ESI Bulletin

ESI Bulletin on Energy Trends and Development (Volume 11 / Issue 1 • April 2018)

Blue Hour @ West Coast Park Singapore, 2010. Photo by William Cho (CC BY-SA 2.0).

INTRODUCTION

This issue from ESI's Energy Economics Division reflects a sample of some of their on-going research work. Either directly or indirectly all four articles have a link to energy efficiency in Singapore, but very much in a global context.

The sole objective of energy efficiency policies should be to maximise social welfare, not to minimise energy demand. To achieve a state of social welfare maximisation, a major requirement is that the price of energy (and all other goods for that matter) should reflect its scarcity (i.e. its value to society). So why not let Adam Smith's "invisible hand" determine how much energy society consumes? In other words, let the market determine the optimal allocation of society's scarce resources. However, as Joseph Stiglitz (Nobel Prize winner in Economics, 2001) is reported to have observed: "the reason that the invisible hand often seems invisible is that it is often not there".

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"Free" markets (i.e. free of external, usually government, interference) suffer from a number of potential inadequacies:

- They generate too little basic research;
- They generate too much pollution (i.e. un-priced environmental externalities);
- They deliver underinvestment in "social" goods (e.g. public health, defence, policing, education, etc.);
- They do not encourage perfect information;
- They deliver a lack of regulation (which can range across all sectors of an economy);
- They have weak enforcement of contracts and property rights; and
- They provide incentives to gain and maintain monopoly rents through the imposition of market barriers.

Where these imperfections exist, the conventional wisdom is that government should fill the voids. In the context of energy efficiency, it is the un-priced environmental externalities of energy use that tend to be of primary importance today.

ESI Senior Research Fellow, Dr. LIU Yang, addresses the issue of energy efficiency from the perspective of Singapore's climate change policies. He concludes that the ideal policy combination is for energy efficiency policies to focus on directly correcting for energy efficient investment distortions by influencing appropriate purchasing and capital investment decisions, supported by a carbon tax directly targeting energy use externalities and consequently energy utilisation decisions.

A fundamental issue when considering global climate change policy options is the nexus between energy use and GDP. Specifically, the question that must be addressed is "do economies become less energy intensive as they grow richer"? ESI Senior Research Fellow, Dr. Brantley LIDDLE, surveys the literature on estimation of the energy-GDP elasticity, using both cross-section and time series data. He concludes that energy intensity has tended to increase with GDP in low-income economies, whilst decreasing with GDP in high income economies. Further, over time, the elasticity of income for the latter tends to be less than unity for final energy consumption but not significantly different from unity for the transport energy sub-sector.

Government policies to encourage energy efficiency in the automobile sector have received global attention as governments around the world have attempted to address the issue of pollution (both local and global) resulting from the use of internal combustion engine vehicles (ICEVs). The most straightforward option is to utilise the taxation regime to encourage adoption of low-polluting technologies (via, for example, a sales tax on ICEVs) and/or an excise tax on fuel to discourage driving. Both options would also discourage car ownership, which would assist in reducing road congestion. ESI Research Fellows, Mr. Hari M.P. and Dr. Victor NIAN address this issue from the perspective of Singapore, in the context of promoting electric vehicles (EVs) without changing the current vehicle taxation scheme. Their novel suggestion is that the EV car dealer, rather than the car owner, pays the Certificate of Entitlement on EVs, thus reducing the capital cost of the vehicles, and that they claw back this subsidy from the owner on a monthly basis. Since future fuel costs (electricity) of EVs are expected to be significantly lower than those of ICEVs (petrol), the customer's up-front impost has been removed and is spread over a period when EV running costs are relatively low.

Financial technology, or Fintech, refers to technological innovations that are emerging as major disruptors of every aspect of traditional financial systems. Fintech covers the full spectrum of financial services, from mobile payment platforms to high-frequency trading, and from crowdfunding and virtual currencies to blockchain. Green Fintech is concerned with utilising fintech innovations to harness the financial system to align financing with sustainable development outcomes. ESI Research Associate, Jaqueline TAO, and ESI Research Fellow, Dr. Dina AZHGALIYEVA, discuss how Fintech can facilitate the "greening" of industry and commerce, although with a warning that the traditional role of regulators in the financial sector is also going to be disrupted as their regulatory territory expands into unchartered domains.

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

Professor Anthony D. Owen,
ESI Principal Fellow and Head of the Energy Economics Division
(On behalf of the ESI Bulletin Team)

Energy Efficiency in Singapore's Climate Change Policy

Dr. LIU Yang, ESI Senior Research Fellow

Given its lack of viable energy resources, energy efficiency is Singapore's first fuel. The island state has pledged to reduce its emissions intensity by 36 per cent from 2005 levels by 2030. From 2008 to 2015, CO_2 emissions in Singapore grew by 25 per cent, notably from international marine bunkers, aviation bunkers and the manufacturing industry. These trends raise the need for unlocking greater energy efficiency potential. Energy efficiency policies feature strongly in Singapore's climate mitigation strategies. There is significant potential for interaction between climate and energy efficiency policies. Singapore faces significant challenges in terms of land space and high intermittency when promoting solar energy. Energy efficiency can play an important role in the near term, while saving time for a transition towards a low-carbon energy mix, which will occur in the long-term.

Singapore has made big strides towards improved energy efficiency. Since the introduction of the Mandatory Energy Labelling Scheme (MELS) and the Mandatory Energy Performance Standards (MEPS) in 2008 and 2011, respectively, as well as the introduction of the Green Mark (GM) Scheme for buildings in 2005, Singapore has strengthened the regulatory instruments in the area of energy efficiency. The Energy Conservation Act (ECA) came into effect in April 2013. More recently, amendments to the ECA have included tightening of energy monitoring and reporting requirements for large energy users. The Energy Efficiency Fund launched in April 2017 is a new step forward to engage small and medium sized enterprises to invest in energy efficiency.

It is natural to ask whether energy efficiency and climate policies are friends or foes in Singapore's context. The implications are three-fold. First, Singapore has decided to implement a carbon tax in energy-intensive industries from 2019 forward. Carbon taxes may have undesirable effects such as disproportional impacts on low-income households or on the competitiveness of industrial sectors. Meanwhile, energy efficiency policies aim to enhance energy productivity and thus may offset the unintended effects of the carbon tax. Energy is a vital input to the economy. Like labour, capital and other inputs, using energy more productively enables economic growth and protects the environment. An alternative way to view global energy intensity improvements is to recognise that they deliver an energy productivity bonus, because the world is able to produce more GDP for each unit of energy demand. Our recent study reveals that gradually achieving higher energy efficiency in non-energy production up to 10 per cent in 2040, instead of a baseline scenario, will help boost the global GDP by 1.3 per cent from 2015 to 2040, without making any regions worse off.[1] Singapore will actually benefit from this energy efficiency prosperity.

Second, improving energy efficiency is a powerful and cost-effective tool to promote economic growth as well as reduce energy consumption and greenhouse gas emissions. However, economic growth and the improvement of living standards still involve both improving energy efficiency and rising energy consumption in Singapore, while most OECD countries already reached their peak energy demand around 2007.[2] In addition, the expected energy savings are often reduced to some extent, due to well-known rebound effects.[3] This is why the first-best policy must impose the right price on the energy consumption decision. As long as consumption is not fully price-inelastic, energy efficiency will not achieve the first-best, because energy efficiency measures, if implemented alone, will tend to decrease energy prices in the long run and consumers will not face the true social cost of energy when deciding, for example, how intensively to use a car or how much electricity to consume. While a carbon tax will tend to increase the marginal cost of energy production and final use, this Pigouvian tax[4] may provide a larger incentive for consumers with higher utilisation to choose energy efficient capital stock because it changes the relative prices of energy for all consumers equally.

Last but not least, the stringency of energy efficiency policies will have different implications under Singapre's climate targets. Singapore has set a national target to reduce its emissions intensity by 36 per cent from 2005 levels by 2030, allowing for more flexibility in absolute emissions indexed to economic growth. In such a context, a sound energy efficiency policy may lead to additional abatement and reduce mitigation costs. However, combining climate mitigation and energy efficiency in a coherent policy framework is extremely important. There have been lessons from overlapping energy and climate policies in the European Union's emissions trading scheme. If the emissions target is binding, the energy efficiency and renewable policies cannot reduce additional emissions. They may instead lower the carbon price signal and hinder the financial viability of renewable energy and energy efficiency investments. Thus, energy efficiency may potentially conflict with the emissions target in such a context. In Singapore's case, a stringent energy efficiency policy may unlock a huge potential of least-cost abatement opportunities, which may further make emissions intensity targets non-binding when the country's carbon intensity declines due to economic growth being surpassed by energy efficiency improvements. This will undermine the effectiveness of the combination of energy efficiency and climate policy instruments.

To what extent can energy efficiency policies provide synergy with the national climate policy? This question has profound implications for Singapore. Though a precise answer largely depends on the specific context, the most important policy recommendation is to address market failures as directly as possible. Is it useful to investigate whether investment inefficiencies exist in Singapore's energy efficiency market? The answer is very likely yes. Global investment in energy efficiency grew by 9 per cent to reach USD 231 billion in 2016. The buildings sector

has become increasingly dominant and now represents 58 per cent of the total energy efficiency investments. The pure market for energy efficiency services continued to grow in 2016, with energy service company (ESCO) revenues increasing by 10 per cent to USD 26.5 billion.[5] With the industrial sector strongly dominating its energy landscape, Singapore is well positioned to take a lead in encouraging an energy services market and enhancing energy efficiency investment at the forefront of energy efficiency discussions and policies.

In doing so, energy efficiency policies such as financial incentives and minimum energy efficiency standards will have larger welfare gains compared to the first-best Pigouvian tax, such as a carbon tax. The first-best policy involves both Pigouvian taxes on energy and a second mechanism to increase quantity demand for an energy efficient good. The ideal policy combination operates in a way that energy efficiency directly corrects energy efficiency investment distortion by affecting good purchasing or capital investment decisions, while a carbon tax directly responds to energy use externalities and consequently energy utilisation decisions. As consumers are quite heterogeneous with respect to the degree of their investment inefficiencies, it is critical to design target policies.

If agents are imperfectly informed and the government has poor information disclosure technology, the information dislosure approach should be strenghened. If the economy-wide rebound effects are strong, more stringent energy efficiency targets must be in place to compensate for the increase in energy consumption without sacrificing the macroeconomic benefits of energy efficiency improvements.

1 T. Wei and Y. Liu, "Estimation of Global Rebound Effect Caused by Energy Efficiency Improvement", *Energy Economics* 66 (2017: 27-34).

2 International Energy Agency. *Energy Efficiency Market Report: Market Trends and Medium-Term Prospects* (Paris: OECD/IEA, Paris, 2017).

3 Wei and Liu, op. cit.

4 A Pigouvian tax is a tax on any market activity that generates negative externalities.

5 IEA, 2017, op. cit.

The Long-run Income Elasticity of Energy Consumption

Dr. Brantley LIDDLE, ESI Senior Research Fellow

Mechanised Ploughing in Cambodia, 2013. Photo by Department of Foreign Affairs and Trade (Australia) (Permission under CC BY 2.0).

There has long been interest in the applied energy economic literature with respect to estimating/understanding the macro-energy-GDP elasticity—the per cent change in energy consumption associated with a one per cent change in GDP. Previous work on the income elasticity of energy consumption has found a lack of leapfrogging (i.e., economic growth has not become less energy intensive in developing/industrialising countries), despite obvious technology transfer (current developing countries employ technology more advanced than that used in OECD countries circa 1960-1970). Understanding more about the energy-GDP elasticity is important for several reasons. Knowing the elasticity can help in assessing the feasibility/stringency of intensity-based targets (e.g., energy or carbon emissions over GDP); and the elasticity is utilised in energy forecasting and as an input to larger energy systems or integrated assessment models that are used to examine climate change options.

Indeed, the macro energy elasticity of GDP is useful in projecting energy consumption for a given economic growth rate, and several countries, as part of the Paris Agreement on Climate Change, have committed to reducing their emissions intensity (i.e., the ratio of carbon emissions to GDP). For example, Singapore has formally pledged to reduce its emissions intensity by 36 per cent from 2005 levels by 2030. Given Singapore's energy system, carbon intensity and energy intensity evolve nearly one-to-one (as is the case for many other countries as well). Moreover, Singapore, as an APEC member, is party to the APEC economies' aspirational goal of lowering APEC aggregate energy intensity by 45 per cent from 2005 levels by 2035; and Singapore is a party to the ASEAN goal of lowering energy intensity by 20 per cent from 2005 levels by 2020 and 30 per cent by 2025. In addition to Singapore, many key Asian countries set intensity-based targets, e.g., China, India and Malaysia. Several other Asian countries have set goals to reduce emissions off a business-as-usual (growth) scenario, including Indonesia, Thailand and the Republic of Korea. (Indonesia has a goal to lower its macro energy elasticity of GDP too.) If the macro energy elasticity of GDP is less than unity, then energy intensity will fall in a "business as usual" economic growth scenario.

Early work on the topic used time-series, cross-sectional data to emphasise the possibility that the energy-GDP elasticity changed with development or GDP growth. Galli analysed ten developing Asian economies using data spanning 1973-1990 and an error correction model that included a quadratic of income.[1] Medlock and Soligo considered 28 countries' (including seven non-OECD)

data from 1978-1995, and a similar nonlinear specification for income with a lagged dependent variable, and used a two-stage least squared approach to address the dynamic panel bias.[2] Both Galli and Medlock and Soligo recognised that a quadratic relationship between energy demand and income is unrealistic at the limits (of high income), but employed the model as an approximation/ simplification. Both papers found that energy demand increased more than linearly with respect to income, and that energy intensity tended to increase with output in low-income economies, and then to decrease with output in high-income economies.

More recent papers—often taking a more cross-sectional approach—have found stability and uniformity in energy-GDP elasticity estimates.[3] Csereklyei et al. determined that the elasticity of energy with respect to income is less than unity, so energy intensity falls with economic growth.[4] Csereklyei and Stern, Csereklyei et al. and Burke and Csereklyei found a higher elasticity of energy use with respect to income in the OECD countries than in the non-OECD countries.[5] By contrast, van Benthem's paper uncovered the following puzzle: he found a lack of leapfrogging (i.e., economic growth has not become less energy intensive in developing/industrialising countries), despite obvious technology transfer (current developing countries employ technology more advanced than that used in OECD countries circa 1960-1970).[6] He offers two offsetting trends that could explain this lack of energy leapfrogging: (i) consumption bundles have become more energy-intensive; and (ii) the heavy industry sector in industrialising countries is composed of more energy-intensive products compared to OECD countries in the past. One reason for greater energy-intensive consumption and production is that because of efficiency/technology improvements, today's developing countries have access to less expensive energy services than OECD countries had at similar income levels.[7]

Current work, considering only 17 OECD countries, but employing a relatively long—spanning 1960-2014—(balanced) panel of energy consumption and price data, examines the stability of the long-run income elasticity demand over time by estimating the relationship at sequential time intervals of 25-30 years.[8] The preliminary results suggest that the income elasticity of energy consumption is stable over time, i.e., there is no evidence that the elasticity estimated from the later periods is significantly different from the elasticity estimated from the earliest periods (for example, the 1960-1985 estimate is not significantly different from the 1990-2014 estimate). The elasticity of income tends to be less than one for total final energy consumption and industrial energy consumption, but not different from unity for transport energy consumption.

1 R. Galli, "The Relationship between Energy and Income Levels: Forecasting Long Term Energy Demand in Asian Emerging Countries" *The Energy Journal* 19, 4 (1998): 85-105.

2 K. Medlock III and R. Soligo, "Economic Development and End-use Energy Demand" *The Energy Journal* 22, 2 (2001): 77-105.

3 A. van Benthem, " Energy Leapfrogging", *Journal of the Association of Environmental and Resource Economists* 2, 1 (2015): 93-132; Z. Csereklyei, M. Rubio Varas and D. Stern, "Energy and Economic Growth:" The Stylized Facts", *Energy Journal* 37, 2 (2016): 223-55; and P. Burke and Z. Csereklyei, "Understanding the Energy-GDP Elasticity: A Sectoral Approach" *Energy Economics* 58 (2016): 199-210.

4 Z. Csereklyei, M. Rubio Varas and D. Stern, op. cit.

5 Z. Csereklyei and D. Stern, " Global Energy Use: Decoupling or Convergence?", *Energy Economics* 51 (2015): 633-41; Z. Csereklyei, M. Rubio Varas and D. Stern, op. cit.; and P. Burke and Z. Csereklyei, op. cit.

6 A. van Benthem, op. cit.

7 R. Fouquet, "Long-run Demand for Energy Services: Income and Price Elasticities over Two Hundred Years" *Review of Environmental Economics and Policy* 8, 2 (2014): 186-207.

8 B. Liddle, "Revisiting the Long-run Income Elasticity of Energy Consumption: An OECD-country Panel Analysis", Presented at 35th USAEE/IAEE North American Conference, Houston, USA, 14 November, 2017.

A Business Model for Promoting Electric Vehicles in the Absence of Policy Support in Singapore

Mr. Hari M.P., ESI Research Fellow and Dr. Victor NIAN, ESI Research Fellow

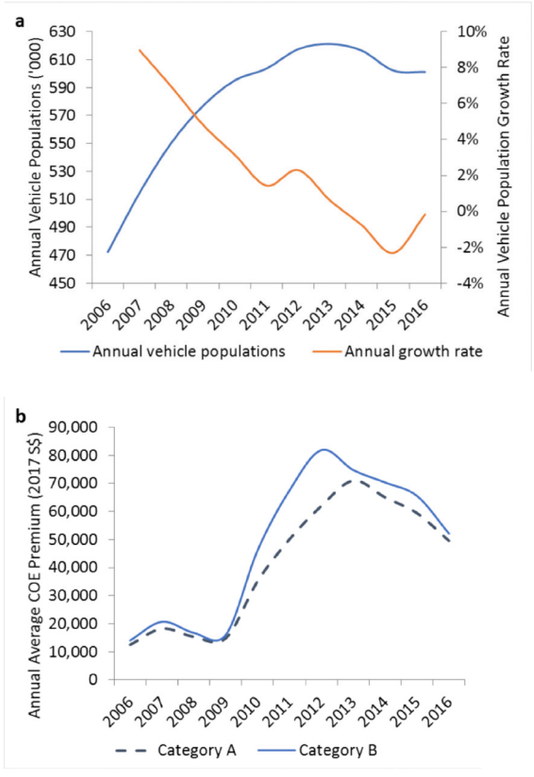
The developments in electric vehicles (EVs) are driven by the need for a cleaner and more efficient vehicle fleet on the road. Mainly due to the cost of the batteries, the manufacturing costs of EVs are higher than those of internal combustion engine vehicles (ICEVs). The fuel economy of EVs is much better than ICEVs when measured in kilometres per unit of energy consumed, but EVs suffer greater constraints in terms of total mileage and refuelling time as compared to ICEVs. Despite the benefits of electrifying the transport sector, both EVs and internal combustion engine vehicles add to road congestion.

Many major cities, conscious about easing road congestion, have already put in place measures to slow the adoption of vehicles, especially ICEVs. Singapore employs a fee or tax-based scheme in which the government imposes heavy taxes on vehicles including

Mitsubishi Electric Car. Photo by Tony Hisgett. (Permission under CC BY 2.0)

both ICEVs and EVs. In addition to those taxes, Singapore also employs a "Certificate of Entitlement" (COE) scheme in which prospective vehicle owners bid for the right to own one of a few license plates released each quarter. The tax revenue from the COEs serves the dual purpose of restricting the number of vehicles on the road as well acting as a progressive taxation scheme that is efficient (see Figure 1). The key question is how to incentivise the adoption of EVs in Singapore without affecting the overall vehicle taxation scheme that is geared towards restricting the number of cars on the road.

Figure 1: (a) Private Vehicle Populations in Singapore from 2006 to 2016; (b) Annual Average COE Premium



Capital Cost refers to the cost of purchasing and registering a car. In a heavily taxed country like Singapore, the capital costs of vehicles are much higher compared to those in other countries primarily due to the COE and registration fees. Vehicle usage of 10 years is encouraged by a refund of 50 per cent value of the Additional Registration Fee (ARF) if the vehicle is scrapped by the 10th year.

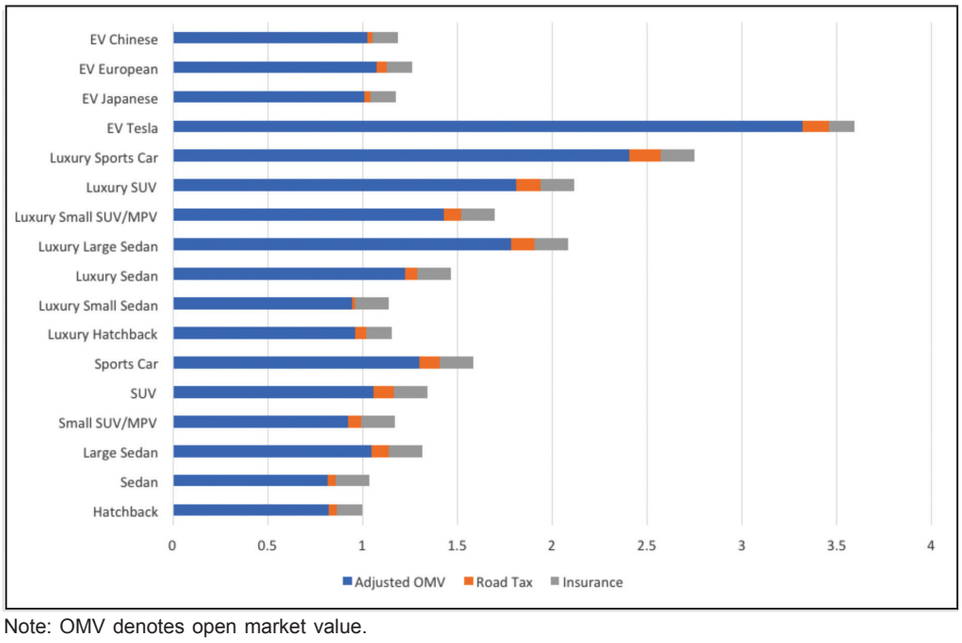
The normalised cost calculation (based on a study of the costs of more than 305 car models on sale in Singapore), with costs normalised to hatchbacks (the most popular segment of cars sold in Singapore) shows that EVs are on average 20 per cent more expensive to purchase and register (see Figure 2). Thus, upfront costs act as a barrier to widespread adoption of EVs, together with the lack of charging infrastructure and lukewarm customer interest, despite many pilot schemes for the adoption of EVs by industry and government.

Gasoline is also taxed heavily in Singapore with the retail price at the pump calculated on the basis of the refinery price of oil products, refinery margins, government fuel taxes, retailer margins and other cost components and government sales tax. We estimated the retail price of fuel in Singapore as a function of the Brent crude oil price (Eq. 1).

$$Retail\ Fuel\frac{Price}{Ltr} \quad \text{Eq. 1}$$
$$= 0.7 * \left((Brent + Refinery\ Margin + 0.64) * 1.6\right) * 1.07$$
$$+ 0.3 * \left((Brent + Refinery\ Margin + 0.56) * 1.6\right) * 1.07$$

Singapore's electricity market is liberalised with the wholesale market being contestable by large consumers from various economic sectors, such as the petroleum, commercial service and transport sectors. More than 97 per cent of the electricity produced in Singapore comes from natural gas fired power plants and 100 per cent of the natural gas is supplied through imports from neighbouring countries. Both the long-term wholesale and retail electricity prices can be approximated as a function of the price of natural gas in the Singapore market. The total cost of ownership of a vehicle includes fuel costs and maintenance costs. This is in addition to the capital cost of the car, which is uniformly incurred irrespective of the usage of the car. We studied the overall cost of ownership of cars in Singapore under various business scenarios.

Figure 2: Normalised PV of Total Capital Cost of Cars in Singapore (with ICEv Hatchback = 100)

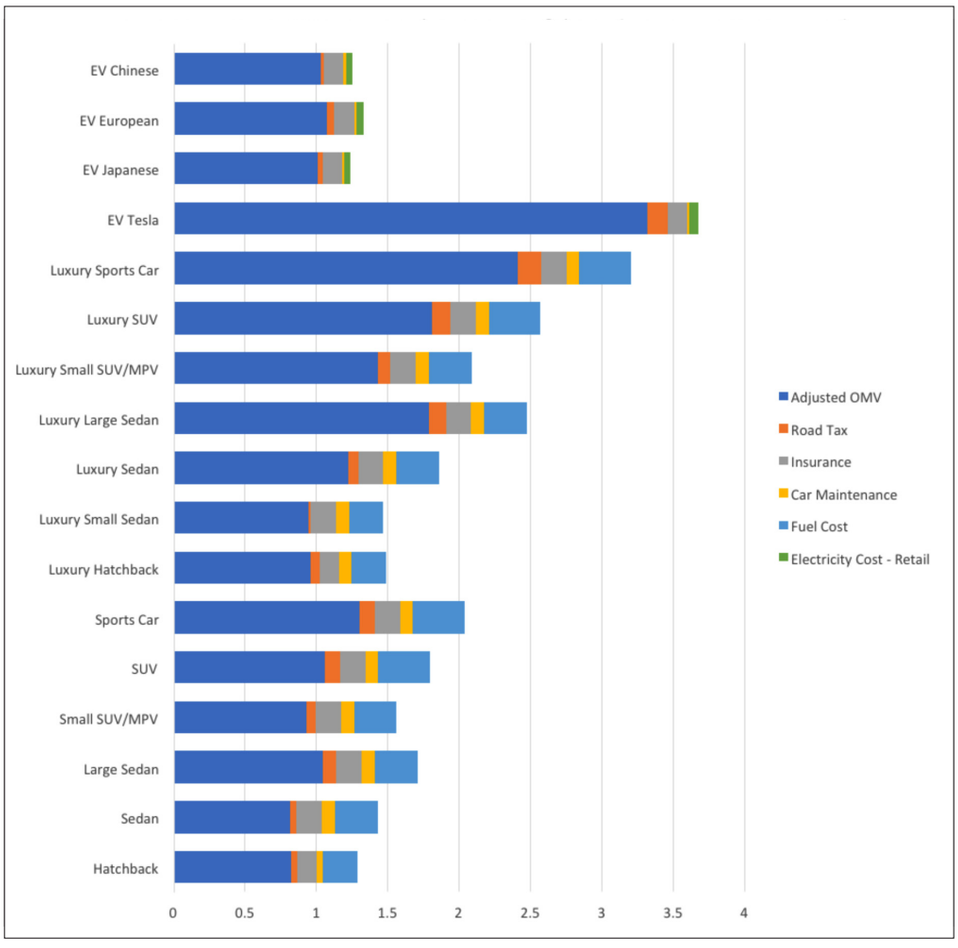


Note: OMV denotes open market value.

1. Base Case: All costs Borne by Vehicle Owners

EVs have a disadvantage against ICEVs when measured in terms of capital cost even with the

Figure 3: Normalised Lifetime Cost of Ownership of Cars in Singapore (with ICEv Hatchback = 100)



low carbon emission vehicle (CEVS) rebate. When measured by the total cost of vehicle ownership over the lifetime of 10 years, EV models except Tesla (a luxury sports sedan) are generally competitive against all body types except hatchback ICEVs. This is reflected by the normalised cost calculation as shown in Figure 3. The average cost of ownership is only 1.3 per cent higher over the lifetime of an EV when compared to a comparable ICEV. We found that EVs are cost competitive with ICEVs with the assumed fuel and electricity price projections in Singapore.

2. Dealer-subsidised COE

Given a balanced consideration over cost reduction for EVs, thus incentivising their adoption and assurance over tax revenue, we have conceived a business model in which the COE is "subsidised" by vehicle dealers. Under this scheme, the COE premium is paid by the vehicle dealers rather than the vehicle owners. In return, EV owners are required to commit to a minimum monthly or specific annual mileage in order to assure a minimum quantity of electricity use at a predetermined electricity price over a fixed period of time. The challenge is to identify an

Table 1: Normalised Lifetime Ownership Cost of Various Cars with No Subsidy, 3-, 7- and 10-year COE Payback Scheme

Normalised Total Cost of Ownership (Hatchback Total Capital Cost = 1)	No Subsidy	Dealer COE Subsidy 3-Year	Dealer COE Subsidy 7-Year	Dealer COE Subsidy 10-Year
Hatchback	1.29	1.29	1.29	1.29
Sedan	1.43	1.43	1.43	1.43
Large Sedan	1.71	1.71	1.71	1.71
Small SUV/MPV	1.56	1.56	1.56	1.56
SUV	1.79	1.79	1.79	1.79
Sports Car	2.03	2.03	2.03	2.03
Luxury Hatchback	1.49	1.49	1.49	1.49
Luxury Small Sedan	1.47	1.47	1.47	1.47
Luxury Sedan	1.86	1.86	1.86	1.86
Luxury Large Sedan	2.47	2.47	2.47	2.47
Luxury Small SUV/MPV	2.09	2.09	2.09	2.09
Luxury SUV	2.57	2.57	2.57	2.57
Luxury Sports Car	3.20	3.20	3.20	3.20
EV Tesla	**3.67**	**3.68**	**3.69**	**3.70**
EV Japanese	**1.24**	**1.24**	**1.25**	**1.26**
EV European	**1.33**	**1.34**	**1.35**	**1.36**
EV Chinese	**1.25**	**1.26**	**1.27**	**1.28**

appropriate period of COE repayment under which the minimum mileage and contracted electricity prices apply. In this study, we examined three cases of COE repayment, over 3 years, 7 years (the duration of a long tenor car loan) and 10 years (the permitted lifetime of a car's usage in Singapore).

3. Full Subsidy with 3-, 7- and 10-year' Payback Period

The total ownership cost analysis of 3-year, 7-year and 10-year payback periods is given in Table 1. Information presented in the table shows that the repayment period for the COE has negligible effects on the total cost of vehicle ownership. The government's tax revenue is also not compromised, the dealer gets the COE paid back (with interest of 5 per cent on the capital) and the customer is paying a slightly higher monthly amount for charging while paying almost 30 per cent less in upfront costs for registering the vehicle.

From the customers' perspective, the lower operating costs of EVs absorb the impact of COE repayment; the burden lessens even further if the repayment is extended to 10 years, which a government can easily encourage and implement because the tenor is higher than most loan repayment periods for commercial parties.

Table 2: Monthly Payment for EVs Inclusive of Charging Costs (Unit: 2017 SGD):

	3-year COE Payback	7-year COE Payback	10-year COE Payback
EV Tesla	1,664	820	632
EV Japanese	1,565	761	582
EV European	1,654	810	622
EV Chinese	1,570	766	587

The COE is paid upfront by the dealers, who adjust for the COE from EV buyers as a monthly payment which covers the fuel cost. The monthly payment for a popular EV over a 7-year payback period (typical tenor of a car loan) is SGD 761 inclusive of charging costs (see Table 2). As the operating costs of EVs average 1/5th those of a comparable ICEV, the additional cost of an amortised COE adding to the charging cost over a 7-year period is not significantly different (about twice as much) from the monthly fuel and maintenance costs of SGD 375 for an ICEV.

Discussions and Policy Implications

Under a contractual arrangement over usage and electricity tariff studied in the proposed business model, EV owners effectively pay back the subsidised upfront cost over a fixed period of time. Through an examination over a range of repayment periods and their impacts on costs, we find that the repayment period has virtually no impact on the total cost of vehicle ownership. We further contemplate that the same business model can be applicable to all cities in driving the adoption of EVs without affecting the existing policy infrastructure.

The cost of car ownership in Singapore is among the highest in the world and government taxes account for a major part of the sales price. The findings from our study suggest that there is indeed a business case for encouraging the adoption of EVs based entirely on the efforts of the private sectors. We further contemplate that the same business model can be applicable to all cities around the world to encourage the adoption of EVs without affecting their existing transport policy infrastructure. However, the successful implementation of the business model still depends on the policies and regulations related to infrastructure development, and much less on the EVs.

The Role of Green Fintech for Singapore: Risks and Benefits

Ms. Jacqueline TAO, ESI Research Associate and Dr. Dina AZHGALIYEVA, ESI Research Fellow

"If Singapore is to maintain its position as one of the top financial centres in the world, it must embrace FinTech – maximising its benefits, minimising its risks."

Ravi Menon,
Monetary Authority of Singapore (MAS)
Managing Director[1]

In the coming years, Singapore is likely to see a strong uptake of financial technology, or Fintech, across the economy. Indeed, Singapore is well-positioned to ride the Fintech wave. With deliberate government policies aimed at promoting growth in the emerging industry, a host of start-ups, established technology and social

One Marina Boulevard, Ocean Financial Tower, OUE Bayfront, the Customs House and Fullerton Bay Hotel, 2012. Photo by Nicolas Lannuzel (Permission under CC BY-SA 2.0)

media companies, along with an extensive ecommerce infrastructure, Singapore is a fertile ground for Fintech companies.

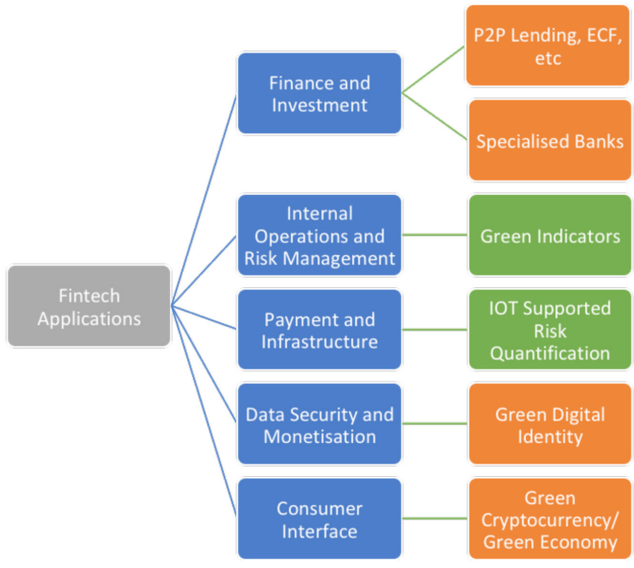
Fintech broadly refers to the technological innovations that aim to disrupt the traditional operational practices in the financial sector. The use of technology in finance is not new. For example, the rise of electronic payment systems in the 1970s and the burgeoning of electronic banking over the past decade are both applications of Fintech. However, the increased interest in the topic in recent years seems to arise due to the pervasiveness of Fintech. Specifically, the potential applications of Fintech seem to cover the full spectrum of financial services, inclusive of, but not limited to (i) finance and investment, (ii) internal operations and risk management, (iii) payments and infrastructure, (iv) data security and monetisation and (v) consumer interface. While less commonly mentioned, the potential of Fintech to support sustainability and the green agenda should not be overlooked. Figure 1 provides a broad taxonomy of how *green Fintech*, or the integration of sustainable values into Fintech applications, could be viewed.

One commonly discussed application of Fintech in the region is the rise of peer-to-peer (P2P) lending and equity crowdfunding (ECF). In Singapore, for small- and medium-sized enterprises (SME), borrowing is often backed by some form of collateral, property or otherwise. This limits the potential for green start-ups, with limited fixed assets, to tap the banking sector. For example, a green SME that focuses on building the *sharing economy*, or operates based on a leasing business model, would not be able to raise the required collateral since the entity does not legally own the fixed assets. P2P and ECF contribute directly towards fund intermediary processes which can support green start-ups and green SMEs without requiring collateral. Such applications are already seen in Malaysia.[2] Both P2P and ECF are used to fund green projects. Many people might not able to produce renewable energy, if for example, they do not have access to the roof to install solar panels, or their funds are not sufficient to fund one project. Instead, they lend as little as ten dollars through green P2P or ECF. Examples of green P2P and ECF include RateSetter (Australia), Open Energy Group (US) and Windcentrale UK).

Fintech also represents massive cost saving opportunities, therefore allowing for smaller specialised banks. Fintech could result in 30 per cent cost savings on day-to-day banking operations,[3] thereby lowering the barriers of entry into the banking sector and allowing for specialised green banks that may deliver financing solutions for green SMEs and develop related experience in evaluating energy efficiency, renewable energy and other green projects.

Green Fintech could mean adding more tools to the investment evaluation toolbox to quantify the benefits of being green and providing an alternative way of quantifying risk for emerging green sectors. For example, Arabesque's S-ray leverages on developments in big data, artificial intelligence (AI) and machine learning to evaluate the environmental performance of large listed companies.

Figure 1: Taxonomy of Green Fintech



Source: Drawn by the authors.

This equips investors with required information to allow for active benchmarking and management of their portfolios to align with their sustainable mandates.

Blockchain, or distributed ledger technologies, has the ability to simplify complex processes for easy verification and record-keeping. Such technologies, when applied in conjunction with developments in the internet of things (IOT), machine learning and AI could potentially facilitate the translation of large volumes of transactional data into useful information. This allows for a better risk estimation, especially for emerging green industries with a short track record, thereby facilitating the fund intermediation. Such applications, when supported with the appropriate customer interface, may allow for the creation of a green digital identity from which every individual could be given an estimated carbon footprint. Armed with such knowledge, more could be done to translate awareness into action for individuals. Small actionable steps could be seen to produce visible results (reductions to the estimated carbon footprint). A further extension of this application could be that a green/sustainable credit rating could be created from which good performance is rewarded. The potential for green actions to be rewarded through a green cryptocurrency is also possible.

With the seemingly unlimited possibilities offered not only by green Fintech, but also Fintech in general, its development also comes with associated risks, particularly in terms of regulatory burden. One key challenge for regulators would be identifying when to intervene. While a less regulated environment stimulates rapid growth, regulatory bodies may potentially miss the "regulatory window" as the industry moves rapidly from "too small to bother" to "too big to fail". Singapore introduced its *Fintech Regulatory Sandbox* in 2016 and invites businesses to experiment with Fintech as a solution to support Fintech growth under controlled environments.[4]

Regulators may also have to contend with which regulatory approach they may wish to take. While some regulators favour approaching Fintech as a managed

disruption to the traditional financial sector, some are worried that Fintech may represent a paradigm shift in the structure of the financial sector. Specifically, some regulators have identified Fintech as a core disruptor to the traditional operational practices in the financial sector. For example, the MAS estimates that Singapore banks may lose in excess of 5 per cent of their operating income should they fail to adequately address the disruptions brought about by Fintech.[5] Others have identified the potential of Fintech to change the makeup of the financial sector through diversification of the financial sector and the segmentation of the too-big-to-fail banking sector into small diversified players. While increasing the pool of actors in the financial industry may dampen the potential contagion effect of a bank failure, the excessive disintermediation could result in the insufficient quantification of microfinancial risk. Furthermore, with less-capitalised financial players, there is increased risk of insolvency as these smaller institutions lack the financial capacity and access to relevant intra-bank markets to tide them through tough times.

The introduction of Fintech disruptors, many of which are not traditional financial actors, may also change the nature of regulatory action. While current regulatory actions usually target key financial institutions, regulators in the future may have to expand their regulatory scope to technology or ecommerce companies who are providing financial services. Regulators would thus have to be adequately prepared to manage the expanded scope, while also ensuring that they have the necessary regulatory expertise.

A final piece of the puzzle is the answer to: who are the regulators? While traditional financial regulators will continue to have a role to play, Fintech extends the regulatory landscape to include previously unchartered territories such as cybersecurity, data protection and privacy.

1 Speech by the Monetary Authority of Singapore (MAS) Managing Director, Ravi Menon, at *Singapore FinTech Festival*, 14 November 2017 http://www.mas.gov.sg/News-and-Publications/Speeches-and-Monetary-Policy-Statements/Speeches/2017/Singapore-FinTech-Journey-2.aspx.

2 Asian Institute of Finance (AIF), "Crowdfunding Malaysia's Sharing Economy", 1 November 2017.

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4 Bud Haslett, "FinTech and RegTech in a Nutshell, and the Future in a Sandbox", The CFA Institute Research Foundation 3, no. 4, July 2017.

5 MAS, *Financial Stability Review* November 2017.

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Internationally Refereed Journal Articles

M. Belitski, Y. Kalyuzhnova and **Dina Azhgaliyeva**, "The Role of Alliances in Leveraging National Local Content Policies for Firm Competitiveness" *International Journal of Strategic Business Alliances* 6, 1-2 (2017): 69-85.

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Li Yingzhu, Shi Xunpeng and Su Bin, "Economic, Social and Environmental Impacts of Energy Subsidies: A Revisit of Malaysia", *Energy Policy* 110 (2017): 51-61.

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Zeng Shihong, Jiang Chunxia, Ma Chen and **Su Bin,** "Investment Efficiency of the New Energy Industry in China", *Energy Economics* 70 (2018): 536-44.

Philip Andrews-Speed, "To What Extent Will China's Ongoing Electricity Market Reforms Assist the Integration of Renewable Energy?", *Energy Policy* 114 (2018): 165-72.

Yao Lixia, Shi Xunpeng and Philip Andrews-Speed, "Conceptualization of Energy Security in Resource-poor Economies: The Role of the Nature of Economy", *Energy Policy* 114 (2018): 394-402.

Han Lei, Han Botang, **Shi Xunpeng, Su Bin**, Lv Xin and Lei Xiao, "Energy Efficiency Convergence Across Countries in the Context of China's Belt Road Initiative", *Applied Energy* 213 (2018): 112-22.

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Dina Azhgaliyeva, M. Belitski, A. Jumasseitova and Y. Kalyuzhnova, "The Role of Quality Education and Gender in Career: Case Study Bolashak Scholarship" *International Journal of Humanities and Social Development Research* (2017).

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Yuan Jun, Victor Nian and Su Bin, "A Meta Model Based Bayesian Approach for Building Energy Models Calibration", *Energy Procedia* 143 (2017): 161-66.

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Allan Loi, Anthony Owen and Choo Qian Ke. "Full Retail Contestability in Singapore's Electricity Market: What to Expect for Residential and Small Business Consumers", *ESI Policy Brief* 20 (8 December 2017).

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Elena Reshetova. "Joint ESI-ISAS Conference: Towards a Low Carbon Asia: The Challenges of Ensuring Efficient and Sustainable Energy", *ISAS Special Report* 49 (February 2018).

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Melissa Low and Goh Tian, "Why Have We Been So Slow in Slashing Electricity-Linked Emissions?", *Eco-business.com,* 12 January 2018.

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Jacqueline Tao and Gautam Jindal, "Singapore: (Not yet) a Rising Green Finance Hub", *Eco-business.com*, 28 March 2018.

Staff Presentations and Moderating

30 March Dina Azhgaliyeva presented "Assessing Energy Security in Caspian Region: the Geopolitical Implications to European Energy Strategy", at the *Multidisciplinary Workshop on Central Asia: 'Visions of Future in Central Asia: 2030 and Beyond',* Almaty, Kazakhstan.

29 March Yao Lixia presented "Energy Security Concerns of East Asia Countries", at the *KAPSARC Workshop on Energy Security,* Riyadh, Saudi Arabia.

29 March Victor Nian presented "Developments in the Internet-of-Things and Artificial Intelligence, and Strategic Implications for the Energy Sector", Zobotech Consultancy Co. Ltd, Beijing, China.

27 March Su Bin presented "Multiplicative Structural Decomposition Analysis of Aggregate Embodied Energy/ Emission Intensities", Hunan University, China.

22 March Li Yingzhu presented "Southeast Asia Energy Transition and Connectivity Developments", Konrad-Adenauer-Stiftung (KAS), Singapore.

22 March Christopher Len presented "Southeast Asia Energy Transition and Connectivity Developments", Konrad-Adenauer-Stiftung (KAS), Singapore.

19 March Philip Andrews-Speed presented "The Governance of Energy in Asian Countries: Balancing Energy Access, Poverty, Air Pollution and Lower Carbon Intensity", at the *World Bank's Asia Gas Workshop,* Marina Boulevard, Singapore.

17 March Melissa Low presented "Sustainability Career Mentorship", at the *Global Compact Network Singapore*, Marina Boulevard, Singapore.

6 March Philip Andrews-Speed presented "China as Global Clean Energy Champion: Lifting the Veil", at the University of Westminster, London, UK.

3 March Philip Andrews-Speed presented "China's New Energy Ambitions", at the *Windsor Energy Group Annual Conference,* Nanjing, China.

9 February Melissa Low presented "Climate Change Policy", at the *NUS Department of Geography Tropical Environmental Change (TEC) Seminar,* National University of Singapore, Singapore.

26 January Gautam Jindal presented "Energy Storage in Singapore", at the *Energy Storage Asia Congress 2018*, Royal Orchid Sheraton Hotel & Towers, Bangkok, Thailand.

25 January Melissa Low presented "Climate Change", at Loyang View Secondary School, Singapore.

23 January Melissa Low presented "Climate Change Policy in Singapore", at Ridge View Residential College, National University of Singapore, Singapore.

22 January Melissa Low presented "Singapore's Climate Change Strategy", to the *Executive Education Programme in Renewable Energy Management (REM-HSG)* participants visiting ESI from the University of St. Gallen, Switzerland.

20 December Li Yingzhu presented "Economic, Social and Environmental Impacts of Energy Subsidies: A Revisit of Malaysia", Nanjing University of Aeronautics and Astronautics, Nanjing, Jiangsu, China.

20 December Melissa Low presented "Global Climate Change Governance", at the United Nations Association of Singapore, Singapore.

19 December Li Yingzhu presented "Economic, Social and Environmental Impacts of Energy Subsidies: A Revisit of Malaysia", China University of Mining and Technology, Xuzhou, Jiangsu, China.

18 December Christopher Len presented "China's Maritime Silk Road and Energy Geopolitics in the Indian Ocean", at the Hopkins-Nanjing Center, Nanjing, China.

16 December Su Bin presented "Multiplicative Structural Decomposition Analysis of Aggregate Embodied Energy/ Emission Intensities", at the *Inaugural Workshop of China Energy Finance Network*, Southwestern University of Finance and Economics, Chengdu, Sichuan, China.

12 December Dina Azhgaliyeva presented "Cost of Energy Storage", at the *5th International Conference & Exhibition on Energy Storage and Microgrids in India,* New Delhi, India.

11 December Melissa Low presented "Climate Change and Singapore", to visitors at ESI from the University of North Carolina at Greensboro.

4 December Dina Azhgaliyeva presented "Renewable Energy Policy Instruments: An Empirical Evaluation of Effectiveness", at the *Academy of Public Administration under the President of the Republic of Kazakhstan Seminar*, Astana, Kazakhstan.

30 November Elena Reshetova presented "Dynamics and Geopolitics of Energy Transition" at the *PYC Intl Energy Conference: The Future of Sustainable Energy in Developing Countries,* Jakarta, Indonesia.

30 November Dina Azhgaliyeva presented "The Impact of Islamic Finance on Renewable Energy: A Panel Data Analysis", at the *Islamic Research and Training Institute, Islamic Development Bank Workshop*, Astana, Kazakhstan.

28 November Dina Azhgaliyeva presented "Implications of Fiscal and Financial Policies on Unlocking Green Finance and Green Investment", at the *Graduate School of Public Policy (GSPP) Nazarbayev University seminar*, Astana, Kazakhstan.

28 November Christopher Len presented "Closing Remarks", at the *South Asia's Challenges and Opportunities in Sustainable Energy Transitions Workshop*, organised by ESI and the Institute of South Asia, UNDP Auditorium, Singapore.

27 November Elena Reshetova presented "South Asia's Challenges and Opportunities in Sustainable Energy Transitions", at the *South Asia's Challenges and Opportunities in Sustainable Energy Transitions Workshop*, organised by ESI and the Institute of South Asia, UNDP Auditorium, Singapore.

27 November Christopher Len moderated "Energy Transition: From Fossil Fuel to Renewables", at the *South Asia's Challenges and Opportunities in Sustainable Energy Transitions Workshop,* organised by ESI and the Institute of South Asia, UNDP Auditorium, Singapore.

24 November Jacqueline Tao presented "Implementation of the Paris Agreement in South East Asia", at the *Asia-Pacific International Conference,* Korea Legislation Research Institute (KLRI), Seoul, Korea.

24 November Jacqueline Tao presented "Singapore's Climate Action Plan", at the *Asia-Pacific International Conference,* Korea Legislation Research Institute (KLRI), Seoul, Korea.

24 November Dina Azhgaliyeva presented "The Role of Quality Education and Gender in Career: Case Study of Bolashak Scholarship", at the *International Scientific Conference on Sustainable Development Goals,* Baku, Azerbaijan.

20 November Philip Andrews-Speed presented "Fossil Fuel Development Under the Belt and Road Initiative", at the *Belt and Road Green Development Conference,* organised by Columbia University and Renmin University, New York, USA.

14 November Brantley Liddle presented "Revisiting the Long-run Income Elasticity of Energy Consumption: An OECD-country Panel Analysis", at the *35th USAEE/ IAEE North American Conference,* Houston, Texas, USA.

13 November Christopher Len presented "Maritime Silk Road: Competition and Cooperation among Southeast Asia States and Regional Security", at the *Workshop on The 21st Century Maritime Silk Road: Considering Security Implications*, organised by Stockholm International Peace Research Institute (SIPRI) and Friedrich-Ebert-Stiftung (FES), Manila, Philippines.

13 November Gautam Jindal presented "ASEAN Power Sector: Developments and Opportunities", at the *CleanConnect 2017*: Belt and Road Forum organised by UMore Consulting, Citic Pacific Zhujiajiao Jinjiang Hotel, Shanghai, China.

13 November Melissa Low presented "Significance of MRV in Driving a Low Carbon Future in ASEAN Countries" at the *Korean Pavilion at COP23,* organised by the Asia Europe Foundation, Centre for Climate and Sustainable Development Law and Policy, Bonn, Germany.

10 November Brantley Liddle presented "Consumption-based Accounting and the Trade-Carbon Emissions Nexus" at the *Policy and Economics Research Roundtable*, Stanford University, Palo Alto, California, USA.

7 November Nur Azha Putra presented "The Dynamics of Nuclear Energy in Southeast Asia" at the Training Course on Nuclear Energy Technologies organised by ESI and the International Atomic Energy Agency, Singapore.

2 November Brantley Liddle presented "The Urbanization and Inequality Nexus" at the *XXVIII* International Union for the Scientific Study of Population *(IUSSP) International Population Conference*, Cape Town, South Africa.

1 November Melissa Low presented "Global Climate Change Governance" to the *GL2103 Global Governance* class at the National University of Singapore.

Staff Media Contributions

Melissa Low interviewed by *Channel News Asia* on "Climate Change, Carbon Tax, Paris Agreement", 29 March 2018.

Philip Andrews-Speed interviewed by *Radio Free Asia* on "China: Air Pollution and Coal Consumption", 19 March 2018.

Melissa Low quoted in "Carbon Tax Plan Allows Emitters Time to Act", *The Straits Times,* 4 March 2018.

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Melissa Low quoted in "Singapore Budget 2018: An Olive Branch in Lower-than-expected Carbon Tax", *The Business Times*, 23 February 2018.

Melissa Low interviewed by *Channel News Asia* on the carbon tax at the time of the Budget 2018 announcement, 23 February 2018.

Melissa Low quoted in "Large Emitters, Observers Welcome Initial Carbon Tax Rate of S$5 Per Tonne of Greenhouse Gas Emissions", *Channel News Asia,* 20 February 2018.

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Christopher Len quoted in "Linking Singapore, Asia and the Arctic", *High News North*, 9 January 2018.

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Melissa Low quoted in "Looking Ahead to 2018: To Tackle Climate Change, All Hands Needed on Deck", *TODAY*, 28 December 2017.

Victor Nian quoted in "Asia Hails Bangladesh Entry into N-club with Rooppur Nuclear Power Plant", *Nuclear Asia,* 21 December 2017.

Philip Andrews-Speed interviewed by *Radio Free Asia* on "China's Gas Shortages", 7 December 2017.

Philip Andrews-Speed quoted in "ASEAN Power Markets", *S&P Global Platts,* 30 November 2017.

Melissa Low interviewed by French Film production company *Born TV* on "Singapore: Future is Now", 26 July 2017.

Recent Events

19 March, "Integrating Solar and Storage Technologies into South Korea's Energy Landscape: Business Models and Policy Implications" (ESI Seminar)

Mr. Yoonjae Heo, who is a Senior Manager at Ernst & Young in South Korea and leads the company's Power and Utilities consulting practice there, gave a presentation on the role of storage technologies and solar PV in Korea's clean energy transition. He spoke about the key drivers promoting clean energy in Korea, namely its growth in carbon emissions, local air pollution affecting the quality of life, as well as the growing competitiveness of domestic clean energy manufacturers. He then discussed the policy instruments being used to achieve the ambitious national renewable energy target of 20 per cent by 2030. Finally, he shared his thoughts about various business models and how key market players involved are responding to the renewable energy targets through solar PV and battery storage technologies.

8 March, "International Maritime Transport under Carbon Pricing, Potential Merits and Hazards" (ESI Seminar)

Mr. Antoine Gaudin is a research assistant at the NUS Centre of Maritime Studies and is currently pursuing a double Master's degree hosted by the Faculty of Engineering at NUS and ENSTA ParisTech. In this seminar, he discussed the growing interest in using carbon pricing (part of Market-based Mechanisms, MBMs) as a tool to reduce CO_2 emissions in international shipping, and focused on the quantitative and qualitative effects of the two most common forms of carbon pricing, namely, the carbon tax and cap-and trade system. In his presentation, Mr. Gaudin spoke about how such measures might alter market dynamics in international shipping due to changes in travel times, fuel-related costs and freight rates. By way of conclusion, he made the following four points. First, for similar carbon prices, a cap-and-trade scheme induces higher carbon reduction and a lower cost to final consumers. Second, a tax is robust and effective in all market conditions, contrary to a closed cap-and-trade scheme. Third, if free allocations are based on market needs, all types of shipping markets would have similar reductions in emissions and increases in freight rates due to carbon pricing. Fourth, surges and falls in a potential

emission trading system (ETS) price can be evaluated according to shipping market conditions.

7 March, "Carbon Pricing Bill Commentary: The Pathway to Paris: On Our Way!" (ESI Seminar)

Mr. Eric Bea and Ms. Sarah Lu, Vice-President and Research Director of the Environmental Law Students Association (ELSA) at the NUS Faculty of Law gave a presentation on Singapore's plans to implement a carbon tax on greenhouse gas emissions. The two provided a commentary on the carbon pricing bill (CPB), based on a paper prepared by an ad-hoc Joint Working Group on Carbon Pricing (JWG) that was convened by ELSA, which included members from the NUS Bachelor of Environment Studies Student Committee; I'dECO at Yale-NUS College, and the Asian School of the Environment Club at Nanyang Technological University. The two speakers also gave an overview of how the planned carbon price scheme would work in Singapore. In discussing their study, they spoke about how the CPB legislation could be improved to further promote accountability, transparency and efficiency in the implementation of the carbon tax regime. They concluded their presentation by going through the 14 recommendations from their paper on ways to enhance the CPB and the subsequent implementation of the carbon tax. Their full paper is available at this link: http://bit.ly/elsaco2pricing.

13 February, "Facilitating Evidence-Based Policy Making in an Era of Globalization" (ESI Seminar)

Mr. Mahinthan Joseph Mariasingham, Statistician and Project Officer at the Asian Development Bank (ADB) discussed how public policy is becoming increasingly anchored on multifaceted information developed through multi-sourced data. In his presentation, he shared that in light of multiplying global interlinkages and interdependencies at the personal, business and country levels, multilateral organisations like the ADB have been collaborating with governments and research institutions to develop, update and modernise data capture and measurement frameworks to better map, measure, analyse and understand any phenomenon and decide on appropriate actions. He also shared the usefulness of the System of National Accounts (SNA), the System of Environmental Economic Accounting (SEEA), extended Supply-and-Use Tables (SUTs), Social Accounting Matrices (SAMs) and Multi-Regional Input-Output Tables (MRIOTs) in structured data development in facilitating research and policy making.

9 February, MOU Signing between the Institutes of Science and Development, Chinese Academy of Sciences (CASISD), China and the National University of Singapore

Professor Pan Jiaofeng (left) and Professor Ang Beng Wah (right) (Photo by ESI).

MOU signing between Professor Pan Jiaofeng, (left) and Professor Ang Beng Wah, (right) (Photo courtesy of CASISD).

On 9 February, the Institutes of Science and Development, Chinese Academy of Sciences (CASISD), China and the National University of Singapore (acting through ESI) signed an MOU to promote joint research and development activities. The MOU signing ceremony was attended by Professor Tan Eng Chye, NUS President; Professor Ho Teck Hua, Senior Deputy NUS President and Provost; Professor Ang Beng Wah, Executive Director, Energy Studies Institute (ESI), Dr. Su Bin, Senior Fellow and Deputy Head of the Energy and the Environment Division, ESI; Dr. Christopher Len, Senior Fellow, ESI and Ms. Adeline Ang, Associate Director, NUS Global Relations Office. The CASISD delegation also visited the ESI office and were joined by Dr. Philip Andrews Speed, Senior Principal Fellow and Head of the Energy Security Division; and Professor Anthony David Owen, Principal Fellow and Head of the Energy Economics Division for an exchange on research trends and collaboration opportunities.

31 January – 1 February, Training Course on Nuclear Security

Course trainers with Mr. Anthony Wetherall (second from left) (Photo by CIL Staff).

ESI and the NUS Centre for International Law (CIL) jointly organised a two-day training course on nuclear security for Singapore government officials, which was held on 31 January and 1 February 2018. The closed-door event was the third capacity building activity held under the umbrella of the ESI-CIL Nuclear Governance Project. The objective of the course was to provide an introduction to those aspects of nuclear security that are likely to be most relevant to Singapore, namely: (1) the international legal framework for nuclear security; (2) state responsibilities in nuclear security governance; (3) security of nuclear transport in Southeast Asia; and (4) contingency planning in response to a nuclear event.

Mr. Roger Brunt (former Director of the UK's Civil Nuclear

Security); Mr. Denis Flory (former Deputy Director General of the International Atomic Energy Agency); Mr. Ben Whittard (Head of Security and Resilience at International Nuclear Services); together with Mr. Anthony Wetherall (CIL Senior Research Fellow); lent their expertise to the 15 course participants representing a number of relevant government agencies in Singapore. The event was also observed by five researchers from local universities and think tanks.

26 January, "The Rollercoaster Ride of Oil and Gas Investments" (ESI Seminar)

Dr. Bård Misund, Associate Professor at the University of Stavanger Business School in Stavanger, Norway, delivered a presentation based on research findings from a study on how oil prices affect investment behaviour among oil and gas companies. In his research, he used the Tobin's Q methodology to examine the interaction effects of oil price change on companies' investment behaviour. He concluded his presentation with the following four points: First, vertical integration leads to lower responsiveness to oil price changes. Second, the substantial impact of cash flows on investments, and companies with good liquidity/profitability are able to invest more countercyclically. Third, dividend levels are not significantly affected by oil price changes. Fourth, leverage does not significantly impact investments (consistent with separation principle).

28 November, "Towards a Low Carbon Asia: The Challenges of Ensuring Efficient and Sustainable Energy" (Joint ESI-ISAS Conference)

Speakers at the ESI-ISAS Conference (Photo by the organisers).

ESI and Institute of South Asian Studies (ISAS) co-organised a half-day conference *Towards a Low Carbon Asia: The Challenges of Ensuring Efficient and Sustainable Energy*. This event brought together experts from government, policy think tanks and the private sector.

Professor Ang Beng Wah, ESI's Executive Director, delivered welcome remarks. Mr. Vikram Singh Mehta, Executive Chairman of Brookings India and Senior Fellow at the Brookings Institution in the United States, then delivered the Keynote Address entitled "Transitioning towards a Sustainable Energy Future: Challenges and Opportunities for India". He then participated in the dialogue session chaired by Ambassador Gopinath Pillai, Chairman of ISAS and Ambassador-at-Large of Singapore's Ministry of Foreign Affairs. The speakers shared their thoughts on the challenges and opportunities that Asia faces in its low-carbon energy transition efforts and of their assessment of key issues affecting energy developments in 2017. They also provided brief assessments of their outlooks for 2018.

The panel discussion that followed was chaired by Dr. Amitendu Palit, Senior Research Fellow and Research Lead (Trade and Economic Policy) at ISAS. The panellists included Mr. Ng Wai Choong, Chief Executive of the Energy Market Authority of Singapore; Dr. S. Narayan, Visiting Senior Research Fellow at ISAS; Mr. Henning Gloystein, *Asia Energy* Editor at Thomson Reuters; and Dr. Anthony D. Owen, Principal Fellow and Head of the Energy Economics Division at ESI. Dr. Christopher Len, ESI Senior Research Fellow delivered the event's closing remarks.

27 November, "South Asia's Challenges and Opportunities in Sustainable Energy Transitions" (Joint ESI-ISAS Workshop)

ESI and Institute of South Asian Studies (ISAS) jointly organised a one-day Workshop entitled "South Asia's Challenges and Opportunities in Sustainable Energy Transitions". This event brought together a diverse group of participants from Bangladesh, India, Sri Lanka and Singapore, who are affiliated with policy think tanks, universities, International and non-governmental organisations and the private sector.

Following the opening remarks by Professor Ang Beng Wah, ESI's Executive Director, Professor Syed Munir Khasru, Chairman of the Institute for Policy, Advocacy and Governance, delivered the Keynote Address entitled, "Regional Integration through Energy Connectivity: The Low Hanging Fruit for South Asia" where he shared his thoughts on the role of energy as a vehicle for peace in the region.

In the subsequent workshop panel sessions, participants discussed issues on transition from fossil fuels to renewables, the political economy of energy, climate change and low carbon economy, as well as the drivers and limitations of electrification in South Asia.

Dr. Amitendu Palit (ISAS Senior Research Fellow and Research Lead (Trade and Economics) and Dr. Christopher Len (ESI Senior Research Fellow) served as co-convenors for the workshop. Four researchers from ESI took part in the event as session chairs and


Group Photo of the ESI-ISAS Workshop Participants (Photo by the organisers).

discussants: Professor Anthony D. Owen, Principal Fellow and Head of the Energy Economics Division (Panel Chair); Dr. Christopher Len, Senior Research Fellow (Co-convener, Panel Chair and Presenter); Dr. Liu Yang, Senior Research Fellow (Panel Chair and Discussant); and Mr. Hari M.P. Research Associate (Discussant).

20 November, "The Future of the Global Solar Industry" (ESI Seminar)

Dr. Varun Sivaram, Philip D. Reed Fellow for Science and Technology at the Council on Foreign Relations first reviewed the literature on value deflation by considering case studies in Europe and North America. He noted the reduction in the value of PV-generated electricity as a function of increasing deployment, as well as the increasing strain on power grids as PV penetration rises. However, he underscored that technological innovation can reduce the cost of PV as well as improve the feasibility of other solar technologies including concentrated solar power and solar fuel production. Dr. Sivaram added that interconnected, smart power grids equipped with storage and connected to adjacent sectors such as transportation and heating can accommodate a rising share of intermittent PV electricity. Finally, he concluded by discussing what it will take for the global solar industry to pursue the innovation needed to sustain solar power's momentum through mid-century, touching on what is needed for the Singaporean solar industry to thrive.

8 November, "Small Modular Nuclear Reactors: The Outlook for Development" (Joint ESI-CIL Conference)

Group Photo of the Conference Participants (Photo by CIL staff).

Organised jointly by ESI and the Centre for International Law (CIL), this conference was the first public event held under the ESI-CIL Nuclear Governance Project Conference Series. Held at Singapore's Jen Tanglin Hotel, it addressed the prospects of SMR technology in the commercial nuclear reactor market, especially in relation to developing countries with smaller-sized grids; countries with distributed grids (e.g. archipelagic states); and more established nuclear power countries experiencing stagnant electricity demand. International experts Dr. Hadid Subki and Mr. Frederik Reitsma from the International Atomic Energy Agency; Mr. Robert Armour from Gowling WLG; and Dr. Peter Bird from Rothschild Global Advisory covered a range of relevant issues: the advances in SMR design and technology development, including for non-power related applications such as generating heat or for water desalination; advantages and drawbacks of SMR projects; how to finance them and their legal and regulatory requirements. The half-day event was attended by more than 60 participants from government, academia and the business sector.

7 and 9 November, ESI Training Course on Nuclear Energy Technologies

The Training Course Instructors and ESI Staff (Photo by ESI Staff).

The ESI-CIL Nuclear Governance Project organised a two-day training course on nuclear energy technologies for Singapore government officials, which was held at the ESI. The course instructors were Dr. Hadid Subki, the Project Manager for small modular reactor development at the International Atomic Energy Agency (IAEA), Mr. Frederik Reitsma, the Project Manager for high temperature gas-cooled reactor and molten salt reactor technology development at the IAEA, and ESI Research Associate Mr. Nur Azha Putra. This course was the second of a number of short training courses that the project intends to run for Singapore government officials. It was attended by 24 officials from eight different ministries and agencies.

Contact

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Published by The National University of Singapore

ISSN 2424-8169 (print) ISSN 2424-8177 (online)