Article Review: Thailand's Future Green Energy for Sustainable Urban Development

Pawinee Iamtrakul[1*], Suapphong Kritsanawonghong[2]

[1] *Faculty of Architecture and Planning, Thammasat University, Pathumthani 12121, Thailand*

[2] *Business Development (Japan), Prime Road Group Co. Ltd, Phra Nakhon Si Ayutthaya, 10110, Thailand*

* Corresponding author e-mail: iamtrakul@gmail.com

ReceReceived 8 Apr 2019; Revised 20 Jun 2019; Accepted 27 June 2019

Print-ISSN: 2228-9135, Electronic-ISSN: 2258-9194, doi: 10.14456/built.2019.1

Abstract

Due to energy efficiency action plan to reduce the energy intensity, the recommendation for utilization of renewable energy integration plays a vital role among several choices of renewable energy, especially solar, biomass and wind energy and development the cogeneration system. However, different available sources of distributed energy resources both combined heat and power (CHP) system or renewable energy system have its own potential of implementation through urban development. Thus, this paper reviewed the situation and demonstrated the potential of the implementation of different energy options under constrains and limitations. Furthermore, under the rules and regulations in obtaining permission and trend of investment, the paper could be strategically propose the possibility to allow private sector to participate in the energy generation business which could be in order to promote the competition of power industry.

Keywords: green energy, sustainable planning, urban development, Thailand

1. Introduction

Thailand has high potential for the implementation of distributed energy resources due to the predominantly of electricity production based on thermal and combined cycle generation while renewable energy accounts approximately 1% of total electricity generation capacity only. Due to the next 20-year energy efficiency action plan under government policy which aims to reduce the energy intensity by 25%, the utilization of renewable energy integration with distributed energy resource systems is one of the most important development methods that should be established as soon as possible. However, at end of 2011, the Department of Mineral Fuel reported proven reserves of petroleum both onshore and offshore at 215 million barrels of crude oil, 239 million barrels of condensate, and 284 billion cubic meters (10.06 trillion cubic feet) of natural gas. It presented that production rates, crude oil reserves would last another four years, condensate reserves another seven years, and natural gas reserves would be depleted in less than 15 years. Although Thailand's coal reserves are large, most of the proven coal reserves are lignite coal of low calorific value. Furthermore, conservative assumptions suggested that Thailand would need to continue to increase imports of oil and gas from neighboring economies. Thailand has had gas pipeline interconnections with Myanmar since 1999 and Malaysia since 2005 which were constructed as a part of the on-going Trans-ASEAN Gas Pipeline (TAGP) project. Within the country, the total natural gas network covers 4,056 km. and natural gas was distributed to power generators, including the Electricity Authority of Thailand (EGAT), independent power producers (IPP) and small power producers (SPP), as well as to 272 industrial users (PTT, 2011a). In addition, it has been also the good challenge for development the electricity generating from renewable energy, especially solar, biomass and wind energy and development the cogeneration system by using the effectiveness utilization of natural gas through city gas pipeline (Electricity Generating Authority of Thailand (EGAT), 2010).

However, when considering the barrier of fiscal and tax incentives, it comes to the obstacles for the utilization of combined heat and power (CHP) system and renewable energy system for decentralized power generation either for suppliers or consumers. This article review presents the preliminary investigation results from several available sources to demonstrate the potential of the implementation of distributed energy resources both combined heat and power (CHP) system or renewable energy system integration towards urban development.

2. Potential of renewable energy resource in Thailand

2.1 Solar Energy

Figure 1 shows data of monthly global solar radiation which collected from year 1990 to 2010. It was revealed that the solar radiation in all over Thailand has similar trend. The average sunlight of the whole country is 18 MJ/m2-day. The variation of solar radiation depends on location and time of the year.

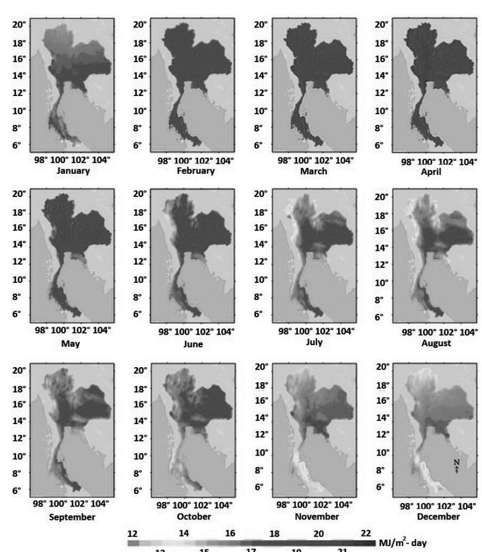

Figure 1. Monthly average global solar radiation maps (**Source:** GIZ, 2013)

Figure 2. Yearly average solar radiation map in Thailand (**Source:** Ministry of Energy, 2010)

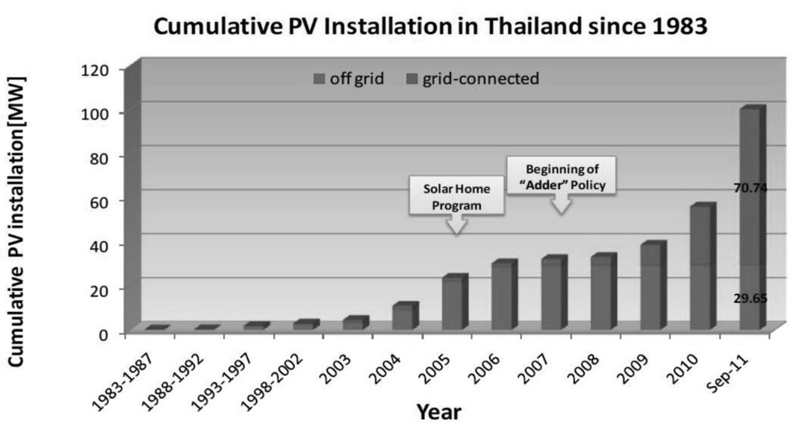

Figure 3. PV system's growth in Thailand (**Source:** Electricity Generating Authority of Thailand (EGAT), 2010)

The areas which receive the highest radiation (20-22 MJ/m2-day) are mainly in the Northeast and partly in the Centre. The solar radiation is the highest during the year from March to April and is gradually lower during the monsoon, from May to September; yet still higher comparing to the value of solar radiation during winter from October to January. The yearly average of solar radiation map in Thailand is shown in Figure 2. Thailand's Department of Alternative Energy Development and Efficiency (DEDE) evaluates that there would be 55 MWe and 500 MWe installed capacity by the year 2011 and 2022, respectively, with 10 years incentives of adder cost for solar power generation at 6.50 Baht/kWh (the new adder cost rate reduced from 8.50 Baht/kWh since June 2010). This adder cost is proven as the main incentive to the investor since 2009.

However, Solar thermal offers a small output which is not widely used due to the high initial investment cost, compared to electric water heaters. In 2006, more than 50,000 m^2 of flat plate collectors were installed on commercial buildings, hotels, hospitals and private residences. Solar thermal capacity ranged from 3,000 to 3,500 m^2 of solar water heaters per year in 2006. Most solar panels were made for export, but private firms are now beginning to market solar roofing and smaller-scale systems for residential and commercial use in the domestic market. However, due to the decrease of the equipment price for solar PV and the 30% direct subsidy by DEDE which thermal energy production by solar thermal is increased to be approximately 5 ktoe of in 2010 and expected to be 38 ktoe by 2022 (Figure 3).

2.1.1 Solar power application in Thailand

- Off-grid PV system: Most of off-grid systems in Thailand were installed in rural and un-electrified remote areas to improve the quality of rural inhabitants' lives which was always used for lighting, telecommunications, water pumping, electricity generation for schools and healthcare clinics. However, other development of solar power with off-grid system also can be supported by government subsidy, e.g. the application of PV system in military and police based along the border areas or in royal agricultural projects. During 2004 – 2005, the "Solar home program" was introduced, 2003,000 units of solar home systems which were installed by Provincial Electricity Authority (PEA) throughout the country. In 2011, the cumulative installation capacity of the off-grid PV systems is about 29.65 MW.

- On-grid PV system: Electricity Generating Authority of Thailand (EGAT) introduced solar rooftop projects for 10 systems during 1997-1998 and also 50 systems during 2002-2004. In 2004, first large grid supported PV power plant of 500 kW in Mae Hong Son Province was installed. In addition, installation of large PV rooftop of 460 kW was first introduced in commercial building in Thailand by installation at Tesco Lotus Department Store which located in Bangkok. Since 2007, the on-grid PV system was growth in rapid rate from the adoption of the adder or Feed-in Premium. In 2011, the installed capacity of on-grid PV systems is about 70.74 MW.

The rooftop package has a total quota/ target of 200 MW, which is further distributed as shown in Table 1. Out of this 200 MW, 80 MW are allocated to be installed in three provinces namely Bangkok, Nontaburi and Samut Prakarn (40 MW of which residential and 40 MW commercial). Applications for these systems will be processed by the Metropolitan Electricity Authority (MEA), while for all other applications, the Provincial Electricity Authority (PEA) will be the focal point handling the applications (the breakdown of the quota to the different provinces can be taken from the Rules and Regulation).

2.2 Wind energy

From the recorded data of 15-year period of hourly wind speed by DEDE and Department of Meteorology, it was found that the monthly maps revealed wind speed and direction in the country are mainly influenced by the northeast and the southwest monsoons and local geography (Department of Energy Affairs, 2001). Wind speed increases with the increase of the elevation (The World Bank Asia Alternative Energy Program, 2001). For instance, at the elevation of 10 meters, the wind speed is in the range of 3-4 m/s, while at the elevation of 40 meters, the wind speed increased to 4-5 m/s for most parts of the country. In the case of geometer elevation, the relatively high wind speed of 6 m/s which is found in mountain ranges, mainly in the South, the Northeast and the Western part of the Central region as shown in Figure 4.

Table 1. Solar rooftop scale and tariff rates categorized by economic sectors. (**Source:** National Science Technology and Innovation Policy Office (STI), 2012.)

Classification	Scale	Quota	Feed-in-tariff
Residential	0-10 kW	100 MW	6.96 THB/unit
Small and medium commercial	> 10-250 kW	100 MW	6.55 THB/unit
Medium and large commercial / industrial	> 250 kW – MW		6.16 HB/unit

Figure 4. The average wind power classes and percentage in Thailand (**Source:** Elliott, Schwartz, Scott, Haymes, Heimiller & George, (2002))

Table 2. Wind energy potential in Thailand. (**Source**: Department of Energy Affairs, 2001.)

Description of Wind energy potential	Poor (< 6 m/s)	Fair (6-7 m/s)	Good (7-8 m/s)	Very good (8-9 m/s)	Excellent (> 9 m/s)
Land area (km^2)	447,157	37,337	748	13	0
% of total land area	92.60%	7.20%	0.20%	0.00%	0.00%
MW potential	NA	149,348	2,992	52	0

Table 2 estimates the wind energy potential available for power generation in the country. The wind energy potentially is located along the coasts of the Southern Thailand. Even though the technology for electricity generation from wind energy is readily available, it is relatively new to Thailand. Implementation is rather limited due to the local wind condition and the high cost of producing energy from a wind turbine. The government also sets up the adder cost for 10 years incentives for wind power developers at 4.50 Baht/kWh (for less than 50 kW installed capacity) and 3.50 Baht/kWh (for more than 50 kW). From the adder cost incentives, the low-cost wind technology fr om China can compete in Thailand's wind market from its low investment cost in the forthcoming 200 to 300 MWe installation from eight wind farms in Thailand in 2011. The total installed capacity and energy potential of Thailand was around 7.3 MW, which separated by region as shown in Figure 5.

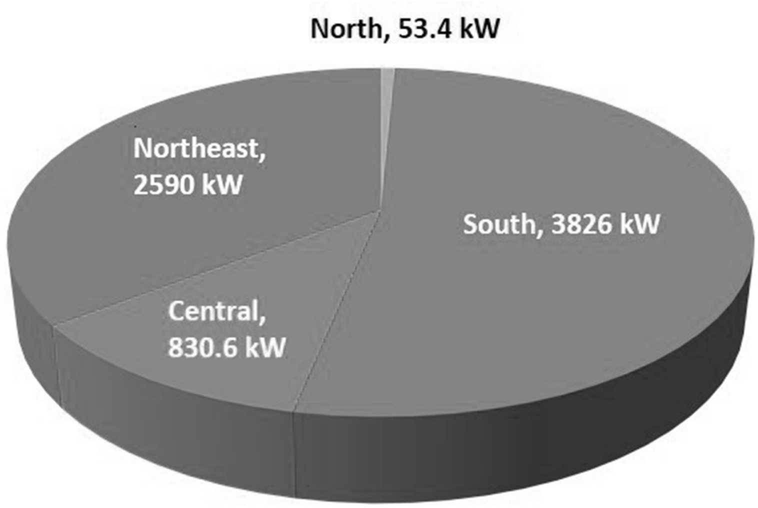

Figure 5. Installed capacity and potential of wind energy by regions in 2011
(**Source:** Department of Energy Affairs, 2001.)

2.3 Biomass Energy

Thailand is one of the major food producing and supplying country of the world. Agricultural products and their residues are, therefore, left abundant and available for biomass exploitation (Seksan et al., 2003). Recently, utilization of biomass sources has been continuously used in both households and generation. The potential of solid biomass in Thailand has been accessed by gathering and estimating from the quantity of agricultural waste such as industrial sugarcane, rice, maize, cassava, oil palm, coconut, groundnuts, cotton, soybeans, sorghum, para rubber, pineapple and black liquor which is accounted for 33,004.54 ktoe. The average annual amount of agricultural waste is approximately 61 million tons. However, about 41 million tons of residues that can produce 426 PJ of energy are still unused.

The most significant energy sources of biomass in Thailand are forestry and agricultural residue. Rice husk, bagasse, oil palm residue, forest industry, and residential are the major sources with high availability that contributed to high feasibility of heat-power co-generation (Rikke, et al., 2011). The technology used for biomass which is direct and thermo-chemical combustion is the most applicable methods used in commercial heat and power generation. In the past five years, bagasse and rice husk were among the most widely available biomass materials. Other agricultural products having high potential for energy production are cassava roots, coconut, and palm products. From the REDP, biomass is considered the main potential renewable energy with the existing 1,644 MW electricity generation. Approximately 2,749 MW installed capacity has been planned for the year 2011. This capacity comprises 1,520 MW from rice husk, 395 MW from bagasse, 624 MW from fuel woods, and the rest 210 MW from other agricultural wastes.

However, many obstacles still need to encounter for the development of Thailand's biomass, e.g. poor raw material management from the severe competition and a risk to procure materials at reasonable prices has affected project viability considerably. Lack of knowledge on gas emission including environmental issues among local people is another drawback which has led to public resistance. Complicated and time consuming rules, regulations in obtaining permission, inadequate transmission line capacity, power, purchasing terms and price, mode and duration, and insufficient data on raw

material availability have also been drawbacks and affected high costs of investment. As such, the establishment of biomass development is not an easy task.

2.4 Biogas Energy

In Thailand, waste water and waste from industries, farms and communities have to be treated with waste water and waste treatment standard and measure before being discharged (Thawatch, 2013). Treatment by using Anaerobic Digestion will yield biogas that consists of 60-70% by volume of Methane Gas (CH_4), 30-50% of Carbon dioxide Gas (CO_2) and a small portion of Ammonia (NH_3), Hydrogen sulfide (H_2S) and water vapor. Biogas can be used to replace conventional fuels like heavy oil or firewood. Moreover, biogas production from anaerobic digester presents the additional advantage of treating organic waste and reduces the environmental impact caused by these wastes. It contributes to a better image of the agro-industries and farming community while reducing odor, pathogens and weeds from the manure and producing an enhanced fertilizer that can be easily assimilated by plants.

At present, biogas energy is normally used for producing heat and generating electricity for supplying to manufacturing process and also selling to the grid. In 2007, about 10,000 food factories and 20 million heads of livestock in Thailand generated wastes and wastewater suitable for biogas production. The existing power generation from biogas is 66.15 MW and 243 ktoe for thermal use. Most is from wastewater treatment of cassava and crude palm oil industry and swine manure. Ministry of Energy plans to increase the power generation to 60 MW and the thermal/heat generation to 470 ktoe from the remaining swine manure, cassava and palm oil wastewater. This expands to include new industries such as ethanol, food and rubber by the year 2011.

The current capacity of biogas power plants is approximately 159.17 MW and the target to be reached in 2021 is 600 MW. For producing heat, the current capacity is approximately 421.34 ktoe and the target to be reached in 2021 is 1,000 ktoe. In 2011, the power generation from tapioca, food, oil palm, ethanol industries and livestock farms was accounted for 191.58 MW. Biogas energy consumption in commercial electricity generation was 89.0 MW for On-Grid and 70.17 MW for Off-Grid. Therefore, the total utilization reached at 159.17 MW and the target of 2012 and 2021 are set at 194.57 and 600 MW, respectively.

Table 3. Estimate of viable renewable energy power under expected feed-in policies. (**Source**: Ministry of Energy. (2012))

Renewable energy power	Installed capacity (MW)		
	2005	2011	2016
Biomass residues	2191	3229	4938
Biogas for heat and power	4	519	384
Small hydro	53	338	338
Wind	0	194	1783
Solar PV	26	60	120

2.5 Other renewable energy technologies

Other renewable energy such as geothermal, wave energy has low significant potential compared to other renewable energy.

3. Potential of combined heat and power in Thailand

Many researchers investigated that Thailand has lots of potential for the implementation of combined heat and power system by making the effective use of waste heat from the combustion processes used to generate the electricity One of the effective results was from the studies by the Thai Ministry of Energy's Energy Planning and Policy Office (EPPO) and carried out by the Joint Graduate School on Energy and Environment (JGSEE). The study estimated the quantity of commercially viable new CHP in 817 existing factories and 966 existing commercial buildings located in areas that will be served by planned Thai natural gas pipeline expansion (Wantana, 2011). The study is likely to underestimate potential by year 2015 because (a) it overlooks opportunities for CHP in large government buildings, residences, etc; (b) because the study disregards hundreds of potential industrial and commercial sites for which data was incomplete; and (c) and because the study considers only existing buildings and not new facilities that will be built by 2015. Results derived from preliminary study findings are shown below in Table 4. Commercially viable CHP new potential capacity is estimated to be 3,271MW (The European Commission (EC), 2010; Greacen, 2007).

It is also founded that in commercial buildings, the study considered small CHP units (<5MW) using gas engines together with absorption chillers. MW and GWh reductions thus come from two sources: first, electricity is directly produced by the CHP unit offsetting local loads and contributing excess electricity to the grid; second, waste heat is used to drive absorption chillers that substitute for electrically powered air conditioning. This paper assumed that heat-driven absorption chillers have a coefficient of performance (COP) of 0.75 and replace electric air conditioners that have a COP of 2.8. CHP in commercial buildings is assumed to run 3,500 hours per year, and is dispatched according to air conditioning needs in the building. Since Thailand's peak electricity consumption is also driven by air conditioning, this overlap is perfect for reducing Thailand's peak generation requirements. Also for the case of factories, the study considered natural gas combustion engines and gas turbines with waste steam used to offset natural gas, heavy fuel oil, or coal in steam boilers.

From the study results of Wantana S. et al. (2011) illustrated that at present, the potential of cogeneration system for buildings in the city is impossible to reach with the existing gas pipeline, however, if the natural gas pipeline extension plan within year 2020 is successful, the development of cogeneration system in both commercial and industrial sector can be developed successfully. Also, concerning the current small power plants (SPP)

Table 4. Estimate of commercially viable power and energy saving through CHP in commercial buildings and industry. (**Source**: The European Commission (EC), 2010.)

Type of facility	No.	Commercially viable CHP generating capacity (MW)	Peak load offset through avoided electrical A/C demand (MW)	Total (MW)	Total energy saving (GWh/yr)	Payback period (yr)
Factories	817	2771	0	2771	30667	3-5
Commercial buildings	966	500	147	647	1354	5-6
Total (commercial viable)				3418	32021	

regulation schemes in Thailand which are adopted from EU CHP Directive, the generator will get support “adder” at maximum rate of 0.0103 US$/kWh if the system presents overall efficiency of CHP ≥ 45% and Primary Energy Saving (PES) ≥ 10%. It is noticeable that overall efficiency of the system used in Thailand is much lower than the efficiency benchmark in EU Directive, which is around 75–80% depending on the type of plant. It is acceptable for operating plant in Thailand to have lower system efficiency than operating plant in Europe because of the climate condition and technology development. However, setting up the benchmark at 45% efficiency would be too low to achieve high efficiency CHP utilization. It is recommended that the benchmark of overall efficiency at 45% should be improved in order to move into the right direction in promoting real CHP with high efficiency and primary energy saving. In addition, one of the main obstacles for the construction of city gas pipeline in Thailand is about the public concern because Thai people never have the experience about the city gas pipeline and do not have enough understanding of the system regarding its safety and reliability. Therefore, to convince people to accept this new city gas, the government should provide more information about reliability of the technology and show some experiences from other developed countries and advantages that can be obtained. The authors stated two typical examples of applying cogeneration in public buildings, certainly very typical for Thailand –Suvarnabhumi Airport (Main airport in Thailand) and new government office building complex.

In case of Suvarnabhumi Airport, the District Cooling System and Power Plant (DCAP) is designed for supplying electricity, steam and chilled water for cooling purposes at the airport area with a total capacity of 52.5MW electrical power and 25,240 RT (88,765kW) of cooling. The improvement of plant efficiency by replacing old gas turbines with new ones provides overall efficiency improvement of 10% and results in the significant amount of primary energy saving by 24% and CO_2 emissions reduced by 27%. After improvement, the system also provides greater amount of electricity which can be sold to the grid. More revenue has increased the profit to 24.80 Million US$ and results in shorter payback period. The efficiency improvement then benefits in both environmental and economic aspects.

In case of new government office building complex, the cogeneration plant in the new government office building complex which was designed to supply electricity and cooling for the building complex. The building complex is comprised of offices, restaurants, shops with the main office buildings open from 8:00AM to 5:00PM from Monday to Friday. The plant is natural gas based cogeneration with 9.9MW electricity and 6,000 RT (21,000kW) cooling capacity. The total air conditioned area is 500,000 m^2 out of totally 1,000,000 m^2 belonging to building complex. The purpose of cogeneration in this building is to present the concept where the operation mode which can be flexible by applying chilled water storage tank. The chilled water storage tank can fulfill peak demand during peak period and/or at most critical times. Based on financial calculations for this case study, it can be concluded that operating hours both for gas turbine and absorption chillers are important factor that influences the economics of the project. Plan 5 generates the largest profit with an increase of 1.27 Million US$/a in relation to base case and shorter payback period (9.18 years). It can be concluded that the operating time of absorption chillers and gas turbines requires long period of operation to get the most revenue from chilled water and electricity production, leading to best benefits. The more electricity and chilled water produced, the more profit and better payback period will be achieved. Unfortunately, the time of office buildings usage is limited to 8:00–17:00 h. These are rather low operating hours for the cogeneration plant to achieve its maximum profits under such circumstances.

4. Barriers of the implementation of distributed energy resources in Thailand

Even though much progress has been made to the adoption of distributed energy resources, however, several major hurdles still remains, including nontechnical barriers that technology improvements can only partially address (Greacen, 2006). Although the long-term goal is a plug-and-play interconnection system, this goal may primarily apply to smaller DER units with less complex interconnection schemes (Chris, 2007). Larger DER units typically have more stringent utility interconnection requirements as well as greater siting complexity. Thus, there may eventually be two distinct DER markets: one for type-tested, plug-and-play, residential and small commercial units and one for larger site-specific DER units. Regardless of these market categorizations, functional compatibility of interconnection technology architecture and components among different manufacturers and vendors would prove fruitful.

Because the distributed energy resources system in Thailand is not widespread for whole country, the management and technology utilization are one of the key parameters in order to implement the DER system.

For example, the integrated power electronics technology that provides the foundation of the interconnection package is advancing quickly, with functional performance available today that was not possible even a year ago. Developments in digital design and advanced processors have boosted performance to impressive levels, and a convergence of software and hardware engineering is equipping state-of-the-art digital technology to provide protective relaying and coordination functions at lower cost and higher reliability.

As mentioned in previous section, in order to develop the DERs integrating with CHP system in the city, the distributed of city gas pipeline is the main parameter that need to be done as the first priority. Also, the problems about CHP policy, prices, and public concern should be followed for the implementation. For example, the awareness of the city gas pipeline should be well understood for the users in order to guarantee the safety and reliability. Therefore, to convince people to accept this new city gas, the government should provide more information about reliability of the technology and show some experiences from other developed countries and advantages that can be obtained. Public relations for the city gas plan should be taken as the first priority. As an alternative of the development plan, the central CHP district cooling at the outskirts of Bangkok close to the city is also an option. Since the main natural gas pipeline is already there, implementation of chilled water or heat distribution network will be easier and cause less stress to people than implementing gas pipeline network in the city.

The government should make a serious study regarding this option. Nevertheless, in order to promote cogeneration in buildings within existing building categories based on energy demand, designated buildings, particularly those located close to natural gas pipeline network, should be encouraged to consider cogeneration plant as their first choice energy supply because of energy efficiency and because it is a secure supply source (Greacen, 2007). Furthermore, for the investor of CHP system should be concern the challenging to make investment decisions in a rapidly changing policy and economic environment. Uncertain factors affecting project economics include: fuel and electricity prices, regional/national economic conditions, market sector growth, utility and power market regulation, and environmental policy. Sizing the CHP system to maximize efficiency in many industrial facilities (i.e., thermal match) often produces power in excess of the host site's needs, introducing the added market risk of power pricing to a consumer usually in a different core business.

For the barriers to the development with DERs with RE system, first is about cost of renewable energy which would be the incremental financial costs between RE and fossil fuels. Consequently, price-based policies that either put a price premium on RE or tax fossil fuels are most effective to scale-up RE (Thawatch, 2013). The costs and tariffs for small hydro, wind, and solar energies in Thailand are substantially higher than those in other countries. The government is quite concerned that the high costs of RE would increase financial burdens on consumers, and maintains a ceiling on the increase in consumer electricity prices. Therefore, future RE development in Thailand needs to focus on cost reduction.

For the consideration of biomass energy, the most abundant RE resource in Thailand at an affordable cost, and is the largest contributor to the RE target for heating, transport fuels, and power in the REDP. But it ran into difficulties with fuel supply. Balancing food and energy security is a key challenge for biofuel supply in the transport sector. To that end, biofuel policies need to coordinate energy and transport policies with agriculture, forestry, and land-use policies to manage the competing demands of water and land for food. If energy crops take land away from agriculture, the "medicine" of the requisite interventions might be worse than the "disease" in the sense that mitigation might heighten climate risks. In addition, biomass has been falling behind other RE resources in recent years, due to the shortage of materials for larger, and hence, a more economic, scale of power plant. Given that large-scale biomass plants are mostly built, the future trend is going to be small-scale biomass plants. But these plants face the challenges of insufficient fuel supply, unproven technologies, and a lack of community awareness (Chingulpitak & Wongwises ,2014)

5. Current status of power generation utility in Thailand

5.1 Electricity generating authority of Thailand (EGAT)

The Electricity Generating Authority of Thailand is the state enterprise under the Ministry of Energy. EGAT presently manage most energy production in Thailand including builds, owns and operates the power plants, and also purchases electric power from private power companies and neighboring countries (National Science Technology and Innovation Policy Office (STI), 2012). Under the national long-term power development plan (PDP 2010), EGAT and private power producers were implemented power projects, imported capacity from neighboring countries, as well as transmission system development projects to timely accommodate the power expansion programs as the following (The European Commission (EC), 2011):

- During the short-term period of 2010 - 2015, new power projects totaling 3,234.70 MW will be developed by EGAT comprising 4 natural gas-fired combined cycle power projects totaling 3,070 MW, and 18 renewable energy projects totaling 164.70 MW

- The power purchase from small power producers (SPPs) using cogeneration systems or renewable energy technologies. Under the government's 2007 Regulation for the Purchase of Power from SPPs, the purchase capacity from SPPs during 2010 - 2014 is 1,919 MW consisting of 1,604 MW from firm energy contract SPPs using co-generation systems and 315 MW from SPPs using renewable technologies. For the 2015 - 2021 periods, the purchase capacity from SPPs (under the 2010 Regulation) will increase to 3,500 MW in response to the government's policy to promote power generation using cogeneration systems.

- The development of new transmission system to increase the capability of transmission lines and ensure the continuity and reliability of the power supply system. A number of transmission system interconnection projects have also been developed to receive electric power from domestic IPP projects as well as IPP projects in neighboring countries.

- Development of REDP (Renewable Energy Development Plan) and renewable energy generation such as Wind Turbine Power Plant at Lam Takhong, Wind Turbine Power Plant at Promthep Alternative Energy Station, Solar Power Plant at Pha Bong, and Solar Power Plant at Sirindhorn dam. Development of small hydropower projects at existing dams of the Royal Irrigation Department (RID) since 2004 in order to maximize the utilization of water resource with hydropower generation.

5.2 Independent power producer (IPP)

Since 1992, the government promoted private sector to participate in the generation business in order to promote the competition of power industry in the form of Small Power Producers (SPPs) and Independent Power Producers (IPPs) and need to sell electricity to EGAT that subsequently transmits to the distributors.

5.2.1 Small Power Producers (SPPs)

SPP generators are divided into two categories: firm and non-firm, depending on their ability to guarantee availability. Firm fossil fuel-fired SPPs must generate for at least 7,008 hours per year and must generate during the months March, April, May, June, September and October. SPPs could sell up to 90 MW of capacity and employ Combined Heat and Power (CHP) or Cogeneration systems burning conventional fuels (i.e. natural gas and coal) or renewable technologies using non-conventional resources (i.e. waste, agricultural residues, biomass and solar energy) to generate electricity.

For the renewable energy production from SPPs, government was implemented the "adder" incentive in order to encourage the power generation from RE sources. According to PDP 2010, the total purchase capacity from SPPs using renewable technologies during 2010–2015 is 1,045 MW comprising 315 MW of Firm Contracts and 730 MW of Non-Firm Contracts.

For the Cogeneration system from SPPs, National Energy Policy Council (NEPC) had a resolution to promote power generation by cogeneration system in 2009 which aimed to receive power from Cogeneration SPPs under Firm Contract up to 2,000 MW in 2015 – 2021 and more in the future year. As of January 2010, the contract capacity of 50 potential SPPs using cogeneration system was 3,600 MW comprising 3,391 MW Firm Contracts (43 projects) and 209 MW Non-Firm Contracts (7 projects). Among these, only 31 projects with a total capacity of 1,956 MW were commissioned including 25 Firm Contracts (1,788 MW) and 6 Non-Firm Contracts (169 MW). The other 19 upcoming projects consisted of 18 Firm Contracts (1,604 MW) and 1 Non-Firm Contract (40 MW). Both IPPs and SPPs have long-term power purchase agreements with EGAT as the single buyer. The Power Purchase Agreements allocate market risk to EGAT (and its captive ratepayers) leaving SPPs and IPPs to manage the operating and fuel price risks. SPP contracts are between 5 and 25 years with terms and specifications set by EGAT, the national power monopoly. EGAT has defined two types of purchasing rates for buying SPP power, non-firm and firm power.

5.2.2 Very Small Power Producers (VSPPs)

For the renewable energy system, the Very Small Power Producers (VSPPs) are private power producers selling electricity to the Metropolitan Electricity Authority (MEA) or the Provincial Electricity Authority (PEA) with generating capacity of less than 10 MW. They can be Combined Heat and Power (CHP) or Cogeneration systems or renewable technologies using non-conventional resources (i.e. waste, agricultural residues, biomass, and solar energy). Considering the advancements and high potential of renewable technologies, it was found that VSPPs using renewable energy are also feasible for the generating capacity greater than 1 MW. As a result, NEPC agreed to enlarge the VSPP's contract capacity from 1 MW to 10 MW in 2006. As well as SPPs using renewable technologies, all VSPPs are eligible for the "Adder" scheme. It was anticipated that power generation from renewable energy would increase dramatically and be strategically important to the sustainable development of the country. On 6 December 2006, the government approved the Adder Rates for ≤10 MW VSPPs that supply power to the grid, at the following "fixed rates" (Table 5):

Table 5. Fixed rate of adders which categorized by fuel type

Fuel/Technology	Adder (Baht/kWh)
Biomass	0.30 (US$ 0.88)
Biogas	0.30
Mini-hydro (50-200kW)	0.40 (US$ 1.18)
Micro-hydro (<50kW)	0.80 (US$ 2.35)
MSW	2.50 (US$ 7.35)
Wind	2.50
Solar	8.00 (US$ 23.53)

Remarks: 1) PEA/MEA announcements issued on 1Feb07 and 2Feb07 respectively
2) VSPPs must submit the proposal to sell electricity by Dec 2008
3) Rate used: 34Baht/US$

Considering the cogeneration system from VSPP, the "National Power Development Policy and Plan" which enacted in 2006 was support energy conservation and efficiency through a suitable purchase from cogeneration SPPs, regarding the Regulations for the Purchase of Power from SPPs and VSPPs. The promotion scheme encourages power purchase from VSPPs using cogeneration system with unlimited duration and capacity. However, the purchased power from cogeneration VSPPs assembled in PDP 2010 is only 113 MW as estimated by distribution utilities.

From the above information, IPP, SPP and VSPP schemes are essential parts to promote the distributed energy generation and power producer and eventually to support the development of Smart Grid in Thailand. Therefore, the promotion and improvement of policy for IPP, SPP and VSPP is inevitably necessary as infrastructure for smart grid development and deployment in Thailand. From the revised Power Development Plan (PDP) 2010 to 2030 assumes that SPPs and VSPPs will supply small but significant renewable generation and cogeneration capacity. From 2012 to 2020, small and very small producers are projected to account for approximately 9.5 GW (with 5GW from cogeneration and 4.5 GW from renewable energy) of growth generating capacity. Therefore, in order to put the growth in this context, the government has announced plans for policy adjustments to support these targets since 2011, including the transitioning from the adder for renewable generation to a fixed-price tariff system, preparing for development of DERs and smart grid transmission system which should also consider promoting research and public education for renewable energy generation.

References

Chingulpitak, S., & Wongwises, S. (2014). Critical review of the current status of wind energy in Thailand. *Renewable and Sustainable Energy Reviews 31 (2014)*. 312-318.

Chris, G. (2006). *Decentralizing Thai Power: Towards a sustainable energy system.* Greenpeace Southeast Asia: Chonburi Province, Thailand.

Department of Energy Affairs. (2001). *Wind resource assessment of Thailand. Final report.* Central Press: Bangkok, Thailand.

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. (2013). *Final reports of electricity generation from Thailand's solar panel*. September 2013.

Electricity Generating Authority of Thailand (EGAT). (2010). *Summary of Thailand power development plan 2010-2030 (PDP 2010)*. Retrieved from https://www.egat.co.th/en/images/about-egat/PDP2010-Rev3-Eng.pdf

Elliott, D., Schwartz, M., Scott, G., Haymes, S., Heimiller, D., & George, R. (2002). *Wind Energy Resource Atlas of Southeast China*. U.S. Department of Commerce National Technical Information Service: Springfield.

Greacen, C., & Bijoor, S. (2007). *Decentralized Energy in Thailand: An emerging ligh*t. Unit for Social and Environmental Research (USER) - Chiang Mai University. International Rivers: Oakland CA 94612, USA.

Kerdchuen, T. (2013). Renewable Energy in Thailand: Opportunity and Technology Allocation. *Energy Procedia, 34*, 13-16.

Lybaek, R., Andersen, J., Hansen, O.E., & Kjaer, T. (2011). Improving the Framework Conditions for CDM in Thailand. The Journal of Transdisciplinary Environmental Studies, 10, no. 1.

Ministry of Energy. (2012). *Research and Development in the field of Energy Conservation and Renewable Energy in Thailand*. Department of Alternative Energy Development and Efficiency (DEDE): Bangkok, Thailand.

National Science Technology and Innovation Policy Office (STI). (2012). *Thailand: Technology needs Assessments report for climate change, mitigation.* United Nations Publication: Bangkok 2012.

Papong, S., Yuvaniyama, C., Lohsomboon, P., & Malakul, P. (2004). *Overview of Biomass Utilization in Thailand*. National Metal and Materials Technology Center: Bangkok, Thailand.

The European Commission (EC). (2010). *Enhancing Institutional Capacities for the Market Development of Decentralized Energy Systems in Thailand.* The Energy Conservation Center of Thailand (ECCT).

The Joint Graduate School of Energy and Environment (JGSEE). (2007). *Energy policy research project to support the development of renewable energy and energy efficiency in Thailand*. Retrieved from https://www.jgsee.kmutt.ac.th.

Samudrala, S., & Gonzales, A.D. (2010). *Enhancing Institutional Capacities for the Market Development of Decentralized Energy Systems in Thailand*. Retrieved from http://www.techmonitor.net/tm/images/3/31/10may_jun_sf5.pdf

Somcharoenwattana, W., Menke, C., Kamolpus, D., & Gvozdenac, D. (2011). Study of operational parameters improvement of natural-gas cogeneration plant in public buildings in Thailand. *Energy and Buildings 43,* 4(April 2011), 925-934.