Thailand's Experiences with Clean Energy Technologies: Power Purchase Programs[]

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Abstract

Thailand is endowed with abundant renewable energy resources, especially biomass, but is currently heavily dependent on fossil fuels which account for 80% of the total primary energy consumption and 91% of the electricity production in 2001. While the utilization of solar energy, wind energy and small-scale hydropower is limited due to high investment costs or limited potential within the country, Thailand's vast biomass potential has been partially exploited through the use of traditional as well as more advanced conversion technologies for biogas, power generation, and biofuels. The Energy Conservation Promotion (ENCON) Fund has several projects that promote these clean energy technologies.

The main policy that has been adopted is the Small Power Producer (SPP) Program, allowing cogeneration or renewable energy generators to sell power to the grid. So far 1,970 MW of electricity is sold to the grid by SPPs, but only 9% of the capacity is generated from renewables. Consequently, the government has approved a subsidy program using money from the ENCON Fund to promote more investment in renewables-based power generation. 31 new SPPs (totaling 511 MW) have been selected to receive the subsidy, pending organization of a public hearing process. In addition, the government recently approved the net metering and stream-lined technical regulations to facilitate the interconnection of small-scale (<1MW) renewable generators to the grid. Through these power purchase programs, renewable generators can sell electricity to the electric utilities at rates that are favorable.

There have been changes to the pricing formula and other terms in the power purchase regulations in response to changing economic conditions, particularly after the economic crisis in 1997. Without these changes, many projects would not have been viable. But there remain challenges ahead before Thailand fully realizes its renewable energy and advanced clean technology potential. Well-targeted training, R&D, incentive programs are needed to overcome barriers to the adoption of clean energy technologies. Cooperation at the regional level in the form of information and expertise sharing as well as local manufacturing market development can help accelerate Thailand towards the goal.

Keywords: Thailand, Clean energy technologies, Renewable energy, Small Power Producers (SPPs)

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Contents

1. Introduction

Thailand is currently heavily dependent on fossil fuels for energy consumption, with oil, gas, and coal being the predominant energy sources, accounting for 80% of the total primary energy consumption in 2001. Nevertheless, a large potential exists for the production and exploitation of clean energy in Thailand. Thailand is generously endowed with abundant renewable energy resources such as biomass, solar, and hydro energy, which are widely distributed across the country and can be harnessed via commercially viable technologies to generate energy or electricity. Thailand, however, has so far exploited relatively a small portion of its full potential. The total commercial power generation potential, for instance, from the abundant biomass residues, has been estimated at around 1000 MW[1] whereas the current installed capacity is around 476 MW[2], of which 176 MW is exported to the grid from Small Power Producers (SPPs) (See Table 4). Moreover, the majority of the potential is utilized in inefficient ways, which often cause environmental problems.

It has been recognized worldwide that enormous utilization of fossil fuels has created various adverse effects on the environment, such as air pollution, acid rain, and green house gases. In light of this, interest in clean energy technologies in Thailand has been growing steadily over the past twenty years. This interest has been given particular attention due to a number of concerns over the use of conventional energy technologies and their environmental impacts. The impact of emissions of sulfur dioxide (SO_2) has been one of the major environmental concerns in Thailand especially during the 1990s. The amount of emissions of SO_2 from the energy sector was 1.1 million ton (Mt) in the early 1990s and subsequently declined to 0.34 Mt in 2000 mainly thanks to improvements in the power sector. [3]

Thailand ratified the United Nation Framework Convention on Climate Change (UNFCCC) in 1994 and later signed but not yet ratified the Kyoto Protocol. Though the impact of greenhouse gas (GHG) emissions has not been one of the major environmental concerns in Thailand, GHG emissions have been given particular interest in recent years. In 1998, the amount of GHG emissions from the energy sector was 152 million tons of carbon dioxide (CO_2)-equivalent, accounting for 51% of the total net greenhouse gas emissions.[4] The amount of GHG emissions from the energy sector was estimated around 2.5 tons of CO_2-equivalent per capita in 2000 and is projected to increase from 148 million tons of CO_2-equivalent in 2000 to 361 million tons of CO_2-equivalent in 2020.[5]

In addition to its concerns over the impact of fossil fuels being the main driving factor for cleaner energy, Thailand, being an oil importing country, has been severely affected by oil price volatility in recent years. In order to reduce dependency on oil import and to ensure the national energy supply security and sustainable energy development, Thailand's energy policy has placed greater emphasis on diversification of energy supplies. Several programs have been set to boost indigenous renewable energy resource development, in particular biomass, biogas, solar and small-scale hydro energy technologies.

The Thai government has formulated and employed policies and initiatives in order to overcome in particular financial and institutional barriers to clean and renewable energy development and implementation. One such initiative which has had a significant impact in Thailand is the introduction of the Small Power Producers (SPPs) Program.

This paper reviews Thailand's current energy situation (Section 2), potential for clean energy and experiences with clean energy technologies (Section 3), with an emphasis placed on the promotion of clean energy technologies through the SPP program and other power purchase programs in Thailand (Section 4). The prospects for regional cooperation in clean energy technologies are also recommended in Section 5.

2. Energy Situation in Thailand

Currently there is no Ministry of Energy in Thailand. Responsibilities related to energy are scattered across 9 Ministries. The National Energy Policy Council (NEPC), chaired by the Prime Minister and comprising relevant ministers and government agencies, is responsible for determining energy policy. The National Energy Policy Office (NEPO) acts as the secretariat to the NEPC and undertakes policy as well as regulatory work. The current government, however, has a plan to establish the Ministry of Energy in October 2002. And in the near future, an independent regulatory authority will be set up for the energy sector.[6]

With regard to the overall energy sector, Thailand's primary energy consumption increased from 50 million tons of oil-equivalent (Mtoe) in 1982 to 76.1 Mtoe in 1997 and subsequently decreased to 71.4 Mtoe in 1998 due to the Asian financial crisis. The primary energy consumption rose again to 79.8 Mtoe in 2001, an averaged increase of 1.8% from 1997. Thailand is currently heavily dependent on fossil fuels accounting for approximately 80% of the total primary energy consumption in 2001 (See Figure 1). Petroleum alone dominated nearly half of the total energy consumption. Renewables accounted for about 18% and the remaining 2% included hydro power and electricity imports. About 48% of the total primary energy consumption was supplied by imported energy resources, with oil accounting for about 89% of the total import of commercial primary energy in 2001 (See Table 1). As for the final energy consumption by sector, the transportation and industrial sectors were the most energy consuming sectors in Thailand, accounting for 39% and 35% of the total final energy consumption in 2001, respectively. The rest were contributed by the residential and agricultural sectors.

For the electricity sector, the supply in Thailand is overseen by three state-owned utilities. The predominant generating capacity as well as transmission facilities are owned by the Electricity Generating Authority of Thailand (EGAT). The responsibility of distribution in Bangkok, Nonthaburi and Samut Prakan is undertaken by the Metropolitan Electricity Authority (MEA), whilst distribution for the rest of the country is overseen by the Provincial Electricity Authority (PEA). EGAT owns and operates the majority of the power generation capacity in Thailand, but also buys electricity from private power producers through the Independent Power Producer (IPP) and Small Power Producer

(SPP) programs. EGAT then sells the electricity to some direct customers and to MEA and PEA for distribution to end-users.

Thailand has seen rapid power demand increase during the past two decades owing to the rapid economic expansion. The electricity consumption increased from 16,900 Gigawatt-hour (GWh) in 1982 to 82,000 GWh in 1997. The peak power demand grew from 2,838 MW to 14,506 MW during the same period. Thailand's financial crisis in 1997 however resulted in a decline in power demand in 1998 and early 1999, but the demand has picked up again. The peak power demand this year (2002) was 16,681 MW, an increase of 3.44% from last year, while the total electrical energy consumption in the last fiscal year (FY 2001) was 92,866 GWh, an increase of 6.0% from last year.[7]

To serve the country's demand for electricity, Thailand has a total installed generation capacity of 22,034 MW as of 2001. Electricity production is predominantly based on thermal and combined cycle generation, with natural gas accounting for 69% and lignite/coal about 20%(FY 2001 statistics). The remaining is made up of 6% large-scale hydropower, 2% fuel oil, and 3% others (mainly imports from Laos and less than 1% from renewables).[8] Industrial co-generation (combined heat and power) for the FY 2001 accounts for 10,024 GWh or about 10% of total electricity supplied to the grid.[9]

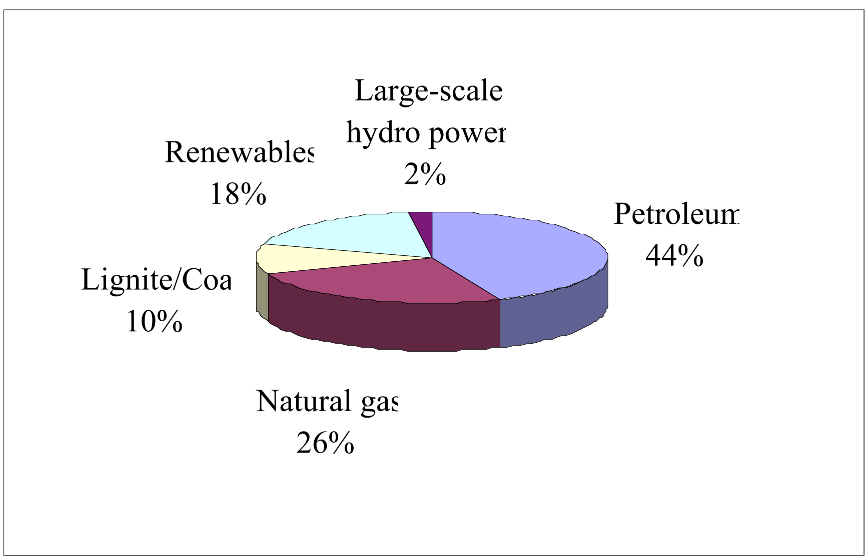

Figure 1: Primary Energy Consumption by Fuel Type (2001)

Table 1. Production, Net Import and Consumption of Primary Energy (Million tons of oil equivalent)

	1998	1999	2000	2001
Production	**39.4**	**41.1**	**43.4**	**42.1**
Comercial primary energy	**26**	**27.2**	**29.3**	**27.6**
Crude oil	1.5	1.7	2.9	3.3
Condensate	2.1	2.3	2.4	2.1
Natural gas	15.2	16.8	17.5	15.5
Lignite	6	5.7	5.2	5.3
Hydro	1.1	0.8	1.3	1.4
Renewables	**13.5**	**14**	**14.1**	**14.5**
Net Import	**32.6**	**35.1**	**34.6**	**38.1**
Comercial primary energy	**32.6**	**35.1**	**34.6**	**38.1**
Crude oil	33.9	34.5	32	33.8
Condensate	-0.8	-0.6	-0.2	-0.2
Petroleum products	-1.7	-1	-1.6	-3.8
Coal	1	2	2.6	3.1
Hydro/Electricity	0.1	0.2	0.2	0.2
Natural gas	0	0	1.5	5
Consumption	**71.4**	**75.4**	**78**	**79.8**
Comercial primary energy	**58**	**61.4**	**64**	**65.2**
Petroleum products	34.3	36	35.8	34.7
Natural gas	15.2	16.8	19	20.5
Coal/Lignite	7.2	7.7	7.6	8.3
Hydro/Electricity	1.3	1	1.5	1.7
Renewables	**13.4**	**14**	**14.1**	**14.5**

Source: NEPO, unpub.

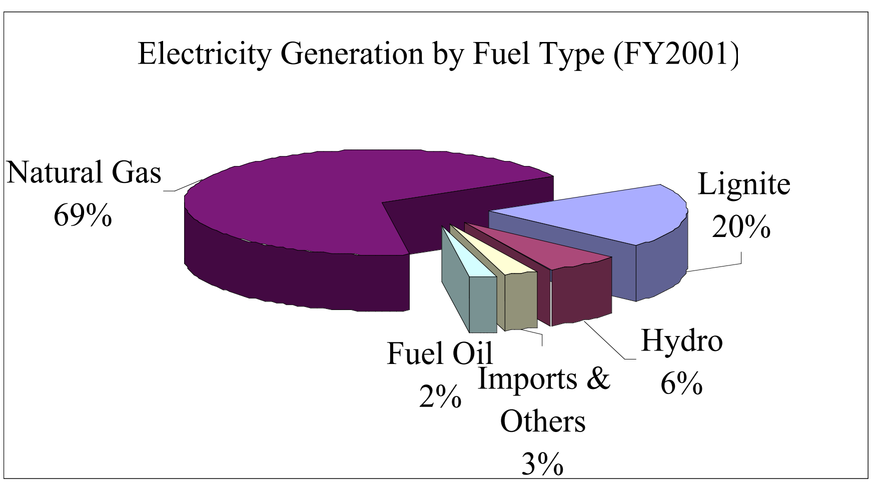

Figure 2. Electricity Generation by Fuel Type (FY 2001)

One of the major environmental impacts linked to energy production and use in Thailand is the air emissions generated from fossil fuel combustion in the transport, electricity and industry sectors. The environmental impact of SO_2 emissions released from the electricity and transportation sectors was of one of the major environmental concerns during the 1990s. In 1999, about 67% of the total SO_2 emissions were generated due to electricity production especially by lignite-fired power plants. In recent years, the amount of SO_2 emissions has declined chiefly due to improvements in the power sector such as the installation of Flue Gas Desulfurization Unit (FGD) in the lignite-fired plants and the increased percentage of using natural gas to replace fuel oil as fuel in the power sector (See Table 2). Emissions of SO_2 from the transportation sector also declined substantially during 1990s due to the improved specifications of diesel oil for vehicles. On the other hand, other air emissions, such as nitrogen oxides (NO_x), CO_2, carbon monoxide (CO) and particulate matter (PM10) have been fairly stable.

According to the National Clean Development Mechanism Study for the Kingdom of Thailand, the trend of CO_2 emissions generated from the energy sector is, however, projected to considerably increase in the future, from 140 Mt in 2000 to 351 Mt in 2020.[10] The majority of CO_2 emissions from the energy sector in Thailand is generated from fossil fuel combustion in the transportation and electricity sectors (See Table 3) where renewable energy and fuel switching is particularly promoted.

Although renewable energy has so far replaced a relatively small portion of fossil energy being utilized in the electricity sector and currently forms only about 1% of the electricity generation in Thailand, the environmental benefits of renewable energy are clearly recognized. The percentage of renewable energy use is expected to increase in the future mainly through the Small Power Producers (SPPs) Program and the subsidy program for SPPs (Section 4).

Increased use of natural gas in electricity generation in recent years has also contributed to slowed increase in CO_2 and SO_2 emissions. However, the country's currently level of dependency on gas has reached almost 70% of the total fuel mix for power generation. More dependency on natural gas is thus considered a risk as the country has limited gas reserve and the gas prices, indexed to oil prices and U.S. dollars, are quite volatile. As a result, the government's energy strategy still see the continued significance of coal, especially low-sulfur coal, in diversifying fuel risks and keeping electricity production costs low.

Although the planned increased use of coal will inevitably lead to higher emissions levels, the government has set aggressive targets for savings from energy efficiency and energy conservation programs and adoption of renewable energy technologies. According to the Strategic Energy Conservation Plan during 2002-2011, energy conservation and efficiency programs in factories and households are expected to save energy consumption by 1.2 Mtoe/year in the next 5 years, while similar programs for the transportation sector are anticipated to reduce consumption of oil by 2.8 Mtoe/year during 2002-2006. In addition, the programs for renewable energy technologies are projected to result in a large substitution for commercial primary energy by 11 Mtoe/year in the next 5 years.[11]

Table 2. Air Emissions from Energy Use and Production in the Transport, Electricity and Industry sectors (Mt)

Emissions	1998	1999	2000	2001	2002*	2005*
NO_x	0.7	0.42	0.42	0.43	0.46	0.52
CO	2.0	1.81	1.76	1.73	1.78	1.90
CO_2	142.8	142.9	139.7	139.5	150.2	171.8
SO_2	0.76	0.54	0.34	0.29	0.29	0.3
PM10	2.8	2.4	0.21	0.22	0.22	0.22

*These are projected emissions
Source: NEPO, unpub.

Table 3. CO_2 Emissions by Sector (Mt)

CO_2 emissions	1999	2000	2001	2002*	2005*
Electricity	54.6	55.4	54.2	56.8	66.2
Transport	57.4	57.3	57.6	60.5	72.4
Industry	30.9	27	27.7	33	33.3
Total	142.9	139.7	139.5	150.2	171.8

*These are projected emissions
Source: NEPO, unpub.

3. Thailand's situation in the area of clean energy technologies

3.1 Resource potential for clean energy, status and technology capabilities for clean energy production and use

In spite of Thailand's heavy dependence on fossil fuels for energy consumption, there is a huge potential for the production and exploitation of clean energy in Thailand. Thailand is generously endowed with renewable energy sources especially biomass, solar and hydro energy which are widely distributed across the country and can be utilized through commercially viable technologies to generate energy/power. Thailand's vast biomass potential has been partially exploited through the use of traditional and more advanced conversion technologies for power generation, biogas and biofuel while the utilization of solar energy and small-scale hydropower is limited owing to high investment costs or limited potential within the country, respectively. This section describes the energy resource potential, status and technology capabilities for clean energy production and use in Thailand. This includes biomass energy, solar energy, wind energy, hydro energy and cleaner fossil energy.

Biomass energy

According to a recent study on Assessment of Sustainable National Biomass Resource Potential for Thailand, many potential biomass sources were identified, including agricultural and wood residues, woodfuels, new plantations, waste water from livestock farms and industries, and municipal solid wastes.[12] In this paper, agricultural and wood residues and waste water are given particular attention.

Agriculture is a large economic sector in Thailand, generating large amounts of agricultural and wood residues. Rice, sugar, palm oil, and wood-related industries are the major potential biomass energy sources. It has been estimated that about 60 million tons of agricultural and wood residues including rice husk, bagasse, palm oil residues, and wood residues, etc. are produced each year in Thailand.[13] Currently, about 1 million ton of rice husk is consumed in rural households and 17 million tons of bagasse and rice husk are utilized as fuel for industries' heat and power requirements.[14] In addition, 12 million tons of fuel wood and charcoal are utilized in the rural households and mills.[15] Consequently, biomass contributes to about one-fifth of the final energy consumption in Thailand but, in general, a lot of biomass are still disposed of through open burning or dumping and are utilized in very inefficient manners, which often cause environmental problems.

The surplus availability of the residues was estimated around 40 million tons per year, which is equivalent to about 426 PJ of energy.[16] Most of these residues are cheaply available and the price of these residues including the transportation cost ranges from 0-500 Baht/ton. The potential for exploiting biomass residues for power production and cogeneration, other than those already identified, is appreciable. Aggregate commercial power generation potential from main residues including rice husk, bagasse, and palm oil residues is estimated to be around 1,000 MW.[17] Harnessing such potential is still constrained by factors such as inappropriate conversion technologies, high investment costs, other competitive uses of the residues, lack of information on the residues, etc. Since 1995, around 176 MW of electricity has so far been supplied to the national grid from 22 small power producers (SPPs) using biomass residues (See Table 7).

Biomass conversion technologies for power generation can be classified into three categories: traditional, state-of-the-art, and emerging technologies. Most of the existing technologies employed in Thai industries are traditional technologies which have been used for a long time without any technological barrier. System (boiler) efficiencies range from 50% to above 80% and have minimal environmental features to meet current environmental standards.[18] State-of-the-art technologies which are considered more efficient and environmentally-friendly than the traditional technologies are currently available in the market, with minimal developmental barriers, although its uptake is still limited to a few industries.[19] Thailand needs substantial support for local manufacturers for the development of high-efficiency biomass systems (including boilers and components). Boilers that are produced locally are for low-pressure operation (less than 20 bar) and thus yield low-efficiency. High-pressure boilers, turbines and biomass power equipment and components have so far had to be imported mainly from Europe and Japan. Emerging technologies are long-term technologies which require further research before commercialization. There is little information about the uptake of such technologies in Thailand on a pilot or demonstration scale.[20]

In addition to biomass residues, wastewater containing organic matters from livestock farms and industries has increasingly been used as a potential source of biomass energy. Biogas systems using anaerobic digestion techniques such as Upflow Anaerobic Sludge Blanket (UASB) and Fixed Film technology have substantially been established especially for pig farms and food processing industries. In general, the biogas systems can be locally produced and installed. The biogas technology has been rapidly and widely accepted particularly in both large and small-sized livestock farms chiefly because the production of biogas in the livestock farms helps alleviate not only the pollution problems but also the energy cost by substituting the on-site use of fuel oil, LPG or electricity.

The production potential of biogas from livestock farms in 2000 was estimated at 560 Mm^3. [21] According to a survey performed by Chieng Mai University in 2000, there are approximately 5.4 million pigs nationwide, 65% of which are in medium and large farms.[22] These farms have a high demand of power for various activities, such as the incubation of piglets, grinding of animal feeds, pumping of effluent etc. In 2001 the installation production capacity of biogas system using wastewater from the pig farms nationwide totalled 80,000 m^3.[23] A total capacity of 4.6 MW of electricity can be generated from biogas produced from approximately 20 large farms.[24] If all biogas produced from pig farms in Thailand is used for electricity generation, the power generation potential will be around 50 MW.[25]

The production potential of biogas from industrial wastewater from palm oil industries, tapioca starch industries, food processing industries, and slaughter industries is also significant. It was estimated that in Thailand a total of 440 Mm3 of biogas could potentially be produced from wastewater from such factories.[26]

To estimate the total power generation potential from biogas produced from both livestock farms and industries, it is assumed that 1 m^3 of biogas can produce electricity at 1.2 kWh[27] and the power generation is operated 8 hours a day. Thus, a total of 560 and 440 Mm3 of biogas produced from livestock farms and industries, respectively could potentially generate about 410 MW (See Table 4). There is thus a considerable potential for electricity generation from biogas from livestock farms and industries, though it is currently more likely that most farms and industries substitute biogas for the on-site use of LPG or fuel oil.

At present, most of the pig farms and food-processing factories use modified diesel engines for electricity generation. The technology has low upfront costs but requires frequent maintenance and a major overhaul every 3-5 years due to corrosion problems that are caused by the presence of hydrogen sulfide in the biogas.[28] More efficient and longer-lasting gas turbines technologies are available but have to be imported and cost 3-5 times more, so their adoption in Thailand is still limited.[29] There is thus a clear need to develop biogas-fuelled generation technologies that are reliable and low-cost, and to build up local capabilities to manufacture such technologies so that the use of biogas for electricity generation can be accelerated.

In addition to the use of biomass residues and wastewater containing organic matters for energy production, several efforts have in recent years been made to investigate the potential and use of biomass as bio-liquid fuels for engines and vehicles, which can replace the use of petrol and diesel oil and thus help to reduce dependency on oil import. Interest in using agricultural products, such as cassava for ethanol production, has been given particular attention.

According to the Ethanol-Biodiesel Club of Thailand, in 2001, the production of cassava amounted to 20 million tons while only 4 million tons were for domestic consumption and the rest was for export. The surplus of cassava was estimated to be 2 million tons per year which could be used for ethanol production of up to 1 million litre per day.[30]

The National Ethanol Committee of Thailand has recently approved 5 private ventures on ethanol production. A combined daily output of 875,000 litres of ethanol could be produced commercially by the middle of 2003.[31] Raw materials to be used in the production are cassava roots and molasses. Ethanol would be used to blend with petrol at 5.5% and 11%, and to substitute for methyl tertiary butyl ether (MTBE), a fuel additive.

Solar energy

Thailand is endowed with solar energy all year long. According to the Solar Map carried out by the Department of Energy Development and Promotion (DEDP) and Silpakorn University in 1999 [32], most areas in Thailand received maximum energy from the sunlight in April to May, ranging from 20-24 Megajoules (MJ)/m^2/day. The Northern region and part of the central region of Thailand annually received the most intensive energy with an average of 20 MJ/m2/day. These areas accounted for 14 % of the country's total area. In addition, about half of the total area received 18-19 MJ/m^2/day. For the whole country, the average energy from the sunlight amounted to 18 MJ/m^2/day. The potential for exploiting solar energy in Thailand is thus considerable.

Solar energy can be used in the form of thermal energy, via the use of solar collectors, and electricity, via solar cells or photovoltaic (PV) cells. For solar thermal energy, approximately 50,000 m^2 of solar collector surface areas have so far been installed.[33] An average increase of 2,500 m^2 is expected annually.[34] The solar water heating industry has been commercially established, with more than ten manufacturers in the market.[35]

During 2002-2006, it is expected that solar water heaters can be installed for 10,000 households, 20 hotels and 20 hospitals.[36] Promotion will be made on the use of solar dryers for 50 factories in the vegetable/food drying industry to reduce fuel oil or electricity consumption in the industry.

With regard to the PV technology for power generation, up to now about 5.5 MW PV for stand-alone and grid connected applications have been reported.[37] Most of them (95%) are in remote areas and are off-grid, such as solar cell battery charging stations and PV pumping for village water supply. Besides, there are projects demonstrating integrated systems of PV/wind turbine/diesel engine for power generation in national parks and wildlife sanctuaries. PV rooftops and grid supports are listed in the grid-connected category.

Although the PV technology has proved to be environmentally friendly, one major barrier to wider PV utilization is its high investment costs, about 4-5 times more expensive than the present average generation cost since most of the PV system components have to be imported. However, with the government support, coupled with worldwide stimulus for cleaner energy technologies, the future role of PV in power supply, especially in off-grid rural areas, is promising. At present, no less than 10 local companies are known to have activities or keen interest in PV-related business, such as module fabrication, system design and installation, local representatives of imported items, etc. And one company, Thai Photovoltaics Ltd., is setting up Thailand's first solar cell production plant using thin-film technology, and plans to begin its commercial operation in 2003 with a target of producing 20 MW/year of electricity-producing modules.[38]

During 2002-2006, it is targeted that 20 MW of the PV system will be installed.[39] Of this, 8 MW is expected to be stand-alone systems in remote areas for water pumping, mini-grid for primary schools and public health facilities, and traffic lights. Another 3 MW for factories, buildings, private homes and government buildings for on-site consumption and for selling excess electricity back to the utilities' systems, where a grid system exists. The remaining 9 MW will be grid support.

Wind energy

According to a report on wind resource assessment of Thailand done by the Department of Energy Development and Promotion (DEDP) in 2001 [40], there are good wind areas with an annual average wind speed of 6.4 m/s or higher at 50 m height . These areas are influenced by the monsoons and are located along the eastern coastline of the southern part of the Gulf of Thailand and in the mountains of the west and southern regions of Thailand. The fair wind areas with an annual average wind speed of 4.4 m/s or higher are mainly located on the west side of the Gulf of Thailand. At its present situation with limited potential and associated high investment costs, wind energy is unlikely to be a major potential source of energy for Thailand. There are currently two main types of windmills used in Thailand, according to their applications -- one is for water pumping for household uses in remote areas and the other is for electricity generation.

So far, only 192 kW of electricity produced from windmills has been installed in Phuket Province in the South of Thailand (See Table 4).[41] It is expected that by the year 2006 the development of wind energy for power generation can be achieved at an approximate capacity of 3-6 MW.[42] Support from the government will be given to research and development on equipment and materials related to wind energy and to develop appropriate types of wind turbines that are simple to operate.

Hydro energy

The Department of Energy Development and Promotion (DEDP) has been the main government agency involved in the installation of mini- (200 kW – 6 MW) and micro-hydroelectricity (<200 kW) turbines around hilly areas of the country.[43] Since 1983, 59 micro-hydro power generators sized under 200 kW have been installed in rural communities, mainly in the northern part of Thailand. The purpose of the program was to provide electricity to communities with no access to the grid electricity. The total installed capacity is approximately 2 MW but only half of the total capacity is now under operation.[44] The rest is now out of service due to disrepair or abandoned after the PEA has extended the distribution lines to these villages. In the past, the micro-hydroelectricity villages were not allowed to connect their systems to the PEA's grid, forcing the villagers to choose either the micro-hydroelectricity or the grid power. With the passage of the Regulations for the Purchase of Power from Very Small Renewable Energy Power Producers (see Section 4.4), these communities will more likely keep the micro-hydropower systems running as they can receive revenues from selling power to PEA. Besides the micro-hydroelectricity systems, the DEDP also has a number of mini hydropower facilities across the country. The electricity generated is either used for irrigation or sold to the grid.

The Electricity Generating Authority of Thailand (EGAT) plans to install 3 hydro power generators at 3 irrigation dams with a total capacity of 32 MW of electricity in 2004. Recently, the 3 projects have been selected for a subsidy on the energy payment from the ENCON Fund, pending organization of a public hearing process (See Section 4.2). In addition, with the possible support from the ENCON Fund under the Renewable Energy and Utilization Project, the DEDP plans to build or renovate mini and micro hydropower plants with a combined capacity of up to 45 MW within 2016.[45]

Cleaner fossil energy

Although Thailand relies heavily on fossil fuels, such as oil that is predominantly used in the transportation sector, and gas and coal utilized in the electricity sector, there is relatively little information and promotion about the uptake of advanced fossil fuel technologies in Thailand. Among fossil fuel-using power generation technologies, a few technologies such as combined-cycle and cogeneration have been in use in gas-fired power plants. The government's main policy has so far been channeled towards fuel switching and increasing use of cleaner fossil energy resources such as natural gas or low-sulfur content coal.

This policy is particularly encouraged in the transportation sector, which is the most oil consuming sector. To partly alleviate the air pollution problems from vehicle exhaust as well as to reduce dependency on oil import, switching of fuel from oil to natural gas in vehicles such as public buses and taxis running in Bangkok and metropolitan areas has been promoted. It is estimated that there are currently around 6,000 buses and 60,000 taxis running in the mentioned areas.[46] By the end of this year, as a demonstration project, around 80 buses and 1,100 taxis will be installed with conversion kits, enabling them to run on natural gas. A target of another 10,000 taxis is planned to install within 2007.[47]

For the electricity sector, natural gas currently accounts for 69 % of the total electricity generation while lignite accounts for about 20%. The percentage of the electricity generation by natural gas is already high. Increased use of imported coal with low sulfur content is encouraged so as to keep power production costs down and diversify fuel price risks.

Table 4. Resource and Power Generation Potential, Total Installed Power Capacity, and Cost of Electricity Generation

Technology	Resource potential[48] (per year)	Power generation potential (MW)	Total installed Capacity (MW)	Average cost of electricity generation (Baht/kWh)
Biomass power	40 Mton of residues	1,000[49]	476	2.0**
Biogas power	1,000 Mm^3 of biogas	410	4.6	1.8
Solar PV	-	20	5.5	9.5
Hydropower	-	77	2*	1.1
Geothermal	-	10-20	0.5	N/A
Wind power	-	10	0.2	7

* Including only micro-hydro generation capacity.
** Average purchase price of firm and non-firm renewable energy SPPs.
Source: NEPO 2001, *Strategic Plan for Thailand's Energy Development.*

3.2 Promotion of clean energy technologies

Among a number of supporting mechanisms, the following two supporting mechanisms play vital roles in promoting wider utilization of clean energy technologies in Thailand. The first mechanism is financial support for a wide range of projects using renewable energy while the other is focused on the power purchase programs for clean energy technologies for grid-connected systems.

3.2.1 Projects under the Energy Conservation Promotion Fund (ENCON Fund)

Renewable energy has many environmental benefits but the costs of harnessing renewable energy resources are still high compared with the costs of using commercial energy, especially fossil fuels. Consequently, the government has to take the role in promoting renewable energy technologies development, using financial support from the Energy Conservation Promotion Fund (ENCON Fund). Established in 1995, the Fund has provided Thailand with unique resources for supporting renewable energy and energy conservation projects in Thailand. Its revenues are derived from the premium rates imposed on domestically sold petroleum, a fossil energy, and channeled to support a wide range of projects on renewable energy and energy conservation. The Fund has to a certain extent helped to overcome financial barriers and opened up opportunities to implementation of renewable energy technologies as well as energy conservation in Thailand. Since October 1998, the premium rate has been adjusted from 0.01 to 0.04 Baht/litre and imposed on gasoline, diesel, kerosene and fuel oil. Currently, there is Baht 13,000 million in the Fund and its annual revenue is around Baht 1,000 million.

The Fund supports a great variety of projects, ranging from projects on improvement of energy consumption efficiency by using proven or existing technologies; projects on the introduction, demonstration, and dissemination of renewable energy technologies; research and development projects; to projects on enhancing a market of renewable technology equipment as well as projects on training, education and public relation.

The support from the ENCON Fund may be in the form of financial assistance or subsidy for the project expenditure, divided into two parts: project management and funding for project participants. Requests for financial assistance can be made by government agencies, state enterprises, educational institutions and non-profit organizations.

Projects in relation to renewable energy technologies supported by the ENCON Fund are divided into 4 major projects: (1) Renewable Energy and Utilization Project, (2) Industrial Liaison Project, (3) Research and Development Project, and (4) Promotion of Small Power Producers (SPPs) Using Renewable Energy Project (See Section 4.2)

As of September 2001, of the total 138 projects under the Renewable Energy and Utilization Project, Industrial Liason Project and Research and Development Project funded by the ENCON Fund since 1995, 36 projects have been completed, consisting of 3 Renewable Energy and Utilization projects, 4 Industrial Liaison projects and 29 R&D projects. The remaining 102 projects are still on going. Besides, there are 58 projects submitted for financial assistance and are currently under feasibility assessment.

Examples of the projects that have been implemented include promotion of biogas production from pig manure in large-sized and small farms, power generation from landfill, high-efficiency ceramic kiln, power generation using PV cells for schools outside the grid System, demonstration on solar energy utilization such as roof-top PV grid connected, solar city hall, solar water heater, establishment of "Energy Park", PV-pumping for village water supply, and demonstration on energy utilization from reuse and recycling of Waste.

3.2.2 Power Purchase Programs for Clean Energy Technologies

Along with support for renewable energy projects under the ENCON Fund, the government has introduced the Power Purchase Program from Small Power Producers (SPPs) (hereinafter referred to as "the SPP Program"). The program is the first government policy that has a significant impact on promoting the use of domestic renewable energy resources and energy efficiency technologies to generate and sell electricity to the national power grid. Started in 1992, the SPP program has resulted in a total of 3,469 MW of generating capacity already supplying power to the grid. Most of the capacity, however, comes from fossil-fuel based cogeneration systems. As a result, the government in May 2001 approved NEPO's proposal to provide subsidies for renewable SPPs using money from the ENCON Fund (hereinafter referred to as "the subsidy SPP program"). The conditions and terms of both the SPP and subsidy SPP programs are governed by the SPP regulations which have been revised several times in response to arisen problems and changing situations. The regulations are not however designed for very small renewable generators. To further support the use of renewable energy for electricity generation by small-scale (less than 1 MW) generators, the government recently approved the regulations for purchase of power from Very Small Renewable Energy Power Producers (VSREPPs), hereinafter referred to as "the VSREPP program". The VSREPP regulations allow for net metering arrangements and streamlined interconnection process and requirements so as to minimize the costs of connecting a VSREPP to the distribution systems. The SPP, subsidy SPP and VSREPP programs are discussed in more detail in Sections 4.1, 4.2 and 4.3 below, respectively.

4. Implementation of Power Purchase Programs for Clean Energy Technologies

4.1 Power Purchase from Small Power Producers (SPPs)

4.1.1 Overview and background of the SPP program

Prior to 1992, EGAT was entrusted with the sole responsibility of the generation and transmission of electricity for the whole country. The amendment of EGAT Act in 1992 opened up the opportunity for other private-sector companies to generate and sell electricity. Consequently the Small Power Producer (SPP) Program was introduced.

The objective of the SPP program was to[50]:

- encourage participation by SPPs in electricity generation
- promote the use of indigenous by-product energy sources and renewable energy for electricity generation
- promote more efficient use of primary energy
- reduce the financial burden of government investment in electricity generation and distribution.

Under the SPP regulations that were approved by the cabinet on 17 March 1992, EGAT would purchase power from generating facilities which produce power using the cogeneration systems or using renewable energy, such as waste or residues from agricultural activities, garbage, biogas, solar energy, as fuel. Qualified cogeneration systems must have a minimum combined electricity and heat efficiency of 45% and a minimum steam utilization rate of 10%. Renewable SPPs may use up to 25% commercial energy to supplement the non-conventional fuels. Each SPP project has the right to sell no more than 60 MW (or 90 MW on a case-by-case basis) of electricity to EGAT as well as selling directly to local customers resulting in their generation capacities often growing up to 120-150 MW.

The policy not only encouraged the use of residues and waste from manufacturing plants and agricultural activities, which contributed to more efficient use of domestic energy resources, but also alleviated the government's investment burden in the power generation and distribution system.

4.1.2 The SPP regulations

Qualified generators who would like to participate in the SPP program must abide by the Regulations for the Purchase of Power from Small Power Producers ("the SPP regulations" and the Regulations for Synchronization of Generators to the System of a Power Utility ("the technical regulations"). The SPP regulations govern the terms and conditions of power purchase while the technical regulations specify the technical requirements for an SPP to interconnect with a utility system.

Under the SPP regulations, there are two purchasing rates for the supply of electricity from two types of SPPs. "Non-firm" SPPs are paid energy payment which is determined from EGAT's short-run avoided energy cost. "Firm" SPPs, who can guarantee the availability of electricity supply during the system peak months and total production hours of no less than 7,008 per year for fossil-based SPPs or 4,672 per year for renewable SPPs, are entitled to both capacity and energy payments. The capacity and energy payments for firm SPPs are based on EGAT's long-run avoided capacity and energy costs resulting from purchasing electricity from the SPPs. Initially the short-run avoided costs were calculated using fuel oil as the fuel for electricity generation. If the cost of fuel oil changes, EGAT will adjust the energy payment rates accordingly as specified in the contract. The length of firm contracts are between 5 and 25 years, usually 20-25 years, while non-firm contracts are valid for one year but renewed automatically[51].

4.1.3 Other regulations applicable to SPPs

For the SPP and subsidy SPP programs, the terms and conditions governing the sales of power by SPPs are stipulated in the SPP regulations as discussed above. In addition, an SPP who wishes to sell electricity in Thailand has to abide by Thai laws and is therefore required to obtain documents and/or licenses/permits as follows:

- A Power Purchase Agreement (PPA) with EGAT. The SPP and EGAT are bound by the PPA to comply with the SPP regulations as well as the technical requirements as specified by the Regulations for Synchronization of Generators to the System of a Power Utility. The PPA also contains provisions related to billing and settlement, breach of contract, force majeure, and dispute and arbitration.
- A permit by the Department of Industrial Works, Ministry of Industry to operate a power plant;
- A concession to operate an electricity business issued by the Public Works Department, Ministry of Interior (concession is valid for twenty-five years);
- A permit to produce controlled energy issued by the Department of Energy Development and Promotion, Ministry of Science, Technology and Environment;
- A certificate of boiler safety issued by the Industrial Safety Division, Department of Industrial Works, Ministry of Industry;
- A permit to connect to one of the three utilities' system issued by the respective utility; and

- A permit to sell electricity issued by the Public Works Department, Ministry of Interior.

Besides the regulations and permits listed above, all power producers in Thailand, SPPs included, must abide by the following environmental laws: 1) The Enhancement and Conservation of National Environmental Quality Act B.E. 2535 (which is the primary piece of environmental protection legislation); 2) The National Environment Quality Act BE 2535 (1992); and 3) The Hazardous Substances Act BE 2535 (1992).

The main thrust of the legislation is that thermal power projects with a generating capacity greater than 10 MW, must complete an Environmental Impact Assessment (EIA). This is applicable to all new projects meeting these criteria, regardless of ownership. The Office of Environmental Policy and Planning (OEPP), under the Ministry of Science, Technology and Environment, and an Expert Committee (established under the National Environmental Board) reviews the EIA before being submitted to the National Environmental Board for final approval.

Furthermore, the National Environmental Board has published various environmental standards. The standards applicable to power plants are Atmospheric Ambient Air Quality Standards, Water Quality Standards, and Emission Standards for SO_2, NO_2 and particulate. In general, the emissions standards of SPPs are more stringent than the standards of EGAT's existing power plants as shown in Table 5.

Table 5: Comparison of emissions standards for private power producers (including SPPs) and EGAT's power plants.

Power Plants	SO_2 (ppm)	NO_x (ppm)	Particulates (mg/m^3)
1. Private Power Plants (incl. SPPs)			
- > 500 MW	320	350	120
- 300 – 500 MW	450	350	120
- < 300 MW	640	350	120
2. Mae Moh (EGAT—lignite-fired)			
- Unit 1-3: no FGD	3,800	500	250
- Unit 4-11: with FGD	320	500	250
- Unit 12-13: with FGD	350	350	250
3. Bang Pakong (EGAT)			
- Fuel Oil	320	200	120
- Natural gas	60	450 (Block 1-2)	60
		230 (Block 3-4)	
4. South Bangkok (EGAT)			
- Fuel Oil	320	180	120
- Natural gas	60	175-250	60

Source: NEPO, Information for Consideration of Coal-fired Power Projects, 21 January 2002, page 74.

4.1.4 Progress of the SPP program to date

As of April 2002, 106 SPP project proposals have been considered by EGAT. 60 power purchase agreements (PPA) with EGAT have been signed with four other PPAs still under negotiation. 50 SPPs have already been in operation selling a total of 1,970 MW of power to EGAT, whilst numerous others are in development. (See Table 6) Of all the SPP projects that are operational, the majority of them (1,398 MW or 71%) use natural gas as fuel. 9% of the capacity uses renewable energy, wastes or residues. (See Table 7.)

Table 6: Power Purchase from SPP (as of April 2002)

	Firm	Non-Firm	Total
1. SPP Proposals Submitted			
1.1 Number of projects	69	37	106
1.2 Generating capacity (MW)	7,824	797	8,621
1.3 Offered sale to EGAT (MW)	4,559	267	4,825
2. SPPs with Notification of Acceptance*			
2.1 Number of projects	32	32	64
2.2 Generating capacity (MW)	3,631	758	4,389
2.3 Offered sale to EGAT (MW)	2,057	261	2,318
3. SPPs with Contract Signed			
3.1 Number of projects	31	29	60
3.2 Generating capacity (MW)	3,481	704	4,185
3.3 Offered sale to EGAT (MW)	1,967	232	2,199
4. SPPs Already Supplied Power to the Grid			
4.1 Number of projects	27	23	50
4.2 Generating capacity (MW)	2,859	610	3,469
4.3 Offered sale to EGAT (MW)	1,768	202	1,971

* Excluding SPPs which have not presented the Proposal Security and have withdrawn.
** Including the Phuket municipality project with installed capacity of 2.5 MW.
Source: NEPO, unpub.

Table 7: Power Purchase from SPPs by Type of Fuel (as of April 2002)

Type of Fuel	Accepted		Selling to the System	
	No.	MW	No.	MW
Natural Gas	22	1,588	19	1,398
Bagasse	21	102	17	88
Coal	8	476	7	386
Rice Husk, Wood Chips	5	85	4	82.9
Rice Husk	3	18	1	5
Fuel Oil	1	9	1	9
Refuse	2	94	1	1
Waste Gas	1	12	-	-
Black Liquor	1	25	-	-
Total	**64**	**2,318**	**50**	**1,970**

Source: NEPO, unpub.

At present, purchase of power from generation projects using renewable energy, waste or residues as fuel is still ongoing under both firm and non-firm contracts without limit on the purchase volume or period. Determination of purchasing price will be in line with the current regulations for power purchase from SPPs. However, in the power purchase consideration, the available capacity of transmission and distribution systems of the power utilities will also have to be taken into account.

4.1.5 Issues in the implementation of the SPP program

1997 economic crisis and impacts on SPP projects's viability

Following the economic crisis and sudden depreciation of the Baht in July 1997, several private power producers were left with projects that were no longer profitable. SPPs originally agreed to sell power to EGAT at prices denominated in Baht, but a significant portion of their costs and financing were in foreign currency. Furthermore, the country suffered economic decline as a result of the 1997 crisis, leading to a decline in domestic demand for electricity. Several SPP projects thus faced delays and lost or had a hard time finding direct customers to purchase their steam and excess electricity generation. The feasibility as well as bankability of projects were severely affected as a result. In order to help SPP projects become more viable after the economic crisis, the government approved several changes to the terms and conditions of the SPP program, as follows.

1) Foreign Exchange Partial Indexation

To cushion the impact of Baht depreciation after July 1997, EGAT agreed to absorb most of the increased costs incurred by SPPs and agreed to raise the purchase price of electricity according to the increased foreign currency risks. This was done through the partial indexation of the capacity payment (covering the investment and fixed operation and maintenance costs) to US dollars—80% and 70% of the capacity payment for coal-fired SPPs and oil- and gas-fired SPPs was denominated in US dollars respectively. The new terms have saved the SPPs from collapsing by reason of foreign exchange risk.

2) Relaxation of definition of cogeneration

Due to the economic slowdown, some direct customers of SPPs could not buy as much electricity from SPPs as previously planned. The regulations with respect to the definition of the qualified cogeneration systems was thus relaxed to accommodate the difficulties faced by the SPPs. According to the cabinet resolution of 4 November 1997, SPPs were allowed on a case by case basis to 1) generate electricity on an open cycle (using only gas turbines instead of a combination of gas and steam turbines) for one year since the commissioning dates; 2) have a steam utilization rate of lower than 10% for three years; and 3) have lower combined electricity and heat efficiency than 45% as required by the regulations for three years.

If after the specified time, an SPP is still unable to perform as required by the SPP regulations, its energy payment is subject to a deduction in proportion to the deficiency in the SPP's steam utilization rate. The relaxation in the enforcement of the SPP regulations essentially allowed SPPs to be less energy efficient, but without which many SPP projects would not have been viable.

Oil price increases and change in energy payment calculation for renewable SPPs

The purchase prices for electricity from renewable SPPs, both firm and non-firm, were originally based on fuel oil prices. As oil prices rose from US$16.13 in 1999 to US$25.23 in 2000, the purchase price (energy payment) of electricity from non-firm SPPs also went up and was higher than the combined prices of capacity and energy payments for electricity from firm SPPs of all fuel types. Moreover, EGAT's marginal plant (the last plant on the merit order to be called into operation to serve the system load) had shifted from an oil-fired power plant to a gas-fired one. As a result, it was deemed appropriate and beneficial to power consumers to modify the calculation of the energy payment based on the short-run avoided cost of a gas-fired plant. This change, approved by the cabinet on 10 July 2001, resulted in purchase price reduction from 2.00 to 1.61 Baht/kWh for non-firm SPPs (EGAT's actual purchase prices as of April 2002). The purchase price of renewable firm SPPs stay roughly the same depending on the relative prices of fuel oil and gas. [52]

The gas-based purchase price for renewable SPPs was applied to new projects including the SPP subsidy program (See Next Section). Existing SPPs enjoyed the high oil-based prices until their contracts expired and were renewed.

4.2 Subsidy for Renewable Energy SPPs

Despite a considerable number of SPP projects with a total capacity of around 2,000 MW in operation supplying electricity to the grid, only 176 MW of power is fueled by renewable energy, wastes or residues. In order to attract the private sector to invest in more SPPs using renewable energy which is currently not competitive with conventional fuels, the National Energy Policy Office (NEPO) issued a Request for Proposals (RFP) in July 2001 inviting potential investors and small power producers (SPPs), using non-conventional energy, waste or residues from agricultural activities or from industrial and agricultural production processes, garbage or woodchips, or renewable energy as fuel, to submit a proposal to NEPO for a subsidy on energy payment. The subsidy will be provided on top of the power purchasing rate from SPPs using renewable energy as stipulated by the Electricity Generating Authority of Thailand (EGAT).

In this regard, NEPO has allocated a budget of around Baht 2,060 million from the ENCON Fund to provide subsidization in the form of energy payment. With the given budget, it is expected that EGAT will be able to increase its purchase of electricity from non-utility generators using renewable energy by approximately 300 MW within 2005, as a pilot scale.

The budget will be used to subsidize applicants who have viable projects and have requested for an additional incentive of no more than 0.36 Baht per kWh of electricity sold to the grid for a period of up to 5 years under a competitive bidding. Power producers who are eligible for applying for the subsidy must be qualified under the SPP regulations of EGAT. However, they must not hold a Power Purchase Agreement before the announcement, unless the proposal presents an expansion of the capacity into the grid. They also have to submit the technical and commercial appraisals for evaluation. All qualified technical and commercial submissions will subsequently be considered for the subsidy. The project with the lowest rate of adder proposed throughout the project life, or the Average Levelized Adder (ALA), will have the priority for the subsidization.

Following the proposal submission deadline in October 2001, a total of 43 proposals have been received, accounting for an accumulative proposed sale of almost 775 MW and total requested subsidization of Baht 6,000 million, which is much greater than the expected target. With the given budget of Baht 2,060 Million , 17 SPPs, with a total capacity sale of 313 MW have initially been selected, pending organization of a public hearing process. Of these 17 SPPs, the average and maximum levelized adder is 0.18 and 0.225 Baht/kWh, respectively. It should be noted that the majority of the capacity sale (almost 70 %) of 313 MW would be generated by rice husk (See Table 8).

Although the technical and commercial evaluations take into account factors such as the availability of the energy resources as well as the promise in finding sources of fund, some qualified projects may practically not be able to be implemented. Failure may be caused by a competitive use of the residues resulting in an increased price of raw materials or by difficulties in finding financial sources, or even local unacceptance of power plants due to concerns over the impact on the environment and livelihood. In recognition of this, NEPO has allocated an additional budget of Baht 1,000 Million to provide subsidization for the other potentially qualified SPPs of the 1st round, which have to bid their desired adder rates again at no more than the maximum levelized adder of 0.225 Baht/kWh of the 1st round selection.

The 2nd round of project proposal selection was completed in May 2002 and 14 SPPs, with a total proposed capacity sale of 198.1 MW, have been selected (See Table 8). Consequently, a total of 31 SPPs with a total proposed capacity sale of 511 MW has been selected, pending organization of a public hearing process.

It is expected that at least 300 MW of electricity generated by these renewable SPPs will be exported to the grid within 2005. The subsidy SPP program phase 2 in 2006 is envisaged to target more renewable SPPs to supply a total of 400 MW of electricity to the grid within 2012.

Table 8. SPPs selected for subsidy by Type of Fuel (as of May 2002)

Type of Fuel	Selected (1st round)		Selected (2nd round)	
	No.	**MW**	**No.**	**MW**
Rice husk	9	208	3	38
Bagasse	2	11	6	38.6
Rice husk+ Woodchips			1	16
Rice husk+ Woodchips +Bagasse			2	30.1
Rice husk+ Woodchips +Black liquor			1	40
Rice husk+ Woodchips + Palm residues				10.4
Woodchips	1	20		
Woodchips + Palm residues	1	20		
Hydro	3	32		
Black liquor			1	25
Cassava rhizome	1	32		
Total	**17**	**313**	**14**	**198.1**

Source: NEPO, unpub.

4.3 Very Small Renewable Energy Power Producers (VSREPP) Program

The existing SPP regulations of EGAT are not designed for power producers that are smaller than 1 MW. If small-scale power producers using renewable energy, wastes or residues as fuel have to comply with the SPP regulations, a substantial cost for grid connection will be required, making the projects uneconomic. The cabinet thus resolved in 2000 that another set of regulations was needed to address the opportunities for very small-scale renewable electricity generation. The cabinet approved the technical and commercial regulations for connection of VSREPPs on 14 May 2002, and applications are accepted starting June 2002, with no limits on total capacity connected to the distribution grid.

A VSREPP is defined as a generator with his own generating unit, whose power generating process utilizes renewable energy sources, agricultural and industrial wastes and residues, or by-product steam, and who sells no more than 1 MW of electrical power directly to a distribution utility (MEA or PEA). The objective of the VSREPP program is to promote participation of small generators in electricity generation and efficient use of domestic natural resources that are environmentally friendly.

The program supports potential VSREPPs in several ways. Firstly, the regulations call for a stream-lined approval process so as to minimize the generators' time and costs of connecting very small generation systems to the grid. Secondly, through adoption of the net metering policy (consumption and generation quantities are netted, meaning generation that is below consumption is credited at the full retail rates), qualified generators can use the grid as a battery (storing and supplying electricity depending on the needs of the generator at a given time). Thirdly, generators with net generation can generate income by selling electricity to the distribution utilities at their avoided costs (the wholesale price that MEA and PEA pay to EGAT for bulk electricity).

The pro-forma power purchase agreement between a VSREPP and a distribution utility that has been approved is also simplified and short so as to minimize redundancies and inconsistencies between the contract and the approved regulations. Both the VSREPPs and distribution utilities must abide by the commercial and technical regulations which form an integral part of the contract. The contract is effective for one year but is automatically renewed. Conditions for bill settlement, force majeure and dispute resolution are also covered.

The main targets of the VSREPP program are pig farms and food processing industries. The manure and organic wastes from the farms and factories can generate biogas which can then be used as fuel for electricity generation. A comprehensive survey of such small-scale generators has yet to be carried out to determine the potential for the whole country.

Because the VSREPP program has recently been in effect, there has yet to be issues arising from the implementation of the VSREPP PPAs. Though it is difficult to predict the success of the program at this beginning stage, plans are underway to further facilitate potential renewable energy generators to be connected to the grid. Some technology such as photovoltaics and wind may be far from commercial viability without additional incentives besides the net metering tariffs. And for other technology that is near commercial viability, such as biogas for the pig farms and food processing industries, non-financial assistance in the form of training, information clearing house or a loan program, may be necessary to help potential generators get started. NEPO in collaboration with the distribution utilities is in the process of devising an effective public relations program to publicize the program and exploring different options and incentive mechanisms to get the program off the ground.

4.4 The Power Purchase Programs and socio-economic and environmental benefits

The power projects under the SPP program and subsidy SPP program sell electricity to EGAT and their direct customers. Due to the size of the projects (installed capacity between 5 and 150 MW for each SPP project), SPPs' direct customers are mainly industrial customers that are located near the SPP projects as the direct customers are required to use private distribution lines. To allow more open access to the utilities' distribution grid so that SPPs could sell power to customers located further away from the SPPs, NEPO drafted network access tariffs governing the terms and conditions for wheeling electricity through the distribution utilities' lines. The tariffs were however never implemented as the utilities and SPPs were unable to come to an agreement on the details of the tariffs. As a result, customers that had direct access to clean energy technologies under the SPP program are limited to industrial customers only.

Though small or low-income customers do not benefit directly from the SPP program, Thai farmers and the agricultural sector saw an indirect benefit in terms of increased revenues from the agricultural waste or residues that could be used to generate electricity. For example, rice husks used to be considered waste and thus given away for free or disposed off at a cost to owners of rice mills. The demand for rice husks as a result of the power purchase programs have increased the value of the husks, which are now sold at prices between 0 and 500 Baht/ton depending on the season. Moreover, the use of agricultural residues which are available within the country benefits the rural economy as the money stays within the local communities. In contrast, if fossil fuels are used for electricity generation as is the case of Thailand currently, not only do communities not benefit but the country also has to use hard-earned foreign currency to buy fossil fuels that are imported or whose prices are (partially) denominated in U.S. dollars.

Furthermore, the introduction of the VSREPP program opens up opportunities for owners of pig farms, local rice mills, food processing factories and rural communities living in areas with micro-hydroelectricity, wind, or solar potential to generate income from electricity generation using their local resources. In addition to the additional revenues for the small-scale renewable generators, widespread implementation of the VSREPP program will also foster a viable market for clean power generation technologies (such as micro-hydropower turbines and biogas-fired generators) and create job opportunities for equipment manufacturers, vendors and installers. As well, connection of generation capacity at the end of the distribution lines, where loads are located, reduces or slows the need for distribution upgrades/investments, thereby saving overall taxpayers' as well as ratepayers' money.

Besides the mentioned economic benefits, the program will provide a significant incentive for owners of pig farms and food processing factories to better manage their waste stream. With the extra revenues that the farm or factory owners can get from electricity generated from biogas and by-products of waste treatment processes (such as fertilizer), the farms and food industries have more incentives to put in place a waste treatment system that pays for itself while solving environmental problems. In the case of a micro-hydroelectricity project, communities that benefit from the electricity generated will also have an incentive to preserve the watershed so as to ensure healthy flow of water for electricity generation. Electricity generated from renewable sources can also displace that generated from more polluting fossil fuels and thus reduce the environmental impacts of electricity generation in the country as a whole.

Lastly, smaller-scale power projects tend to have relatively few negative social impacts compared to large-scale power plants. Local communities are more able to control the use of their own resources to generate income that stays within their communities. Small but numerous projects are also better in terms of income distribution.

5. Prospects for Regional Cooperation in Clean Energy Technologies

There remain several challenges before Thailand can overcome barriers to the development and utilization of clean energy technologies on a scale wide enough to significantly contribute to a sustainable energy future. In spite of some progress in promoting renewable energy applications in recent years in Thailand, numerous constraints and barriers continue to exist. Besides, due to its continued reliance on fossil fuels in the future, it is necessary for Thailand to further explore ways to promote the development and deployment of advanced and cleaner fossil fuel technologies. Some following project ideas that can facilitate Thailand's achievement towards its goal are programs that allows for countries in the region to cooperate, especially in the form of information sharing and dissemination, research and development as well as market and local manufacturing capability development. Some of the specific activities may include:

1. Promoting training and exchange of experiences in renewable energy and advanced fossil fuel technologies and lessons learned as well as exchange of experiences in policy mechanisms employed to promote clean energy technologies in the region. For instance, regional training or information sharing workshops that bring together experts in the field of biomass (for example), policy makers, utilities, vendors and potential generators from different countries.
2. Strengthening and where appropriate establishing regional networks or centers of excellence for the exchange of information and experience in the research, development and application of renewable energy and advanced fossil fuel technologies.
3. Developing a college-level curriculum to enhance understanding and skills in the field of clean energy technologies that are appropriate for each country. Curriculum is shared among countries where appropriate.
4. Fostering regional cooperation in undertaking research and development on renewable energy technologies such as biogas-fueled generators that are low-cost and long-lasting, advanced fuels for transportation, advanced fossil fuel technologies such as clean coal technologies, and carbon sequestration technologies especially in private sectors.
5. Incentives for building up local manufacturing capability and matchmaking for the diffusion of renewable energy technologies and the development of high-efficiency renewable energy systems and components especially for biomass high presure boilers and biogas power systems or promoting freer trade in renewable energy devices and systems.
6. Creating a regional market for clean energy technologies and qualified personnel as a critical mass of products and trained technicians is required for the industry as a whole to be viable.
7. Program to provide financial assistance or other forms of incentives to promote the development of appropriate technologies using local resources.
8. Available funding for relevant research and development projects mentioned above.
9. Establishment of a regional information clearing house to provide information and consultancy services to relevant players in the industry.

6. Conclusion

Given its abundant renewable energy resources, Thailand is poised to reap the numerous environmental and socio-economic benefits of clean energy technologies. The country's agricultural sector has a large amount of residues and waste that can be turned into significant energy and electricity sources. The government has long had well-targeted policies to allow the utilization of renewable energy resources as well as high-efficiency technologies for electricity generation, especially after the introduction of the Small Power Producer program. In addition, the establishment of the ENCON Fund has provided the country with a unique resource to help facilitate the implementation and promotion of these policies. Undoubtedly, the power purchase programs for renewable and cogeneration energy in Thailand are among the most established and progressive in the region. While the SPP Program has targeted and benefited mostly for industrial customers, the VSREPP Program is anticipated to provide more direct benefits for the small consumers in rural communities and the agricultural sector.

Past achievements were considerable; still there is a wide window of opportunities to further promote clean and renewable energy technologies so that the country can better realize its full potential. Renewable energy currently makes up only a small percentage of the total electricity mixes in the country. Advanced clean fossil-fuel based technology is left largely unexplored despite the continued significance of fossil fuels in Thailand. It is thus important for Thailand to promote the implementation of advanced fossil fuel technologies as well as the development of alternative clean fuels.

Thailand's experiences with its Power Purchase Programs suggest that there is a need for Thailand to accelerate the development of local manufacturing capability and market for clean energy technologies. The market for local equipment and technologies is still largely in its initial stage. There is also a need to encourage the dissemination of information and benefits of clean energy technologies as well as their minimal environmental impact among key actors such as local communities, financial institutions, etc. At present, qualified personnel in the renewable energy sector are limited in number. Financial institutions may also lack understandings and are thus unwilling to provide financing to potential energy producers.

Although the existing policies for promoting clean energy technologies especially through the power purchase programs are favorable, the government is in the process of conducting a study on other additional mechanisms that will help potential generators overcome the various barriers. More research and development activities, training programs, experience sharing and cooperation at the local as well as regional levels will help accelerate Thailand towards its goal.

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