Progress of Solar Photovoltaic in ASEAN countries: A Review

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Abstract.

The present global energy scenario, in which fossil fuels play a preponderant role, faces significant energy and environmental challenges. To help address these challenges, countries across the world are increasing the contribution made by renewable energy (RE) resources to their energy supplies. Feed-in Tariff (FiT) is one of the most effective incentive policies used to promote the RE sector especially at the micro-generation level. The key objective of the FiT schemes is to provide financial support to residential, industrial and commercial consumers to encourage them to become RE producers. Solar photovoltaic (PV) is one of the most promising RE technologies. This paper provides an overview of the solar PV developments in the Association of South East Asian Nation (ASEAN) countries. It reflects upon the RE trends in the world as well as providing an introduction to the ASEAN countries. It reviews the progress of solar PV in each of the ASEAN countries especially in terms of RE policies, growth in terms of PV installations and research and development activities. Finally, the paper presents conclusions and a set of recommendations. Out of the 10 ASEAN countries, 5 have implemented FiT as a key policy incentive to stimulate the progress of RE. It is found that the ASEAN countries have great potential for solar PV in term of their annual solar insolation levels, which ranging from 1,460 to 1,892 kWh/m^2 per year.

Keywords - ***Solar energy; solar photovoltaic; feed-in tariff; ASEAN.***

Abbreviation.

ACE	ASEAN Center for Energy	MYR	Malaysian Ringgit
ADB	Asian Development Bank	NREP	National Renewable Program
AEDP	Renewable and Alternative Energy Development Plan	NEPC	National Energy Policy Commission
AFTA	ASEAN Free Trade Area	PDP	Power Development Plan
ASEAN	Association of South East Asian Nation	PEP	Philippines Energy Plan
BEEP	Building Energy Efficiency Programme	PS	Pioneer Status
BIPV	Building Integrated Photovoltaic	PV	photovoltaic
BNERI	Brunei National Energy Research Institute	R&D	research and development
CO_2	carbon dioxide	RE	renewable energy
CSPS	Centre for Strategic and Policy Studies	REMP	Rural Electrification Master Plan
DC	direct current	REN21	Renewable Energy Policy Network for the 21st century
DECC	Department of Energy & Climate Change	RES	Rural Electrification Strategy
DOE	Department of Energy	RGC	Royal Government of Cambodia
EDPMO	Energy Department at the Prime Minister's Office	ROI	return on investment
EEDP	Energy Efficiency Development Plan	SCBP	Solar Capability Building Programme
EMA	Energy Market Authority	SEDA	Sustainable Energy Development Authority
ERC	Energy Regulatory Commission	SGD	Singaporean Dollar
FiT	Feed-in Tariff	SHS	solar home systems
GBI	Green Building Index	SREPP	Small Renewable Energy Power Programme
GBP	Great British Pound	UK	United Kingdom
GTFS	Green Technology Financing Scheme	UKERC	UK Energy Research Centre
HDB	Housing Development Board	UKM	National University of Malaysia
IDR	Indonesian Rupiah	UM	University of Malaya
ITA	Investment Tax Allowance	UPM	Universiti Putra Malaysia
MBIPV	Malaysia Building Integrated Photovoltaic	USA	United States of America
MEMR	Minister of Energy and Mineral Resources	USM	Universiti Sains Malaysia
MIEEIP	Malaysia Industrial Energy Efficiency Improvement Project	UTM	Universiti Teknologi Malaysia
MoU	Memorandum of understanding	VND	Vietnamese Dong
MTOE	Million Tonnes of Oil Equivalent	WWF	World Wide Fund for Nature

1.0 Introduction

Energy is one of the most vital human needs in the 21st century. All modern day activities including household, transportation, industry, agriculture, education and communication crucially depend upon energy. Availability of energy in societies also directly influences their economic wellbeing. Due to the fact that the majority of this energy comes from fossil fuels such as coal, oil and natural gas, this is causing a lot of problems, especially to the environment. Some of the major environmental consequences of using fossil fuels include high carbon dioxide (CO_2) emissions that pollute the atmosphere; depletion of forested areas, which has worsened global warming; and, very importantly, these energy resources are non-renewable and will eventually run out [1]. A recent example to reflect upon the environmental implications of extracting fossil fuels is the explosion of an oil rig in the Gulf of Mexico in April 2010. This led to the loss of 11 human lives and to a massive oil spill that had a devastating impact on the environment. [2]. Another example of the detrimental effects of extracting fossil fuels is the incident reported on February 2014, when hazardous waste from hydraulic fracturing to extract oil was being dumped off the coast of California in the United States of America (USA) for years, creating risks to wildlife and people living near the area [3]. Apart from the associated environmental issues, the use of fossil fuels also has other problems, which include price fluctuations and concerns about security of supply. Another major source of energy, nuclear power, is not without problems either. The incident with the Fukushima nuclear power plant in the aftermath of the tsunami in Japan in November 2011 has prompted many countries to reconsider using nuclear as their primary source of energy [4].

As researchers, scientists and government agencies realise that the world cannot rely on conventional energy resources such as coal, natural gas and petroleum alone, several solutions are being explored. While energy conservation and management through improvements on energy efficiency across all sectors including residential, industrial, commercial and transportation is needed, renewable energy (RE) is regarded as vital for a sustainable energy future. Prominent RE resources include solar power, wind power, hydropower, biomass, geothermal power and wave and tidal power [5]. There are many advantages of using RE sources. These include, not only reducing the dependence on finite energy sources, but also eliminating or minimising the safety issues related to the use of fossil fuels and atomic energy [6]. Furthermore, RE reduces the release of greenhouse gases emissions to the atmosphere, which increases environmental quality and helps to fight climate change. Moreover, RE sources are vast, sustainable and free for the taking, disregarding the process costs and equipment required to collect them.

The global awareness of the need for RE has increased considerably in recent years as more and more countries are shifting their energy generation to RE resources [7]. RE projects are making significant contributions to the national energy supplies of many countries across the world while helping to preserve the environment [8]–[12]. According to The Energy Report 2011, World Wide Fund for Nature (WWF), the RE supply will be sufficient to fulfil the global energy needs by 2050 and will save almost £4 trillion per year through energy efficiency and reduced fuel costs [13]. RE supplied an estimated 19% of the global final energy consumption by the end of 2012; with approximately 9% coming from traditional biomass[1] and 10% from modern renewables sources[2] (see *Figure 1*). RE has grown significantly in the past few years. According to the latest report by the Renewable Energy Policy Network for the 21st century (REN21), the global of RE capacity increased by 8.5% from 2011 to 2012, surpassing 1,470 GW in total installed capacity. The report also indicates that the industrial, commercial and residential consumers are increasingly becoming producers of RE [14].

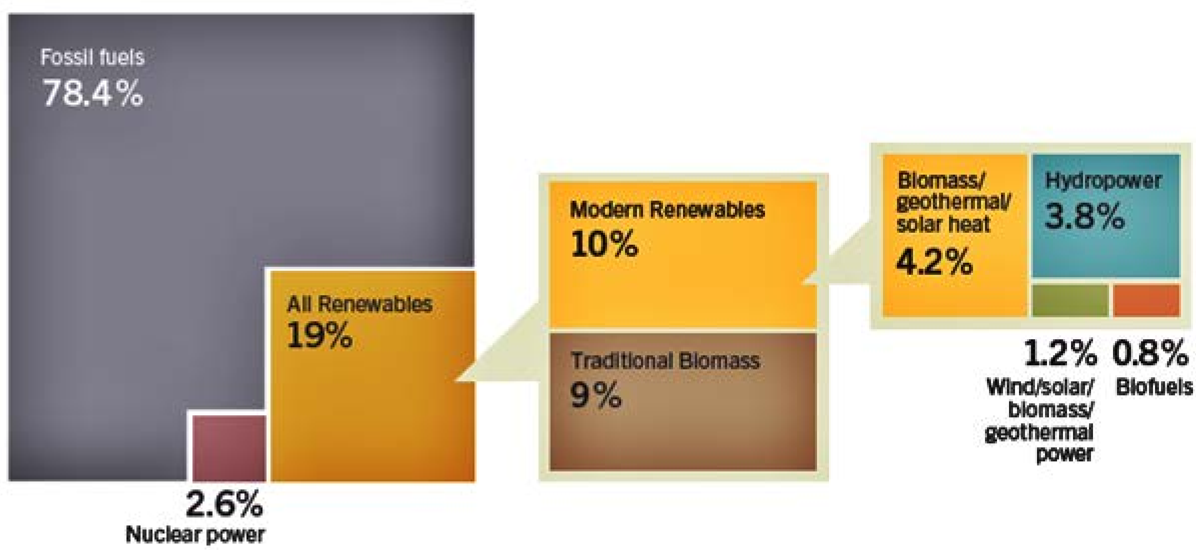


***Figure 1*: Estimated RE Share of Global Final Energy Consumption, 2012 [14].**

While, as described above, RE offers numerous benefits in general, it has the inherent weakness of intermittency. For optimum results, it is important to identify the right type of renewable technology for a particular country or region. In this respect a number of factors including costs related to the generation of electricity, the efficiency of the chosen system, the land and water requirements and also the social and economic impact related to their implementation have to be taken into account [15].

Solar energy is one of the most promising forms of RE. Solar energy is considered as inexhaustible, sustainable and practically unlimited. The two most popular and well known solar energy technologies are the solar photovoltaic (PV) system and the solar thermal system. In general, solar PV systems harness the sun's energy using PV cells, which is a specialised semiconductor diode that converts

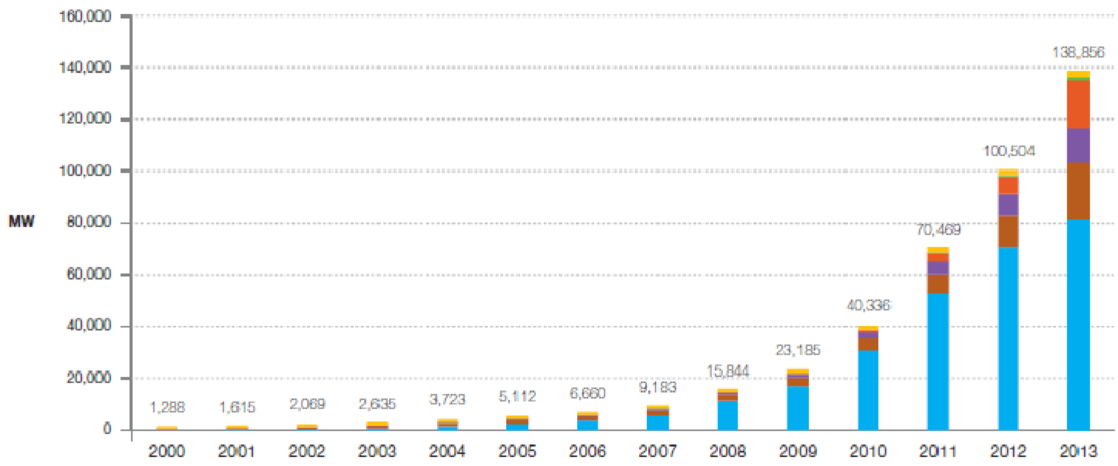
1 Traditional biomass here is defined as direct combustion in inefficient ways of woods, charcoals, leaves, agricultural and forest residue and solid waste.

2 Modern renewables here is defined as modern biomass (more efficient and cleaner ways of using biomass for electricity generation, heat production and production of transportation fuels by adopting advanced and improved technology), solar, wind, geothermal and hydropower energy.

solar radiation into direct current (DC) electricity for usage. Solar PV is used in grid-connected systems to power residential appliances, commercial equipment and lighting for most types of buildings. Through stand-alone systems and the use of batteries, it is also well suited for remote regions where there is no other electricity source. PV panels can be ground level mounted or installed on building rooftops. Mostly, PV modules mounted on building roofs can produce as much electricity as the building consumes. Whereas solar thermal refers to harnessing solar energy to generate heats and electricity is generated from it [16], [17]. This paper focuses on solar PV.

Solar PV can contribute significantly to address the current energy and environmental challenges because it is considered a carbon-free energy (close to zero) and produces no emissions when in operation. However, the manufacturing of PV panels cells involves a high energy consumption and the use of toxic chemicals and other potentially harmful materials to the environment such as silicon tetrachloride, sulphur hexafluoride and cadmium. To overcome these issues, several governments have implemented policies and legislations to prevent environmental damage. This includes recycling the PV equipment at the end of its life, recycling the materials used in the PV panel production and governing the disposal of electronic equipment and making the manufacturer responsible for the eventual disposal or recycling [18], [19].

In 2013, at least 38.4 GW of PV systems were installed globally and a global total cumulative installed capacity of 138.9 GW reached in that year [20]. According to the Global Future Report 2013 REN21, it is projected that global solar PV capacity could reach 400–800 GW as soon as 2020 and as much as 8,000 GW by 2050, saving more than 53 million tons of CO_2 [21], [22]. *Figure 2* shows the evolution of global PV cumulative installed capacity in year 2000 to 2013.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Rest of the World	751	807	887	964	993	1,003	1,108	1,150	1,226	1,306	1,590	2,098	2,098	2,098
Middle East & Africa	n/a	n/a	n/a	n/a	1	1	1	2	3	25	80	205	570	953
China	19	24	42	52	62	70	80	100	140	300	800	3,300	6,800	18,600
Americas	21	24	54	102	163	246	355	522	828	1,328	2,410	4,590	8,365	13,727
Asia Pacific	368	496	686	916	1,198	1,502	1,827	2,098	2,628	3,373	4,951	7,513	12,159	21,992
Europe	129	265	399	601	1,306	2,291	3,289	5,312	11,020	16,854	30,505	52,764	70,513	81,488
Total	1,288	1,615	2,069	2,635	3,723	5,112	6,660	9,183	15,844	23,185	40,336	70,469	100,504	138,856

Figure 2**: The evolution of global PV cumulative installed capacity 2000-2013** [20]

This paper provides a comprehensive review of solar PV development in the Association of South East Asian Nation (ASEAN) countries. Section 2 provides a brief explanation of ASEAN, while Section 3 discusses in detail the solar PV progress in each ASEAN country, particularly in terms of RE policies implemented, research and development (R&D) that is being carried out as well as the installed capacity of solar PV in the country. Finally, conclusions and some recommendations are presented in Section 4.

2.0 ASEAN and ACE background

ASEAN stands for "Association of Southeast Asian Nations". It was formed on 8 August 1967 by Indonesia, Singapore, Thailand, Philippines and Malaysia. In 1984, Brunei joined the Association, followed by Vietnam in 1995, Myanmar (Burma) and Laos in 1997 and Cambodia in 1999 making up what it is today, the 10 Member States of ASEAN [23]. ASEAN aims to accelerate economic growth, social progress and cultural development in the region through collaborations. In addition to that, ASEAN members intend to provide assistance to each other in the economic, educational, technical, scientific and administrative fields [24]. *Figure 3* shows the territories and energy information in the ASEAN region.

***Figure 3*: The boundaries and energy information in the ASEAN region** [25]**.**

The Chair of ASEAN is rotated among the 10 countries on an annual basis, and acts as host of the summit and key ministerial meetings. For example, Brunei was the Chair of ASEAN for 2013, followed by Myanmar in 2014 [17]. The ASEAN Community is structured around three pillars, which are the ASEAN Political-Security Community, the ASEAN Economic Community and the ASEAN Socio-Cultural Community [19]. In January 1992, ASEAN member states agreed to further expand economic cooperation by forming an ASEAN Free Trade Area (AFTA). Under AFTA, manufactured goods and processed agricultural products undergo tariff reductions. The lowering of high tariffs among ASEAN members enable companies to improve efficiencies and sourcing within the ASEAN markets. In the same year, ASEAN economies which comprised of over 330 million people experienced an average growth rate of almost 6 percent, ranking ASEAN as one of the fastest growing markets in the world [20].

ASEAN is one of the fastest developing regions in the world and as such it requires rising energy supplies to fuel its fast paced of economic expansion [26]. This condition needs serious attention from policy makers in the region. An inter-governmental organization called the ASEAN Center for Energy (ACE) was established in January 1999 by ASEAN to initiate, coordinate, and facilitate regional, joint and collective activities on energy [26]. ACE's main purpose is to accelerate the integration of energy strategies within ASEAN by providing relevant information, up-to-date technology and by ensuring that the energy development policies and programs are consistent with the economic growth and the environmental sustainability of the region [26]. ACE was involved in preparing the ASEAN Plan of Action for Energy Cooperation 1999-2004 which included programmes such as ASEAN Power Grid, Trans-

ASEAN Gas Pipeline, Energy Efficiency and Conservation Promotion and Energy Policy and Environmental Analysis [26]. Under the ASEAN Plan of Action for Energy Cooperation 2010-2015, there are more strategic targets and responsive plans for RE, including achieving a cumulative target of 15% of the region's RE generation by 2015 [27]. In the last 2 decades, energy consumption and economy in the ASEAN region have been increasing in parallel. According to the 3rd ASEAN Energy Outlook [28], with the assumed GDP growth rate of 5.2% per year from 2007 to 2030, the energy consumption in ASEAN will rise to an average yearly rate of 4.4% from 375 MTOE to 1,018 MTOE [28].

3.0 Solar PV in ASEAN Countries

3.1 Thailand

Thailand has high levels of insolation all over the country. The insolation ranges from 1,825 to 1,935 kWh/m^2 per year, averaging about 1,875 kWh/m^2 per year [29]. High values are observed particularly during April and May; with insolation in the range of 5.6 to 6.7 kWh/m^2 per day. The north eastern and northern regions receive roughly 6 to 8 sunlight hours per day [30].

Thailand's primary source of energy is fossil fuels, accounting for over 80% of the country's total energy supply in 2010 [31]. Oil accounted for 39%, followed by natural gas at 31%, coal 13% and the rest of the share from RE consisting of solid biomass and waste, biofuels and hydropower (see *Figure 4*) [31]. In the power sector, The Electricity Generating Authority of Thailand (EGAT), managed by the Ministry of Energy, is the leading state-owned power utility and manages the majority of Thailand's electricity generation capacity, as well as the nation's transmission network. EGAT purchase electricity from private power producers such as Independent Power Producers (IPP), Small Power Producers (SPP) and neighbouring countries, and sells large-scale electric energy to two distributing authorities, the Metropolitan Electricity Authority (which supplies the Bangkok region) and the Provincial Electricity Authority (which supplies the rest of Thailand) [32], [33]. In 2012, the total installed generating capacity in Thailand was 32,600 MW, shared by EGAT at 46%; IPP at 39%; SPP at 8%; and imported 7% of it’s electricity from its neighbouring countries Malaysia and Laos [32]. The electricity generation trend in Thailand has been on the rise and has been highly dependent on natural gas for electricity generation. In 2012, this accounted for 67% of the total fuel consumption for electricity generation, followed by coal/lignite (19%), electricity import/exchange and others (7%) hydropower (5%) and oil and diesel (1%) [32].

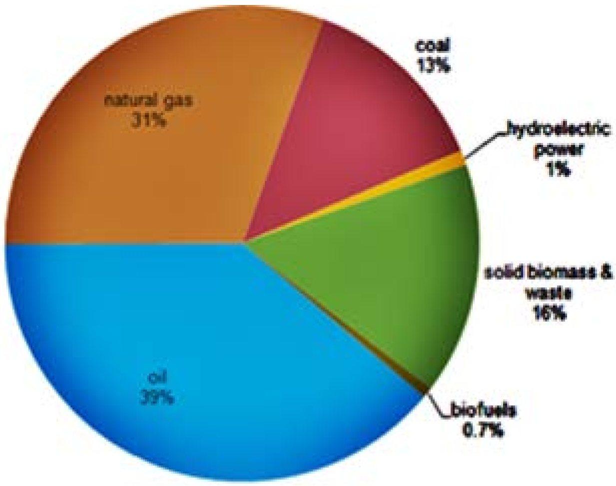


***Figure 4*: Total Energy Consumption in Thailand in 2010** [31]**.**

The Energy Policy and Planning Office (EPPO) under the Ministry of Energy of Thailand, is an agency that formulates and administrates the energy policies and planning for national sustainability. Thailand's *Power Development Plan 2010-2030 (PDP 2010)* is a national plan that focuses on electricity production. In 2012, the 3rd revision of the plan was approved to bring 2 extensive plans into action: the *Alternative Energy Development Plan (AEDP 2012–2021)* and the *20 Year Energy Efficiency Development Plan (EEDP 2011-2030)*. AEDP 2012-2021 sets the framework to increase the share of renewable and alternative energy to contribute for 25% of the country final energy demand by the year 2021 [26].

Thailand was one of the first countries in ASEAN to introduce a form of FiT incentive policy which is called the "Adder" program to accelerate RE growth, particularly in solar power. The policy directive was initiated in 2006 and implemented in early 2007. The program is called "Adder" because it adds additional payment to RE generators on top of the normal prices that power producers would receive when selling electricity to the power utilities [31]. Thailand enacted a Small and Very Small Power Purchase Agreements Act, which regulated the connection of small producers to the electricity grid and the sale of their electricity. The 'Adder', a feed-in-premium, guarantees higher rates for RE, making the investments profitable. This policy also acts as a base for the FiT for solar, wind, waste, biomass, biogas, and hydro power. In June 2010 the Thai government approved a plan to switch from a premium-price FiT payment to a fixed-price FiT payment, and studies to determine the rate for each type of RE are underway [34].

The Department of Alternative Energy Development and Efficiency (DEDE) under the Ministry of Energy of Thailand claimed in their Action Plan on Science Technology and Innovation for RE Development (2012-2016), that there will be a total budget of £120 million, with approximately £9 Million allocated for solar energy development [35]. These R&D in solar will include the study and development of low cost solar hot water and cooling systems in small scale, building integrated PV and the study of the PV module recycle process. The support from the government of Thailand in terms of policy and R&D funding has also attracted local and international investors. For example, Zhongli Telesun Solar, one of a leading producers of solar modules and solar cells corporation has officially started a project of 500 MW of integrated solar cells and modules assembly plant in Thailand and now aiming to expand another 1.2GW PV grid-connected project in 2015 [36]. The solar installed capacity in Thailand, in 2013 was 690.6 MW compared to 167 MW in 2011. The installed capacity is expected to increase to 2,000 MW by 2021 [26], [37]. In 2013, The National Energy Policy Commission (NEPC) has approved FiT rates for 200 MW of rooftop solar and 800 MW of community-owned ground mounts for a 25 years period [38]. *Figure 5* shows the RE targets based on the AEDP 2012-2021, of which 22% is intended to come from solar energy.

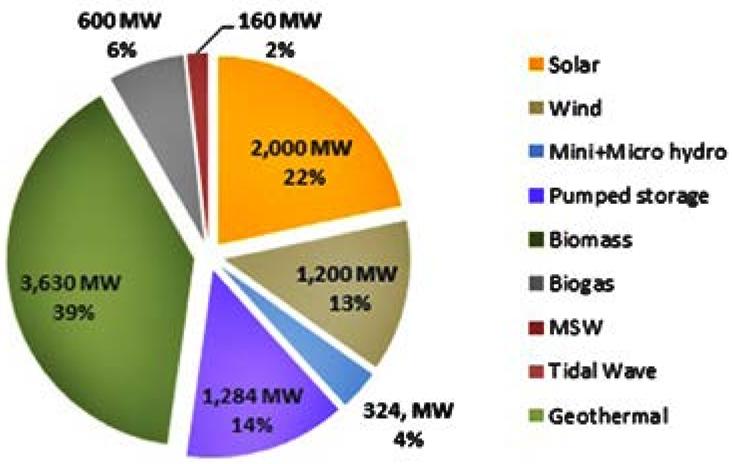


***Figure 5*: Thailand's RE targets according to the 10-Year Alternative Energy Development Plan (AEDP 2012-2021)** [34]**.**

3.2 Malaysia

Currently, Malaysia's primary energy supply is dominated by fossil fuels. Oil and natural gas are the main primary energy sources consumed in Malaysia [26]. In 2012, Malaysia was the 2nd largest oil and natural gas producer in Southeast Asia and the 2nd largest exporter of liquefied natural gas globally [31]. In the power sector, the majority of Malaysia's electricity generation capacity comes mainly from fossil fuels with high contributions from natural gas (53%) and coal (40%). The electricity generation from RE is mostly from hydropower (5%) [26].

Malaysia receives a high amount of solar insolation, ranging from 1,400 to 1,900 kWh/m^2 per year [39], averaging about 1,643 kWh/m2 per year [40]. This suggests that Malaysia has potential for solar PV development. The Malaysian Government aims to reach 7,000 MW of RE installed capacity by 2030. Solar PV will have to play a predominant role to achieve this objective, as it is expected to contribute about

60% of the cumulative RE supply [41]. To accelerate the solar PV penetration, the Malaysian Government has spent significant amounts of money in research and development (R&D) activities related to energy [63]–[65]. For example, it was reported that by April 2010, approximately Ringgit Malaysia (MYR) 157 million (£28.3 million)[3] had been awarded to green technology research, including solar energy, under the 9th Malaysia Plan [66]. Most of the research is carried out by the research universities in Malaysia, which include The University of Malaya (UM), The National University of Malaysia (UKM), Universiti Sains Malaysia (USM), Universiti Putra Malaysia (UPM) & Universiti Teknologi Malaysia (UTM) [67].

In terms of policies and regulations, a number of policies to help accelerate the usage of solar energy technologies in Malaysia have been created [42]–[44]. In this respect, there have been a number of key projects implemented in Malaysia since 1999 such as the Malaysia Industrial Energy Efficiency Improvement Project (MIEEIP) (year 2000 – 2012), the Small Renewable Energy Power Programme (SREPP), the Malaysia Building Integrated Photovoltaic (MBIPV) Technology Application Project, the Building Energy Efficiency Programme (BEEP) and the Green Building Index (GBI) [66], [70], [71].

Feed in Tariff (FiT), which started in November 2011, was the latest scheme launched in Malaysia. This scheme puts great emphasis on solar PV. The FiT has a payback period of 21 years and a degression rate of 8% per year [45]. The FiT scheme is financed by the consumers themselves. This was achieved by increasing the electricity tariff by 1.6%, and pooling that amount into the FiT fund [46]. This fund will be available until 2030 when it reaches a cumulative value of MYR 18.9 billion (£3.4 billion). With a degression rate in place, it is expected that by that year, the cost of solar electricity will reach grid parity, driven by the environment necessity and the energy security in Malaysia [42], [43]. The FiT scheme is projected to catalyze the grid-connected PV installation in Malaysia, producing a cumulative value of 18.7GWh, which could avoid an emission of 17,649,620 tonnes of CO_2 a year by 2050 [42].

The installation of solar PV in Malaysia started to soar during the MBIPV Project which was launched on the 25th of July 2005 [47]. The main objective of this programme was to reduce the long-term cost of Building Integrated Photovoltaic (BIPV) technology in Malaysia, with the intention of increasing the BIPV technology penetration whilst reducing the emission of greenhouse gasses in the country. This project ended on the 31st of December 2010, with a total successfully installed capacity of 1,516 MW, covering 109 buildings. The MBIPV program has benefited from the reduction in PV prices – the cost of PV systems reduced from MYR 31,410 (£5,653.8) per kWp in December 2005 to MYR 19,120 (£3,441.6) per kWp in March 2010, recording a reduction of about 40% [47].

[3] Please note that the conversion rate from Malaysian ringgit (MYR) to Great British Pound (£) is 0.18 (as of April 2014). This conversion rate will be use throughout this report.

After the launch of the FiT scheme, the number of solar PV installations in Malaysia has been showing an upward trend. In 2012, the Sustainable Energy Development Authority (SEDA) Malaysia reported that solar PV projects which were in operation and under construction accounted for approximately about 46.81MW and 110.18MW respectively [43]. Catalysed by the FiT scheme, RE sources are expected to play a significant role in Malaysia, with a projected cumulative capacity of 11.5 GW by 2050 of which around 9GW are expected to come from solar PV, as illustrated in *Figure 6.*

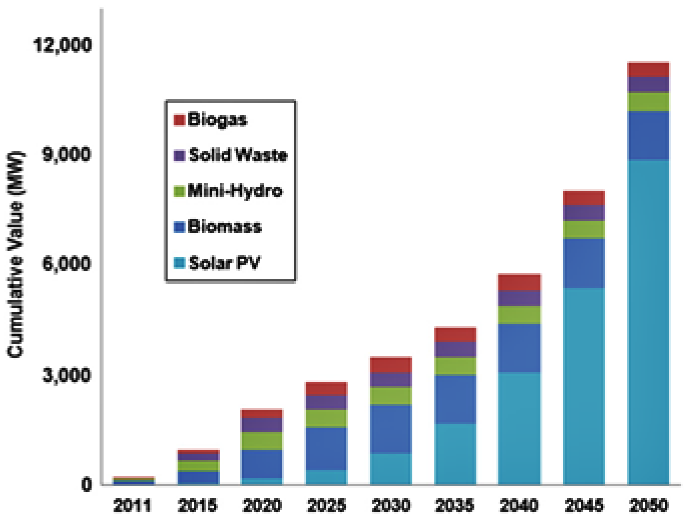


***Figure 6*: Potential cumulative values of RE installed capacity in Malaysia for the period (2011-2050)** [48]**.**

3.3 Indonesia

Based on its average insolation levels of 4.8 kWh/m^2 per day [49] and approximately 1,752 kWh/m^2 per year, Indonesia also shows potential for solar energy. A report by Reinders et al. [50] projected that a solar PV installation with a capacity of 80 GW in Indonesia with a conversion efficiency of 15% could generate approximately 94 TWh per year. Realizing the profit and high potential of RE in the country, the Indonesian government has set the target of obtaining 25% of the country's electricity from renewable sources [51], including 1.1% from solar energy, by 2025 [52].

In 2011, statistics shows that fossil fuels contributed to around 76% of the primary energy consumption of the country. Crude oil represented the highest portion with 38% of the total. The RE share was 24% of the total primary energy, with biomass contributing most of it (20%), as illustrated in *Figure 7(a)*. With regards to the energy consumption for electricity generation, 82% of the contribution comes from conventional fuels, as illustrated in *Figure 7(b)*. The RE share is 18% of the total with 14% coming from hydropower. Biomass does not play a significant role in the electricity generation sector as it is used mainly for thermal energy generation especially in rural areas [26].

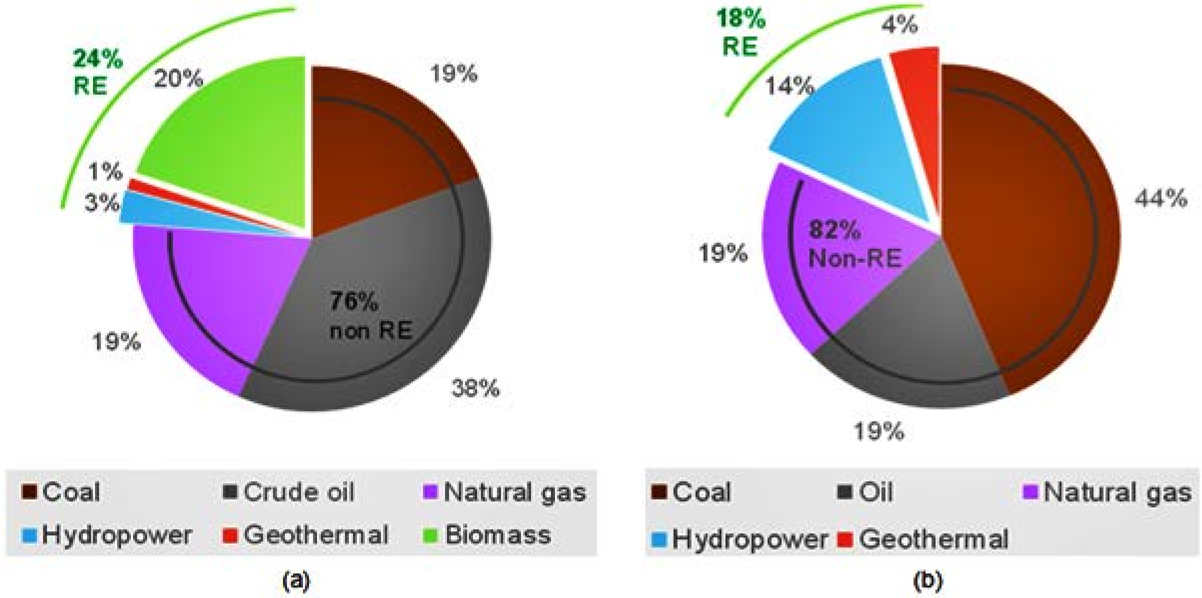


***Figure 7*: (a) Share of energy sources in primary consumption and (b) Share of energy sources for electricity generation in Indonesia in 2011** [53]**.**

In line with the aims to reduce the dependence on fossil fuels and to accelerate the development of RE technologies, including solar PV, the government has introduced several policies and regulations. One of the policies introduced in 2004 was the Green Energy Policy (No. 0002/2004) of which one of the aims was to reduce the country's reliance on oil and to implement the maximum utilisation of RE. On 10 August 2007, Indonesia enacted the Energy Law (Law No. 30/2007) to further strengthen the utilisation of RE resources, security of supply, energy supervision and protection of the environment, and the government had to provide incentives for RE developers for a certain period of time. Subsequently, in 2010, another law was introduced – the Electricity Law (Law No. 30/2010), stating that the use of RE and clean technologies was of high priority. It also encouraged private investors to engage in the supply of energy [93], [94].

In June 2013, the Indonesian Minister of Energy and Mineral Resources (MEMR) issued a Ministerial Decree on Solar PV (No. 17/2013), which allows any solar power producer to sell the electricity generated back to the grid at a maximum capped price of Indonesian Rupiah (IDR) 2,853/kWh[4] (£0.15/kWh), or IDR 3,423.6/kWh (£0.17/kWh) if the PV panels contained a minimum of 40% of local components [95], [96]. This new policy has increased the number solar PV installations in Indonesia. The

[4] Please note that the conversion rate from Indonesian Rupiah (IDR) to £ is 0.000051 (as of April 2014). This conversion rate will be use throughout this report

solar power capacity installed in Indonesia reached only 14MW in 2011 [97], but this amount increased to 59MW in 2013 [96], predominantly from utility scale power plants and solar home systems (SHS) [97]. As of 2013, the government is tendering 80 projects related to the development of solar power plants development which will have a combined size of up to 140 MW and will cost approximately IDR 2.8 trillion (£140 million) [96]. *Figure 8* shows the increase of RE installed capacity from 2012 to 2015 including solar PV.

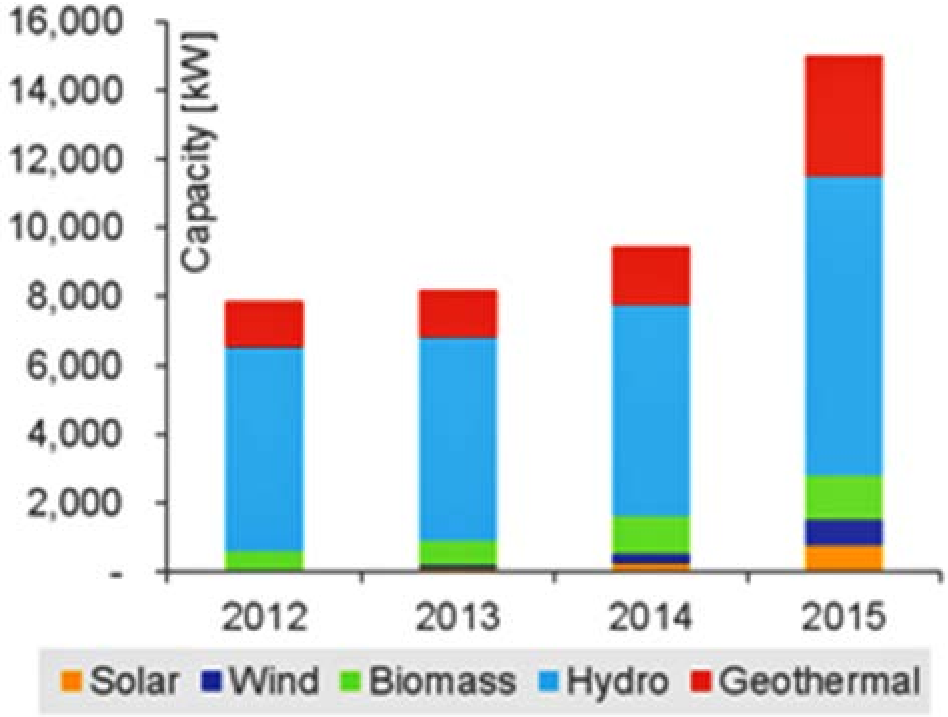


***Figure 8*: Renewable energy development plan by MEMER until 2015 to pursuit for a target outlined in Presidential Regulation 5/2006** [26]

3.4 Philippines

Philippines has potential for solar energy applications both on-grid and off-grid. The average solar insolation in the country varies from 1,643 to 2,008 kWh/m^2 per year [29].

In the Philippines, conventional fossil fuels are the dominant primary energy source. In spite of this, the share of renewable sources is comparably high (41%) due to large contribution from geothermal and biomass energy resources. The contribution from solar, wind and biofuel, however, is of only 1% (please see *figure 9*). Philippines is currently the world's second largest producer of geothermal energy after the USA [54].

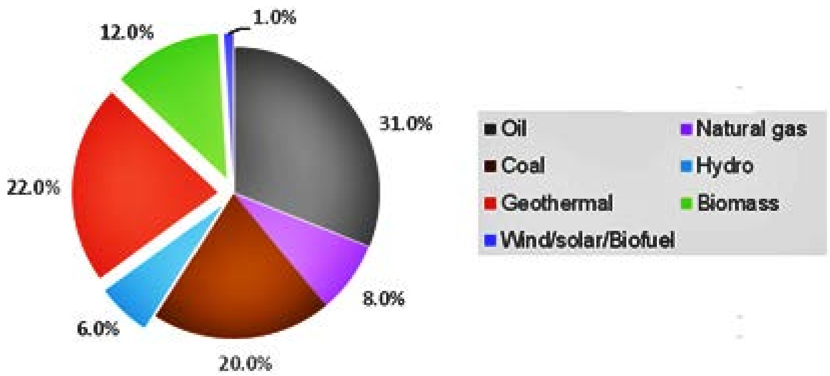


***Figure 9*: Share of energy sources contributions to Philippines primary energy consumption in 2011** [26]**.**

The Philippines Department of Energy (DOE) passed the *Renewable Energy Act (2008) and* has formulated a *National Renewable Program (NREP) 2011-2030)* to promote development, usage and commercial exploitation of RE resources. Some of the incentives include income tax holiday for 7 years, duty free of machinery, equipment and materials importation, 0% value-added tax rate on the sale of power generated and tax exemption from carbon credits [55]. The country targets to triple the country's RE generation capacity from around 5,232 MW in 2010 to almost 15,300 MW in 2030, with an estimated contribution to the grid of 284 MW coming from solar energy by 2030 [26]. *Figure 10* shows the NREP target on RE installation from 2010 to 2030.

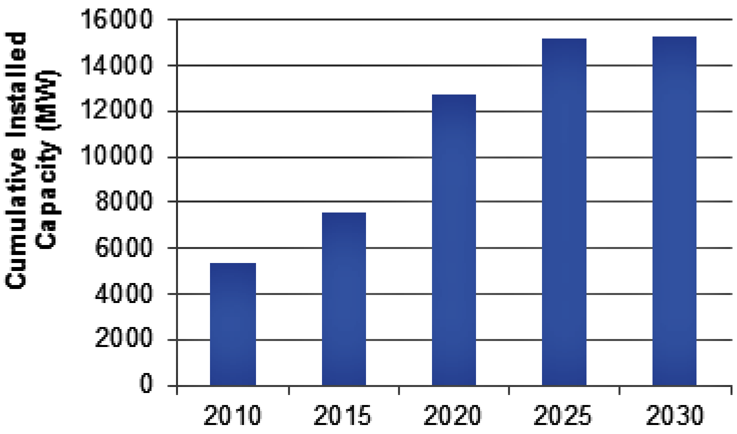


Figure 10*: The installation capacity target of RE in the Philippines from the *National Renewable Program (NREP) [56]**.**

In July 2012, the Energy Regulatory Commission (ERC) implemented a FiT scheme to attract private investors and to increase the production of energy from renewable resources. FiT will allow investors and power producer to have an advance contract with the power utilities, reduce the risk of business loss, facilitate the obtention of bank loans for solar panel installation, earn profits, reduce the cost of panel module and installation from the market competition. At present, the FiT scheme is only available on 4 types of RE resources: solar PV, wind, biomass, and hydropower. The FiT has been defined for a 20-year period and with no degression rate for the time being. However, there will be a review and readjustment by the Energy Regulatory Commission (ERC) after 3 years of its implementation [57]. In 2012, the Asian Development Bank (ADB) has proposed a £ 64.5 million credit facility that may be used to fund solar power projects and developments in Philippines [58]. The local universities, industries, and investors are working closely in solar R&D. SunPower and Solaria are two global established designers and manufacturers of solar panels which are involved in solar projects and R&D in the Philippines. They also work as a solar supply chain to the local solar industries. SunPower also claimed that with the help of local engineers and researchers, they managed to bring down the cost of the solar module, improve the manufacturing production and reduce system installation costs by half in 2012. Some of the industrial collaboration in solar R&D with academia include a project with De La Salle University to built a solar vehicle called SINAG that used SunPower solar cells, and the Ateneo de Manila University Innovation Center who works on solar project using solar panels to drive converted dehumidifiers that end up generating high-purity water from humidity in the air [59].

3.5 Singapore

According to the Energy Market Authority (EMA) [60], solar energy remains the most promising RE source for Singapore when it comes to electricity generation, with an average insolation of around 1,635 kWh/m^2 per year [61]. Due to limitations of land and natural resources, Singapore depends on an external energy supply, particularly of natural gas, mainly from Indonesia and Malaysia. Oil is the major source of energy covering 87% of the total supply while the remaining comes from natural gas (approximately 13%). Only a small fraction (less than 1%) is contributed by indigenous resources such as solid waste and solar energy [26]. Due to its high solar insolation and strong semiconductor manufacturing and innovation base, the government is committed to developing its clean energy sector, and in particular its solar energy capabilities [31]. Since 2008 the installed capacity of grid-connected solar PV systems has risen continuously. In 2011, the total installed capacity of solar PV reached 3.7 MW. Primarily, the non-household sector supplied about 92.1% of the total capacity, with the remaining capacity contributed by household installations [62]. According to the EMA Singapore, in 2012, there were 120 grid-connected commercial solar PV installations with a capacity of 5.26 MW [31].

Singapore aims to become a leading RE researcher and developer in the region. In 2007, they introduced the *Clean Energy Program* by allocating a budget of Singaporean Dollar (SGD) 700 million[5] (£329 million) to strengthen five areas, which are: R&D, investing in human power, smarten-up Singapore-based enterprises, promoting Singapore's industry internationally and expanding a dynamic industry ecosystem [63]. In terms of solar energy policy, the Inter-Ministerial Committee for Sustainable Development approved the Housing Development Board (HDB) to develop the solar technology capability and innovation in 2009. With a budget of SGD 31 million (£14.57 million) the Solar Capability Building Programme (SCBP) for public housing was started in 2009 where HDB examined a large-scale solar PV test-bedding in both new and existing HDB estates island-wide. *Figure 11* shows the installed capacity of grid-connected Solar PV in Singapore between 2008 and 2012 [62].

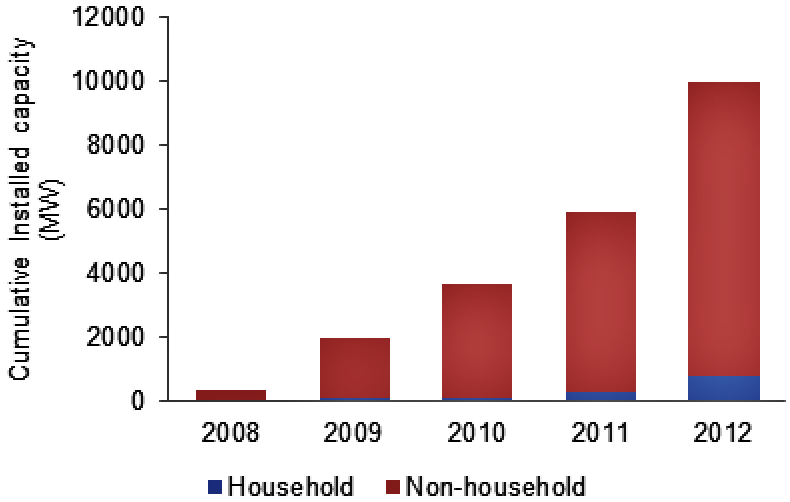


***Figure 11*: Installed Capacity of Grid-Connected Solar PV in Singapore from 2008 to 2012** [62]**.**

3.6 Vietnam

Vietnam receives high levels of solar insolation, with an average insolation of about 1,825 kWh/m^2 per year in the southern region, which has a tropical climate, and about 1,460 kWh/m^2 per year in the northern region, which is more monsoonal [64]. It also enjoys of around 2,000 and 2,600 sunshine hours per year and 1,800 to 2,100 sunshine hours per year, in these region respectively [64].

The energy demand in Vietnam is dominated by conventional fossil fuels. RE contributes to 46% of the total energy mix (please refer *figure 12*), mainly in rural areas. In terms of electricity tariff, the commercial sector has a higher rate compared to the residential and industrial sectors. The average rate is

5 Please note that the conversion rate from Singapore Dollar (SGD) to £ is 0.47 (as of April 2014). This conversion rate will be use throughout this report.

approximately 1,464 Vietnamese Dong (VND) (£0.04)[6] per kWh in 2011 which is lower than other ASEAN countries. It is predicted to rise up to around average of 1758 VND (£0.05) per kWh in 2020.

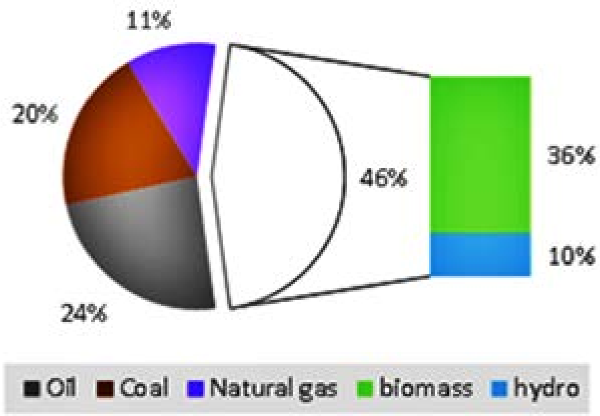


***Figure 12*: Vietnam's primary energy mix in 2012** [31]**.**

Vietnam has ambitious targets for the development of RE. The *National Master Plan for Power Development 2011-2020* was established to increase the proportion of RE in the total energy production in Vietnam. Although there is an FiT mechanism since 2011, it does not cover solar projects [25], [63], [64]. The solar energy contribution to the total RE energy scheme in Vietnam is still small. In terms of solar PV development, some of the ASEAN countries that have implemented FiT like Thailand, Malaysia and Indonesia have attracted a lot of investors and solar companies to invest on big solar projects. Whereas in Vietnam, not being subject to government FiT, the solar project investors can benefit from negotiated Power Purchase Agreements contracts with the electricity consumers, particularly in locations not connected to the main grid like sector with electricity shortage [65].

To date, there are some large scale solar projects in operation. One of these projects is the result of a solar energy agreement between Big C Vietnam, one of the largest shopping centre companies and Schneider Electrics Vietnam. This involved the installation of solar panels with a capacity of 212 kWp, on the roof of the shopping centre's car park in Big C's Di An store in Binh Duong. This system can produce 230 MWh per year and it is expected to reduce the electricity supply needs of the shopping centre by 7% and to reduce CO_2 emissions by 150 tonnes per year [66]. Another project involved the installation of a 200 kWp system on Intel's factory in Saigon High-Tech Park [67].

6 Please note that the conversion rate from Vietnamese Dong (VND) to £ is 0.000029 (as of April 2014). This conversion rate will be use throughout this report.

By the end of 2011, Vietnam's total solar power capacity was estimated to be between 1.6 and 1.8 MWp distributed evenly between rural consumers (between 25% and 30%), marine communications facilities (35%) and telecommunications (35%). By 2012, the solar installed capacity in Vietnam reached 3 MW [26].

3.7 Brunei Darussalam

Brunei or Brunei Darussalam receives a high daily average solar insolation of 5.43 kWh/m^2 , averaging around 1,982 kWh/m^2 per year [68]. However, the RE contribution to the country's energy supply is very low. The primary energy supply has been dominated by the crude oil and natural gas industries [68]. Brunei does not have a committed policy framework for RE. Instead they have centred their energy policy on oil and gas.

In 1981, the Oil Conservation Policy was created to prolong the life of the country's oil reserves. Later the Brunei Natural Gas Policy (Production and Utilisation) was introduced in the year 2000 with the aim of opening new areas for exploration and development, and encouraging increased exploration by new and existing operators. Under this policy, priority was always given to domestic utilisation of gas, especially for electricity generation. Brunei implements 5 year economic development plans known as the National Development Plans. The most recent plan to be implemented was the 9th National Development Plan (2007–2012). In parallel with this plan, Brunei also commenced a long-term development plan called Brunei Vision 2035 to achieve its industrialization and economic diversification aspirations [69]. They plan to have at least 10% of the total energy capacity from RE by 2035, which corresponds to approximately 50 MW of installed capacity [70].

Even though Brunei has substantial oil resources [68], the local government has already turned their attention to less polluting energy resources, including solar energy. Through the Centre for Strategic and Policy Studies (CSPS), Brunei is currently conducting research to identify the best alternative energy sources and policies for the country. The Energy Department at the Prime Minister's Office (EDPMO) and Brunei National Energy Research Institute (BNERI) are conducting research into the benefits and opportunities offered by an FiT scheme in order to increase the use of solar energy [65]. To support commencement of the programme, the government is considering a number of incentives, including low-cost loans to consumers to fund solar panel installation, which could then be paid back using earnings from electricity generation [66]. On 9th of September 2013, the Brunei's Minister of Energy announced the target of introducing the FiT into the Brunei's energy framework within the next 2 years. He also claimed that the smart grids and FiT would be a big investment which would allow individuals and businesses to sell the electricity they generate back to the national energy provider [67] .This is in line with one of the goals outlined in the Brunei Vision 2035, which is to generate 10% of Brunei's energy from renewables. It is also claimed that the scheme will be effective in attracting private sector investment for rapid deployment of RE [77].

In August 2008, Brunei worked together with Mitsubishi Corporation (Japan) for a joint project known as the Large-Scale Photovoltaic Power Generation Demonstration Project Tenaga Suria Brunei (TSB Project). The power plant installed and assessed the performance of 6 different types of advanced PV modules which are single-crystalline silicon, poly-crystalline silicon, amorphous silicon, CIS (copper-indium-selenium) and two ‘hybrid’ amorphous/microcrystalline silicon solar [26], [71]. The major aims of the project were to identify the most suitable and high performance PV technology for the local weather conditions and to accumulate data that can be used to assist the Government in developing policies on RE in the future [68]. The Solar power plant is set to generate 1.344 MWh of electricity each year and is expected to save some 340,000 litres of crude oil and reduce carbon monoxide emissions by 960 tonnes, equivalent to the CO_2 absorption power of 260 hectares of forest [72]. The solar power plant is connected to the power grid of the Department of Electrical Services (DES) and is supplying electricity to around 200 households. The output capacity on a sunny day, can reach between 5,000 and 6,000 kWh whereas on a cloudy day it is limited to 3,000 – 4,000kWh [73].

3.8 Cambodia

Cambodia is one of the sunniest countries in the world. It has an average solar insolation of about 1,825 kWh/m^2 per year and an average of 5 kWh/m^2 per day and sunshine from 6 to 9 hours duration [74]. Cambodia’s climate is dominated by the annual monsoon cycle, the northeast monsoon (dry season) and southwest monsoon (wet season). The temperature reaches its highest values in March and April during the dry season with values between 30°C and 40°C [75].

About 85% of the population live in rural areas where almost 2 million households do not have access to electricity from the public grid [76], [77]. Because of that, 55 % of the households use rechargeable car batteries and 35 % use dry cells or have no access to any form of electricity at all [78]. The Rural Electrification Strategy (RES) of the Royal Government of Cambodia (RGC) policy for rural electrification aims to scale up access to grid and off-grid electricity services for rural areas while at the same time improve the standard of living, reduce poverty and foster economic development.

According to Reinders et al. [79], PV systems can provide affordable and sustainable electricity in rural areas. Since 1997, the solar PV technology has been used for domestic electricity, lighting and telecommunication in rural areas. The development of RE in Cambodia is still limited to the installation from the utility companies and establishment of demonstration projects. The financial incentives for RE have not yet been put in place. A report by Rogier van Mansvelt [76] showed that some of the issues of the

Cambodian solar market are: limited finance opportunities and high interest rates, no solar strategy or implementation plan, lack of financial support from the government and no FiT and grid connection policy.

In 2011, Cambodia's total electricity imports grew by 18.3% in comparison to the previous year, reaching a total of 1,829.8 GWh. This accounted for 64.2% of the total electricity supply within the country. The percentages of the imports of electricity were 76.1% from Vietnam (1,392.4 GWh), 23.5% from Thailand (430.8 GWh) and 0.4% from Laos (6.6 GWh) [74]. According to a report conducted by the ASEAN ACE in 2011, Cambodia's electricity tariffs are the highest in the ASEAN region because its domestic electricity generation is highly dependent on oil. The high rates of electricity tariffs make Cambodia less competitive for global and regional trade and investment [80].

In order to promote RE development, the RGC has introduced a rural electrification strategy to improve the best electricity supply services in rural areas. By 2020, they targeted 100% of the villages to have access to electricity and by the year 2030 at least 70% of all rural households should have electricity. The remaining 30% of rural households will be marked by a "Renewable Energy Development Program" which will provide quality RE services in remote regions by using mostly solar applications (solar lanterns and Solar Home Systems - SHS). The rural electrification strategy will be working on the grid expansion from the existing grids, upscaling of power generation and cross border power supply from neighbouring countries such as Thailand, Vietnam and Laos and promoting solar battery lighting [81].

Apart from the aforementioned developments, in order to facilitate access to the electricity supply at a reasonable and affordable price in rural areas, the Government of Cambodia has established the 'Rural Electrification Fund' to enable the development of electricity supply facilities in rural areas. The objectives of the fund include promoting and encouraging the private sector to participate in providing sustainable rural electrification services. Also, the objective of the Rural Electrification Fund for the next 5 years term includes the provision of grants for development of 850 kW of micro hydropower and 6,000 kW of mini hydropower plants as well as 12,000 solar home systems. Sunlabob, a foreign company in collaboration with a local partner in Cambodia are working on the SHS project [81].

3.9 Laos

Laos, or also known as the Lao People's Democratic Republic (Lao PDR) is a country surrounded by Cambodia, Myanmar, Thailand, Vietnam and the People's Republic of China. Its population in 2013 was 6.7 million. Solar insolation in Laos is between 3.6 and 5.5 kWh/m^2 per day, with 6 to 8 hours of daily sunlight. With such solar energy potential, if PV technology was used (assuming an overall efficiency of 10%), it would generate approximately 146 kWh/m^2 per year [82].

Currently, Laos is focusing their energy policy on increasing electricity access, especially in rural areas. The governments set the Rural Electrification Master Plan (REMP) 2010-2020, which aims to upscale the solar energy capacity in 11 districts in Laos [82]. The Renewable Energy Development Strategy in Lao PDR (2011) sets 3 specific short-term strategies (2010-2015) aiming for provision of necessary studies and capacity building, mid-term strategy (2016-2020) to create a clear RE framework, and long-term strategy (2021-2025) to establish a full competition RE market [26]. In 2011, more than 50% of the share of energy generation from RE sources came from Hydropower, while solar contributed 11% from the RE total. Laos target installed capacity and energy production from RE source in 2025 is 651 MW, with 33 MW coming from solar energy [26]. *Figure 13* shows the milestones for installed electricity capacity by energy sources to reach 30% RE share target in 2025.

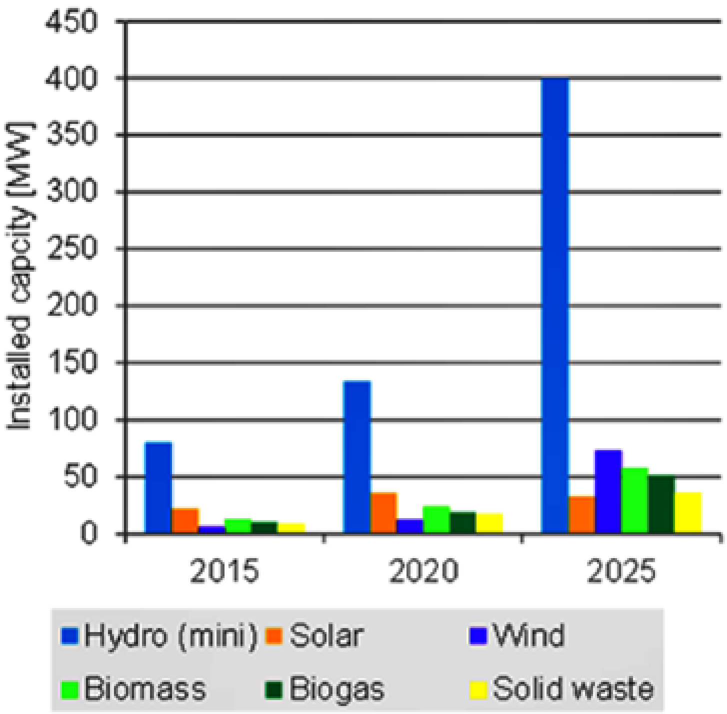


***Figure 13*: The milestones for installed electricity capacity by energy sources to reach 30% RE share target in 2025** [26]

Solar PV systems were first introduced into the Laos in 1980 with the purpose of supplying electricity to telecommunications systems and vaccine storage. As electrification moves to more remote areas, on-grid electrification becomes more costly, and this has driven the government to promote off-grid options. Between 1997 and 2004, the Technology Research Institute installed solar home systems, battery charging stations, water pumps, water purification, and communications [83], [84]. In 2011, around 20,000 households have been supplied with electricity through solar home systems which have been carried by both the public and private sectors. As these are usually off-grid systems, there is no nation-wide data about electricity generation available [26].

3.10 Myanmar

Myanmar, also called Burma, is the second largest country in ASEAN. The country receives annual solar insolation in the range of 4.5 to 5.5 kWh/m^2 per day [85]. Myanmar's current energy policy framework aims to maintain the status of energy independence, promote the wider use of new and renewable sources of energy, promote energy efficiency and conservation and promote the use of alternative fuels in household [26]. Myanmar targets to have a 15–20% RE share of its total energy production by 2020 [55]. One of the challenges to achieve this target is to develop a stable policy environment to encourage investment in energy development. Myanmar is currently in the process of drafting a national energy policy that includes tax incentives to foreign investment [55].

Myanmar has a large population of around 60 million and the country is struggling to meet the increasing electricity demand. According to the Asian Development Bank (ADB), only 16% from the 40 million people living in rural areas are connected to the power grid. The rest of them still depend mainly on diesel oil generators, which produce greenhouse gas and cause damage and pollution to the environment [86]. Myanmar has substantial RE resources, especially hydropower and biomass, but also high potential for wind, solar, and other types of RE. Among these resources, hydro power is the country's biggest clean energy asset, with an estimated potential of more than 100,000 MW. In 2012, the electricity generated from hydropower was 13,267 GWh. The other RE resources remain under research and in the development phase [87].

While hydropower continue to dominate the share of RE sources, Myanmar has established aggreements with neighbouring Asian countries like Thailand, Singapore, China and Japan to develop its solar potential, especially in importing solar panels. In 2013, Green Earth Power Co., Ltd., a Thailand based company signed a memorandum of understanding (MoU) with the Ministry of Energy (MOE) of the Myanmar Government to build a 210 MW solar power plant in the city of Minbu in the Magway region at a cost of approximately £178 million. This power plant is claimed to be the 3rd largest solar power plant in the world. The power plant is being build-up in 3 stages — 50 MW, 70 MW, and 90 MW which 70% of the cost will be paid via credit while the remaining funding will come from equity [55].

4.0 Conclusions and Recommendations

The South-East Asian countries have quite similar climatic conditions – tropical hot and humid - as they are situated in the same geographical region. Most of these countries are considered as developing and middle-income countries. In terms of solar energy, they have a similar resource potential. This investigation of the progress of solar PV in this region can show researchers, policy makers, government and private companies the opportunities and position of Solar PV systems in this region. **Table 1** shows a brief summary of the progress made by all the ASEAN countries in the field of solar PV. As it can be seen here, the country with the highest installed Solar PV capacity is Thailand (690.6MW), followed by Malaysia (74.7MW) and Indonesia (42.8MW). Currently, Philippines's share of Solar PV installed capacity is less significant compared to these 3 countries, however it is projected that it will have the highest growth in 2014[7]. In spite of the fact that Singapore has limited land and surface area, it is one of the leading countries in Asia in term of Solar R&D. It is forecast that the total cumulative solar PV for ASEAN countries will reach approximately 1,064 MW by the end of 2014[8]. To date, there are 5 countries already implementing FiT which are Malaysia, Indonesia, Thailand, Philippines and Vietnam. Brunei will implement FiT at the end of 2015.

[7] It is not possible to get an update on the progress made in 2014. The report by ASEAN is expected to be out in mid or late 2015
[8] Refer footnote 7

Table 1: Summary of Solar PV Progress in ASEAN Countries.

Country	2013 installed capacity(MW) [37]	December 2014 forecast (MW) [37]	Target (RE Share in Total Installed Capacity)	Primary Renewable Energy (Respectively)	Solar Insolation (kWh/m^2/year)	Policies related to RE	FiT rate for Solar in 2013 in (£/kWh)
Thailand	690.6	753.6	25% by 2021 (with approx. 2000 MW Solar Energy) [26]	Hydropower, Biomass, Solar and Wind	5.0 to 5.3 kWh/m^2 /day, approximately 1875kWh/m^2/year [30]	Power Development Plan 2010-2030 (PDP 2010) Renewable and Alternative Energy Development Plan (AEDP 2012–2021) Feed-in Premium (Adder): Feed-in Tariff (2007) amended (2009) review rate (2013)	(Year 2013) For period of 25 years [112], [113] 1)Rooftop solar rate: 0-10kW = 0.13 10-250kW = 0.13 250kW-1MW = 0.12 2) Community ground- mounted solar: 1-3 year = 0.19 4-10 year = 0.13 11-25 year = 0.09
Malaysia	74.7	89	7000 MW by 2030 (with 4200 MW expected from solar)	Solar, biomass, mycrohydro	4.5 kWh/m^2/day [39], averaging about 1,643kWh/m^2/year [40].	Renewable Energy Law (2011) SEDA Law (2011) Feed in Tariff Scheme (2011)	(year 2015) For period of 21 years [45] 1)community: 0-4kW = 0.16 4-24 kW = 0.16 24-72 kW = 0.13 2)Individual: 0-4kW = 0.16 4-12kW = 0.16 3)Non-individual: 0-4kW = 0.16 4-24 kW = 0.16 24-72 kW = 0.13 72-1MW = 0.12 1-10 MW = 0.10 10-30MW = 0.0

Indonesia	42.8	74.5	17% by 2025 (with approx. 80 MW Solar Energy)	geothermal, hydro, biomass and solar	4.8 kWh/m^2/day [49], averaging about 1,752 kWh/m^2/year	Energy Law (Law No. 30) 2007 Ministerial Regulation No 04/2012 Ministerial Decree on Solar PV (No. 17) 2013: FiT for Solar PV introduced National Energy Implementation Program 2005-2025	(Year 2013) 0.16 – if using modules with local content <40% ,i.e. considered as imported modules) 0.19 – if using modules with local content ≥40%
Philippines	14.6	89.9	15,304 MW by 2030 (with approx. 284MW Solar)	Geothermal, hydro and Wind	4.5 to 5.5 kWh/m^2/day, approximately averaging 1,862 kWh/m^2/year [114]	National Renewable Program (NREP): Renewable Energy Act (2008) The Philippines Energy Plan (PEP 2012-2030)	(Year 2013) 0.14 (fixed rate)
Singapore	15.3	20.3	N/A	Solar, Solid waste	4.5 kWh/m^2/day, approximately 1,635 kWh/m^2/year [61]	N/A	N/A
Vietnam	4	N/A	4.5% by 2020 6.6% by 2030	Hydro, biomass, wind and solar	Southern region - an average insolation of 1,825 kWh/m^2/year. Northern region - an average insolation of 1,460 kWh/m^2/year [64]	The National Master Plan for Power Development 2011-2020 Feed-in Tariff 2011	N/A
Brunei	1.2	N/A	10% by 2035	N/A	Average solar insolation of 5.43 kWh/m^2/day [68] averaging around 1,982 kWh/m^2/year [68]	FITs are currently being developed, to be implemented in 2015.	N/A
Cambodia	1.5	N/A	N/A	Solar, mycrohydro	Average solar insolation of 5 kWh/m^2/day , averaging around 1,825 kWh/m^2/year	Renewable Energy Development Program	N/A
Myanmar	N/A	N/A	15–20% by 2020	Hydropower and biomass	Ranging from 4.5 to 5.5 kWh/m^2/day	Myanmar is currently in the process of drafting a new national energy Policy.	N/A
Laos	N/A	N/A	30% by 2025	Hydropower, Biomass, Biogas, Solar	Ranging from 3.6 to 5.5 kWh/m^2/day	Rural Electrification Master Plan (REMP) 2010-2020 Renewable Energy Development Strategy in Lao PDR (2011)	N/A

From the review of solar PV progress in ASEAN countries, there are some suggestions that can be made for development and improvement. The suggestions have been classified into 5 main fields:

1) Regulatory and policy

- The countries that currently do not have policies to support the uptake of RE should implement an FiT system to help accelerate the penetration of RE, especially of solar PV technology. This has been successfully demonstrated in many countries e.g. Germany [88], Indonesia [89], Malaysia[90], Japan [91] and the United Kingdom (UK) [92]. According to REN 21 [14], by 2013, there were already 98 countries globally implementing FiT.

- Countries that have already implemented an FiT scheme should make sure they have a reliable and efficient regulatory mechanism to effectively manage this policy and its relevant developments. For instance, in Malaysia there is The Sustainable Energy Development Authority of Malaysia (SEDA) [45] and The Department of Energy & Climate Change (DECC) in the UK [93]. This is to ensure that the policy is delivered in a way that best serves the interests of all the involved stakeholders and maximises the benefit to the country's economy in terms of jobs, growth and investment. This will also help to make sure that the costs and benefits of the policy are distributed fairly so that the most *fuel poor* households will be protected.

- The FiT scheme should consider a variety of technologies. This will help to elevate the usage of RE technologies in these countries. By and large the ASEAN countries have considerable potential for a range of RE options including solar PV, wind, geothermal and hydropower [25]. However, certain countries have only opted for one or two technologies to be included under the FiT scheme, e.g. Indonesia includes only geothermal and hydropower [41] while Malaysia opted only for solar and hydropower [88]. The inclusion of a variety of technologies will help make the most of the available RE potential in these countries.

- The FiT rate for any RE technology should be high enough to generate a reasonable annual return on investment (ROI) to consumers. The annual ROI differs according to the country – e.g. the UK government suggested an annual ROI of 5% [92], while the Malaysia government is looking at around 7% [90]. A lower ROI could deter the uptake of RE technologies [92].

- It is a good practice to provide a capping limit on the size of installed capacity. It is an efficient way to stop further applications to the FiT scheme when the cap achieved its target, in order to make sure there will be sufficient funds to pay the RE producers under the FiT scheme. This cap however, can be removed when a country already has strong and enough fund for the FiT system after a certain period of time. For example, in 2011, the UK did not have an FiT capacity limit for the installed RE technologies [92]. The number of installations increased dramatically causing the UK government to spend more than its original yearly budget - resulting into an additional spending of £14m in 2011-2012 and £35m in the 2012-2013 period [92], [94].

- Governments should make appropriate analysis and take appropriate measures before deciding to reduce the FiT rate, taking into account the impact of the FiT rate reduction on the market. Muhammad-Sukki et al [92] claimed that the drastic reduction in the FiT in the UK had created the following problems: the cut doubled the payback period for householders from 10 years to 18 years for £10,000-£12,000 worth of solar PV installation, reducing returns from around 7% to 4%. The drastic reduction caused an 80% drop in demand and affected a number of companies and jobs [95]–[98]. This resulted into widespread complaints and disappointment from the public and the private sector. The repercussions could make investors to pull out from the project, jeopardise the RE industry and the overall growth of these technologies. The same can potentially happen to ASEAN countries if the rate change is not being measured properly. Some of the factors to take into account when reducing the rate include: the current PV cost, the number of installations and a sufficient return on investment to the investor/installer.

2) Finance

- Sufficient funding for RE to finance FiT is a very important aspect for a successful policy. The most common method for funding the FiT involves sharing the costs amongst end-users of electricity (electricity consumers) by increasing the price of electricity to be paid by them. If it has been set too high it would strongly affect and burden up the consumers especially the poor and low-income ones. In Malaysia for instance, in January 2014, after some review and consideration, the government raised the surcharge from 1% to 1.6%, which is claimed fair and not supposed to burden up the consumers [99]–[101]. Failure to ensure sufficient funding to finance the FiT could possibly end up in a repeat of the mistakes made by Spain in 2009, which caused their solar PV market to collapse [102]–[104].

- Governments should introduce more fiscal incentives to attract the solar PV industry. Malaysia for example provides several fiscal incentives to promote the development of renewable technology development. Some of these include the Green Technology Financing Scheme (GTFS), Pioneer Status (PS), Investment Tax Allowance (ITA), import duty and sale tax exemption on the manufacturing machinery and equipment, industrial materials, spare parts and consumables [105], [106].

- It is desirable to introduce a soft loan for residential and non-residential (companies) [88]. Many countries have opted for this approach [88]. In 1999, Germany introduced a 0% interest rate for soft loan and the total cumulative installed capacity increased greatly in the coming 5 years, from 18 MW to 345.5 MW [107], [108]. Similarly, the Korean government provided a soft loan to finance the initial installation cost with a low interest rate. The loan can be utilized to fund up to 60% of the total cost [88]. This incentive has managed to promote the installation of PV from 13MW to 73 MW in a 2 year period [88]. To ensure it is a successful approach, the loan must cover as much of the cost as possible, with low interest rates and possibly longer loan tenures [88]. Muhammad-Sukki et al [90] calculated that the average return should be range between 7 and 13% per annum.

3) The PV markets

- The government and related bodies should monitor and control the market of solar PV appropriately. For example, in 2012 the PV market crashed badly and affected the global PV industry, especially in China. According to the solar market research firm ENF Solar [109], the year 2012 was unfortunate for the solar PV industry as a large number of manufacturers struggled to avoid bankruptcy and acquisitions.

4) Infrastructure, skilled personnel and Research and Development (R&D)

- The governments and private sector should invest more in the RE R&D. Malaysia for instance has spent approximately MYR 157 million (£28.3 million) in their 9th Malaysia Plan to boost the RE technology development [90].

- It is essential to have skilled and experienced engineers and technicians to design, build, integrate and install solar PV panels and systems as more consumers are seeking efficiency and reliability over low prices. Continued R&D in solar PV technology is required to ensure eliability and durability of PV systems over a long period of time. This will drive the cost down and the efficiency up [90].

- In spite of the abundance of RE resources in the ASEAN region, yet hydro-electricity and solar energy are still seriously under developed due to a lack of technology and funding. RE such as geo-thermal, solar and wind energy are still capital intensive and not as affordable as conventional energy. ASEAN requires more technology transfer and substantial partnerships to make these energy sources viable for its growing requirements [27].

- It is highly recommended to establish national technology-based working groups, comprising of all the relevant stakeholder groups, including the government, finance, industry and academia, as in the case of Myanmar for instance. This will help to assure that rural electrification (through the respective technology) will be addressed on a long-term and continuous basis [110].

5) Public acceptance and awareness

- Governments should raise public awareness of the impact of climate change and of the environmental challenges they are facing. A report from the UK Energy Research Centre (UKERC) published in 2012 concluded that ‘there is a public confusion over the climate change topic’ because they have ‘vague understanding’ on the issue [111]. In order to make sure that the climate change problems is tackled successfully; it requires the contribution and action from all stakeholders, including households, firms, individuals, non-government organisations and civil society. There are several ways to step up efforts at raising public awareness of climate change and its impact such as run campaigns for a certain group of people, spreading the messages by setting up an online database, printed leaflets or flyers and by effective media campaigns.

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References

[1] E. Vine, “Breaking down the silos: the integration of energy efficiency, renewable energy, demand response and climate change,” *Energy Effic.*, vol. 1, pp. 49–63, 2008.

[2] C. Q. Choi, “Gulf Oil Spill Paves Way for Alternative Energy Push | LiveScience,” *June 10, 05:35am ET*, 2010. [Online]. Available: http://www.livescience.com/6572-gulf-oil-spill-paves-alternative-energy-push.html. [Accessed: 28-Mar-2014].

[3] K. Care, “Up in Smoke: The Extreme Cost of Fossil Fuel | World Business Academy,” 2014. [Online]. Available: http://worldbusiness.org/up-in-smoke-the-extreme-cost-of-fossil-fuel/. [Accessed: 30-Mar-2014].

[4] M. Grimston, "BBC News - Fukushima: What happened - and what needs to be done," *11 April*, 2011. [Online]. Available: http://www.bbc.co.uk/news/world-asia-pacific-13017282. [Accessed: 28-Mar-2014].

[5] Wei Zhou, L. Chengzhi, L. Zhongshi, L. Lin, and Y. Hongxing, "Current status of research on optimum sizing of stand-alone hybrid solar–wind power generation systems," *Appl. Energy, Vol. 87, Issue 2, Febr. 2010, Pages 380-389*.

[6] A. Strupczewski, "Accident risks in nuclear-power plants," *Appl. Energy, Vol. 75, Issues 1–2, May–June 2003, Pages 79-86, ISSN 0306-2619*.

[7] A. Evans, V. Strezov, and T. J. Evans, "Assessment of sustainability indicators for renewable energy technologies," *Renew. Sustain. Energy Rev. Vol. 13, Issue 5, June 2009, Pages 1082-1088*.

[8] R. Langton, I. M. Davies, and B. E. Scott, "Seabird conservation and tidal stream and wave power generation: Information needs for predicting and managing potential impacts," *Mar. Policy, Vol. 35, Issue 5, Sept. 2011, Pages 623-630*.

[9] G. M. Shafiullah, A. M. T. Oo, A. B. M. S. Ali, and P. Wolfs, "Potential challenges of integrating large-scale wind energy into the power grid–A review," *Renew. Sustain. Energy Rev. Vol. 20, April 2013, Pages 306-321*.

[10] H. Long, X. Li, H. Wang, and J. Jia, "Biomass resources and their bioenergy potential estimation: A review," *Renew. Sustain. Energy Rev. Vol. 26, Oct. 2013, Pages 344-352*.

[11] E. Toklu, "Overview of potential and utilization of renewable energy sources in Turkey," *Renew. Energy, Vol. 50, Febr. 2013, Pages 456-463*.

[12] T. eddine Boukelia and M.-S. Mecibah, "Parabolic trough solar thermal power plant: Potential, and projects development in Algeria," *Renew. Sustain. Energy Rev. Vol. 21, May 2013, Pages 288-297.*

[13] World Wide Fund for Nature (WWF)., "The Energy Report 2013: 100% Renewable by 2050," 2013. [Online]. Available: http://wwf.panda.org/what_we_do/footprint/climate_carbon_energy/energy_solutions/renewable_energy/sustainable_energy_report/.

[14] REN21, "Global Status Report 2014," 2014.

[15] R. Baños, F. Manzano-Agugliaro, F. G. Montoya, C. Gil, A. Alcayde, and J. Gómez, "Optimization methods applied to renewable and sustainable energy: A review," *Renew. Sustain. Energy Rev. Vol. 15, Issue 4, May 2011, Pages 1753-1766.*

[16] Mosaic, "What is Solar Energy? | Mosaic." [Online]. Available: https://joinmosaic.com/what-is-solar-energy. [Accessed: 31-Mar-2014].

[17] National Geographic, "Solar Power Energy Information, Solar Power Energy Facts." [Online]. Available: http://environment.nationalgeographic.com/environment/global-warming/solar-power-profile/. [Accessed: 31-Mar-2014].

[18] "Solar Waste Recycling: Can the Industry Stay Green? : Greentech Media." [Online]. Available: http://www.greentechmedia.com/articles/read/solar-waste-recycling-can-the-industry-stay-green. [Accessed: 23-Feb-2015].

[19] “What is the environmental impact of photovoltaic (PV) solar panels? | CAT Information Service.” [Online]. Available: http://info.cat.org.uk/questions/pv/what-environmental-impact-photovoltaic-pv-solar-panels. [Accessed: 23-Feb-2015].

[20] G. Masson, M. Latour, M. Rekinger, I.-T. Theologitis, and M. Papoutsi, “Global Market Outlook for Photovoltaics 2014-2018,” 2014.

[21] Eric Martinot, “Renewables Global Futures Report 2013 - REN21.”

[22] Gaëtan Masson, M. Latour, M. Rekinger, I.-T. Theologitis, and M. Papoutsi, “Global Market Outlook for Photovoltaics 2013-2017,” 2013.

[23] ASEAN Secretariat, “Association of Southeast Asian Nations.” [Online]. Available: http://www.asean.org/asean/about-asean. [Accessed: 31-Mar-2014].

[24] S. K. Karki, M. D. Mann, and H. Salehfar, “Energy and environment in the ASEAN: challenges and opportunities,” *Energy Policy, Vol. 33, Issue 4, March 2005, Pages 499-509, ISSN 0301-4215*.

[25] IEA, “Southeast Asia Energy Outlook,” 2013.

[26] ASEAN Centre for Energy, “ASEAN Renewable Energy (ARES),” 2013.

[27] B. Suryadi, “Will ASEAN realise its 2015 renewable energy goals? | The Energy Collective,” 2012. [Online]. Available: http://theenergycollective.com/benisuryadi/95741/asean-races-152015-smes. [Accessed: 18-Feb-2015].

[28] “The 3rd ASEAN Energy Outlook.” [Online]. Available: https://www.iea.org/media/workshops/2011/ipeecweact/s1_Suryadi.pdf. [Accessed: 25-Feb-2015].

[29] Reegle, “Country Energy Profiles - Clean Energy Information Portal.” [Online]. Available: http://www.reegle.info/countries/. [Accessed: 17-May-2014].

[30] T. C. Malhotra, “Emerging markets: Solar tech jostles for SE Asia market share | CSP Today,” 2011. [Online]. Available: http://social.csptoday.com/emerging-markets/emerging-markets-solar-tech-jostles-se-asia-market-share. [Accessed: 18-May-2014].

[31] EIA, “Countries Analysis - U.S. Energy Information Administration (EIA).” [Online]. Available: http://www.eia.gov/countries/. [Accessed: 17-May-2014].

[32] Energy Policy and Planning Office (EPPO) Ministry of Energy Thailand, “Energy Statistics of Thailand 2013,” 2013.

[33] “About EGAT.” [Online]. Available: http://www.egat.co.th/en/index.php?option=com_content&view=featured&Itemid=101. [Accessed: 23-Feb-2015].

[34] S. Tongsopit and C. Greacen, “An assessment of Thailand’s feed-in tariff program,” *Renew. Energy*, vol. 60, pp. 439–445, 2013.

[35] T. Sutabutr, “Renewable Energy R&D Trends in Thailand,” 2012.

[36] M. Osborne, “Talesun building 500MW integrated PV manufacturing plant in Thailand | PV-Tech,” 2015. [Online]. Available: http://www.pv-

tech.org/news/talesun_building_500mw_integrated_pv_manufacturing_plant_in_thailand. [Accessed: 22-Feb-2015].

[37] IHS, "The Tiger Re-Emerges: Southeast Asia Gas, Coal and Power Market Opportunities," 2014. [Online]. Available: http://www.ihs.com/products/cera/multi-client-studies/southeast-asia.aspx. [Accessed: 18-May-2014].

[38] M. Hall, "Thai FITs for further 1 GW of solar," *PV Magazine*, 2013. [Online]. Available: http://www.pv-magazine.com/news/details/beitrag/thai-fits-for-further-1gw-of-solar_100012097/#axzz2ZlvNYVwB. [Accessed: 18-May-2014].

[39] S. Ahmad, M. Z. A. A. Kadir, and S. Shafie, "Current Perspective of the Renewable Energy Development in Malaysia," *Renew. Sustain. Energy Rev. vol. 15, no. 2, pp. 897-904, 2011*.

[40] A. H. Haris, "MBIPV Project: Catalyzing Local PV Market, presented at the Finance & Investment Forum on PV Technology, Kuala Lumpur, Malaysia, 2008," 1008.

[41] Ipsos Business Consulting, "Meeting the Energy Challenge in South East Asia - A Paper on Renewable Energy," 2012.

[42] B. A. Malek, "Renewable Energy Development in Malaysia," in *34th Expert Group on New and Renewable Energy Technologies (EGNRET)*, 2010.

[43] A. H. Haris, "Introduction & The Malaysian Feed-In Tariff Scenario," in *The Malakoff Community Partnerships Energy Expert Series*, 2010.

[44] A. R. Mohamed and K. T. Lee, "Energy for Sustainable Development in Malaysia: Energy Policy and Alternative Energy," *Energy Policy, vol. 34, no. 15, pp. 2388-2397, 2006.*

[45] Sustainable Energy Development Authority Malaysia, "SEDA PORTAL." [Online]. Available: http://seda.gov.my/. [Accessed: 13-May-2014].

[46] L. H. Yee, "You Can Make Electricity at Home and Sell It to TNB," *MyStarJob*, Kuala Lumpur, 2010.

[47] "Malaysia Building Integrated Photovoltaic (MBIPV) Technology Application Project." [Online]. Available: http://www.mbipv.net.my/. [Accessed: 17-May-2014].

[48] KETTHA - Kementerian TenagaTeknologi Hijau dan Air, "Handbook on tHe Malaysian Feed-in Tariff for the Promotion of Renewable Energy," 2011.

[49] A. Hiendro, R. Kurnianto, M. Rajagukguk, Y. M. Simanjuntak, and Junaidi, "Techno-economic analysis of photovoltaic/wind hybrid system for onshore/remote area in Indonesia," *Energy*, vol. 59, pp. 652–657, 2013.

[50] A. Reinders, H. Veldhuis, and A. Susandi, "Development of grid-connected PV systems for remote electrification in Indonesia," in *2011 37th IEEE Photovoltaic Specialists Conference*, 2011, pp. 002420–002425.

[51] S. Ali-Oettinger, "Strong Chinese presence at Renewables Indonesia: pv-magazine," *PV Magazine*, 2012. [Online]. Available: http://www.pv-magazine.com/news/details/beitrag/strong-chinese-presence-at-renewables-indonesia_100006603/#axzz2Rq21vzbO.

[52] REN 21, “Renewables Interactive Map - Country Profile,” 2013.

[53] Center for Data and Information on Energy and Mineral Resources, “Handbook of Energy & Economic Statistics of Indonesia,” 2012.

[54] M. S. Ogena and A. Fronda, “Prolonged Geothermal Generation and Opportunity in The Philippines,” 2013.

[55] Winston & Strawn, “Feed-in Tariff Handbook for Asian Renewable Energy Systems,” 2014.

[56] F. S. . Sibayan, “National Energy Program (NREP) Philippines,” in *The 1st Philippine Green Jobs Conference SMX Convention Center*, 2011.

[57] B. Bakhtyar, K. Sopian, A. Zaharim, E. Salleh, and C. H. Lim, “Potentials and challenges in implementing feed-in tariff policy in Indonesia and the Philippines,” *Energy Policy*, vol. 60, pp. 418–423, Sep. 2013.

[58] “Solar Power still being promoted, despite lack of FIT support | Renewable Energy Philippines.” [Online]. Available: http://www.renewableenergy.ph/solar-power-still-being-promoted-despite-lack-of-fit-support.html. [Accessed: 25-Feb-2015].

[59] “How the Philippines Can Be a Solar Power - Businessweek.” [Online]. Available: http://www.bloomberg.com/bw/stories/2008-10-10/how-the-philippines-can-be-a-solar-powerbusinessweek-business-news-stock-market-and-financial-advice. [Accessed: 25-Feb-2015].

[60] Energy Market Authority (EMA), “Singapore Energy Statistics,” 2013.

[61] R. Kannan, K. C. Leong, R. Osman, and H. K. Ho, “Life cycle energy, emissions and cost inventory of power generation technologies in Singapore,” *Renew. Sustain. Energy Rev.*, vol. 11, no. 4, pp. 702–715, May 2007.

[62] J. L. H. Wong, P. S. Teh, V. X. Wang, and L. M. H. Chia, “Solar Capability Building Programme for Public Housing,” *Energy Procedia*, vol. 33, pp. 288–301, Jan. 2013.

[63] Singapore Economic Development Board (SEDB), “Clean Energy Fact Sheet,” 2012.

[64] T. Q. Dung, “Photovoltaic technology and solar energy development in Viet Nam,” *Renew. Energy Technol.*, 2009.

[65] J. Peron, “Wind and solar opportunities in Vietnam,” 2013.

[66] Groupe Casino, “Big C Vietnam signs a ‘solar energy’ agreement with Schneider Electrics Vietnam.” [Online]. Available: http://www.groupe-casino.fr/en/Big-C-Vietnam-signs-a-solar-energy.html. [Accessed: 21-Jul-2014].

[67] D. D. Tuong, “Latest technologies for harnessing Vietnam sun power,” in *Power Industry Conference*, 2012.

[68] A. Q. Malik, “Assessment of the potential of renewables for Brunei Darussalam,” *Renew. Sustain. Energy Rev.*, vol. 15, no. 1, pp. 427–437, Jan. 2011.

[69] Central Intelligence Agency (CIA), “The World Factbook.” [Online]. Available: https://www.cia.gov/library/publications/the-world-factbook/geos/xx.html. [Accessed: 01-Apr-2014].

[70] S. Mathew, L. C. Ming, and L. K. C. Patrick, “Sustainable electricity model for brunei darussalam.”

[71] “Universiti Brunei Darussalam.” [Online]. Available: http://www.ubd.edu.bn/news-and-events/highlights-archive/2014/february/. [Accessed: 25-Feb-2015].

[72] J. Shim, “The Largest Photovoltaic System of Its Kind in Seria at Tenaga Suria Brunei.”

[73] C. G. Cheong, “Bruneians receiving power from the sun,” *The Brunei Times*, 2010.

[74] Institue of Technology of Cambodia, “Renewable Energy Development in Cambodia.”

[75] K. Poch, “Renewable Energy Development in Cambodia: Status, Prospects and Policies,” 2013.

[76] R. V. ; Mansvelt, “Solar Roadmap for Cambodia - How to scale-up solar diffusion in Cambodia?,” 2011.

[77] M. Sarraf, B. Rismanchi, R. Saidur, H. W. Ping, and N. A. Rahim, “Renewable energy policies for sustainable development in Cambodia,” *Renew. Sustain. Energy Rev.*, vol. 22, pp. 223–229, Jun. 2013.

[78] “Rotman, M., ‘Exploratory research for appropriate Product Market Combinations in Cambodian rural areas’, (University of Twente, Enschede, 2006).”

[79] A. Reinders, H. Gooijer de, and J. C. Diehl, “How participatory product design and micro-entrepreneurship favor the dissemination of photovoltaic systems in Cambodia,” in *17th International Photovoltaic Science and Engineering Conference*, 2007.

[80] H. Kimsay, “Electricity co-operation crucial,” *The Phnom Penh Post*, 2013.

[81] Energypedia, “Cambodia Energy Situation.” [Online]. Available: https://energypedia.info/wiki/Cambodia_Energy_Situation#Solar. [Accessed: 25-Jul-2014].

[82] “Country Energy Profile: Laos - Clean Energy Information Portal - reegle.” [Online]. Available: http://www.reegle.info/countries/laos-energy-profile/LA. [Accessed: 18-Feb-2015].

[83] “Energy Sector in the Lao People’s Democratic Republic - 47180387.pdf.” [Online]. Available: http://www.oecd.org/countries/laopeoplesdemocraticrepublic/47180387.pdf. [Accessed: 25-Feb-2015].

[84] “Renewable Energy Development Strategy in Lao PDR - LIRE-Renewable_Energy_Development_Strategy_in_Lao_PDR.pdf.” [Online]. Available: http://www.lao-ire.org/data/documents/data_research/general/LIRE-Renewable_Energy_Development_Strategy_in_Lao_PDR.pdf. [Accessed: 25-Feb-2015].

[85] M. Bodenbender, C. Messinger, and R. Ritter, “Mission Report Energy Scoping Myanmar,” 2012.

[86] M. Chadha, “Off-Grid Solar Power Projects For Myanmar | CleanTechnica,” 2013. [Online]. Available: http://cleantechnica.com/2013/01/13/off-grid-solar-power-projects-for-myanmar/. [Accessed: 14-Feb-2015].

[87] Asian Development Bank, “Myanmar - Energy Sector Initial Assessment,” 2012.

[88] F. Muhammad-Sukki, A. B. Munir, R. Ramirez-Iniguez, S. H. Abu-Bakar, S. H. Mohd Yasin, S. G. McMeekin, and B. G. Stewart, “Solar photovoltaic in Malaysia: The way forward,” *Renew. Sustain. Energy Rev.*, vol. 16, no. 7, pp. 5232–5244, Sep. 2012.

[89] PVTech, “Indonesia’s new feed-in tariff spurs solar projects in isolated regions,” 2013. [Online]. Available: http://www.pv-tech.org/news/indonesias_new_feed_in_tariff_spurs_solar_projects_in_isolated_regions.

[90] F. Muhammad-Sukki, R. Ramirez-Iniguez, S. H. Abu-Bakar, S. G. McMeekin, and B. G. Stewart, “An evaluation of the installation of solar photovoltaic in residential houses in Malaysia: Past, present, and future,” *Energy Policy*, vol. 39, no. 12, pp. 7975–7987, Dec. 2011.

[91] F. Muhammad-Sukki, S. H. Abu-Bakar, A. B. Munir, S. H. Mohd Yasin, R. Ramirez-Iniguez, S. G. McMeekin, B. G. Stewart, N. Sarmah, T. K. Mallick, R. Abdul Rahim, M. E. Karim, S. Ahmad, and R. Mat Tahar, “Feed-in tariff for solar photovoltaic: The rise of Japan,” *Renew. Energy*, vol. 68, pp. 636–643, Aug. 2014.

[92] F. Muhammad-Sukki, R. Ramirez-Iniguez, A. B. Munir, S. H. Mohd Yasin, S. H. Abu-Bakar, S. G. McMeekin, and B. G. Stewart, “Revised feed-in tariff for solar photovoltaic in the United Kingdom: A cloudy future ahead?,” *Energy Policy*, vol. 52, pp. 832–838, Jan. 2013.

[93] The Government of The UK, “Department of Energy & Climate Change.” [Online]. Available: https://www.gov.uk/government/organisations/department-of-energy-climate-change. [Accessed: 18-May-2014].

[94] E. Ares, O. Hawkins, and P. Bolton, “Feed-in Tariffs: Solar PV Review,” 2012.

[95] A. Vaughan, F. Harvey, and H. Gersmann, “Solar subsidies to be cut by half,” *The Guardian*, 2011.

[96] J. Gifford, “British feed-in tariffs for ‘larger’ solar installations dramatically cut,” *PV Magazine*, 2011.

[97] E. Hughes, “FiT cuts 2011: DECC proposes 21p rate; December deadline,” *Solar Power Portal*, 2011. [Online]. Available: http://www.solarpowerportal.co.uk/news/fit_cuts_2011_decc_proposes_21p_rate_december_deadline_5478. [Accessed: 19-Sep-2014].

[98] E. Hughes, “Coping with the cuts: the feed-in tariff fallout,” *Solar Power Portal*, 2011. [Online]. Available: http://www.solarpowerportal.co.uk/editors_blog/coping_with_the_cuts_feed-in_tariff_fallout_5478. [Accessed: 19-Sep-2014].

[99] L. Hung Yee, “RM325mil boost for renewable energy fund - Business News,” *The Star Online*, 2014.

[100] I. Clover, “Malaysia increases surcharge to fund FIT program,” *PV Magazine*, 2013.

[101] L. A. Zakaria, “Kadar Tarif Elektrik 2014 Tidak Membebankan,” 2013. [Online]. Available: http://ladfeamir.com/2013/12/25/kadar-tarif-elektrik-2014-tidak-membebankan/. [Accessed: 21-Sep-2014].

[102] C. Morris, “The Spanish solar collapse,” *Grist*, 2009. [Online]. Available: http://grist.org/article/the-spanish-solar-collapse/. [Accessed: 19-Sep-2014].

[103] P. Voosen, “Spain’s Solar Market Crash Offers a Cautionary Tale About Feed-In Tariffs,” *The New York Times*, 2009.

[104] B. Yauch, “Governments rip up renewable contracts,” *Financial Post*, 2014.

[105] S. C. Chua and T. H. Oh, “Green progress and prospect in Malaysia,” *Renew. Sustain. Energy Rev.*, vol. 15, no. 6, pp. 2850–2861, Aug. 2011.

[106] S. C. Chua and T. H. Oh, “Solar energy outlook in Malaysia,” *Renew. Sustain. Energy Rev.*, vol. 16, no. 1, pp. 564–574, Jan. 2012.

[107] International Energy Agency (IEA), “Market deployment strategies for PV systems in the built environment – An evaluation of Incentives, Support Programmes and Marketing Activities,” 2002.

[108] A. Lopez Polo, R. Haas, and D. Suna, “Promotional Drivers for PV,” 2007.

[109] S. Ali Oettinger, “Fall in market share for top ten PV inverter suppliers,” *PV Magazine*, 2013.

[110] “International Best Practices and Options for Policy Makers.” [Online]. Available: http://www.euei-pdf.org/sites/default/files/files/field_pblctn_file/EUEI PDF_Myanmar_Workshop Rural Electrification_Jun2013_EN.pdf. [Accessed: 18-Feb-2015].

[111] UKERC, “Climate Change and Energy Security: Assessing the impacts of information and its delivery on attitudes and behaviour,” 2012.