Maximizing decentralized energy utilization through renewable energy interventions in Thailand

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Highlights

- Given increasing demand, Thailand needs to explore all energy alternatives to secure the energy requirements. Renewable energy offers opportunities with significant potential to reduce the use of fossil fuels in Thailand.
- Decentralized energy has paramount importance in promoting renewable energy, reducing the transmission losses and GHG emission reduction in Thailand.
- Decentralized and grid connected renewable energy in Thailand is already making a rapidly growing contribution to the country's energy supply and it should continue in order to fulfill nation's 30% renewable energy target by 2036.

Renewable Energy for Development

Thailand is the second largest economy in Southeast Asia. Considering the population growth, the energy demand is definite to soar up in the near future thereby leading to more additional energy requirement. With over 80% of the country's 7.3 million poor living in rural areas (as of 2013), some regions—particularly the North and Northeast—and some ethnic groups lag greatly behind others, and the benefits of economic success have not been shared equally, especially between Bangkok and the rest of the country. Thus, Poverty has primarily been a rural phenomenon here [1]. Thailand has made significant progress in last four decades to uplift itself from the low level income group to upper income group. There are many success stories in Thailand which helped to achieve sustained strong growth and poverty reduction, particularly in the 1980s. During the late 1980s and early 1990s, Thailand's economic growth was significantly higher at 8-9% per year which got interrupted by the "Asian Crisis" of 1997-1998. Since then, economic growth has been moderate, with period of robust growth, such as at around 5% from 2002 to 2007, followed by the fall-out from the global financial crisis of 2008-2009, the flood in 2011. The rural population of Thailand were basically concentrated in the rice-growing areas of central, north eastern and northern regions. However, with growing urbanization, a vast majority of population migrated to urban areas. As per the World Bank Data, the percentage of urban population out of total population in 2014 is 49.17% and the rate of its growth is 2.94% [2]. A featured news of World Bank reports that the growth rate of Bangkok's urban area made itself the fifth largest urban area in East Asia in 2010, larger than megacities such as Jakarta, Manila and Seoul [3]. The cheap energy supply in Thailand has helped transforming the country from the agrarian society toward industrial economy. As of 2009, the ratio of primary energy consumption over gross domestic product, measured in US dollars at constant purchasing parity, of Thailand is 0.23 which is relatively higher than world's average of 0.19[1]. Thus, the energy intensity level reveals that Thailand's economy is heavily dependent on energy consumption.

As Thailand is highly dependent upon energy imports, with a view to strengthen national energy security, four national level strategies were established on 28 August 2003 by Ministry of Energy. These strategic plans were Energy Efficiency, Renewable Energy Development, Energy Security

[1] Taken from http://www.nationmultimedia.com/opinion/Energy-policies-will-be-crucial-to-Thailands-econo-30174340.html accessed on 2017.12.24

Enhancement and capacity Development to function as "Regional Energy Center"[2]. Moreover, APEC Energy Overview 2011 states that the country's energy policy is based on following five strategies: energy security, alternative energy, supervising energy prices and safety, energy conservation and efficiency, and environmental protection [4]. At the same time, the promotion of alternative energy development plan (2015-2036) is aiming to increase the portion of renewable energy generation from currently (in 2014) 8 percent to 20 percent of the total power requirement in 2036 which accounts for 19,634.4 MW. The plan intended to prioritize waste, biomass and biogas power generation, along with solar, wind and hydropower [23]. Moreover, Decentralized and Grid connected renewable energy in Thailand has made a rapidly growing contribution to the country's energy supply [6] and it should continue in order to fulfill the 20% target in the country by 2036.

Evolving Decentralized Energy System

Decentralized energy system refers to a system which necessitate locating the energy production facilities closer to the energy consumption site. It helps reduce the fossil fuel use and increases eco-efficiency as this system allows more optimal use of renewable energy and combined heat and power (CHP). World Alliance for Decentralized Energy (WADE) defines Decentralized Energy (DE) as: "*Electricity production at or near the point of use, irrespective of size, technology or fuel used- both off-grid and on-grid*." Thailand relies heavily on imported fuels [7]. Centralized Generation constitutes 91% of total electricity generated in Thailand [8]. On the contrary, Decentralized energy system seek to put sources closer to the end user, which can reduce the inefficiencies of transmission and distribution and associated costs. Decentralized energy technologies classified in the WADE model for Thailand's power generation are coal CHP, oil CHP, gas CHP, biomass, biogas, solar PV, wind, small-hydro and Waste to Energy (WtE) [8].

Thailand's final energy consumption[3] in 2013 was 75,214 Kilo tons of Oil Equivalent (ktoe) [5], out of which around 78.36 % of the energy was contributed by Fossil fuels (Coal and its product, Petroleum products, and Natural Gas) alone whereas renewables contributed 9.41%, traditional renewable 10.7% and imported electricity 1.49%. An article published in 2010 reveals the status of decentralized generation in Thailand, which comprises of gas CHP 724.42 ktoe (8,425 GWh), biomass 196.13 ktoe (2,281 GWh), coal CHP 179.28 ktoe (2,058 GWh), small hydropower 16.25 ktoe (189 GWh), biogas 10.32 ktoe (120 GWh), oil CHP 4.13 ktoe (48 GWh) and others (wind, solar, waste to energy) 4.73 ktoe (55 GWh) [8]. Therefore, each of the energy resources are equally important to ramp the DE generation.

An analytical study reveals that with the penetration of Distributed Generation (DG) in the system regarding its potential and power development plan of Thailand (PDP 2007), DG share will increase from 2% (1,759 MW) in 2007 to 17% (12,282 MW) by the year 2026 [8]. In Thailand, the total primary energy supply[4] is 134,308 ktoe in 2013. Out of total domestic production for the primary energy supply in 2013, the natural gas accounted for 46.63%, coal and its products 5.71%, Crude Oil & Natural Gas Liquids (NGL) 9.43%, condensate 5.78%, Biofuels 2.06%, the renewable

[2] Drawn from http://www.eppo.go.th/doc/strategy2546/strategy.html accessed on 2015.12.24

[3] A part of primary supply was used in energy transformation and non-energy uses, therefore the Final Energy Consumption is always lower than primary supply.

[4] Primary Energy Supply is the domestic production, plus import, less export and plus/less stock change.

12.79% and the traditional renewable energy forms[5] 17.61% [5]. The renewable energy resources are significantly considered to achieve the alternate energy targets in Thailand. Moreover, Biomass seems to be the highest contributor among all the renewable energy resources, be it in terms of electricity or heat. Out of total 1,341 ktoe (3788 MW) of electricity from the renewables in 2013, biomass alone contributed 1,039 ktoe (2320.78 MW) electricity whereas in context of heat consumption, 4694 ktoe out of 5279 ktoe is supplied by biomass [5]. Other renewables sources such are solar, wind, small hydro and biogas add much smaller proportion than conventional energy used.

Table 1: Installed capacity of alternative energy power plants in Thailand and target by 2036 (MW) [23]

Resource	2010	2013	2014	2036 (Target)
Solar	48.6	823.5	1298.5	6000.0
Wind	5.6	222.7	224.5	3002.0
Small Hydro	58.9	108.8	142.0	376.0
Biomass	1650.2	2320.8	2451.8	5570.0
Biogas	103.4	265.7	311.5	600.0
MSW	13.1	47.5	65.7	500.0

In context of renewables, table 1 shows significantly high potential from Solar which can be attributed to the tropical climatic condition of the country. As of 2014, 92 ktoe (1298.5 MW) of solar energy has been installed. A Solar Home System for rural electrification and roof-top solar PV for meeting urban electricity demand have been interesting DE system in Thailand. Moreover, Solar PV has been used at rural community school and national parks for electricity. Similarly, potential wind power sources are located in the Gulf of Thailand [10] and as of 2014, about 224.5 MW of wind energy has been installed [5]. As a part of island electrification where there is no grid-connection available, 80 Hybrid (Solar and Wind) power generation systems have been implemented in Paluai Island in Surat Thani Province with 500W each from wind and 300 W each from solar, thus making power generation stable both in day and time [11]. Similarly, hydropower too has a good potential, however these are difficult to exploit due to environmental impact on the resource area. A small hydropower installed as of 2014 is about 142 MW [5], more of such would add to the DE in Thailand. The use of solar, wind, plantation-based biomass, MSW and biogas are considered for power generation, while agricultural residues are considered for cogeneration and residential cooking in the future [12].

Similarly, as Thailand is an agricultural country with a huge agricultural output, such as rice, sugarcane, rubber sheets, palm oil and cassava, there is overwhelming prospect for Bio-energy. Under the Alternate Energy Development Plan (2015-2036), Biomass and biogas power plants are targeted at 5570 MW and 600 MW respectively [13]. In processing the agricultural products, large amount of residues are generated and such residues are used for power generation and fuel production. Such biomass power plants are located where the access to such residues is easier. While in some other cases, they are set up close to point of use, which then uses co-generation technology and thus further the development of decentralized generation.

[5] It includes fuel wood, charcoal, paddy husk, and agricultural waste using in residential and industrial household.

The changes in total primary energy supply throughout over two decades in Thailand are shown in figure below.

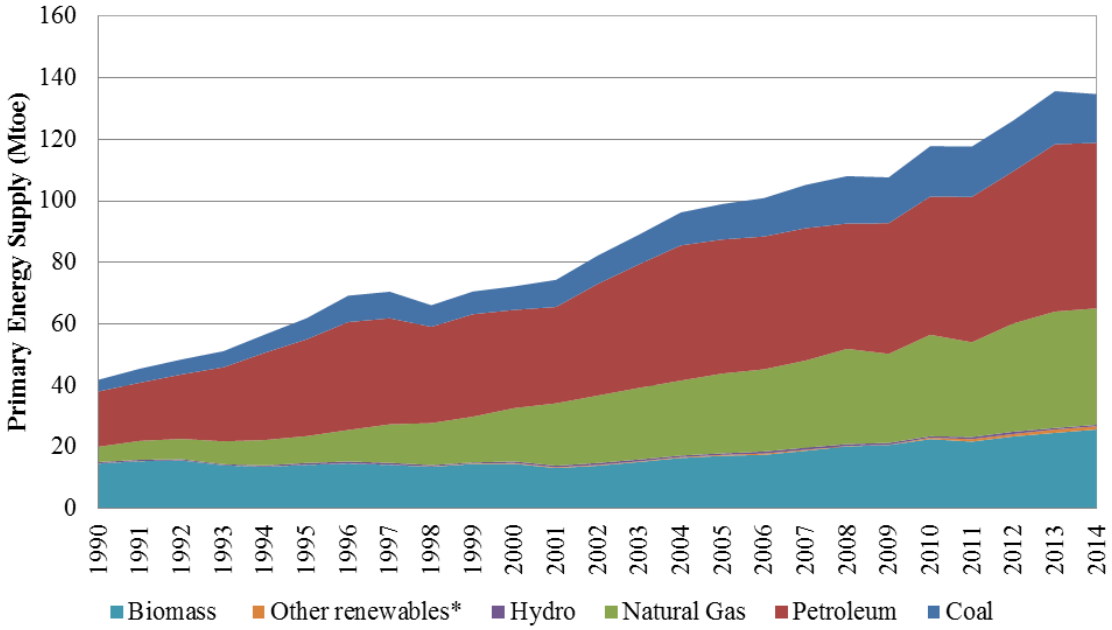

Figure 1: Primary energy supply during the period of 1990-2014 [24]

With the total of four-fold increase in total final energy demand over 1990 to 2014, fossil fuels has increasing share which accounted for 79.8% of TPES in 2014. Biomass and hydro mostly accounted for almost new and renewable energy consumption [24]. Thailand's government has already foreseen energy prices' problems, international competition for energy resources, impact on the environment and climate change resulting from energy production and its utilization [9]. These factors necessitate the need of alternative options to address the potential problems in addition to fulfilling the future demands. This is where the importance of Decentralized Energy systems and distributed generation becomes paramount.

Policy Interventions and Achievements

Thailand's foray into distribution generation/ decentralized energy began in 1992 when the national energy policy was revised to allow private participation in power-sector investment, providing opportunities for them who deals in renewable energies, indigenous by-product of the energy sources being used and more efficient use of primary energy through cogeneration [14]. The NEPC's approval to include the SPPs in power investment brought an opportunity for DE to flourish in the country against the nation's centralized generation concept. The regulations allowed grid interconnection of small-scale renewable energy and fossil-fuel fired combined heat and power (CHP) generators up to 90 Megawatts (MW) in size. Within a span of 4 years, this Small Power Producer (SPP) program has contributed nearly 1000 MW of renewable energy capacity, which is significant considering Thailand's total peak load in 2006 was just over 21000 MW [15].

The Decentralized Energy developments are embedded within Alternate Energy Development Plans (AEDP), Power Development Plans (PDP) and Energy Efficiency Development Plan

(EEDP), which are the strategic plans for the way forward. These plans, though contrasting in targets, includes targets through renewables (which includes the SPPs and VSPPs production and is ultimately the small scale decentralized renewable energy) and cogenerations. The policies related to energy, including electricity and Renewable Energy policies are completely taken care of by the Ministry of Energy (MoE).

Figure 2 below shows the overall generation, transmission and distribution of Thailand Electricity sector and represents the Thailand's electricity structure, which shows stakeholders from generation to the end consumers. The state-owned Electricity Generating Authority of Thailand (EGAT), which was established in 1968 controls most of the power generation and the country's transmission completely. EGAT purchases electricity from public and private producers and sells it to unbundled distribution companies and few large direct customers [16]. Provincial Electricity Authority (PEA) is held responsible for electrification of the provinces including the rural electrification. However, electric power to the Bangkok Metropolitan area and two adjoining provinces is distributed by the Metropolitan Electricity Authority (MEA). According to PEA, 99.7% of Thai villages are now electrified, but there is an increasing demand in line with the with Thailand's residential, commercial and industrial growth [17].

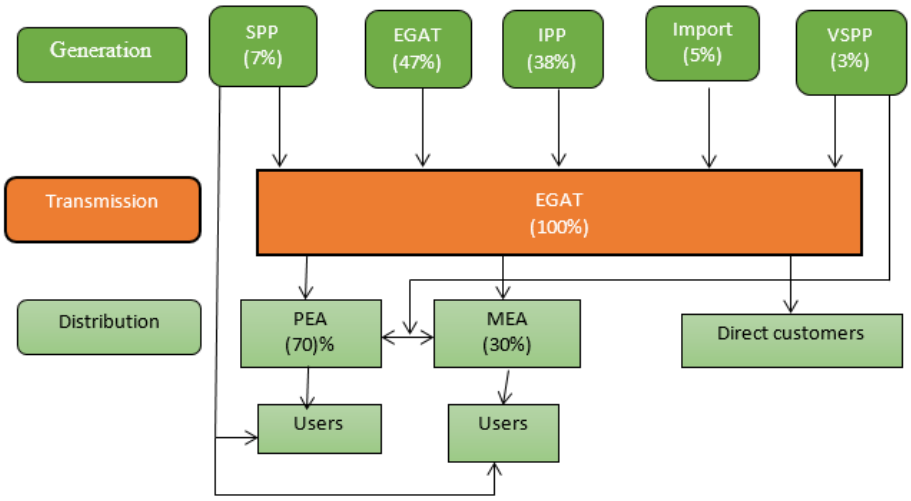

Figure 2: Structure of Thailand's Electricity Sector (Year 2013) [18]

This figure help identify key players in the electricity sector. In context of decentralized energy, it can be clearly inferred that SPP and VSPP, not only produces electricity and sells them to EGAT for transmission but also distributes electricity to direct customers/ users. Such production and distribution occurs either at rural community where national grid has not reached citing low demands of electricity or at places where SPP generates more electricity than allowed (which it sells to the community/ industry nearby directly). Thus, SPPs and VSPPs are both significant players for promoting Decentralized Energy Systems in Thailand.

Decentralized energy system in Thailand has been considered both in terms of on-grid and off-grid system. The on-grid system is both the renewable energy systems (Net Metering) and the coal powered plant, where cogeneration is very vital in the latter and additionally the excess energy from SPP generators. Micro/Mini grids have been established in various parts of different

provinces where direct national grids have not reached. Smart Grids have been considered an evolving technology in DE system. The off-grid system in Thailand is either diesel power generator or renewable energy system. Electrification of rural villages and islands are largely done by renewable energy systems. Solar home system (SHS) stands as a successful DE intervention in Thailand.

It is imperative to mention that Thailand was among the first countries in Asia to introduce incentive policies for electricity generation from renewable source of energy. In 2006, Thailand's state owned electricity distributors offered to buy electricity from renewable energy producers under power purchase agreements (PPAs) in which an adder rate (based on the technology used) was payable on top of the prevailing wholesale price of electricity. It can be observed in the rapid growth of solar energy in different areas throughout the country. The "Adder", a feed-in premium, guarantees higher rates for renewable energy, making the investments profitable. Adder rates are distinguished by technology type, installed capacity, contracted capacity, and project location. Furthermore, a sophisticated Feed-in-Tariff (FiT) is introduced to control cost, while continuing to enabling suitable environment for investments in renewable energy [19]. In 2010, NEPC approved transitioning from adder to Feed-in-Tariff (FiT), in which a fixed amount per kWhr is paid during the life of the PPA. The Energy Regulatory Commission (ERC) ordered Thailand's state owned electricity distributors (PEA, MEA and EGAT), to cease offering PPAs to power producers generating less than 10 MW (VSPPs) and instead to issue PPAs based on the ERC's FiT subsidy program. The FiT PPAs are for a 20 year term for all eligible forms of renewable energy with the exception of land fill, for which a ten year PPA is offered. The future energy outlook will have more decentralized energy in close co-operation and communication with local consumers.

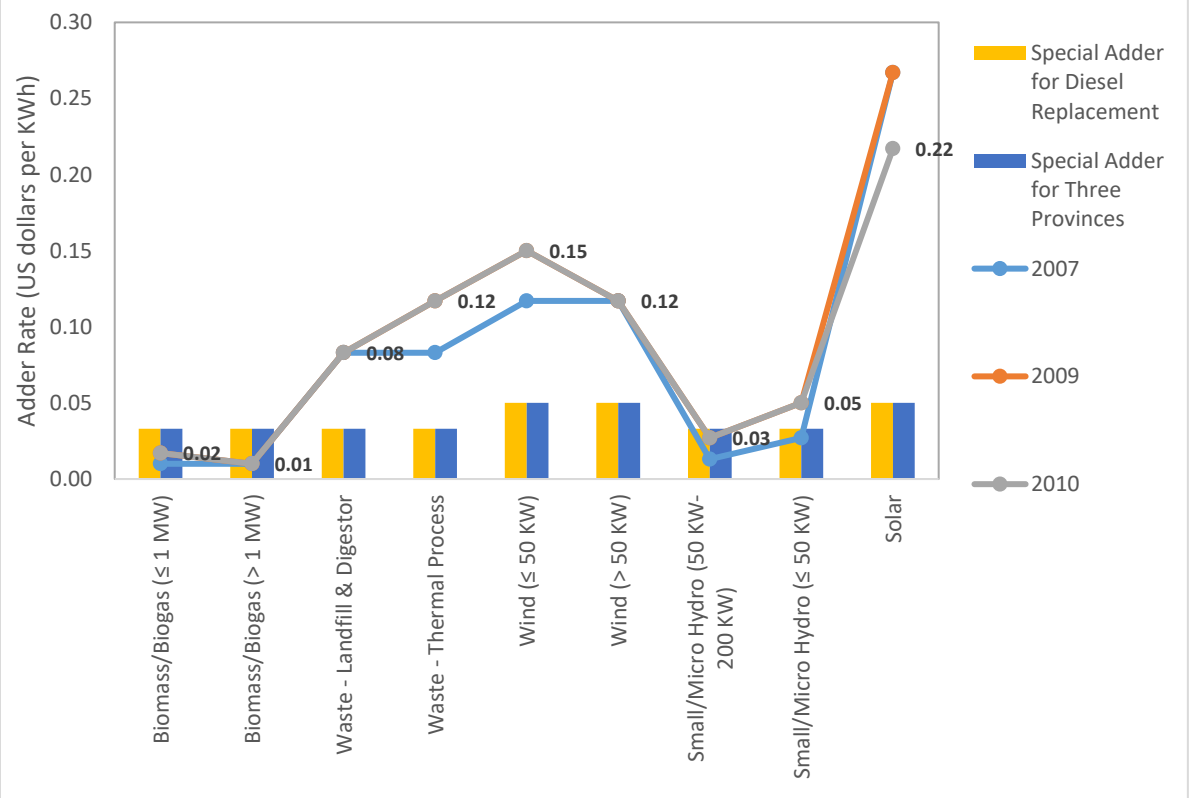

Figure 3: Thailand's Adder Rate (Exchange Rate: 1 USD = 30 THB)

Thailand's adder program gave incentives for private investors to invest in small scale renewable energy projects, by guaranteeing attractive power purchasing rates. VSPPs and SPPs that utilize solar, wind, biomass, hydro and waste energy are eligible to participate. VSPPS and SPPs may be private or public entities, but may not include the utilities themselves. The rate structure since 2007 is paid on top of the utilities' avoided cost. This constitutes a "premium price FiT payment as defined by Cory et al. (2009). In addition, there are "additional" adders paid to RE generators of three southernmost provinces, viz. Yala, Pattani and Narathiwat, which have experienced political unrest and off-grid areas. The figure above depicts the adder rate as of January 2013 (the same rate prevailed in 2010), with exception to solar power which no longer accepts application based on Adder programs [18].

Probably considered the most important program for clean, decentralized energy in Thailand, the Small Power Producer (SPP) Program opened up the market for private investment. The SPP program applies to renewable energy and to fossil fuel-fired combined heat and power (CHP) [17]. As shown in figure 2, SPP generators sell electricity to EGAT, which gets distributed over to end users through PEA and MEA. SPPs contribution towards decentralized energy comes into effect when SPPs produce electricity in excess of upper limit (i.e. more than 90 MW), which is either used for self-consumption or sold directly to factories or buildings nearby, in addition to selling steam generated through waste heat to the nearby industrial state. SPPs have been involved with such production and distribution, thereby going beyond the secured 90 MW level and contributing towards the decentralized energy through distribution of excess electricity and co-generation. As of April 2008, SPP's generating capacity was 3877 MW out of which 2286 MW of electricity is connected to grid whereas the remaining is sold to users located nearby. Out of 61 SPP projects, 26 were fossil fuel (mainly natural gas) cogeneration project totaling 1670 MW [18]. SPPs are generally 10 MW or larger and limited to export a maximum of 90 MW. SPP generators above 8 MW must connect to high voltage (69 kV or 115 kV) lines.

The Very Small Power Producer (VSPP) Program is another transition in Thailand's private investment. In mid- 2002, the government announced a VSPP power purchase to aim at power generation through non-conventional energy, making use of domestic resources efficiently, and to provide electricity access to the rural areas with sufficient community participation, through MEA and PEA upto 1 MW, which was later revised to 10 MW [21]. The VSPP program was developed as a Net Metering Regulation in Thailand. In addition, since the production is at small scale (less than 1 MW) and this will be sufficient for a small community, the whole idea is to promote the very small scale producers and the decentralized energy system in Thailand. Figure 2 above shows VSPPs can bypass EGAT and sell electricity directly to distribution companies as well as direct customers.

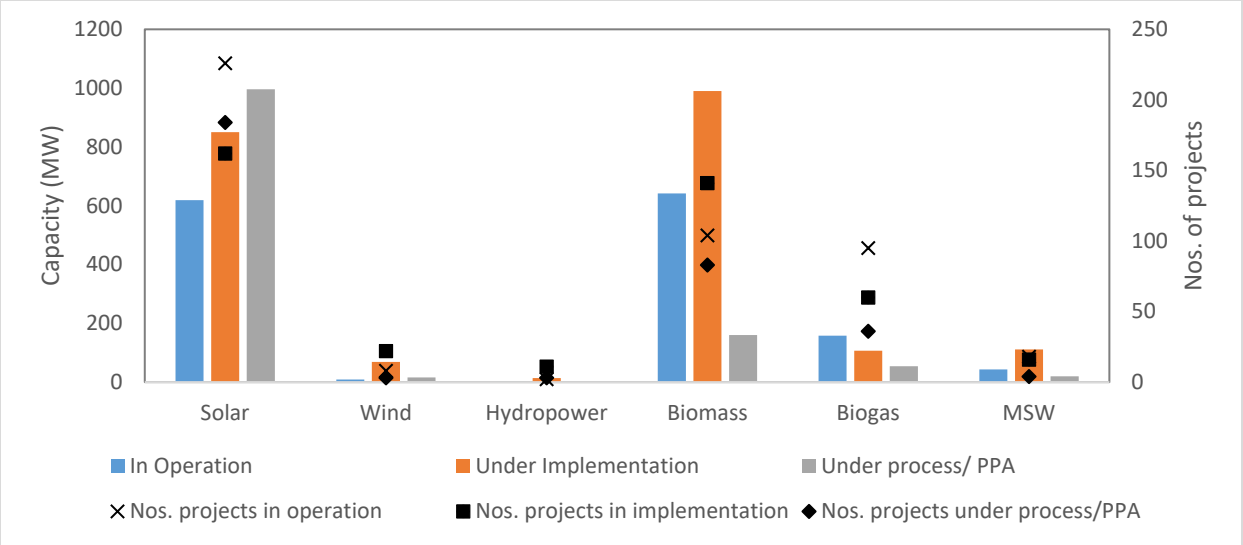

Figure 4: Status of VSPP as of February 2014

Way Forward

As per Ministry of Energy's fact and figures 2014, more than 70 % of the total energy is consumed in transportation and industrial sectors. The Industrial sector includes mining, manufacturing and construction. The agriculture sector accounted for only 5.2 % whereas 15.1 % and 7.2 % are consumed by residential and commercial sector respectively in 2014. The long term power demand forecast for Business-as-usual scenario (using statistical data of year 2013), showed that power demand would increase to 59,300 MW in 2036 from 30,304 MW in 2016 and for base case scenario, power demand will peak to 49,655 MW in 2036 from 30,218 MW in 2016. Furthermore, Energy Efficiency Development Plan 2015, aims to achieve energy conversation targets up-to 89,672 GWh in year 2036 by adopting six measures namely, Specific Energy Consumption, Building Energy Code, High Energy Performance Standard & Minimum Energy Performance Standard, Monetary incentives, LED promotion and Energy Efficiency Resource Standard [23]. In

- Considering the ever-increasing demand and while achieving GHG emission reduction target, Thailand needs to explore all the alternatives possible to secure the energy requirements. In doing so, decentralized energy becomes paramount importance which not only help make the system more efficient by utilizing the waste heat through cogeneration but also promotes renewable energy thus thereby reducing the transmission losses and the GHG emission.
- Moreover, the government aims to improve the efficiency and use energy-efficient products to lower the consumption of energy. An estimate reveals that increasing the decentralized generation share from 2 % (1759 MW) in 2007 to 17 % (12,282 MW) by the year 2026 would result in 11% savings on primary energy (84.3 TWh/year), 17 % emission reduction (40 Ton), 3 % capital cost saving (US $ 1.42 Billion) and 6% reduction of required additional capacity of around 4955 MW [22].
- The optimum Feed in tariff for DE systems should be developed involving all possible stakeholders for power generation. Also rural and semi-urban/urban DE policies should be distinctly distinguished so as to get the DE development equally over the country.

- Efficient planning such as strong post installation repair and maintenance program should be implemented by government funded program. Some initiation was taken by few NGOs to repair and maintain some of the SHS.
- Academic institutions have significant roles as catalyst in overcoming issues of technologies, building local capacities, finding suitable economic incentives through technical and policy research. Government and academic institutions should work closely such as the problem are well identified and addressed through professional trainings, scientific and policy research.
- The need of cogeneration in conventional and renewable energy systems along with development of electricity through renewables is highlighted in every government plans in Thailand which urge for developing the decentralized energy more vigorously. The decentralized energy developments have the potential to create job opportunities, new tax revenues for the government and lowering the emission level of the country. Local value creation and national energy security are the keywords that highlights the benefits of decentralized energy revolution.

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