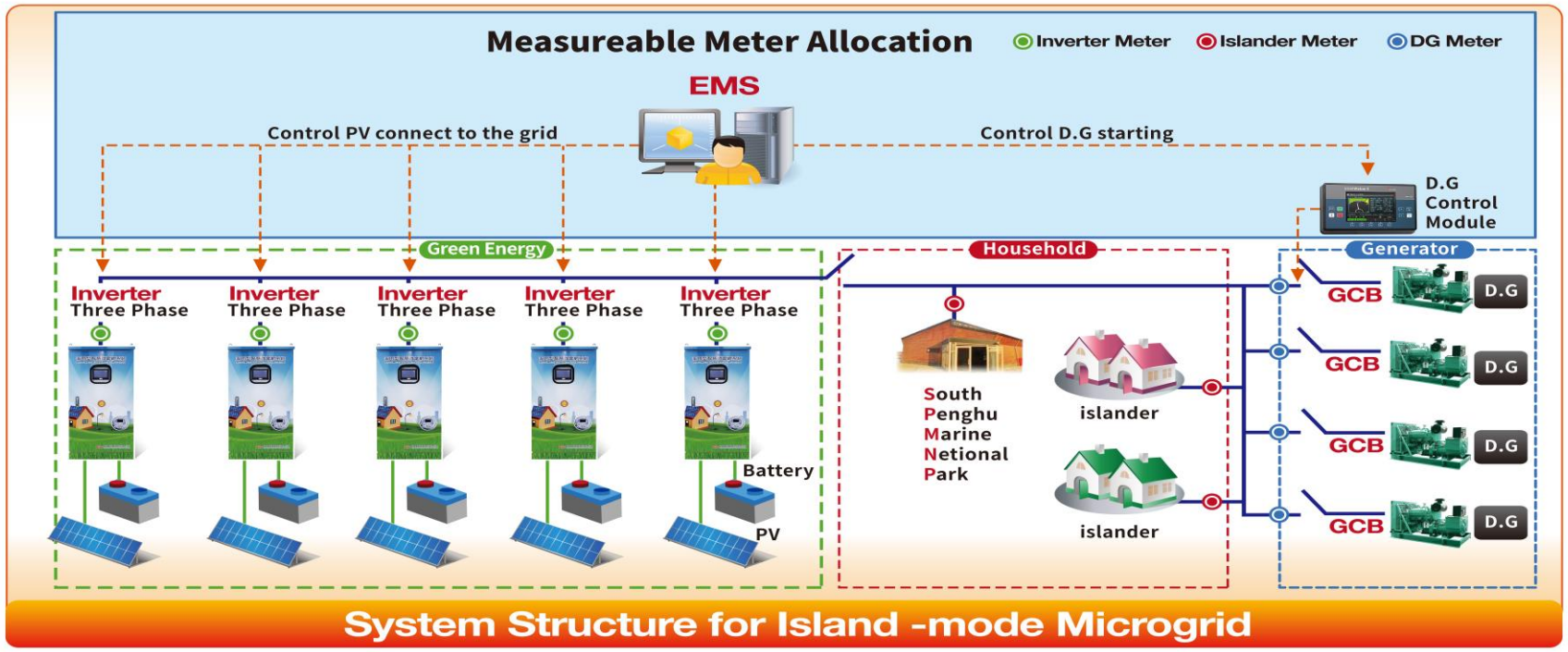
OVERVIEW

➢ Chung-Hsin Electric & Machinery Mfg. Corp. (CHEM) & the project

- CHEM completed the grid connection project of Dongjiyu's 85kWp photovoltaic and D.G systems.
- Communication Interface: Direct RS-485 for Phase I Monitoring System and Phase II Smart u-MEMS, Wireless Communication for Auto Meter Reader on DC and AC Panel and Power SCADA.



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MOTIVATION & OBJECTIVES

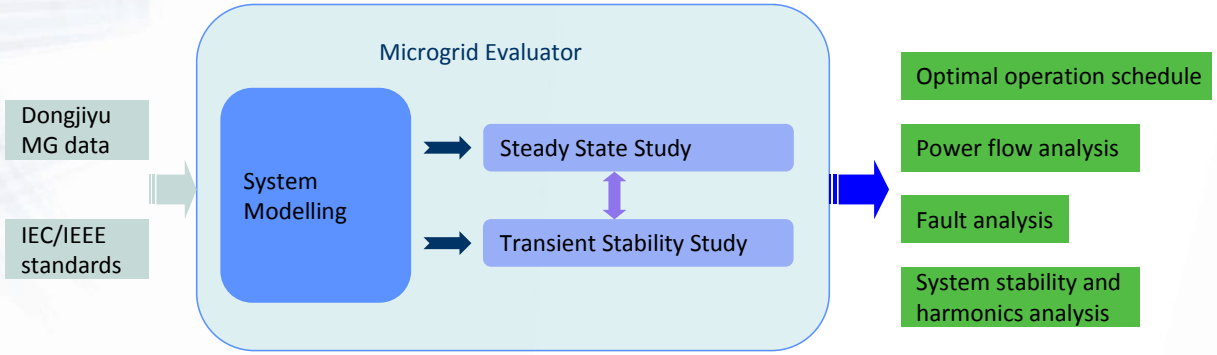
Problems/Issues to Address	Overall Project Objectives	Significance and Relevance to Taiwan
Renewable intermittency assessment and control on a micro-grid	To perform impact assessment of intermittent energy sources on the quality of electricity supply from a micro-grid standpoint and specific measures for improvement	Assisted in Penghu County Government enhancement solutions for bettering grid's tolerance and capacity for increased intermittent generation sources through the use of grid-tie energy storage
Emerging microgrid component and algorithmic technologies (e.g. energy storage technologies) performances and their associated deployment configurations	Dongjiyu hybridized system and component performances, conditions and their associated deployment configurations by collecting year-long operational field-data	The project team lead in developing an internationally verified microgrid solution that is suited for Taiwan and Asia countries, and effectively lift up Taiwan's strategic positioning in the global energy industry development

APPROACH & METHODOLOGY

Existing Limitations	Improvement/Enhancement	μ-E	S-μMEMS	S-ES
Diesel generator needs to be in standby status as ancillary generation for load variation and photovoltaic intermittency.	– Storage Switching, & Economic Dispatching, achieve – Greater flexibility in system design and operation – Extended life-time of overall system & lower operational cost		✓	✓
Power quality issues (e.g. reduced power factor due to current system control mode on diesel generator)	– Improved on forecasting, scheduling, generating capabilities – Shorter response time for storage and can accommodate varying load profiles with flexible output range.		✓	✓
System instability risks (e.g. Fault of DC bus, battery, PV panel, or generator)	– Improved overall system data analysis, real-time power quality information, online system transient analysis, accurate and reliable communication system, and high efficiency power conditional equipment	✓	✓	✓

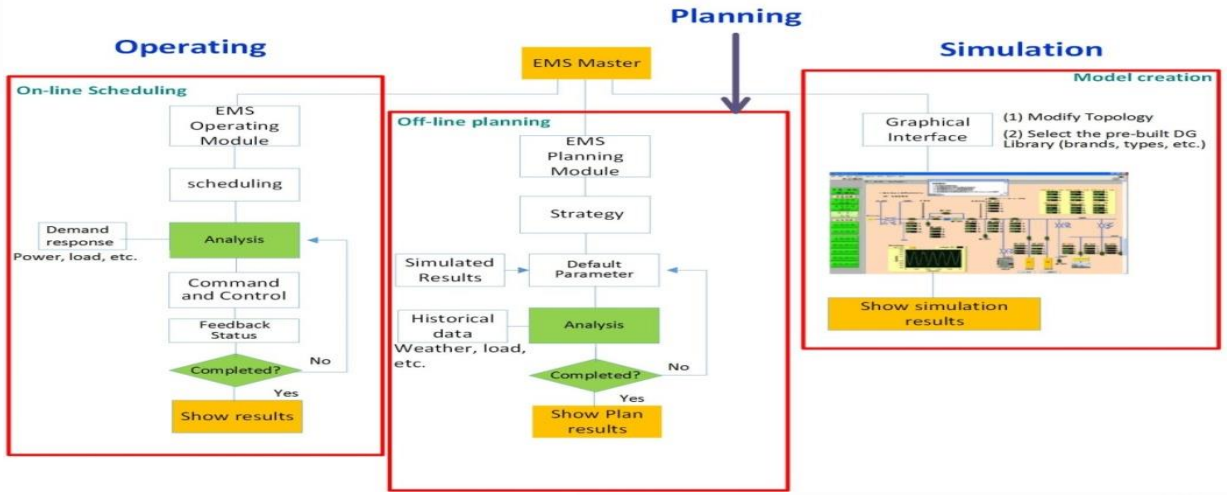
APPROACH & METHODOLOGY

Flowchart of the Microgrid evaluation



Microgrid evaluation aims to develop a comprehensive microgrid model, which is used to analyse the systematic power flow, fault currents, transients, harmonics, and the overall system operational economics.

Flowchart of the *Smart μ-MEMS*



Smart *μ*-MEMS aims to achieve advanced optimized resource allocation, while delivering overall enhancement in system reliability and quality.

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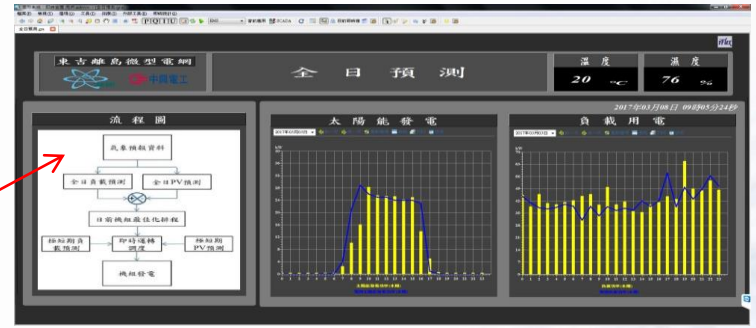
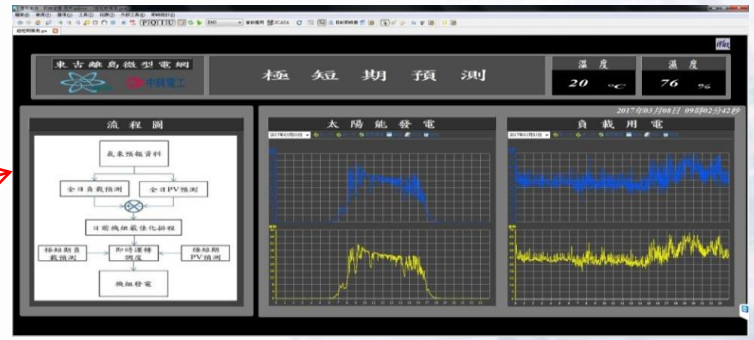
APPROACH & METHODOLOGY - Smart μ-MEMS

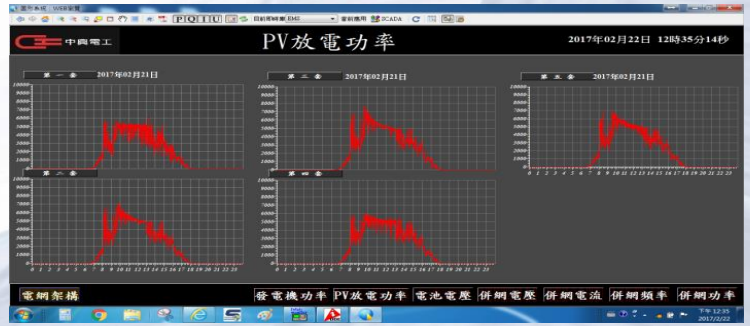




Historical Trend Chart

Power Supply & Load Information

PV Information



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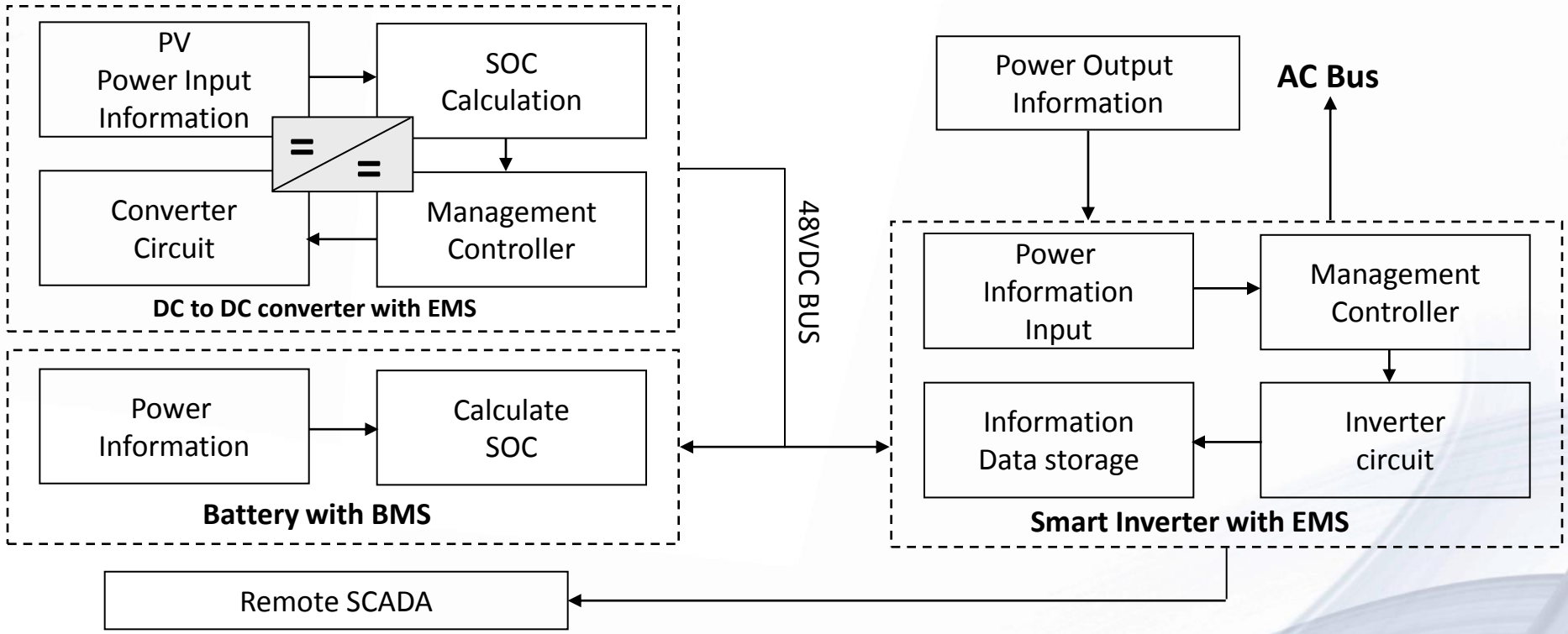
APPROACH & METHODOLOGY

- Use of lead acid batteries - higher availability & technology acceptance, cost effective
- **Smart ES solution** - To improve controlling for fuel efficiency on inverters and batteries

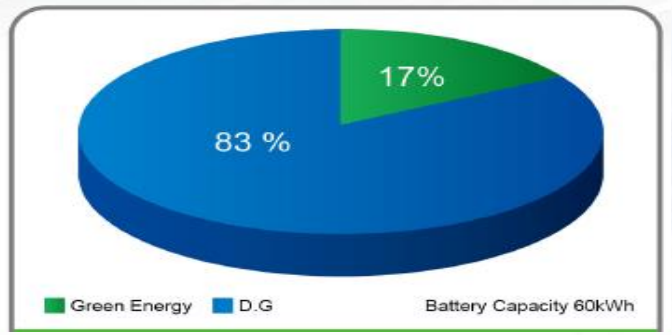


Flowchart of the *Smart ES*

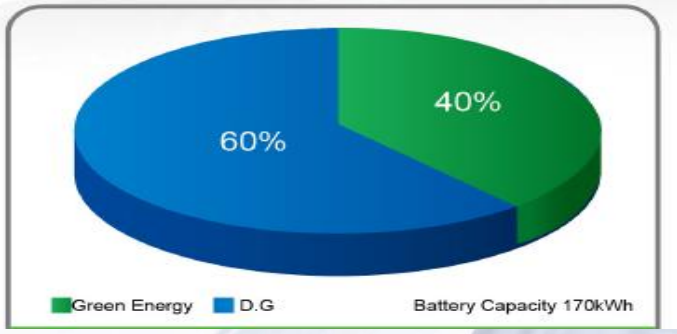
PENETRATION RATE

- Penetration rate of solar power increased from 17% up to 40% average,
- Battery capacity increased from 60kWh to 180 kWh

The Monitoring Figure of Dongjiyu Microgrid



Before improvement



After improvement

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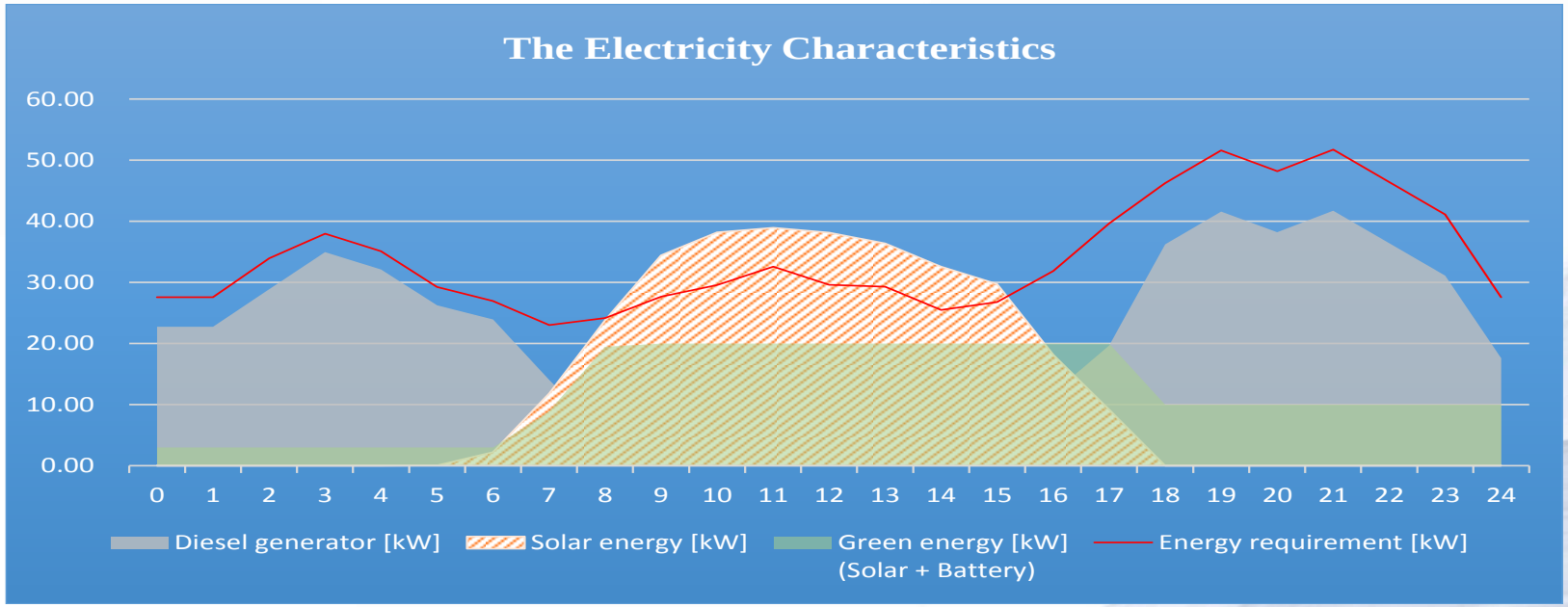
ACHIEVEMENT

Key power network & integration characteristics

- Maximum penetration rate of solar energy ＞ 80%
- Average daily penetration rate of solar energy ＞ 40%
- Operation costs reduction > 48%
- Generation cost below USD 0.18/kWh



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MULTIPLE OPERATING AREA

- Microgrid is a localized grouping of electricity sources and loads that are operated and connected to the traditional centralized electric grid. Disconnecting and functioning autonomously are also possible for different physical and/or economic conditions.
- It provides the solution for emergency power supplying with flexibility between islanded mode and grid-tied mode.
- Control and protection are big challenges in this type of network configuration, which is generally treated as a hierarchical control.

Off-Grid Mode	Grid-tied Mode	Mini Power Station
Rural areas	Urban areas	Tele-communication station
No utility	Utility available/unstable	No utility
Islands	High electricity price	Good power quality required
Diesel fuel is expensive	Interactive with grid	Diesel generator standby
Maintenance free	Grid feed-in (optional)	Minimum maintenance
Larger PV and battery	Smaller PV and battery	Larger PV and battery

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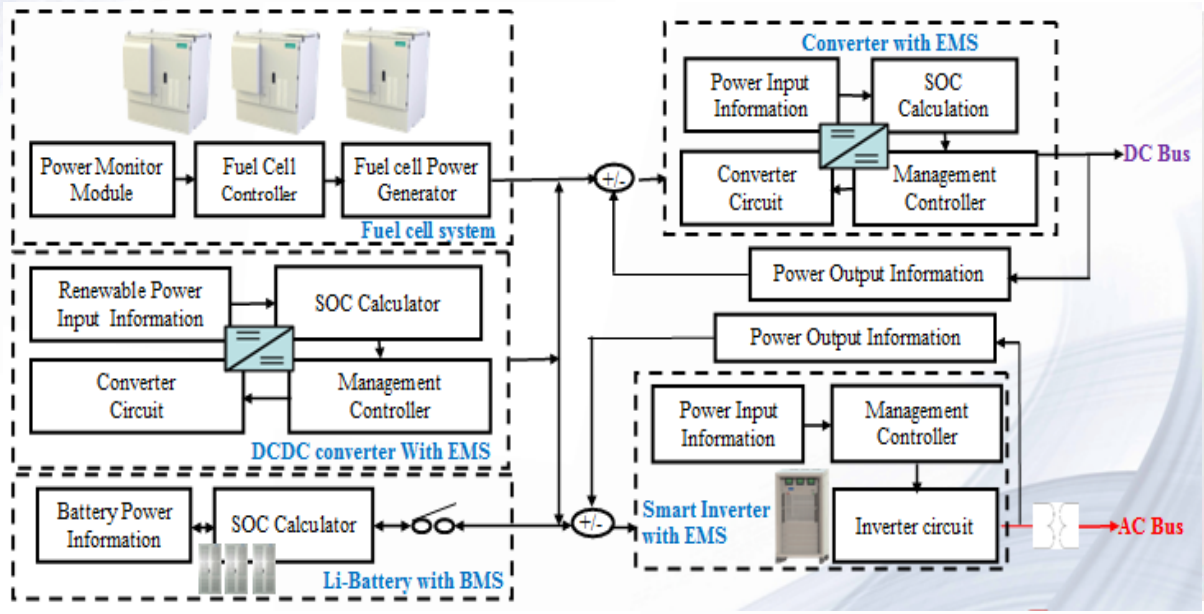
FUTURE UPGRADES

- Hybrid ES solution - characterized by the combined fast response of lithium battery and long stable power supply of methanol fuel cells,
- Improves the overall supply stability and power quality issues (i.e. Low-carbon island of clean energy).



Taiwan's 1st low-carbon island with 100% clean energy

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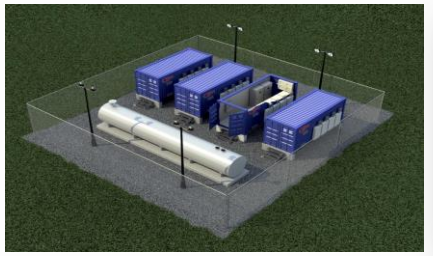
FUEL CELL μGRID – Trust Community, S.A



Three 5kW Methanol FC systems
batteries, DC/AC inverters,
fuel system, control system,
telemetry system and
safety system

Sufficient for everyday use
generates 230V,
50Hz AC quality power
at 200kWh per day.
(peak power 60kVA) .)

Easy access to real time data
remote monitoring,
programmed maintenance,
fault detection and correction,
fuel level monitoring and
remotely scheduled deliveries

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Chung Hsin Electric & Machinery Mfg. Corp

COMMUNITY μGRID – Hsio Lin Village, Taiwan

- Hybrid micro-grid has grid-tied and stand-alone mode available. Its “smart-generation”, “smart-storage”, and “smart-dispatching” solve the problem of voltage drop of the feeder, and act as the regulator of power network with high efficiency.

ZERO ENERGY HOUSE – Nagano, Japan

- A Zero Energy House (ZEH) is a house that consumes less energy than it produces on a net annual basis by creating renewable energy. This should be achieved with a hybrid system of PV system and batteries. The hybrid system also includes a backup system.

Household μ-Grid System

PV: 3-5kWp
Storage system: 9-12kWh
System capacity: 5kW
Build-in Power Management System,
Remote monitoring .

Power Management System

A complete power management solution including Monitoring & Control System (MCS), electrical SCADA, Energy measuring, energy accounting, real-time predictive simulation, event playback, load forecasting, system automation and more.

GREEN ENERGY PARK – Taipei,Taiwan

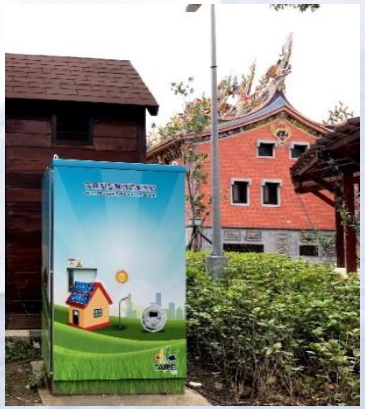
- All these are to incorporate an intelligent city and green energy into the life of Taipei citizens. Beitou District RUAN-QIAO Biological Park utilizes solar panels, battery storage, and energy management system to create high renewable energy utilization and low carbon emission park.

High penetration green energy & low emission

Renewable energy parks not only provide a source of reliable, locally-produced clean energy, but they have also contributed to eco-tourism and served as an educational resource to local schools, universities and business groups.

Energy Storage System

The solar energy produced during day time is stored in the battery storage system for street light usage at night. On a cloudy and raining day, when the stored battery power is not enough, the system will automatically switch to the city-grid as the energy source for street lighting.



COMMUNITY μGRID - New Taipei City ,Taiwan

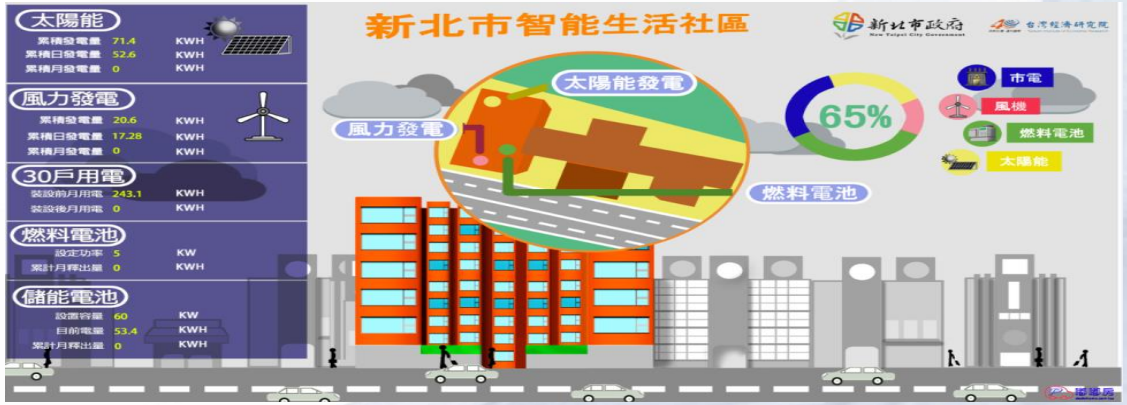
- New Taipei City pioneered the nation's first the Private residence building of energy creation, energy storage and energy saving, combined with solar, small wind turbine, fuel cell and IoT to build a smart micro-grid, the community can operate independently and be power autarky, and build up public consensus of using green electricity and electricity saving with residential.

Community Microgrid

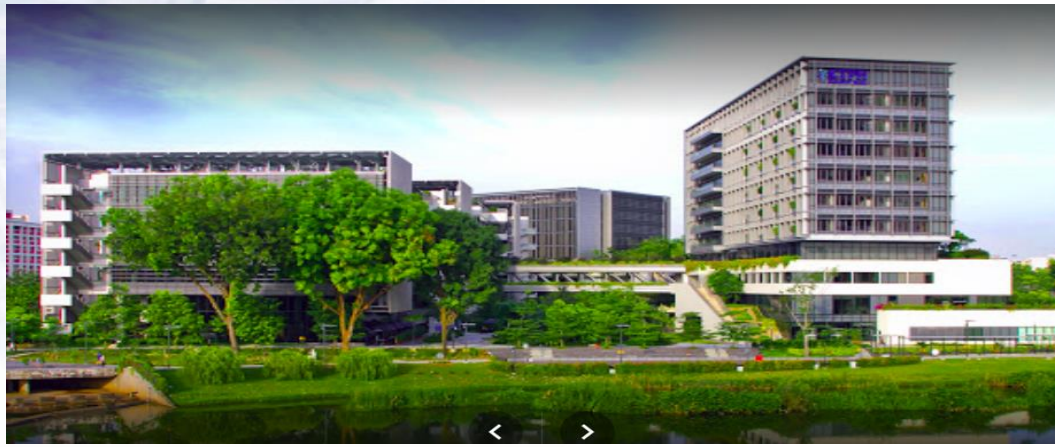
PV: 12.6kWp
Small wind turbine: 3.6kW
Storage system: 60kWh
Methanol Fuel Cell: 5kW
System capacity: 15kW
Smart meter: 30 units
Build-in Power Management System,
Remote monitoring .

Win-Win-Win Strategy

To execute the load regulation by power supply and demand, monitor the building public electricity and to carry out the demand response according consumption power of each home during peak hour. Incorporating IoT technology and through the visible man-machine interface, users can join the procession of energy saving and carbon reduction actually.



DEPLOYMENT FOR HOSPITAL



- **Khoo Teck Puat Hospital Singapore – Green building concept, Fuel cell Uninterruptable Power Supply (FCUPS)**

- **Tan Tock Seng Hospital (TTSH) deployed CHEM FC since 2010 for backup power to produce better environment (no noise, smoke, vibration)**

On the roof top

On the ground

GREEN PRODUCT

Household μGrid

ME²Power
Methanol Fuel Cell

Hydrogen Generating

Single ϕ/3 ϕSmart inverter

URL:http://www.chem.com.tw

Power Generating Module