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"CONNECTING POLICY, TECHNOLOGY & FINANCE THROUGH KNOWLEDGE"

Understanding Micro-Grid Market in South-East Asia

19 – 20 March 2018

Singapore Sustainability Academy, 180 Kitchener Road, City Square Mall, #06-01, Singapore 208539

Contents

Introduction

This programme introduced the basics about South-East Asia's micro-grid market. The participants learn about global trends, fundamentals of technical design and key building blocks for micro-grid business models. 3 country-level dive-in's were presented for Indonesia, Philippines and Myanmar and they were accompanied by selected case studies.

12 participants and 9 speakers from 4 countries attended the programme.

Current market status

Adoption of microgrid seems to be on the rise and large market players are beginning to taking note. The size of the opportunity are as follows:

- Diesel gensets: 40 Billion USD industry globally
- 30 GW of diesel gensets capacity was added in 2015 in developing countries comparing to 56 GW of on-grid.
- Indonesia: 3 GW of installed diesel genset capacity
- Philippines: 300 MW of installed diesel genset capacity
- Myanmar: 60 MW of installed diesel genset capacity

The are opportunity across 3 segments (1) Community energy – 1.2 billion people without electricity access and 130TWh is required (2) Decentralised assets – island resorts (7-80 kWh/pax/night), mines (20 – 153kWh/ton), agricultural plantations (0.5kWh/m2), telco towers (20-200kWh/tower) (3) areas where there are weak grids and unreliable supply.

Regional overview for South East Asia

South East Asia energy mix is primarily dominated by oil at followed by natural gas, coal and bioenergy.. Tpes is 628 mtoe as of 2015 and the demand for energy is expected to grow 4.7% annually until 2035. The Energy demand for producing electricity is expected to increase by 95% by 2025, provided predominantly

by coal, natural gas and large hydro. Of energy use, industry is the largest consumer at 29%, followed by transportation at 27% and residential at 26%.

Currently, 65 million people in ASEAN is still without energy access and 250 million more still rely on traditional biomass for cooking. The prevalent electricity model is that of a single buyer with IPPs and the state national utility company is typically a monopoly and the sole off-taker of electricity produced by the IPPs.

ASEAN plan to collectively secure 23% of primary energy from modern, sustainable and renewable energy sources by 2025 Member states have committed to reduce overall energy intensity by 20% in 2020 and 30% by 2025. Renewables-based electricity is already cost competitive with traditional power sources in some ASEAN countries and expected to become increasingly affordable.

Hydro, solar and wind are the 3 renewable energy technologies with the highest share in the energy mix. Solar leads non-hydro clean energy investment, with investment projects totalling USD 892M in 2016 as compared to USD 588M invested in wind projects In order to maximise the benefits of renewable energy to their economies, ASEAN countries have adopted policies to support the development of the local solar PV industry.

The most promising segments are island resorts, telco towers and remote sites such as mines and plantations.

Market Overview of Renewable Energy Microgrids

There are problems accessing electricity worldwide. According to the Sustainable Energy for All, Global Tracking Framework, (http://www.worldbank.org/en/topic/energy/publication/Global-Tracking-Framework-Report), 17% of the world's population have no access to electricity and 85% of these people live in rural areas. These regions are poor and lacking in infrastructure.

Microgrid is distributed energy resources and loads that can be operated in a controlled, coordinated way either connected to the main power grid or in islanded mode. Microgrid are low or medium voltage grids without power transmission capabilities and are typically not geographically spread out.

Microgrid is generation at the point of consumption and is therefore always available. Microgrid can be grid connected.

According to Reiner Lemoine Institut, the global installed capacity of off-grid diesel power plants is ~20 GW. About 700 million people worldwide use diesel generated electricity and further millions do not even have diesel generated electricity. Diesel generated electricity is costly (USD 0.30-0.60/kWh) and about 25% (~5 GW) of this market is in South East Asia.

There has been high growth rate of microgrid over the decade. It is projected that in 2024, 41% of microgrid revenue will be from Asia Pacific, while 32% will be from North America, with total global revenue to be about $165B. However majority of mircogrids are still not RE based, mainly combined heat and power, natural gas and diesel.

Microgrid applications are typically remote and in institutions or campuses. The rest are spread between commercial, community, utility distribution and military.

Non-military microgrid ownership by capacity are 45% financed by power purchase agreements, 16% by owner financing, 15% by utility rate base and the balance 24% by other sources.

Design of RE Microgrid

RE Microgrid concept and design

A microgrid is a geographically localized electricity network, which contains electrical generation sources, energy storage capacity, electrical distribution hardware, and electrical loads. A microgrid may be able to interconnect with a larger (often national) electrical grid, in which case it is an on-grid microgrid.

Alternatively, a microgrid may be geographically or electrically separate (or even remote) from a larger electrical grid, in which case it is an off grid microgrid. A microgrid differs from a mains electrical grid in both generation capacity, and physical extent. Typically, little or no electrical transmission infrastructure is required. Often, a microgrid operates entirely at low voltage (400 V AC)

Electrical generation sources may include diesel generator sets, solar photovoltaics (PV), small wind turbines, biomass energy generators, or micro-hydro power

Microgrid Components

Microgrid components are basically broken into 3, diesel generator sets, solar photovoltaic systems and batteries.

1. Diesel Generator Sets (Gensets)
    - Diesel engine converts diesel fuel into mechanical energy (and noise, and smoke)
    - Attached alternator converts mechanical energy into electrical energy
    - Gensets produce Alternating Current (AC)
    - Auxiliary control electronics ensure constant output RMS voltage and frequency
    - Gensets are a dispatchable source of electricity
    - Gensets come in a big range of sizes
    - Can be operated in parallel

2. Solar photovoltaic (PV) systems
    - Photovoltaic panels convert sunlight energy into electrical energy
    - PV produces Direct Current (DC) electricity
    - PV electricity is CHEAP
    - PV electricity it is intermittent (day, night) and variable (weather, clouds, seasons)
    - PV systems can be scaled to any size

3. Batteries

- Batteries convert electrical energy into chemical energy, which can be stored, and later converted back into electrical energy
- Batteries are Direct Current (DC) devices
- There are many different chemistries available, lead-acid, lithium, sodium, zinc, etc
- Battery energy storage is still a bit expensive, but prices are declining rapidly
- Battery systems can be scaled to any size

Price parity point between solar PV electricity and diesel generated electricity has been crossed. Price difference will only increase in future due to price trends for renewables and diesel. Substantial cost savings can be achieved if renewable energy is integrated with existing diesel generators

The three technologies diesel gensets, solar PV and batteries, form a good basis for a remote microgrid, especially in the tropics, where there is plentiful sunshine year-round, and not much wind. However, these technologies are quite different, and do not naturally play well together. It is important to understand the different characteristics and dynamics of each energy source or storage element so that they can work well together. AC/DC converters are required to convert between alternating current and direct current. Proper control hardware is required to ensure the smooth operation of these technologies together.

Key Buildings Blocks for Micro-grid Deployment: Policies & Regulations, Customers and Community & Financing

The government is the enabler of socioeconomic development, facilitator for the delivery of public services and enabler of rural/remote areas industrial development. As such to have a clear and stable regulatory framework, there are several general principles suggested. They are:

1. Ensure clear, swift and streamlined regulatory framework
2. Safeguard adequate implementation and enforcement of regulations
3. Ensure swift permitting through standardized procedures
4. Enhanced information transparency and tariff and reduce bureaucracy which in turn will help tacke corruption and facilitate project implementation
5. Develop standardized IPP and PPA documentation

Customer and Environmental Policy and Regulation

Technical regulations ensure safe and reliable operations through technical standards (incl. safety requirements, grid connection etc.). It should be designed specifically for the rural context, be in line with national standards, and published and controlled by one responsible regulator. It should also be as lean as possible and avoid inappropriate obstructions.

Environmental regulations ensure that environmental risks and hazards associated with mini-grids are minimised. It should include appropriate standards and norms, e.g. for waste products (emissions) or raw

material sourcing (biomass, hydro resources) and avoid unreasonable transaction costs (simplified for small projects).

Quality of service (product, supply, and commercial service) protect consumers. Therefore it should be established and enforced (incl. contact point) by regulator / REA and be realistic and affordable to all parties.

Licensing, Concessions, PPA‘s

Licenses and permits give the right to generate, distribute and sell electricity. It should be issued by regulatory, REA or Ministry and ideally include simplified procedures for very small systems, e.g. in Tanzania (<199kW) or Mali (<20kW). Provisional licenses may allow time for preparatory activities, but can be withdrawn in case of non.performance. The process should be transparent and standardized, case-by-case licenses are counterproductive.

Concessions grant the right to establish a mini-grid in a certain area for a certain time and may include larger areas thus aggregation of projects.

Power Purchase Agreements should be in standardised format and guidelines can be recommended. The duration of the PPA should be sufficient to repay the project debt

Financial Support Schemes

Policymakers establish or shape financial support schemes and define access modalities and should be coordinated and managed by designated entity. Ideally, support schemes should be developed and deployed in consultation with the beneficiaries and stakeholders. Financial instruments need to be carefully designed to advoid adverse results. There are precedents for successful subsidy programmes such as Nepal, Sri Lanka, India, and Laos (ARE, 2011).

Other options include grants and subsidies, e.g. at project preparation stage, during implementation / construction, or operations (e.g. tariff top-up, RBF), and loan support and risk mitigation, e.g. interest rate subsidies or specific risk mitigation instruments.

To create favourable market conditions, government should consider high-level political commitment for RE-based rural electrification, clear, stable and swift regulatory framework with transparent bureaucracy, incentives for RE project developers (e.g. REFiT, tax rebates, risk mitigation support) and end-users (e.g. installation grant) & investment (e.g. via national rural electrification fund) and provide market information and determine which areas will not be covered by grid extension.

The day ended with presentations of several case studies, such as Missol Eco Resort and Battery Energy Storage (BES) Case Example (project located in Negros Occidental).

Country Overview: Indonesia

In Indonesia there is a high number of population without energy access. Currently diesel generators are used as a primary source of power in off-grid areas and as complementary source of power in area with unreliable on-grid supply. Opportunity for hybridization of diesel-based grids could be one of the key drivers for solar PV deployment however the number of conditions need to change:

- Administrative requirements slow down projects deployment with number of approvals required (national and local level).
- Agency issues need to be resolved – E.g. Hotel operator (managing power supply) is different from the hotel owner interested in ensuring that power supply is from renewable sources.
- Foreign investment is not possible or limited.
- Subsidized electricity tariff is slowing down the deployment

Government policy and regulation will be somewhat driving new mini-grid projects, but involvement of private developers will be limited due to local administrative complexities. National MediumTerm Development Plan 2015-2019 specifies energy access target of 96.9% by 2019 (Program Indonesia Terang - Bright Indonesia Program). Renewable energy target is 23% of electricity production by 2025, the current share is 13%. The World Bank's Regulatory Indicators for Sustainable Energy indicates low quality of the overall framework which is complicated by local government interventions.

Country Overview: Philippines

Philippines has a stagnating electrification rate. Therefore rural electrification continues to be one of the drivers behind deployment of mini-grid projects. The reliability and cost of off-grid power remain as drivers for mini-grid development in Philippines.

The National Renewable Energy Programme seeks to increase the renewably energy capacity of the country. An estimated 15,304 MW by the year 2030, almost triple its 2010 level and achieve target of 100% household electrification by 2020. The government policy is currently under revision with the support of the EU Access to Sustainable Energy Programme. The changes will target revision of subsidy scheme (no subsidy for commercial and industrial customers) and will creating framework for investment to drive hybridization of diesel-based mini-grids managed by National Power Corporation – Small Power Utilities Group.. This will include revision of regulations for NPPs and QTPs. The World Bank's Regulatory Indicators for Sustainable Energy indicates the main challenge in terms of the overall mini-grids framework (targeted by the above-mentioned revisions).

The Philippines embraces renewables and technology. The Philippines energy minister declared intent to accelerate the installation of mini-grids using renewable energy which was one of IRENA's conclusions in its off-grid electrification report. Crowdfunding is used to raise funds for an eco-resort to replace its diesel generator system with a solar PV system with battery. Energo labs plans to install a pilot microgrid in a Filipino university, using blockchain for peer-to-peer energy trading

Country Overview: Myanmar

Myanmar has very low electrification rate, the lowest in the region. There are unequal energy access across the country.

The Myanmar government has an ambitious plan to achieve universal energy access by 2030 up from the current levels of 30 to 50% of population. Decentralized power solutions (mini-grids and solar home systems) were identified as preferred means of electrification in remote areas that won't be reached by the central grid within the coming decade. The World Bank's Regulatory Indicators for Sustainable Energy indicates several challenges including the overall framework and lack of transparency in government and utility planning.

Financing Solutions

The trainer shared financing options that are available such as grants, foundation – PRI, crowd funding, debt and equity funding.

Investment interests in Micro-grids are improving with companies such as electriFI, Engie's Impact investment, Caterpillar Ventures, Shell Technology Ventures and Total Energy venture. ENGIE and Electric Vine Industries has indicated to jointly invest up to USD 240 million over five years in building PV micro grids for 3,000 villages in the Province of Papua.

Case Study (Part 2)

Pulau Ubin Microgrid Test Bed

Pulau Ubin, an island north-east of mainland Singapore is where DLRE implemented a Micro-grid Test Bed for EMA (Energy Market Authority of Singapore). This micro-grid serves the island residents in the jetty area with high quality, high availability electricity that was previously generated from diesel generators. The test bed consists of hybrid solution of diesel generators, solar panel and battery energy storage systems. It was also created for the government to analyze the impact of a high penetration of renewable energy on the grid stability.

The micro-grid test-bed will bring about more cost-competitive and cleaner electricity, with improved scalability and reliability for both residents and businesses in Pulau Ubin. It looks at incorporating clean and renewable energy sources such as solar PV technology. It provides continuous and reliable supply of electricity to end-users. Electricity is provided by the operator at a competitive price of $0.80 per kWh that is lower than what end-users paid when they used their own diesel generators. Lastly end-users can consider higher load electrical appliances such as refrigerators and air-conditioners. This will enable businesses to expand their operations and operating hours.

Renewable Energy Integration Demonstrator Singapore

The Renewable Energy Integration demonstrator Singapore (REIDS) is located on the Semakau Island. The Semakau Island is the final stage of Singapore's exemplary waste management program. Using the landfill to build a large-scale renewable energy test and demonstration platform, provides a unique and symbolic message. Other advantages to the island is its accessibility and that it is uninhabited.

REIDS is a large-scale multi-energy demonstrator targeting multi-activity small territory needs. Its wide R&D scope ensures that its findings are readily transferable to many different environments and use case.

REIDS, as a performance assessment and testing platform is dedicated to microgrid technologies and seeks to design and execute specific test programs for equipment manufacturers and systems integrators needing to evaluate their products and services in Southeast Asia to leverage business development opportunities.

The knowledge and experience developed in the context of REIDS will be disseminated throughout Southeast Asia to consolidate Singapore's position as a renewable energy integration lighthouse.

Microgrids for Commercial and Industrial Sites

From the microgrid business case studies shared by ABB, commercial and industrial sites can benefit from microgrids by having fuel saving (and associated reduction in CO2 emissions & maintenance costs), reduced levelized cost of electricity (LCOE). They will also have attractive Internal Rate of Return on investments (IRR) and improved power quality.

Biomass to energy opportunity for microgrids

The speakers shared 3 case studies on biogas to energy opportunity for microgrids.

The first case study looks at the palm oil production process generates huge quantities of organic waste material that if not processed has a negative impact on ecological balance. In Thailand, two type if 3 GE's Jenbacher gas engines are supplying 33,000 Thai households with a reliable electrical outut of 2.1 MW.

Next cow power, biogas from 2,500 tons of wo waste daly, powers 1MW plant in India. The methane cogeneration plant at a large dairy complex, helped to address the region's mounting energy and environmental needs.

Lastly a farm in North of Beijing, China owns three million chickens, that produces 220 tons of manure and 170tons of wastewater each day. The biogas engines generate an output of 2MW and helps to solve the farm's waste problems.

Enabling platforms: Explaining Effective Ways for Building Project Pipeline

Reduction in RE technology and energy storage costs are driving economics of micro-grid business models. Decentralized power structure requires more collaborations and technology provider is the preferred partner.

The lessons learnt for development of off-grid markets are

1. Encourage multi-stakeholder partnerships
2. Support governments in developing countries to implement clear policy frameworks
3. Mobilise more investment in education, research, development and capacity building
4. Empower women as key change agents to achieve objectives
5. Empower youth as key change agents to achieve objectives
6. Develop attractive, as well as innovative financing mixes by bringing together different financial partners, and strong investment structures to de-risk investments, make it easier to invest over time, and attract more investors to the sector.
7. Develop and promote matchmaking as well as knowledge sharing tools
8. Consider community involvement and multiplier effects (productive use) when developing decentralised renewable energy businesses and projects.

In summary, micro-grid industry is evolving quickly. Donors and development banks are still playing a strong role but private investors are also taking notice. The industry is pulling together grassroot support to Advise governments, de-risk finance, and build local capabilities.

Annex 1: Programme

Day 1 – 19 March 2018	
Time	**Programme**
08:30 – 09:00 am	Registration
09:00 – 09:15 am	Welcome Remarks & Introduction to the Training
09:15 – 10:00 am	Global Overview - Micro-grid Market Renewable energy microgrids used to be a very niche market segment. However, in last 3 years or so this segment has experienced healthy growth. Even faster growth in the range of CAGR 30-40% is expected over next 5 years. This presentation will discuss the current market status for microgrids in developed countries where microgrids are being deployed as a measure of energy security and several developing nations where microgrids are playing a key role in energy *access*. Discussion(s) regarding current and future market demand for renewable energy microgrids will be encouraged during this session to build understanding of regional baseline among participants. ***Katarina Uherova Hasbani, The August Company***
10:00 – 10:30	Coffee Break
10:30 – 11:15 am	Market Overview of RE Microgrids – a Deep Dive ***Sujay Malve, Canopy Power Pte Ltd***
11:15 – 12:00 noon	Technical Design of Renewable Energy Microgrids: Basics Optimal design plays a critical role in performance of renewable energy microgrids. Typically, an optimizer/simulation software is used for design of such systems. The optimizer ensures that right configuration of different generation technologies are integrated to achieve minimum cost of generation within the constraints of load profile and availability of renewable energy resources such average sun hours and wind speeds. This session will explain the design process using a real life example of a typical off grid system in South East Asia. The focus will be to emphasize importance of optimal design as the first important step in implementation of a renewable energy microgrid. ***Sujay Malve, Canopy Power Pte Ltd***
12:00 – 01:00 pm	Lunch

01:.00 – 01:45 pm	Key Buildings Blocks for Micro-grid Deployment: Policies & Regulations, Customers/Community & Financing Micro-grids offer several opportunities to build power systems of the future. Off-grid renewable energy is key to universal access to electricity. Based on International Renewable Energy Agency, nearly 60% of additional generation required to achieve universal electricity access by 2030 is estimated to come from off-grid installations (stand-alone and mini-grids) . Renewable energy mini-grids are expected to account for the majority share of off-grid generation. Micro-grids also offer an opportunity to hybridise the existing diesel-based small-scale systems and build green-field clean energy grids. Government policy and regulation play the key role in speeding up the deployment of renewable energy based micro-grids. Cost-reflective power tariffs, simplified licensing procedures and clarifying what happens when and if the grid arrives are some of the regulatory items that need to be addressed. This session will outline the essential aspects of government policy and regulation for deployment of micro-grids. ***Katarina Uherova Hasbani, The August Company***
01:45 – 2:30 pm	Key Market Segments and Business Models in South-East Asia: Commercial, Industrial & Community Micro-grids The 'Business Models and Structuring' session will discuss various business and energy off-take models that RE Micro-grids can develop and implement, with a focus on tariff structures, proportions of household and commercial/institutional customers, cross-subsidization, strategies for load acquisition and growth, best practices of PPA terms, financial viability and returns. This session will also discuss exit options for micro-grid developers, such as grid integration, asset transfer and distribution franchise models. C&I: ***Sujay Malve, Canopy Power Pte Ltd*** Community: ***Katarina Uherova Hasbani, The August Company***
02:30 – 03:00 pm	Coffee Break
03:00 – 05:00 pm	Case Studies Part 1 ***Erik Chan*** *- Allotrope Partners (Philippines Noneco Project and MIA initiative by Allotrope/Facebook/Microsoft)* ***Daniel Rye*** *– Ryenergy (Different storage technologies with focus on grid connected storage)* ***Sujay Malve,*** *Canopy Power Pte Ltd (Selected Case Studies)* ***Q&A moderated by Katarina Uherova Hasbani***
05:00 pm	End of Programme

Day 2 – 20 March 2018	
Time	**Programme**
08:30 – 09:00 am	Registration
09:00 – 09:45 am	Dive-in into key markets: Indonesia ***Katarina Uherova Hasbani, The August Company***
09:45 – 10:30 am	Dive-in into key markets: Philippines ***Katarina Uherova Hasbani, The August Company***
10:30 – 10:45 am	Coffee Break
10:45 – 11:30 am	Dive-in into key markets: Myanmar ***Katarina Uherova Hasbani, The August Company***
11:30 – 12:15 pm	Financing Solutions The 'Financing Solutions' session will discuss capital structures of RE Micro-grids, including project finance, debt-to-equity ratios, use of subsidies and viability gap funding, asset finance, off-balance sheet structures, and credit guarantees. ***Arun Gopalan, Ecoforge***
12:15 – 01:15 pm	Lunch
01:15 – 03:15 pm	Case studies Part 2 ***a.*** Pulau Ubin - Operating micro-grid in Singapore ***- Kay Seah, DLRE*** ***b.*** Microgrids for mining industry ***- Chanchal Bahatnagar, ABB*** ***c.*** Renewable Energy Integration Demonstration– Singapore (REIDS) - ***Prof Choo, Energy Research Institute @ NTU*** ***d.*** Biomass to energy opportunity for microgrids***- Jad Elsebaaly, GE Power***
03:15 – 03:45 pm	Coffee Break
03:45 – 04:45 pm	Enabling platforms: Explaining Effective Ways for Building Project Pipeline ***Katarina Uherova Hasbani, The August Company***
04:45 – 05:00 pm	Wrap-up of the training

Annex 2: Participants

Delegates

Full Name	Position	Company	Country
Jasmine Lim Li Fung	Director	Centre of Excellence, SP Group	Singapore
Seraphina Ho Songfang	Assistant Director	Centre of Excellence, SP Group	Singapore
Tabitha Boey Shin May	Assistant Director	Centre of Excellence, SP Group	Singapore
Goh Tong Ye	Assistant Director	Centre of Excellence, SP Group	Singapore
Alexander Lokananta	Senior Engineer	Centre of Excellence, SP Group	Singapore
Lam Yew Lee Adrian	Senior Engineer	Centre of Excellence, SP Group	Singapore
Paulo Dela Rama Alvarado	Principal Engineer II	Centre of Excellence, SP Group	Singapore
Chua Han Lin	Senior Officer	SPRING Singapore	Singapore
Andrew Woo Da Hua	Senior Manager, Cleantech	SPRING Singapore	Singapore
Ramar Subbaih	Senior Assistant Director	Ministry of Trade and Industry	Singapore
Abhinava Moreddy	Energy Storage Specialist	Red Dot Power Pte Ltd	Singapore
LE BARS Gwenolé		Guinard Energies	Singapore

Speakers

Full Name	Position	Company	Country
Katarina Hasbani	Founder	The August Company	Singapore
Sujay Malve	Co-Founder & CEO	Canopy Power Pte Ltd	Singapore
Erik Chan	Director,Renewable Energy Development in Southeast Asia	Allotrope Partners	Philippines
Daniel Rye	Director	Rynergy	Singapore
Arunmozhi Gopalan		Ecoforge	India
Kay Seah		DLRE	Singapore
Chanchal Bhatnagar	Regional Sales Manager	ABB Malaysia	Malaysia
Choo Hook Foong	Co-Director	Energy Research Institute @ NTU	Singapore
Jad Elsebaaly		GE Power	Singapore