REIDS
Renewable Energy Integration Demonstrator - Singapore

An ERI@N Flagship Project

Systems & technologies for a sustainable & affordable energy access-for-all in Southeast Asia

Prof. Fook Hoong Choo

29-30 November 2017
ERI@N structure

ERI@N
Energy Smart, Research Innovation

Flagship Projects: Eco-Campus & REIDS

- Renewables & low-carbon generation
- Energy Storage & Fuel Cells

Energy Systems

- Renewables’ integration
- Multi-Energy Systems & Grids

Grid Systems

- Sustainable Buildings
- Future Mobility
- Maritime Solutions
- Clean Energy

Urban Solutions

Materials, Simulation & Modeling, Electrical Power / Control, Reliability

Colleges of Sciences, Engineering, Humanities, Arts and Business
REIDS

Renewable Energy Integration Demonstrator - Singapore

A Singapore-based RD&D platform for the design, demonstration and testing of solutions for sustainable off-grid and urban microgrid systems
• 1.2 billion people on this earth do not have access to electricity.
• An even higher number do not have access to proper sanitation, including drinking water.
• Most of this population live in Africa, in Southeast Asia and in Latin America.

**The solution must be localized networks - off-grid microgrids.**

The deliberate focus of REIDS is on microgrid applications for:
• Islands
• Remote villages
• Emergency situations – earthquakes, tsunamis, refugee camps, etc..
• Remote mining operations
• “Fringe” networks
• Military bases
Economic development opportunity

While challenging, energy transitions also represent formidable technology and economic development opportunities for energy infrastructure and systems solutions providers.

Indonesia: 17,508 islands - Philippines: 7,107 islands

World’s top five fastest growing electricity production regions from 2010 to 2030
Rural electrification in Southeast Asia

<table>
<thead>
<tr>
<th>Country</th>
<th># people without electricity (Million)</th>
<th>% people without electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vietnam</td>
<td>(2.6;4.0%)</td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td>(0.7;1.7%)</td>
<td></td>
</tr>
<tr>
<td>Brunei</td>
<td>(0.1;1.3%)</td>
<td></td>
</tr>
<tr>
<td>Malaysia</td>
<td>(0.1;1.3%)</td>
<td></td>
</tr>
<tr>
<td>Singapore</td>
<td>(0.0;0%)</td>
<td></td>
</tr>
<tr>
<td>Laos</td>
<td>(0.9;18.5%)</td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>(48.7;34.4%)</td>
<td></td>
</tr>
<tr>
<td>Myanmar</td>
<td>(36.3;81.7%)</td>
<td></td>
</tr>
<tr>
<td>Philippines</td>
<td>(20.6;32.6%)</td>
<td></td>
</tr>
<tr>
<td>Cambodia</td>
<td>(9.9;81.8%)</td>
<td></td>
</tr>
<tr>
<td>Singapore</td>
<td>(0;0%)</td>
<td></td>
</tr>
</tbody>
</table>

106 Mio people without electricity

% of people in rural areas without electricity
Semakau Landfill – An emblematic site for REIDS
Legacy

- On-island loads (residential, commercial, SME’s)
- Desalination
- Aquaculture
- Agro processing
- Clean mobility
- ...
- Connection to neighboring islands
Microgrid Infrastructure
Renewable & storage enabled
Phase-out of diesel as primary provider

Renewable Energy Generation
- Solar Renewables
  - Solar PV
  - Solar Thermal Electric
- Marine Renewables
  - In-stream Tidal
- Wind Renewables
  - Small to Intermediate
  - Onshore & Offshore

Hybrid Microgrid
- Remote Monitoring & Control
- AC/DC

Energy Storage
- Batteries – Li-ion, Redox Flow, Super-capacitor
- Flywheel
- Compressed Air
- Hydrogen

Diesel Gen
- Diesel

Loads
- On-island loads (residential, commercial, SME’s)
- Desalination
- Aquaculture
- Agro processing
- Clean mobility
- ...
- Connection to neighboring islands
Plug & Play expansion

Renewable Energy Generation

- Solar Renewables
  - Solar PV
  - Solar Thermal Electric
- Wind Renewables
  - Small to Intermediate
  - Onshore & Offshore
- Marine Renewables
  - In-stream Tidal

Bio Energy

- Non-food crops
- Algae

Energy Storage

- Batteries – Li-ion, Redox Flow, Super-capacitor
- Flywheel
- Compressed Air
- Hydrogen

Fuel Cell

- H₂

Remote Monitoring & Control
- AC/DC

Diesel Gen

- Diesel

Loads

- On-island loads (residential, commercial, SME’s)
- Desalination
- Aquaculture
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- ...
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REIDS Technology Road Map

Renewable Energy Generation
- Solar Renewables
  - Solar PV
  - Solar Thermal Electric
- Marine Renewables
  - In-stream Tidal
- Wind Renewables
  - Small to Intermediate
  - Onshore & Offshore
- Bio Energy
  - Non-food crops
  - Algae

Hybrid Microgrid

Energy Sources
- Diesel Gen - Diesel

Storage
- Remote Monitoring & Control
- AC/DC

Loads
- On-island loads (residential, commercial, SME’s)
- Desalination
- Aquaculture
- Agro processing
- Clean mobility
- ...
- Connection to neighboring islands

Energy Storage
- Batteries - Li-ion, Redox Flow, Super-capacitor
- Flywheel
- Compressed Air
- Hydrogen

Others

Hybrid Microgrid

Fuel Cell
- H₂

Remote Monitoring & Control
- AC/DC

Grid Connection
P2 plot layout

- 3 plus 4 microgrids on a 6.4 ha land
- Capable of operating in islanded mode at 400 V, 3Ø, 50 Hz

Resources:
- PV & wind
- RLC & other loads
- DGs
- Battery Storage
- ICT infrastructure

- Microgrid inter-operability demonstration and connection to remote assets (production & loads) by way of 6.6 kV Link Buses.
- Flexible allocation of local loads & assets by way of Asset Allocation Module.
- Microgrid cluster
Microgrids 1, 2 and 3 on a 64’400 m² greenfield – Plot 2 (P2)

P2 plot conceptual diagram:

Three separate microgrids

400 VAC – DC distribution possible

Within each microgrid:
• PV – several 100 kWp
• Wind – 50 to 200 kW
• Energy storage – Li-Ion, Redox flow, supercapacitors, etc.
• 400 kW 3Ø passive load
• Microgrid-specific loads
• Possibility to connect to shared loads and sources

Each microgrid should be capable of operating in a fully islanded / isolated mode.

Inter-microgrid operation “interoperability demonstration” by way of 6.6 kVAC network.

Connection to off-P2 assets: 6.6 kVAC
• Fish nursery
• Desalination plants
• In-stream tidal machines
• ....
REIDS 3D rendering
REIDS Development status – “Microgrid 0”

MG0 Test & Commissioning - March 2017

400kW PV

200kW

200kWh
REIDS Development status – “P2 plot”
REIDS Development status – “P2 plot”
REIDS HUB
Summary - Three pillars of long-term strategy for excellence

1. Microgrid R&D
   - Solve engineering, economic, environmental and societal energy transition challenges for off-grid communities and urban microgrid systems.
   - Partner with Southeast Asia private, public and civil society organizations.

2. Microgrid systems demonstration and equipment testing
   - Implement large-scale microgrid system demonstrations under tropical climatic conditions.
   - Design and execute equipment performance assessment tests in a neutral environment under in-the-field operating conditions.

3. Outreach: engineering support, seminars, presentation & publications
   - Broadly disseminate the REIDS message in Southeast Asia: conference participations, seminars, executive education – Singapore and off-site.
   - Road-map energy transition strategies in Southeast Asia.
   - Enroll REIDS public and private sector members in Southeast Asia.
REIDS

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http://erian.ntu.edu.sg/REIDS

Contact:

Prof Fook Hoong CHOO
Director, REIDS
efhchoo@ntu.edu.sg

Energy Research Institute @ NTU – ERI@N
Nanyang Technological University
Singapore 637141