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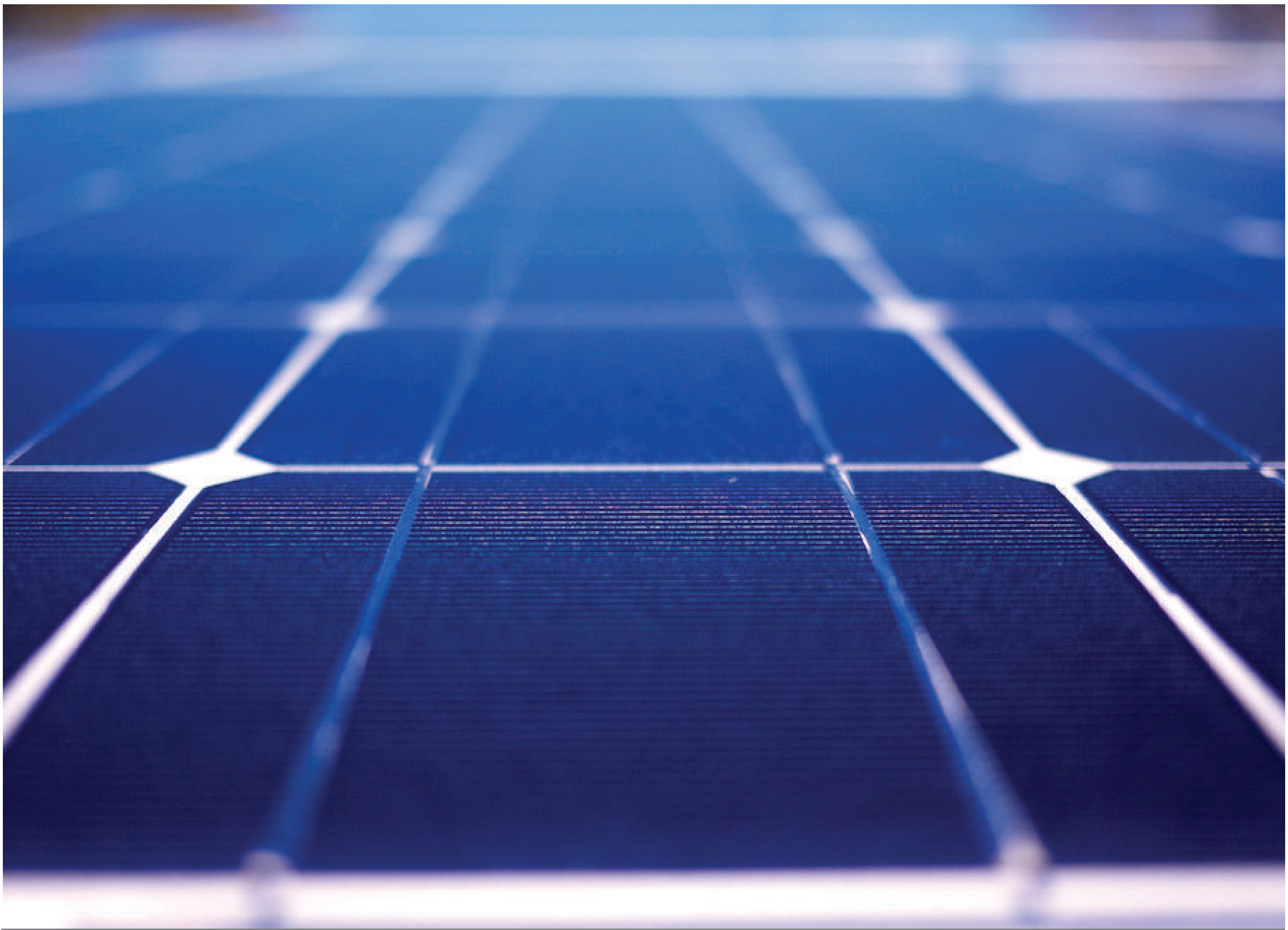


Solar Panels in Action. Photo by Michael Mazengarb (Permission under CC BY-NC 2.0).

INTRODUCTION

The Development of Business Models for Solar Photovoltaic in Singapore is the theme of this issue of the ESI Bulletin.

Developing renewable energy technologies has always been of considerable importance to Singapore. A diversified and clean energy portfolio is essential in safeguarding a sustainable and secure future for a country that currently imports almost all of its energy. Solar photovoltaic (PV) is the most relevant renewable energy technology for Singapore, given the country's equatorial location and lack of feasibility for other renewable energy resources, such as biomass, wind or tidal.

A recent study by the Solar Energy Research Institute of Singapore (SERIS) suggests that solar PV could contribute as much as 20 per cent to the overall electricity mix by 2050.[1] Understanding and quantifying the "value of solar PV", rather than the levelised cost of electricity (LCOE), will play a critical role in supporting this growth. "Value of solar PV" refers to a cost-benefit analysis that includes costs such as those associated with addressing the intermittent nature of solar PV and monetary benefits, e.g. from shaving of peak load. While it is widely acknowledged that the LCOE of solar PV has declined in recent years, methods to correctly quantify the "value" of solar PV require further research.

In this issue ...

Revenue generation from solar PV projects is another important factor in upscaling the implementation of solar PV—which is largely determined by the business model used. In recent years, innovative business models have shifted various aspects of PV ownership, financing and risk from private owners to third parties. In this rapidly changing business environment, an assessment of the suitability of the new innovative models is necessary to better understand if and how they could operate in the Singapore context.

This issue of the Bulletin presents summaries of presentations delivered at ESI's *Singapore Future Solar Strategies Conference* held in April 2015. The purposes of the conference were: to discuss various business models that could accelerate the uptake of solar PV in Singapore; and to explore the various components that contribute to the true cost and value of Solar PV to society. Speakers for the conference included distinguished experts from the International Energy Agency (France), the National Renewable Energy Laboratory (USA), as well as representatives from local regulatory, academia and industrial bodies. The summaries presented in this issue pertain to the role of business models that could increase the attractiveness of solar PV in Singapore.

The first article in this issue is by Mr. Christophe Inglin (Vice Chairman, Sustainable Energy Association of Singapore (SEAS) & Chairman of its Clean Energy Committee). Mr. Inglin notes that Singapore will install decentralised rooftop solar PV systems all across the entire island, rather than a centralised utility scale solar farm. At an aggregate level, the resultant electricity output will be much less intermittent as compared to a utility scale PV plant and, therefore, the overall negative impacts on grid stability will be lower than expected. He also shares a vision for the growth of the electric vehicles (EVs) market in Singapore, and discusses how a huge fleet of EVs could further act as a storage solution and provide a stable output from intermittent solar PV.

The next contribution, by Dr. Sopitsuda Tongsopit (Researcher at the Energy Research Institute, Chulalongkorn University, Thailand) examines solar PV business models in Thailand and Singapore. Both countries are heavily dependent on natural gas for power generation and as a result, both countries have seen similar hikes in retail electricity tariffs in recent years. Dr. Tongsopit analyses various upcoming business models that have shown promise in the US and which hold potential for application within the context of Thailand and Singapore. These business models feature novel concepts such as solar crowdfunding—wherein finance is sourced from individual investors via the Internet—or Property Assessed Clean Energy (PACE) financing—where property owners repay the loan for the PV system through their property tax bills—amongst others.

Mr. Shiva Susarla (Director, RENERGii Asia Pte. Ltd. and former Research Associate at ESI) discusses PV business models and investment, with a focus on investment decisions for solar PV developers in Singapore. Mr. Susarla argues that despite being a small market for solar PV as compared to other countries, Singapore is an attractive destination for investment due to its provision of market-driven electricity tariffs, its business-friendly environment and stable currency. He further explains that Singapore has successfully implemented the "Solar Energy as a Service" model wherein the project developer installs the PV system on the customer's rooftop at minimal cost to the customer and sells electricity to the customer at a pre-determined tariff. Mr. Susarla stresses that it is essential for Singapore to develop a financial environment that will allow project developers and early investors to exit the market with high returns after successfully developing their PV projects.

Finally, Mr. Eugene Toh (Director, Policy Department, Energy Market Authority) presents the regulator's viewpoint on facilitating solar PV deployment in Singapore. While solar PV has multiple benefits for Singapore, the government is committed to promoting PV deployment here without resorting to subsidies in the form of feed-in tariffs (FiTs). Mr. Toh explains that the Energy Market Authority has introduced a number of enhancements to the regulatory framework governing the interaction of intermittent renewable sources with Singapore's electricity grid. These include the removal of cumbersome market registration procedures for owners of small grid-connected PV systems, simplifying the grid connection process, and developing a new approach that allows a higher amount of solar PV to be included in Singapore's electricity grid while ensuring that enough reserves are maintained to ensure grid stability.

We hope you find these articles of interest and welcome your views and comments.

Mr. Gautam Jindal, Research Associate
(On behalf of the ESI Bulletin Team)

1 Singapore Economic Development Board and Energy Market Authority, *Solar Photovoltaic (PV) Roadmap for Singapore* (*A Summary*) (Singapore: Solar Energy Research Institute of Singapore, 2013). https://www.nccs.gov.sg/sites/nccs/files/Roadmap_Solar_20140729.pdf [accessed 23 July 2015].

Singapore: From Centralised to Distributed Electricity Generation

Mr. Christophe Inglin
Vice Chairman, SEAS & Chairman of its Clean Energy Committee, Singapore

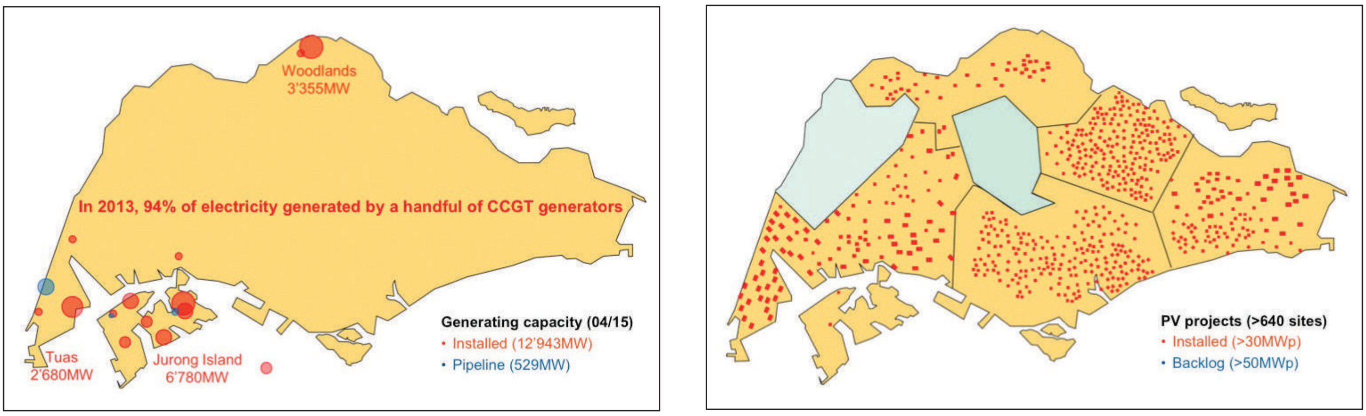
Like most other developed nations, the policies for regulating Singapore's electricity sector were designed to manage a conventional utility-based infrastructure, based on a few large fossil-fuelled power plant clusters feeding a transmission and distribution grid.

As of April 2015, Singapore had approximately 13 gigawatts (GW) of conventional power-generating capacity, 94 of which were generated by a handful of gas-fired combined cycle turbine (CCGT) plants. Within a decade, we expect these to be complemented by up to 2GW of rooftop solar power capacity, distributed island-wide on about 50,000 rooftops. By 2025, electricity generated from solar PV could meet up to 30 per cent of instantaneous demand and 5 per cent of total annual electricity demand in Singapore.

Over the same period, private transportation is likely to experience a disruptive transformation, as electric vehicles (EVs) increasingly displace fossil-fuel-powered internal combustion engine vehicles (ICEVs).

What kind of impact will these two phenomena have on Singapore's electricity infrastructure, and how will Singapore need to adapt its policies and regulations to gear up for the future?

Figure 1: (Left) Centralised Clusters of Fossil Fuel Power Plants; (Right) Decentralised and Widely Dispersed Rooftop PV Systems (33MWp at end of 2014)



Source: Images based on data from the Energy Market Authority (EMA).

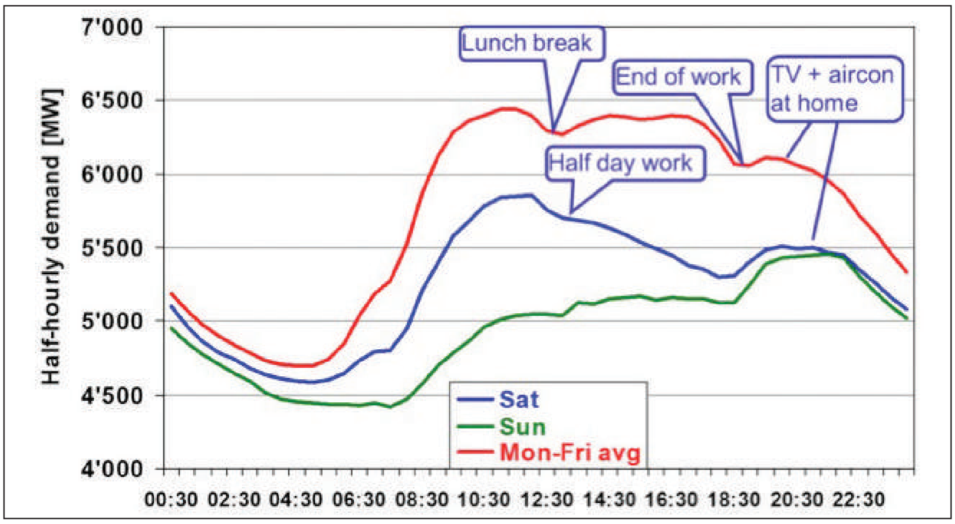
Singapore's Conventional Electricity Infrastructure

Singapore's electricity grid is one the most stable and reliable in the world, and currently enjoys nearly 100 per cent excess generation capacity. Maintaining a stable grid means that both frequency and voltage must be kept within prescribed limits by carefully matching supply to meet demand. Although individual loads can be very intermittent, switching on or off apparently at random, Singapore's aggregate demand follows three very predictable patterns (see Figure 2):

- Mondays to Fridays (work week)
- Saturdays, with many offices working half-days
- Sundays and public holidays

The grid serves over 1.3 million consumers (residential, commercial and industrial), and therefore, no individual consumer can make an impact large enough to destabilise the grid.

Figure 2: Aggregate Demand in Singapore follows a Predictable Pattern

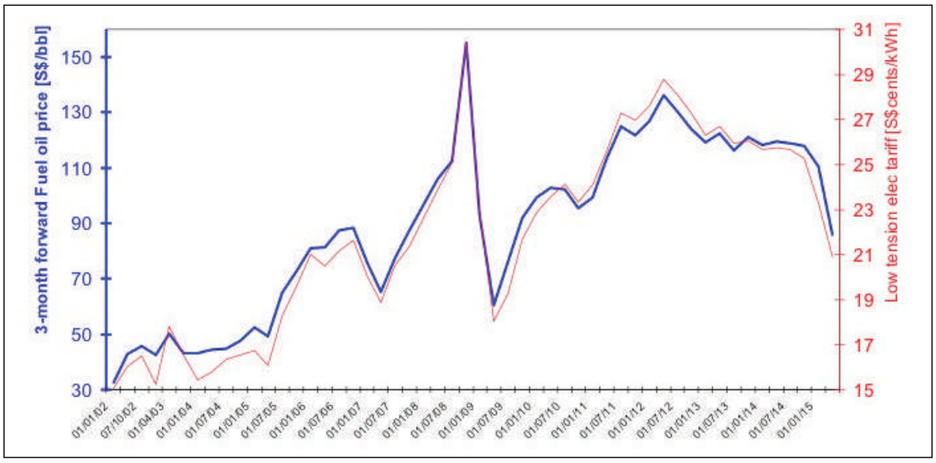


Source*:* Image based on data from EMA—half-hourly demand from 23–29 Sep 2013.

On the other hand, Singapore has 45 generators, 24 of which exceed 360 MW in capacity each (equivalent to 5 per cent of peak demand). If any one of these generators suddenly switches off, it could destabilise the grid. The Power Systems Operator (PSO) therefore requires spinning reserves as backup to mitigate unplanned outages. The spinning reserves comprise generators kept on standby, ready to take up the slack on very short notice in case a running generator suddenly fails. The PSO also monitors the output of all generators in real time, using feedback to fine-tune the generators' output to match small variations in demand.

Singapore fuels its gas-powered generators using natural gas piped from Indonesia and Malaysia, and Singapore's liquefied natural gas (LNG) terminal on Jurong Island. As gas prices are indexed to oil prices, Singapore's electricity prices are at the mercy of global fluctuations in oil prices. From a low of 15.02 cents/kWh in January 2002, retail tariffs more than doubled to 30.45 cents by October 2008, then dropped to 18.03 cents in April 2009. They rose again to 28.78 cents in April 2012 before sliding back to 20.87 cents in April 2015.

Figure 3: Retail Electricity Prices are Closely Tied to High Sulphur Fuel Oil (HSFO) Prices



Source: Image based on data from SP Services.

Benefits of Distributed Solar Power

Situated along the equator, Singapore receives plenty of sunshine throughout the year, with very little seasonal variation. These are ideal conditions for generating electricity from clean and renewable solar PV. Every MWh generated by a renewable source such as PV mitigates approximately 500 kilograms of CO_2 that would have been emitted from gas-fired generators.

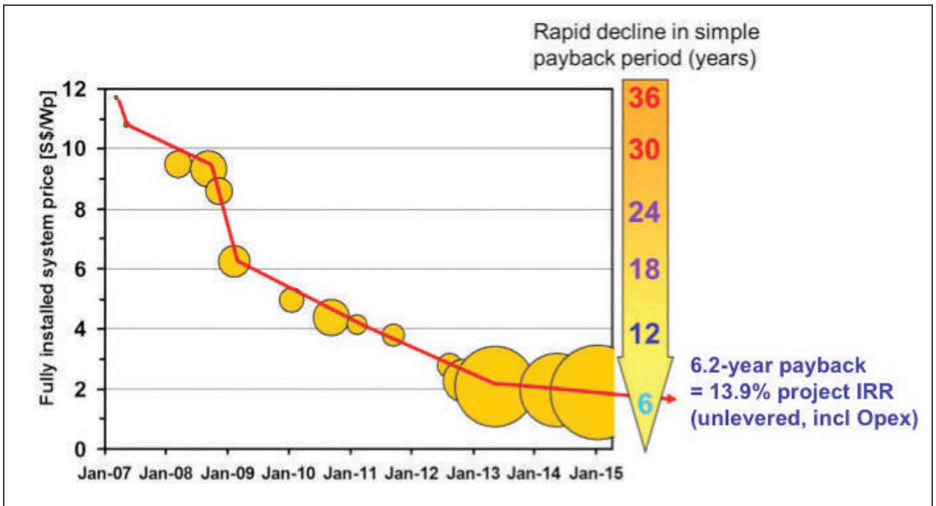
PV output depends on sunshine (irradiance) and is closely correlated with peak daytime demand in Singapore. Stronger sunshine in the afternoon generates more PV energy just as it increases demand for air conditioning. PV therefore relieves the conventional power plant load by shaving peak demand. At the same time, rooftop PV plants generate electricity right at the point of demand, feeding their output directly into the buildings below. As a result, they also unburden the transmission and distribution network.

PV is Now Cost-Competitive

Until quite recently, most renewable energy sources were too costly to consider as a meaningful alternative to fossil fuel, unless they were supported by government subsidies. Those subsidies created growing demand for renewables such as wind power and PV, driving economies of scale that pushed costs ever lower, towards the point where these technologies no longer need subsidies to compete with conventional sources of electricity.

In Singapore, even against unsubsidised conventional electricity prices, rooftop PV became a competitive option from as early as 2013. Building owners found that they could profitably reduce their electricity bills by offsetting a portion of their demand with solar electricity generated on their own rooftops. Despite the drop in retail tariffs since 2013, PV has managed to keep pace as a commercially viable alternative.

Figure 4: Payback Period of PV Systems over Time



Source: Phoenix Solar commercial projects and GeBiz tenders.

Note: Prices at time of final offer (not at installation).
Bubble size is in proportion to project size (kWp). Payback period at 2014/Q1 retail tariff (SGD0.2573/kWh).

Distributed PV is Not Intermittent

A feature of conventional fossil fuel power plants (especially CCGTs) that is almost taken for granted is their ability to produce power on demand. The plant operator can adjust power output to meet demand by simply tweaking fuel supply. On the other hand, PV output varies in direct proportion to the intensity of sunlight, which cannot be controlled and can be predicted only to a certain extent. Singapore, being near the equator, seldom sees all-day clear skies like those in California, Western Australia or the Indian state of Rajasthan. Clouds form rapidly and drift across the sky, leading to sudden variations in PV plant output.

To compensate for sudden drops in a power plant's output, conventional utility regulation measures require reserve generation capacity to be kept on standby. These reserves impose extra costs for electricity consumers, and are typically allocated to the generator that triggers them.

If Singapore concentrated all of its installed PV capacity in a single location, it would experience significant solar intermittency (see Figure 5). However, since rooftop PV is distributed throughout the island, its aggregated output is hardly intermittent; it is merely variable. Figure 6 shows the average sunshine measured at 25 sites. Although an individual PV plant's output can drop quite suddenly, output across all plants cannot drop simultaneously since cloud formations will take time to cross the island. It is impossible for a cloud to instantly obscure the entire Singapore from sunshine.

Figure 5: Solar Irradiation at a Single Location: A clear sky in the early morning, followed by a cloudy midday and an afternoon storm. The intermittency is obvious

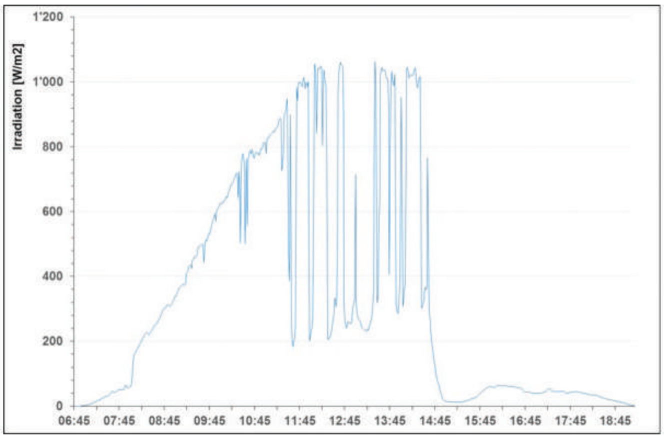
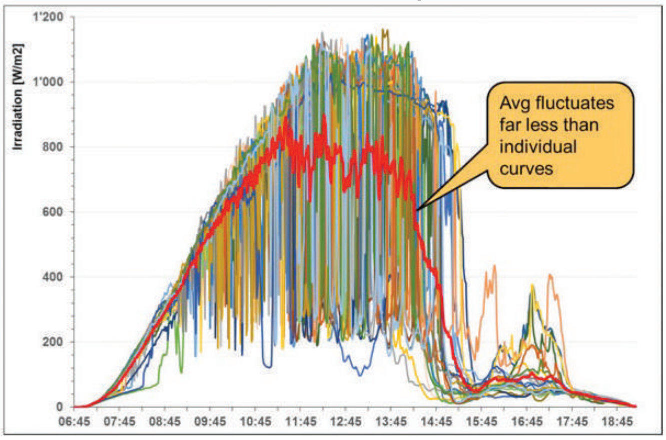


Figure 6: Averaged over 25 Sites across Singapore: The solar irradiation varies rather smoothly



Source: Image generated from data courtesy of the Solar Energy Research Institute of Singapore (SERIS).

The most extreme event of obscuring the sun could be a total solar eclipse. The impact of a near total solar eclipse was tested in Germany on 20 March 2015, with 38 GWp of grid-connected PV. The country's grid was able to handle the impacts without any glitches.

Mapping Irradiation to Predict PV Variability

Solar eclipses are predictable decades in advance, but daily weather patterns are much harder to forecast. Although the aggregated sunshine across Singapore might not fluctuate enough for PV systems to destabilise the grid, their impact on local substations could be harder to handle without any early warning system to rely on.

The Solar Energy Research Institute of Singapore (SERIS) has already installed a synchronised network of 25 solar sensors that monitor solar irradiation at one-second intervals. This sensor network can interpolate the PV production of every individual system in Singapore, and plot a two-dimensional solar intensity map. Using vector analysis, it can also assess the direction of cloud movement to predict when and how the irradiation on each PV system is about to change. This can provide valuable planning information to the PSO as it balances supply and demand in each grid sector.

The Evolving Role of Storage

Beyond smart irradiation forecasts, smart grids and demand response which matches supply with demand, storage helps to buffer the variability of individual PV systems. Storage batteries can also store surplus daytime PV electricity to offset night-time demand. Currently, any electricity generated by the PV system over and above the building's immediate demand is sold to the grid at a discount to retail tariffs.

At today's prices, it makes better sense to sell surplus PV electricity to the grid at a discount than to store it for use after dark. This is because the depreciation expense on a battery is about SGD0.30 per kilowatt hour (kWh) (see calculation in Figure 7). However, for owners of electric vehicles (EVs), it makes more sense to charge the EV battery with surplus PV energy.

Figure 7: Ownership Cost of Lithium-ion Batteries

Depreciation Expense of a Li-ion Battery	
Capex [SGD/kWh capacity]	800
Lifespan in years (without degradation)	10
Cycles per day	1
Depth of discharge (DOD) (%)	80
Charging cycle efficiency (%)	90
Simple depreciation expense: 800/(10x365x80%x90%) =	SGD0.30/kWh

EVs Are about to Disrupt the Car Market

As EVs increase their market share, the resulting economies of scale will also drive down the cost of storage batteries. EVs already exhibit many classic symptoms of a disruptive technology:

- EV motors have ~3x efficiency of internal combustion engine vehicles (ICEVs)[1]
- EVs are 5x cheaper to fuel (~0.20 kWh/km2 @ SGD0.20/kWh vs. 0.1 litres/km @ SGD2.00/litre)

- EVs are much cheaper to maintain than ICEVs as electric motors last a long time and need no oil changes

- By 2020, EVs could cost less than the average petrol car in the US, assuming a 16 per cent annual price decline (2014 Tesla Model-S costing USD70–90k vs an average car costing USD33k in November 2013)

Once EVs achieve ranges similar to conventional cars (at least 300 km on a full charge) and prices close to those of conventional cars, their other advantages are so compelling that ICEVs might even be phased out within a decade of price parity.

Several historic examples illustrate the power of disruptive technology. In the transportation sector itself, cars displaced horse-drawn carriages within merely 13 years in the early 1900s. Similarly, in the music industry, compact discs (CDs) displaced vinyl records, while MP3 players wiped out cassette-based portable players. In imaging, digital photography has all but eradicated silver-halide film photography.

Figure 8: Fifth Avenue, New York, Easter 1900: Just one motor car navigating the road surrounded by horse carriages

Photo by US Bureau of Public Roads. Photographer unknown, 1900.

Figure 9: Fifth Avenue, New York, Easter 1913: Not a horse in sight

Photo by Bain News Service, March 1913 (Library of Congress, Prints & Photographs Division, LC-DIG-ggbain-11656).

EV's Impact on the Electricity Grid

A 60 kWh battery is sufficient to allow 300 km of autonomy for an EV (based on approximately 0.20 kWh/km), which is more than adequate for driving in Singapore. Should EVs happen to displace Singapore's conventional car fleet over the next 10–15 years, how would this impact Singapore's electricity grid?

Firstly, Singapore currently has more than 600,000 cars and 17,000 taxis on its roads. Replacing all existing cars and taxis with EVs will not require additional generating capacity as Singapore already has significant excess generation capacity. Assuming each private EV's mileage is 15,000 km/year and each taxi EV averages 150,000 km/year, this results in a total of 11.55 billion vehicle-km driven. With an average energy consumption of 0.20 kWh/km, the entire EV fleet will consume 2.3 terawatt-hours, equivalent to only 5 per cent of Singapore's 2013 consumption.

Secondly, the total storage capacity for 600,000 private EVs with a 60 kWh battery in each vehicle would lead to 36 GWh of storage capacity, which is sufficient to power Singapore for seven hours at 2013 demand levels (44,923 GWh).[3] This is more than sufficient to resolve any intermittency and variability concerns from grid-connected PV.

Thirdly, even with conservative estimates, private cars are parked for 94 per cent of their lives.[4] When not in motion, EVs can interact with the grid. Consumers will therefore not only pay tariffs that vary by the time of day, but might even be able to sell electricity from their EV batteries to help flatten demand peaks and smooth out solar variability.

Conclusion: Redesign How We Manage the Grid

Exploiting the technological advances in PV, EV's and irradiation mapping will require corresponding innovations in Singapore's electricity policy and regulatory environment. In redesigning how we manage the grid, we can look forward to many benefits from the disruptive potential of both PV and EV technology.

1 EV grid-to-wheel efficiency ~59-62 per cent vs. petrol-to-wheel ~17–21 per cent (www.fueleconomy.gov).

2 27 kWh/100 miles (BMW i3) to 34 kWh/100 miles (Tesla Model-S) (www.fueleconomy.gov).

3 Energy Market Authority, *Singapore Energy Statistics 2014* (Singapore: EMA, 2014).

4 Assume 15,000 km/year for 10 years at an average driving speed of 30 km/h, resulting in only 5,000 hours of driving.

Solar PV Business Models in Thailand and Singapore: Key Policy Considerations

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Energy Research Institute, Chulalongkorn University, Thailand

Lopburi Solar Power Plant, Central Thailand. Photo by the Asian Development Bank (Permission under CC BY-NC-ND 2.0).

Increasing power demand and heavy dependence on natural gas for power generation are driving many ASEAN countries to diversify their fuel mix. While coal-fired generators are expected to increase significantly and will continue to dominate the fleet of ASEAN power plants in the future, distributed solar PV is an emerging trend that has potential for disruptive changes. This article reviews some business models for rooftop solar power expansion that originated in the United States, and provides comparative views of their emerging applications in Singapore and Thailand.

The overall context for rooftop solar PV expansion is similar for Thailand and Singapore. Both countries are largely dependent on natural gas for power generation. As a share of the power generation fuel mix, natural gas accounts for 95 per cent in Singapore and 70 per cent in Thailand. In recent years, retail electricity prices have risen at the rate of 5 per cent in Singapore and around 3 per cent in Thailand. At the same time, both countries have strong solar irradiation at 4.5 kWh/m^2/day and 5.01 kWh/m^2/day, respectively, compared to an average of 3.5 kWh/m^2/day in European countries.[1] Given that the levelised cost of solar power (LCOE) has already achieved grid parity in the retail market in Singapore and is approaching grid parity in Thailand,[2] it makes sense for commercial buildings and manufacturing facilities in both countries to reduce electricity costs by installing solar PV on the rooftops.

Innovative Business Models

While the LCOE numbers are attractive, the expansion of the rooftop solar PV market is hindered by the high upfront cost of solar PV systems, which deters households and businesses from investing in solar power. Despite this, international cases have demonstrated that innovative business models and financing options can play a significant role in relieving the upfront cost burden and stimulating expansion of the rooftop solar market.

The following is a detailed explanation of innovative business models which could be adapted to local conditions by ASEAN entrepreneurs.

PACE Financing

Property Assessed Clean Energy (PACE) is a municipal financing mechanism in which property owners receive 100 per cent financing for renewable energy (RE) and energy efficiency (EE) projects from the local government and repay the loan through their property tax bills over a specified number of years, typically up to 20 years. The fund is financed through bonds issued by local governments, private funding, state or federal funds, or a combination of these. PACE was first piloted in California through the Berkeley First Program. According to the US Database of State Incentives for Renewables and Efficiency, currently 31 states and Washington DC have authorised PACE financing.

Although this model is unique to the US, governments in ASEAN countries could potentially devise a similar scheme to help residents invest in solar power. In Thailand, local governments and communities have already received dedicated funds for economic and social development purposes, such as the Thailand Village Fund and Power Development Fund. These funds can be designed to allocate low-interest solar loans for local residents.

On-Bill Financing

On-bill financing is another scheme that is quite widespread in the US; it is offered by a number of investor-owned utilities as well as municipal utilities.[3] In this model, the utilities that typically have access to low-interest capital obtain low-interest loans and then lend to qualified customers to purchase solar PV systems. Customers repay the utility through the utility bills, hence the term “on-bill financing”. Since the payment collection is bundled with the utility bill, the scheme lowers the transaction cost of loan repayment collection. The low-cost capital, combined with the lower transaction cost and risk to the loan originator, result in lower interest rates for borrowers. On-bill financing is a potential mechanism for utilities to adapt their business model to changing market conditions in which customers are adopting solar power and buying less electricity from the grid.


Solar Panels Powering Basic Needs in Chiang Rai, Thailand. Photo by Shark Attacks/ Flickr (Permission under CC BY-NC 2.0)

Solar Crowdfunding

Pioneered in early 2013 by Mosaic, a solar project finance company founded in 2010 and based in Oakland, California, solar crowdfunding is an innovative financing mechanism that pools capital from individual investors through the Internet. In the case of Mosaic, the money collected from the crowdfunding platform is loaned to developers at an interest rate of 5.5 per cent.[4] The company charges a one per cent fee from individual investors and pays interest to investors at the rate of about 4.5 per cent.

In the context of the US, this model of financing helps commercial-scale solar PV projects that typically fail to obtain loans from commercial banks because they are either not large enough or not bundled into a portfolio of projects.[5] In addition, it also helps finance solar projects in non-profit settings such as schools, communities and churches. Though solar crowdfunding does not exist in Thailand yet, it is becoming a possibility in the near future with the Thai Securities and Exchange Commission's recent release of regulations on internet-based crowdfunding. In Singapore, solar crowdfunding has already been introduced and is likely to help drive solar financing.

Solar Leasing

Solar leasing is a model in which the solar leasing company builds, owns, finances and operates a solar PV system on the customer's property over the term agreed upon in the leasing agreement. The customer consumes the electricity from the system and pays for the system in monthly instalments over the leasing term. In the US, the leasing term generally ranges from 15–20 years.

The term "solar leasing" is also used in Singapore but the arrangement is different from the US. In Singapore, the solar developer also builds, owns, finances and operates the solar systems through an agreement that requires the site host to pay for the solar power generated and consumed, not for leasing the equipment. In this sense, solar leasing in Singapore resembles the solar power purchase agreement (PPA) model reviewed below. The leasing term in Singapore is generally 25 years and the solar tariff is set at a discount from the retail tariff rate. In both countries, the customers pay little or no upfront cost.

The solar leasing model has been a major driving force behind the expansion of solar PV in the US residential sector and in Singapore's public housing sector. The leasing model is still in its initial stages in the Thai market, with one company offering leasing services to commercial-scale rooftop owners and another company offering leasing services for residential customers. Many companies are studying the model and may soon launch leasing products. Based on our market analysis, contract details in Thailand are expected to be very different from those in the US and Singapore. For example, the down payment requirement could be as high as 30 per cent and the leasing term is not expected to exceed eight years.

Solar Power Purchase Agreement (PPA)

In this model, the Solar PPA developer acts like a utility, selling electrical power to customers at a pre-specified tariff. The customer need not pay for the upfront cost of the PV system or make any down payment; he/she must only pay for the electricity generated by the solar system. The price offered by the power purchase agreement (PPA) is usually indexed at a discount to the grid electricity prices with some annual percentage escalation. The developer installs, owns and operates the solar PV system on the customer's rooftop and guarantees performance over the contract term, typically 10–20 years in the US and potentially 20–25 years in Thailand.

The key success factor of this model depends on whether the net savings from buying solar PV electricity are attractive enough over the contract term. The solar PPA model has significant potential to accelerate solar power adoption in Singapore since solar power has reached retail grid parity. In Thailand, this model is currently being marketed to commercial-scale customers and, if successful, could become the game-changer in the Thai power market.

Community-Shared Solar

Community-shared solar, defined by the US Department of Energy as "a solar-electric system that provides power and/or financial benefit to multiple community members",[6] can occur in many forms. The US Department of Energy is studying business models associated with community-shared solar since these projects can potentially reach out to a vast majority of households that cannot host solar PV systems.

In one form of community-shared solar in the US,[7] customers (typically non-homeowners) have a share in a solar farm through cash or a loan. The electricity produced by the system is sold to the local utility through a tariff agreed in the PPA. The electricity generated is also credited to the subscribers' bills through integration between the developer's and utility's billing system. The developer earns profits from equipment mark-ups.

There is a large demand in ASEAN countries to catalyse the development of successful business models which can provide community benefits in solar power systems. Since 2013, the Thai government has launched policy frameworks to support ground-mounted community solar systems, but to date there is no successful business model that can be replicated.

Customers' Values and Key Policy Considerations

From the viewpoint of solar PV adopters, the above business models and financing options offer a combination of the following values:

- Eliminate or lower the upfront cost of solar systems
- Provide alternative forms of financing
- Lower the cost of financing
- Lower the burden associated with solar system ownership, such as acquiring permits, and operation and maintenance
- Distribute benefits to customers in the form of energy savings

However, these business models do not always take off or offer values to customers without any form of government intervention. It is important to understand the roles that governments and regulators can play in catalysing their emergence and sustained profitability. In a number of cases reviewed in this article, the government had to take the lead either by providing alternative sources of financing (PACE financing), legalising a new platform for fundraising (solar crowdfunding), or purchasing solar power on behalf of tenants (solar leasing in Singapore). In other cases, utilities joined the business of solar power either by providing financing (on-bill financing) or cooperating with private developers by integrating their billing system with that of the developer's (e.g. the specific case of community-shared solar reviewed above).

Furthermore, questions remain regarding the extent to which public subsidies are necessary for these business models to grow, given that retail grid parity presently has either been achieved or is fast approaching. Singapore has a long tradition of not subsidising energy, while neighbouring countries such as Malaysia and Thailand have provided feed-in tariffs for several years. Without providing any form of subsidy, the Singaporean government has tried to lay the groundwork for a supportive environment for rooftop solar business models—by defining a clearer framework for market participation, streamlining the process of grid interconnection and payment settlement, and defining a system cap to accommodate intermittent solar generation. On the other hand, Thailand has recently launched a net-metering policy framework and will pilot net-metering for PV systems in certain areas of the country.

In summary, a dynamic business and regulatory environment for rooftop solar is emerging in Singapore and Thailand. The governments of these two countries have laid building blocks for rooftop solar market expansion. Both countries have a positive outlook towards the expansion of the rooftop solar PV market, while local and foreign businesses are constantly innovating new business models, and adapting successful international business models for application in these sun-drenched countries.

1 Average daily solar insolation numbers are from ISEAS (2007) (Singapore), DEDE (2012) (Thailand), Grubb (1995) (EU—15 countries).

2 Omar Sadder, Gavin Adda, Sujay Malve et al., *Study on the Profitability of Commercial Self-Consumption Solar Installations in Singapore* (Singapore: REC Solar Pte Ltd, 2014). In this study, the authors estimate that the solar LCOE of a 100 kW system in Singapore is SGD 19 cents/kWh, compared to the average retail tariff cost to commerce and trade business at SGD 21 cents/kWh. In Thailand, solar power costs 16, 20 and SGD 22 cents/kWh for utility-scale, commercial-scale and residential-scale systems, respectively. When compared to the retail tariff at SGD 17 cents/kWh, rooftop-scale installations in Thailand are expected to approach grid parity soon.

3 Southern California Edison, San Diego Gas & Electric, SoCalGas, Hawaiian Electric Co., Austin Energy, and Fort Collins Utilities.

4 Andrew Herndon, "Solar Mosaic's Crowdfunding Beats Treasuries with 4.5% Returns", *Bloomberg Business*, 8 Jan 2013, at http://www.bloomberg.com/news/articles/2013-01-07/solar-mosaic-s-crowdfunding-beats-treasuries-with-4-5-return [accessed 1 May 2015].

5 Jennifer Kho, "More Pie for All", *PV Magazine*, Apr 2013, at http://www.pv-magazine.com/archive/articles/beitrag/more-pie-for-all-_100010776/572/#axzz3bUzKBKld [accessed 1 May 2015].

6 Jason Coughlin, Jennifer Grove, Linda Irvine et al., *A Guide to Community-Shared Solar: Utility, Private, and Nonprofit Project Development* (Washington, DC: US Department of Energy SunShot Initiative, 2012), at http://www.nrel.gov/docs/fy12osti/54570.pdf [accessed 23 July 2015].

7 Clean Energy Collective, LLC, Colorado, cited in Coughlin, Grove, Irvine et al., *A Guide to Community Shared Solar*.

Solar PV Business Models and Investment

Mr. Shiva Susarla
Director, RENERGii Asia Pte Ltd, Singapore

Malay Kampong House with Its Own Solar Power, Pulau Ubin, Singapore, August 2009. Photo by William Cho (Permission under CC BY-SA 2.0).

As of December 2014, the total installed capacity of solar PV in Singapore was 33.1 megawatt peak (MWp), spread over approximately 500 installations.[1] The 40 MWp "Supernova" tender announced by the Housing Development Board (HDB) and the Economic Development Board (EDB) in June 2015 is expected to push up the installed capacity to about 60 MWp over the next 12 months or so. This tender aggregates the requirements of multiple government agencies and 900 housing blocks into the country's largest solar tender issued to date. The total installed capacity is expected to increase to about 300 MWp in a few years, and eventually reach about 600 MWp.

Singapore is now widely recognised as "alternative energy constrained", due to its small size, limited land availability, and other physical and geographical limitations. Solar PV has been identified, as perhaps, the most technically feasible renewable energy technology, given the island state's unique attributes and associated challenges.

Solar PV technology is commonly deployed either as ground-mounted systems or on the rooftops of buildings. Some recent novel applications include deploying the technology as floating systems on water bodies such as lakes and canals or as building integrated systems. Currently, the rooftop variant seems to be the most feasible type of system for Singapore.

The solar market has evolved significantly over the years since the first tender was issued by the HDB in 2011 for 2 MWp. At that time, the HDB had offered a subsidy of up to 30 per cent of capital expenditure with the objective of kickstarting the nascent solar PV market in the country. In the most recent tender in 2014, however, the government did not provide any form of assistance and the project economics were completely market-driven, reflecting how the government has been successful in weaning the market off state support.

While Singapore is a relatively small market for solar PV, it is still very attractive to developers and investors for a range of reasons:

• The electricity tariffs in Singapore are market-driven, without price-distorting subsidies. This results in competitive tariffs for solar even in the absence of any feed-in-tariffs or other forms of government support.

• The solar market in Singapore is largely driven by government tenders (Singapore Government agencies act as the counterparties). This minimises counterparty risk for developers and investors and lowers the cost of capital for solar projects.

• Power projects are generally long-term in nature and international investors assume significant risks in most countries due to currency volatility, which pushes up currency hedging costs and lowers returns. Lower risk (and cost) is a result of factors such as Singapore's business-friendly environment, stable macro-economic policies and relatively stable currency. This makes the country an attractive place for investors.


Solar-Powered Breeze Shelters in Singapore. Photo by Choo Yut Shing (Permission under CC BY-NC-SA 2.0). Along the Marina Boulevard, these pavilions are made of glass and stainless steel, and feature large fans.

Given these factors, project developers and investors with international portfolios are keen to have a Singapore component in the mix, however small, to lower the overall risk and enhance the value of the entire portfolio itself.

Success Factors for Solar PV in Singapore

Solar PV projects have three key success factors: (i) Business model and project structuring; (ii) Cost of capital (equity, debt, construction capital); and (iii) Successful refinancing and/or exit for developers and risk investors from the project.

Contrary to popular belief, solar PV is not technologically complex to deploy in the majority of applications. Standardised design and engineering have greatly reduced the impact of technological risks and complexities on project economics. The key variables that do have a major impact on the success of a project are: (a) solar yields; and (b) electricity tariffs. For projects in countries or regions with a mature solar industry, solar yields can be modelled to an acceptable margin of error. The critical variable for determining project success, then, is the electricity tariff.

Electricity tariffs are determined by the business model deployed for the project. Across the world, some common business models in use for rooftop solar PV projects include:

• Solar Energy as a Service;

• Solar PV Leasing; and the

• Distributed Merchant Power Model.

Solar Energy as a Service

In this model, the project developer (along with investors) installs the solar PV system on the energy off-taker's rooftop at zero (or nominal) cost to the off-taker. The off-taker agrees to buy all the generated energy at a pre-determined tariff formula. The project developer provides guarantees and manages the risks associated with the same.

Multiple variations of this model are possible. A portion or all of the generated energy could be supplied to the grid at whatever prevailing grid price at the time of supply. Some countries allow multiple off-takers from a single rooftop solar PV system. The state of government policy determines the most lucrative business model for each project.

The determinants of project success in this business model are: the tariff for each kWh of energy generated and sold; and the tenure of the energy purchase agreement (in other words, contract duration in terms of years).

Both of these variables are the outcome of negotiations between the developer and the off-taker. Tariffs over time can be fixed with a pre-determined annual escalation, pegged to a suitable index, and within a certain price-band (floor and ceiling). Tenures in Singapore typically range between 15 years to 25 years. At the end of the tenure of the agreement, both parties may decide to extend, end or renew the contract.

It is important to note here that government policy can play a critical role in encouraging the use of this business model. Most rooftop system sizes are under 1 MWp (which already needs about 100,000 square feet of free rooftop space). At this size, developers and investors struggle to achieve economies of scale through a single project and hence prefer to aggregate multiple projects under a single legal entity to achieve financial success. A favourable policy allows for such aggregation. In Singapore, developers are allowed to aggregate projects as described above.

Case Study: The Singapore HDB Solar Leasing Programme

The Singapore HDB solar leasing programme is a variant of the Solar Energy as a Service Model. In this model, the town council agrees to purchase all the energy generated from the system financed and installed by a chosen developer/vendor. The town council first consumes whatever it needs for its captive needs and exports the excess energy to the grid.

The developer/vendor, therefore, receives two different tariffs for the generated energy. For energy sold to the grid, the vendor/developer receives the prevailing tariff that SP Powergrid (the distribution company) pays for energy at the time of export, minus any grid charges incurred. For energy consumed by the town council, the council pays the prevailing SP Power Services electricity tariff discounted by a factor that forms the criteria for vendor/developer selection. The higher the discount offered by the vendor/developer, the greater the chances are of being selected for the Programme. In recent tenders, a minimum discount of 17 per cent is expected whereas the maximum discount can be as much as 99.99 per cent!

Therefore, the overall energy cost payable by the town council/building manager for the solar energy generated through the PV system is calculated as:

Cost = [T x P1 x (S – E)] + [(T – G) x E]

where,

I is the energy imported from SP PowerGrid (in kWh)

S is the total solar energy generated (in kWh)

E is the exported solar energy (in kWh)

T is the prevailing SP electricity tariff rate (in SGD/kWh)

G is the grid charges (in SGD/kWh)

P1 is the discount factor to be input by the tenderers (value ranges from 0.083 to 0.001)

Clearly, accurate modelling of the expected yield, the town council's energy load and the grid prices are critical for project success; more so because the penalties imposed by the town council for energy shortfalls and below par performance are very steep.

It is also important for the developer/vendor to avoid the winner's curse by aggressively offering a P1 discount factor value that is too low. Project economics should be based on the system capacity and yield curve vis-à-vis the demand curve of the town council's energy consumption. This is because it is more profitable to sell to the town council than to the grid as the grid charges can impact profitability.

Solar Leasing and Distributed Merchant Power Systems

The HDB programme described above, while called "Solar Leasing", fits more into the structure described under the "Solar Energy as a Service Model"). Conventional solar leasing programmes are structured as capital leases, also called the Hire-Purchase Model. This business model eliminates the market risk and the variability of returns for the investors.

In a "Distributed Merchant Power Model", the developer rents multiple rooftops to build solar PV systems, applies for a wholesale power generation licence, and supplies the aggregated energy either to off-takers or injects the energy into the wholesale market at prevailing prices. As solar capital costs drop further, this business model, where solar PV is competing against conventional power, may become increasingly interesting for policymakers and developers in the country.

Conclusion

Ultimately, all businesses must prove profitable for the investors and shareholders. In the power generation business and more generally, infrastructure development, project developers and early investors assume high risks during the development stage and are rewarded when they receive high valuations for their efforts by later stage investors. Similarly, in the solar PV business, developers/investors earn returns for their efforts and investments in any of the following ways:

- Trade sale of assets
- Refinancing
- Securitisation

To conclude, policymakers, industry and academia need to work further in a number of areas, such as assessing the economics of solar PV merchant power systems and the potential for securitisation for solar PV portfolios in Singapore. Additionally, it may also be useful to examine Singapore's potential to evolve into Asia's major financial market for trading solar PV-backed financial instruments.

1 Author's estimate, based on various documents from the Solar Energy Research Institute of Singapore and the Energy Market Authority.

Facilitating Solar PV Deployment in Singapore

Energy Market Authority, Singapore

The Singapore Skyline: Sunshine and Shade—Intermittent clouds. Photo by Erwin Soo (Permission under CC BY 2.0). Intermittent cloud formation can lead to shading and subsequent drop in output from PV systems.

Globally, countries are pursuing renewable energy to diversify their fuel mix and reduce carbon emissions. Unlike other countries, however, Singapore has limited renewable energy options. We have no hydro resources, and our wind speeds and mean tidal range are low. Among the modern renewable energy options, solar is the most promising and viable option for Singapore due to its location in the tropical sun-belt.

The EMA supports the use of solar energy as it brings multiple benefits to Singapore. First, solar energy enhances environmental sustainability as it produces zero carbon emissions. Second, solar energy can reduce our reliance on imported energy, thereby adding diversity to our energy portfolio and enhancing our energy security. Third, solar energy can reduce peak demand, as the peak energy usage in Singapore—typically in the afternoons—coincides with the periods when solar energy can be produced. This can in turn reduce our energy costs.

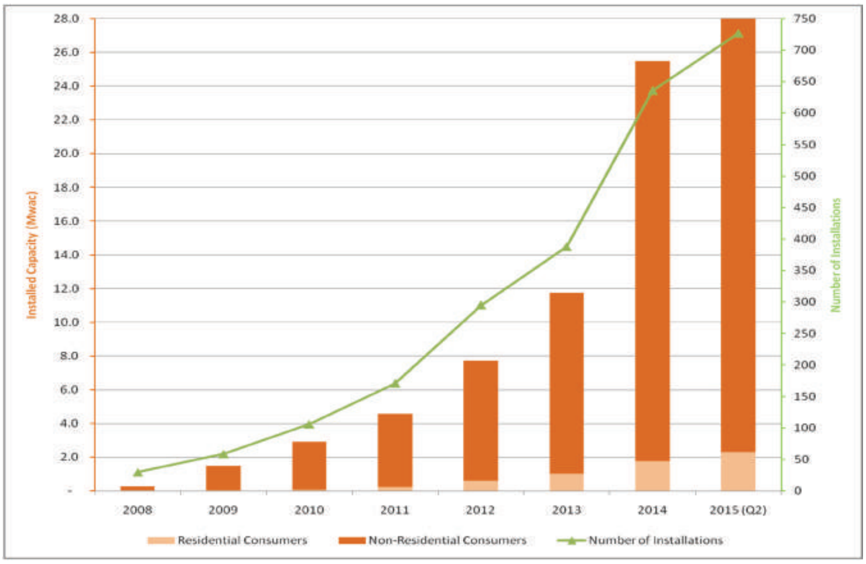
Market interest in solar energy has been growing in Singapore. Since 2008, the total grid-connected installed capacity of solar photovoltaic (PV) has risen from less than 2 megawatts of alternating current (MWac) to around 28 MWac as of the end of Q2 2015. About 93 per cent of the solar PV capacity was installed by commercial and industrial consumers, while the rest was sited on residential premises.

Maximising Solar Deployment in a Sustainable Manner

In anticipation of the growing market interest, the EMA has been taking proactive steps to maximise solar deployment without distorting the economics of solar energy. Singapore recently introduced several regulatory enhancements to facilitate solar deployment.

Ensuring Market Rules Are Robust to Facilitate New Business Models Put Forth by the Solar Industry

The EMA has reviewed the regulatory and market framework to facilitate solar deployment and new solar business models. For example, the solar leasing model—where electricity consumers lease solar panels from panel-providers in return for a discount on the electricity generated (compared to the electricity tariff)—has gained popularity in Singapore over the last few years. The advantage of such a model is that electricity consumers do not have to pay for the upfront cost of the panels. The regulatory and market enhancements have facilitated the development of such business models.



Source: Graphic courtesy of the Energy Market Authority.

A tangible outcome of the EMA's review is the removal of procedures that are less relevant for small generators, allowing owners of PV systems to be paid for excess solar energy in a convenient manner. Previously, market registration was required for payments of excess solar energy. The Central Intermediary Scheme (CIS), implemented in April 2015, allows contestable consumers to receive payment for excess electricity sold to the grid without the onerous market registration for larger generators. This provides further certainty for solar owners to assess the economic viability of their projects.

Streamlining Technical Requirements and Processes

To facilitate the deployment of solar energy, the EMA has set up a taskforce with the SP PowerGrid (SPPG) to review and streamline technical rules and processes.

This involves the reduction of the grid connection process for solar installations from 27 to 7 working days, thereby easing the administrative burden of solar owners. A grid connection checklist has also been established to accelerate the consumers' application process. In addition, licensed electrical workers are now empowered to commission a certain class of solar installations. This means that SPPG need not witness the commissioning process, which in turn reduces transaction costs.

Marina Barrage Solar Park in Singapore. Photo by Tim Lee (Permission under CC

The taskforce also launched a solar PV portal[1] on 30 June 2015 to facilitate information-sharing with consumers, such as the market registration process, and connection requirements.

Maintaining System-Wide Security and Reliability

At the same time, it is important to recognise the characteristics of solar energy and its effects on the power system. For example, solar output is intermittent, i.e., it fluctuates according to weather conditions, cloud cover and shadows. Sufficient resources (such as reserves provided by conventional power generation) are required to make up for the shortfall when solar output drops. Without the corresponding resources as back-up, consumers are exposed to the risk of power disruptions and blackouts.

Hence, to ensure sufficient resources to manage intermittency, the EMA has developed the "Dynamic Pathway Approach". This will allow the amount of resources to grow in tandem with solar deployment. Based on the current amount of reserves in our system, the EMA has raised the threshold for solar PV deployment in Singapore, which is called the Intermittent Generation Threshold, from 350 MWac to 600 MWac. This will be regularly reviewed, and could be further increased in future when there are better methods to forecast solar output, or when additional resources (such as energy storage) become available to support the growing amount of solar in our energy system.

As solar generation requires resources to manage its intermittency, it is important that the cost of providing these resources is allocated in an equitable manner. Hence, to achieve economic and sustainable outcomes for all consumers, the EMA is reviewing a new pricing mechanism to account for this, and at the same time, balance the objectives of encouraging the growth of the solar industry with providing sufficient certainty to solar investors.

Moving Forward

Although solar energy currently contributes less than 1 per cent of Singapore's peak energy demand, its share is likely to increase over time as technologies improve and costs decline. The EMA fully supports solar deployment and has been taking proactive steps to facilitate the entry of these technologies in a fair and sustainable manner.

Looking ahead, the EMA will also prepare for longer-term challenges, such as by building up capabilities in solar forecasting and energy storage to better manage the intermittent nature of solar energy, while working with the grid operator to ensure that the power system infrastructure can support the deployment of such generation sources.

1 See http://www.singaporepower.com.sg/solarpv.

Staff Publications

Internationally Refereed Journal Articles

Christopher Len, "China's 21st Century Maritime Silk Road Initiative, Energy Security and SLOC Access", *Maritime Affairs* 11 (2015): 1–18.

Philip Andrews-Speed, "The Evolving Policy Regime for Pumped Storage Hydroelectricity in China: A Key Support for Low-Carbon Energy", *Applied Energy* 150 (2015a): 15–24.

Philip Andrews-Speed, "Energy Law in Support of the Low-Carbon Transition: Lessons from the United Kingdom and China", *Frontiers of Law in China* 10 (2015b): 296–315.

Shi Xunpeng, "Energy Trade Efficiency and Its Determinants: A Malmquist Index Approach", *Energy Economics* 50 (2015): 306–14.

Book Chapters

Elspeth Thomson, "Asia's Changing Energy Dynamics and Strategy", in *Future Energy Trends: Innovation, Markets and Geopolitics* (Abu Dhabi: Emirates Center for Strategic Studies and Research (ECSSR), 2015).

Elspeth Thomson, "The Role of Oil and Gas in China's Energy Strategy: An Overview", in *Managing China's Energy Sector: Between the Market and the State*, ed. Hongyi Lai and Malcolm Warner (London: Routledge, 2015), pp. 10–25.

Philip Andrews-Speed, "An Institutional Perspective on the Low-Carbon Transition", in *Handbook of Clean Energy Systems*: *Sustainability of Energy Systems*, ed. Jinyue Yan (Chichester: Wiley, 2015), pp. 3589–610.

Shi Xunpeng, "Energy Efficiencies in ASEAN Countries", in *Handbook of Clean Energy Systems*: *Sustainability of Energy Systems*, ed. Jinyue Yan (Chichester: Wiley, 2015), pp. 3681–99.

ESI Policy Briefs

Melissa Low and Adèle Elise Chagué, "COP21 Climate Change Conference: Will Paris Succeed Where Copenhagen Failed?", *ESI Policy Brief* no. 6 (21 April 2015).

Staff Presentations and Moderating

25 June Philip Andrews-Speed presented, "The Involvement of State-backed Companies from Northeast Asia in the Energy Sector of Southeast Asia: Outlook and Implications", at the Meeting of Association of International Petroleum Negotiators and Society of Petroleum Engineers, Singapore.

25 June Philip Andrews-Speed presented, "Why Aren't Prices Going North Again?" at a forum co-organised by ESI, the Singapore Business Federation and the Middle East Institute, entitled *Declining Oil Prices: Implications for Singapore*, Singapore Business Federation.

15 June Philip Andrews-Speed presented, "The Governance of Hydrocarbons", at the Ministry of Energy, Province of Quebec, Public Consultation on Energy Policy, Quebec City, Canada.

13 June Jacqueline Tao presented, "Green Bonds: Potential Drivers of Sustainable Growth in Asia?", at *The Asian Conference on Sustainability, Energy and the Environment 2015*, organised by the International Academic Forum (IAFOR), Kobe, Japan.

13 June Jacqueline Tao was Session Chair for the session, "Renewable Energy and Environmental Solutions", at the *Asian Conference on Sustainability, Energy and the Environment 2015*, organised by the International Academic Forum (IAFOR), Kobe, Japan.

03 June Li Yingzhu presented, "Environmental CGE Modelling on Climate Change Mitigation: Application Issues for Open Economies", at Soochow University, Suzhou, China.

01 June Shi Xunpeng presented, "Revisit the Motivations of Gas Trading Hubs and Hub Pricing in East Asia", at the 1st ERIA Multiple Joint Study for LNG Market, Tokyo, Japan.

27 May Victor Nian presented, "Would Progress in Nuclear Technology Bring the Nuclear Renaissance to ASEAN", at the *38th International Association for Energy Economics International Conference* (IAEE), Antalya, Turkey.

27 May Anton Finenko presented, "Marginal CO_2 Emissions Rates in Singapore's Power Generation Sector: Potentials for CO_2 Abatement", at the 38th IAEE International Conference, Antalya, Turkey.

27 May Liu Xiying presented, "Can ASEAN Countries Promote their Economic Growth by Energy Investment? Lessons Learnt from China", at the 38th IAEE International Conference, Antalya, Turkey.

27 May Li Yingzhu presented, "The Impact of Trade Structure in Environmental CGE Modelling: An Application on Singapore", at the 38th IAEE International Conference, Antalya, Turkey.

26 May Shi Xunpeng presented, "China's Gas Market Liberalization and its Global Impact" at the 38th IAEE International Conference, Antalya, Turkey.

26 May Allan Loi presented, "Reducing Trade-offs Between Economic Growth and Carbon Emissions for Singapore: Promoting Green Energy and Efficiency Policies amidst Constraints and Uncertainties", at the 38th IAEE International Conference, Antalya, Turkey.

25 May Shi Xunpeng presented, "Gas Trading Hubs and Hub Pricing in East Asia: Economic Rationality and Geopolitical Reality", at the 38th IAEE International Conference, Antalya, Turkey.

25 May Hari MP presented, "Comparing Natural Gas Supply Disruption Scenarios", at the 38th IAEE International Conference, Antalya, Turkey.

23 May Elspeth Thomson moderated the Energy Markets Panel for the *NUS Investment Symposium 2015*, SGX Auditorium, Singapore.

21 May Christopher Len presented, "South China Sea Disputes: Trends and Outlook" to the 2015 Jefferson Fellows from the East-West Center, US during their visit to ESI.

19 May Philip Andrews-Speed presented, "The Competitive Landscape for Russia's Energy Involvement in Southeast Asia: The Other Asian Actors", at the *Russia-Asia Energy Summit*, Singapore.

18 May Christopher Len presented, "China's Maritime Power Aspirations and Energy Security: Implications for Asia", at the Hopkins-Nanjing Center, Nanjing, China.

16 May Shi Xunpeng presented, "Assessment of Supporting Instruments for Off Grid RE Investment in ASEAN", at the Economic Research Institute for ASEAN and East Asia in Chiang Mai, Thailand.

30 April Philip Andrews-Speed presented, "China's Energy Transition", at the Green School, Korea University, Seoul, Korea.

28 April Philip Andrews-Speed presented, "The Geopolitics of Shale", at the ASAN Institute of Policy Studies, ASAN Plenum 2015, Seoul, Korea.

17 April Shi Xunpeng presented, "Economic Issues in Sustainability Assessment of the Best Energy Mix", at the Economic Research Institute for ASEAN and East Asia, Singapore.

15 April Philip Andrews-Speed presented, "Governing China's Energy Transition: Identifying the Supporting and Constraining Factors", at the Kadoorie Institute, Hong Kong University, Hong Kong.

15 April Victor Nian presented, "Global Nuclear Power Development and Implications for ASEAN", at the Institution of Chemical Engineers (IChemE), NUS, Singapore.

15 April Melissa Low presented, "Outcome of Lima Climate Talks & the Role of Non-State Actors in the Climate Negotiations", at *Reducing Carbon Emissions: Opportunities and Challenges for Singapore* organised by Green Drinks and NCCS, The Pod, Singapore.

11 April Nur Azha Putra presented, "Singapore's Nuclear Energy Policy Development and Emergency Preparedness Plans", at the Economic Research Institute for ASEAN and East Asia, Tokyo, Japan.

10 April Yao Lixia presented, "Energy Security in Resource: Poor Countries: A Comparative Study of Domestic Policies in Singapore and Japan", at the *2015 5th International Conference on Social Science and Humanity*, Kyoto, Japan.

10 April Shi Xunpeng presented, "Gas Sector in Singapore", at the Economic Research Institute for ASEAN and East Asia, Tokyo, Japan.

9 April Anton Finenko presented, "Solar PV for Singapore: The Road Ahead", at *Singapore's Future Solar PV Strategies* organised by ESI.

1 April Melissa Low presented, "Energy Smart Cities: Perspectives from a City-State, Singapore", at *Designing Smart Cities: Opportunities and Regulatory Challenges*, Glasgow, UK.

1 April Melissa Low presented, "Many Smart Cities, One Smart Nation: Singapore's Smart Nation Vision", at *Designing Smart Cities: Opportunities and Regulatory Challenges*, Glasgow, UK.

Staff Media Contributions

Philip Andrews-Speed was interviewed by *Energy Intelligence* on reform of China's national oil companies, 29 June 2015.

Philip Andrews-Speed was interviewed by *Radio Free Asia* on China's LNG imports, 29 June 2015.

Philip Andrews-Speed was interviewed by *China Oil & Gas Monitor* on piracy in Southeast Asia, 25 June 2015.

Christopher Len was interviewed by *VietNamNet* on South China Sea energy resources, 18 June 2015.

Melissa Low, "Many Smart Cities, One Smart Nation: Singapore's Smart Nation Vision", *Society for Computers and Law (Computers & Law Magazine)*, 15 June 2015.

Yuen Kah Hung, "Innovations Needed for Electric Vehicle Sector to Move Ahead", *Business Times*, 12 June 2015.

Shi Xunpeng, "Further Clarification of Pricing Power in Natural Gas Trade", *Energy Observer*, 1 June 2015.

Philip Andrews-Speed was interviewed by *New York Times* on weakening oil demand in China, 28 May 2015.

Shi Xunpeng was quoted in "Gas Trade Hubs Would Benefit Importers in East Asia", *AA's Energy Terminal*, 25 May 2015.

Philip Andrews-Speed was quoted in "Jordan's New LNG Import Terminal", *Bloomberg*, 22 May 2015.

Christopher Len was interviewed by *Australian Broadcasting Corporation* on the South China Sea and energy issues, 21 May 2015.

Christopher Len was interviewed by *Thai Television Channel 3, Bangkok* on the South China Sea and energy issues, 21 May 2015.

Philip Andrews-Speed was interviewed by *Radio Free Asia* on China's plans to sell off oil and gas pipelines, 19 May 2015.

Philip Andrews-Speed was interviewed by *Reuters* on China's becoming the world's largest oil importer, 11 May 2015.

Philip Andrews-Speed was interviewed by *Energy Intelligence* on the talk of mergers between China's national oil companies, 5 May 2015.

Melissa Low was quoted in "Singapore Struggles to Make Itself More Resilient to Global Warming" by *ClimateWire, Special to E&E Publishing*, 9 April 2015.

Shi Xunpeng was quoted in "Misinterpreted Pricing Power in Natural Gas Trade", *Energy Observer*, 1 April 2015.

Recent Events

25 June, Declining Oil Prices: Implications for Singapore
ESI, together with the NUS Middle East Institute (MEI) and Singapore Business Federation (SBF), organised a forum to discuss the impacts of declining oil prices on Singapore companies. Dr. Philip Andrews-Speed presented, "Why Aren't Prices Going North Again?" at this event.

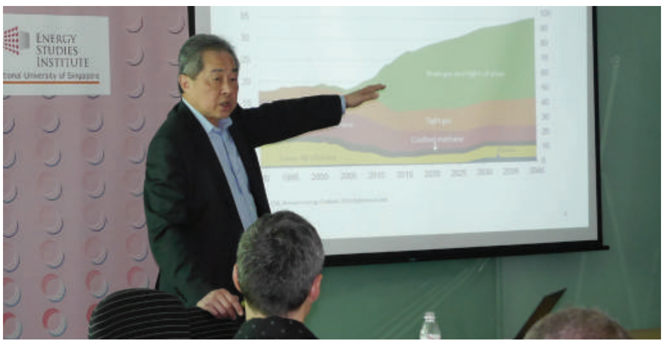
23–24 June, The Future of Sea Lane Security between the Middle East and Southeast Asia
ESI and Chatham House organised a closed-door international workshop involving 20 experts from Asia, Australia and the US to explore the likely scenarios of the future of sea lane security and their implications for the Middle East and Southeast Asian regions.

9 June, Myanmar Integrated Energy and Rural Electrification
Mr Keith W. Rabin, President of KWR International Inc. and KWR International (Asia) Pte Ltd, delivered a seminar at ESI on efforts to facilitate integrated energy development and rural electrification in Myanmar. Mr. Rabin shared details about the scale of Myanmar's electricity challenge,

including the fact that it has one of the lowest per capita electricity consumption levels in the world. He presented some research findings which served as input for the Myanmar Comprehensive Development Vision (MCDV), published in 2013.

Drawing from extensive fieldwork and on-the-ground experience, Mr. Rabin shared some observations and conclusions about the institutional and technical gaps that Myanmar is facing in its bid to achieve 100 per cent electrification. Mr. Rabin recommended the establishment of a Myanmar Integrated Energy and Capacity Development Center (MIECDC) to help facilitate energy and electrification development by building broad awareness and an interactive dialogue among the many stakeholders whose inputs are either essential or desirable for this sector.

18 May, The Impact of the American Unconventional Oil and Gas Revolution
Mr. Edward Chow, Senior Fellow at the Energy and National Security Program of the Center for Strategic International Studies in Washington, DC, presented a seminar at ESI on the impacts of the American unconventional oil and gas revolution on global energy markets and pricing. He noted that the unconventional/shale story is transformative for the



United States. However, due to uncertainties over whether unconventional gas can be transferable internally, the US will continue to remain a part of the global market and its future will depend on its oil and gas exports policy.

Mr. Chow emphasised that Middle Eastern supplies are still critical to global markets and that foreign and defence policy implications are still uncertain. However, it is clear that sanctions have become a foreign policy tool of choice to combat proliferation of nuclear weapons.

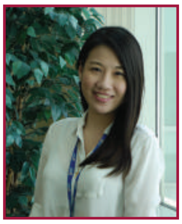
8 April, Economic Reforms and Environmental Quality: Empirical Evidence from European and Central Asian Transition Economies

Dr. Rabindra Nepal, Vice-Chancellor's Postdoctoral Research Fellow in Economics, University of Queensland, Australia, delivered a seminar at ESI which examined economic reforms and environmental quality in the context of European and Central Asian transition economies. He outlined the dynamic panel data model that he employed, which comprised 28 countries spanning 22 years from 1990 to 2012. His preliminary results suggest that reforms in competition policy and corporate governance are significant drivers of emissions reductions in the region. Thus, advances in competition policy and governance reforms are desirable, given the available scope to extend these reforms.

Dr. Nepal added that his results showed how the Kyoto Protocol had no significant effect in reducing emissions levels in transition economies, and that reducing energy use by increasing energy efficiency and investments in renewable energy are necessary to reduce the carbon emissions level and mitigate the adverse impacts of climate change in the region.

New Staff

Eunice Low, Editor



Eunice Low joined the Energy Studies Institute as Editor in July 2015. With over 12 years of publishing experience, she was formerly Editor and Head of the Journals Division at NUS Press (National University of Singapore), where she was based for over 6 years. Prior to that, she worked as Team Leader (Journals Content Management) at John Wiley and Sons, and as Assistant Senior Editor at Marshall Cavendish. She obtained her BA (with merit) in 2002 from NUS's Faculty of Arts and Social Sciences, majoring in Sociology and European Studies (French). Eunice's interests include creative writing and the medium of self-publishing, Europe in the Middle Ages, comparative literature, and theology.

Contact

- Collaboration as a Partner of ESI (research, events, etc)
- Media Enquiries
- ESI Upcoming Events
- Join ESI Mailing List

Ms Jan Lui
esilyyj@nus.edu.sg

Upcoming Event

What: ESI Professional Training Seminar Programme: "Commercial & Legal Practice in the Energy Sector"

An 18-month series of training seminars catered for commercial, management and legal professionals working in the energy sector.

Where: Energy Studies Institute Conference Room, 29 Heng Mui Keng Terrace Block A #10-01, Singapore 119620

Contact: Ms Jan Lui at +65 6516 2000 or email esibox6@nus.edu.sg

For more information, visit http://esi.nus.edu.sg/professional-development/commercial-legal-practice

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