# ALTERNATIVE ENERGY, COGENERATION AND DISTRIBUTED GENERATION: CRUCIAL STRATEGY FOR SUSTAINABILITY OF THAILAND'S ENERGY SECTOR

(BY PIYASVASTI AMRANAND, THAILAND'S ENERGY MINISTER, OCTOBER 2006- FEBRUARY 2008)

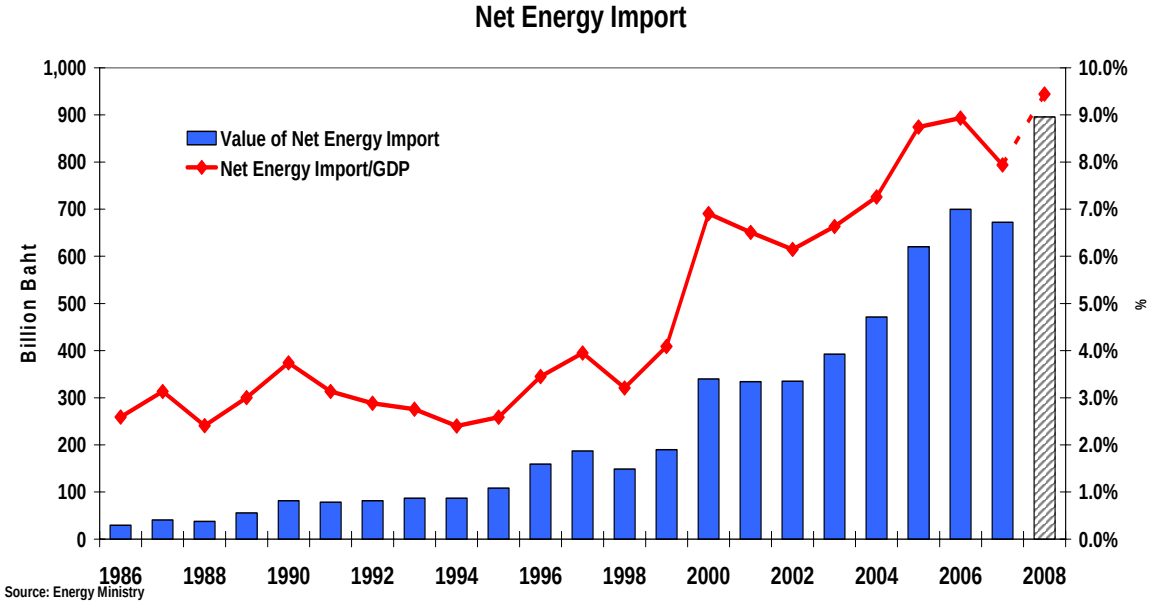
## Introduction

Being heavily dependent on imported oil but endowed with a large agriculture sector, it is not surprising that Thailand is one of the first countries in Asia to have a policy to encourage biofuels, cogeneration, distributed generation, and the generation of power from renewable energy. Although Thailand has a large amount of agriculture raw materials for the production of ethanol and biodiesel for the last few decades, it is the oil price rise beginning in 2004 together with the government policy that led to a dramatic increase in the consumption and production of biofuels in recent years. Cogeneration and the production of power from renewable energy was implemented under the Small Power Producer Program (SPP), introduced in 1992, and became a very effective policy instrument in promoting investment in renewable energy and cogeneration. The economic crisis in 1997 led to an excess capacity in the power system, and the purchase of power from new cogeneration facilities under long term contract was temporarily suspended. Unclear policy by the government led to a substantial slow down in the program in subsequent years, and it was not until 2006 after the coup d'etat in September 2006 that the government of General Surayud Chulanond introduced a number of sweeping changes to the program and allowed investment in cogeneration projects to resume for the first time since 1997. Responses by the business community and investors have been extremely positive, partly helped by the soaring oil prices. By the end of 2007, a very large number of applications have been received from small cogeneration facilities and renewable energy projects while a number of projects have been commissioned. Fuel choice is extremely diverse. Apart from the usual fuels of bagasse, paddy husk and woodchips, we have seen proposals to use many other types of biomass, biogas, municipal wastes and solar energy. The force of financial incentive is remarkable in both the promotion of biofuels and power generation from renewable energy, particularly when combined with the provision of technical advice and other forms of assistance to lower the technological risk in the initial period. Policies adopted by Thailand allow a number of objectives to be achieved at the same time: strengthening energy security of the country by reducing energy imports and promoting indigenous energy resources, competitive energy price for sustained economic growth, and making her contributions in reducing global emission of greenhouse gases.

## Background

In 2007 Thailand's total commercial primary energy consumption was 80,019 thousand tons of crude oil equivalence (ktoe) while peak generation of the electric power system was recorded at 22,586 MW. During the 1970's approximately 90% of Thailand's commercial primary energy consumption (including non-energy use) was imported, mostly petroleum products. The discovery of natural gas in the Gulf of the Thailand and lignite in the Northern part of the country reduced Thailand's import dependence to about 60%. The country's dependence on imported energy has remained at 55-62% since the mid 1980's while about 70% of electricity is generated from natural gas since 2001. Although there has been continuous discovery of oil and gas in Thailand, the domestic demand for commercial primary energy has been growing at an annual compound growth rate of 7.6% during the period 1985-2007 resulting in import dependence remaining at 60%. This together with quadrupling of the

world oil price during the past 5 years have pushed Thailand's net energy import to US$19.5 billion in 2007 equivalent to 7.9% of GDP. Despite the rapidly growing energy demand Thailand's per capita commercial energy consumption is still very low compared with industrialized countries at 1.27 toe. As a result her current per capita emission of greenhouse gases is estimated to be about 5.5 tons of carbon dioxide.




## The SPP and VSPP Program before 2007

The structure of the power system is that of a single buyer with the Electricity Generating Authority of Thailand (EGAT) currently owning about half of the power generation capacity, the transmission system, and acting as the single buyer. EGAT sells bulk power to two distribution utilities: the Metropolitan Electricity Authority (MEA) responsible for the sale of electricity to consumers in Bangkok and surrounding areas; and the Provincial Electricity Authority (PEA) responsible for electricity sale in the remaining parts of the country. Private power producers sell electricity to the electric utilities under power purchase agreements or users located nearby. There is no third part access yet.

Before 1991 there was no private power producer supplying electricity into the grid. The National Energy Policy Office (NEPO) had been trying to introduce private sector investment in power generation since 1989 through implementation of regulation to require the electric utilities to buy power generated by small private power producers, but the policy faced heavy resistance by the electric utilities and their labour unions. It was not until 1992, under the government of Anand Panyarachun, that Regulation to Purchase Power from Small Power Producers (the "SPP regulation") was finally approved and announced. A separate IPP program was announced in 1994 for larger power plants. The SPP program allowed private investment in the generation of electricity using the cogeneration system and generation of electricity using renewable energy. Each facility is allowed to sell excess power to EGAT at a price determined from EGAT's avoided cost. Qualifications of SPPs included criteria on the use of steam and efficiency of the cogeneration system. The size of each facility was kept small by restricting sale to the grid from each facility at 60 MW. This was subsequently increased to 90 MW. There were many similarities between the SPP regulation and Public Utility Regulatory Policies Act (PURPA) implemented in the USA in 1978. The program started slowly as certain parts of the regulation were unworkable and Thai investors were not

familiar with the power business. Obtaining long term funding for power business was also difficult under the structure of the financial system in Thailand at the time. However, after a series of amendment of the SPP regulation and rapid development of the financial market, investment in SPP projects began to take off rapidly from 1994. Most of the projects were cogeneration projects using natural gas as fuel to produce electricity and steam to industrial users nearby, particularly in industrial estates, and selling the excess power to the grid either under long term firm contracts or short term non-firm contracts with EGAT. A large number of small renewable energy projects were implemented in many parts of Thailand, mainly using agriculture wastes as fuels particularly bagasse from sugar mills, paddy husk from rice mills, and woodchips from paper factories. The program was so successful that sugar mills stopped disposing of unwanted bagasse by burning, and that paddy husk price soared to about US$30 per ton from a negligible level.

The economic crisis in 1997 reduced the demand for power in Thailand in 1998 by 2.4% and substantially slowed down demand growth in subsequent years. This resulted in excess generation capacity of the power system where the reserve margin rose from about 10% in 1997 to a peak of 35.1% in 2003. In order to cope with the problem, the purchase of power from new cogeneration facilities under long term contracts was temporarily suspended. However, the suspension turned out to be much longer than earlier intended. With the economic recovery in 2001 and reserve margin declining to 26.8% in 2004, the government wavered on the resumption of power purchase from new cogeneration facilities under long term contracts. Nevertheless, the government allowed renewable energy projects to continue, but many projects faced uncooperative electric utilities in connecting to the grid despite the relatively clear interconnection requirements. Moreover, apart from bagasse, rice husk and woodchips there was little use of other types of renewable energy, mainly because of unattractive purchase price, costly interconnection requirements, and technological risk. In order to reduce some of these costs, the government in 2001 introduced the Very Small Power Producer Program (VSPP) allowing SPP with sale into the grid of less than 1 MW to come under a more lenient set of requirements and less complicated power purchase arrangement of “net metering”. The purchase price is simply the bulk tariff excluding the cross subsidy element between the electric utilities. VSPPs can also sell to any one of the three electric utilities, depending on which transmission system is connected to the facility. In addition, the government also launched a program to encourage the renewable energy SPPs by providing an additional tariff for a period of 5 years from the Energy Conservation Fund. The “adder” was determined through a competitive bidding system which resulted in approval of 14 projects with average “adder” of 0.18 baht per kWh (US¢ 0.56), representing approximately 5% increase from the normal tariff. With a relatively low level of “adder” it is not surprising that all of the 14 projects were using bagasse, paddy husk or woodchips as fuels. There was no submission of other types of projects the government was hoping for.

The establishment of the Energy Ministry (MoE) in 2002 put the SPP program into total disarray. Despite the broad government policy to promote renewable energy, the new policy of introducing Renewable Portfolio Standard (RPS) never got off the ground as the MoE spent the next 4 years drafting RPS guidelines which were never completed, while the SPP program came to a near complete standstill.

By the end of 2006, there were about one hundred SPP and VSPP projects supplying 2,344 MW of electricity to the grid, but since most of these facilities also sold electricity to users nearby, total generating capacity was around 4,160 MW. Almost all of these projects were those launched before 2002 as very few projects were initiated after the establishment of MoE.

## Year 2007: The New Era for Thailand's Green Energy

Thailand's Ministry of Energy estimates that the potential of power generation in Thailand from biomass, municipal wastes (MSW) and biogas is 3,700 MW. Apart from bagasse, paddy husk and woodchips, other sources with good potential are municipal wastes, biogas from pig farms and other types of agro-industry, corn cob, wastes from palm oil factories, and micro hydro. This means that there is a potential to generate another 1,700 MW of power from renewable energy excluding wind and solar energy. A study on wind potential and wind map was made available to the public in 2002, and more measurements were undertaken in a number of selected areas.

Given the renewable energy potential remaining to be tapped, rising oil prices and problem of global warming, the Surayud Chulanond government quickly issued a number of sweeping changes to the policy to promote energy efficiency and renewable energy as follows:

(1) The SPP and VSPP regulations were amended to be more investor friendly and practical, including changes to the criteria for qualifying facility, calculation of the avoided cost, and interconnection requirements. The normal power purchase price is still based on EGAT's avoided cost calculated from the cost of avoiding a gas fired combined cycle plant as 70% of electricity is generated from natural gas and most of the new capacity will still be gas fired. However, as coal is expected to play a more significant role in the power system, non-gas fired SPPs can choose an alternative tariff based on avoided imported coal fired power plant. This reflects the cost structure of biomass power plants more closely than gas fired power plants both in the capacity component and the energy component as in recent years the substitution between biomass and coal in many industries (especially cement) and power plants have caused the prices of various types of biomass to move in line with the price of imported coal.

(2) The VSPP program was amended to include cogeneration facilities and sale from a facility of up to 10 MW while sale of 10-90 MW would come under the SPP program.

(3) SPP cogeneration facilities are allowed to sell power to the grid under long term contracts again, and in the initial phase EGAT has established a target to buy another 1,600 MW of power from new cogeneration facilities under long term contracts.

(4) A higher tariff is granted to SPPs and VSPPs using renewable energy by providing an "adder" on top of the normal tariff for 7-10 years from the Commercial Operation Date (COD) for proposals submitted before the end of 2008. The "adder" depends on the type of renewable energy being used as shown in the Table 1, and the government also announced the initial target for renewable energy capacity being solicited from various types of renewable energy as shown in Table 2. In the case of biomass SPP, the "adder" was determined through a competitive bidding system where the government issued a solicitation for 300 MW on 1 May 2007. There is also a special "adder" for SPPs/VSPPs in the 3 Southern most provinces (Yala, Pattani and Narathivath) of 1.50 baht/kWh for wind and solar energy, and 1.00 baht/kWh for other types of renewable energy to compensate for the political risk from the unrest.

## Table 1: "Adder" to the Normal Tariff for SPPs and VSPPs

| Fuel/Technology | Adder (Baht/kWh) | Number of Years |
|---|---|---|
| **Biomass** | 0.30 (US¢ 0.97) for VSPP<br>Competitive bidding for SPP | **7** |
| **Biogas** | 0.30 (US¢ 0.97) | **7** |
| **Mini-hydro (50-200 kW)** | 0.40 (US¢ 1.29) | **7** |
| **Micro-hydro (< 50 kW)** | 0.80 (US¢ 2.58) | **7** |
| **Municipal Wastes** | 2.50 (US¢ 8.06) | **7** |
| **Wind** | 3.50 (US¢ 11.29) | **10** |
| **Solar** | 8.0 (US¢ 25.81) | **10** |

Remarks: 1) Exchange Rate: 32 Baht/USD.
2) The level of normal tariff is 2.0-2.5 baht/kWh (US¢ 6.25-7.81)

## Table 2: Target for Generation of Power from Renewable Energy during 2008-2011

| | Existing 2006 (MW) | Target in 2011 (MW) |
|---|---|---|
| **Solar** | **30** | **45** |
| **Wind** | **1** | **115** |
| **Mini/Micro Hydro** | **44** | **156** |
| **Biomass** | **1,977** | **2,800** |
| **Municipal Waste** | **4** | **100** |
| **Biogas** | **5** | **60** |
| **Total** | **2,061** | **3.276** |
| **Peak Generation of Power System** | **21,064** | **27,996** |

Source: Thailand's Energy Conservation and Renewable Energy Development Program 2008-2011, September 2007, Energy Ministry

(5) Financial incentives through soft loans and investment subsidies were expanded in amount and coverage for selected types of renewable energy projects, in particular biogas in pig farms and factories producing tapioca starch, palm oil, rubber sheet, ethanol and other types of agro-industry, municipal wastes, and micro-hydro. Some of these are not SPPs or VSPPs, but simply produce energy for their own use or off-grid village-based projects in remote areas

(6) The government budget was also expanded for government agencies to implement mini and micro hydro projects as in most cases obtaining various permits would be extremely difficult for the private sector. Total new generating capacity of 112 MW is targeted during the period 2008-2011.

(7) A larger budget has been made available for the provision of technical assistance to the private sector as well as funding for pilot projects for new or unfamiliar technology.

(8) Private investment is being encouraged through Energy Service Companies (ESCO) and ESCO Venture Capital Fund which is being established

(9) Approval of policy allowing the trading of carbon credit through CDM was made in early 2007 after a 5 year of indecision by the earlier government. This has given an enormous boost to a number of marginal projects, particularly biogas and municipal wastes projects.

## Responses from Policy Changes

There are currently (April 2008) 61 SPP projects supplying 2,286 MW of electricity to the grid, but since most of these facilities also sell electricity to users nearby, total generating capacity is around 3,877 MW (Tables 3-4). Almost all of these projects were those launched before 2002 as very few projects were initiated after the establishment of MoE. Among these, 26 are cogeneration projects using fossil fuel- mainly natural gas with total sale of 1,670 MW. The remaining 615 MW are supplied from 35 non-conventional energy projects and projects using mixtures of fossil fuels and non-conventional energy – mostly bagasse, paddy husks and woodchips. There are also 100 VSPP projects supplying 215 MW of power to the power system with total installed capacity of 540 MW (Table 3,5). Again, most of these projects are bagasse, paddy husk and other biomass. There are also 37 solar energy projects – mostly roof top solar cells under the solar home program funded by the Energy Conservation Fund, and most of these projects are those implemented before the policy change in 2007. Among these SPPs and VSPPs, there are also some projects using other types of renewable energy for example 4 municipal waste projects and 16 biogas projects. Most of the investors in the SPP or VSPP projects are small to medium size companies, but there are a few companies which had built up its business from the SPP and the private power program, namely Banpu Plc. and Glow Plc, which are both listed in the Stock Exchange of Thailand. The company with the largest renewable energy portfolio is Advance Agro – an agro business and paper conglomerate.

Responses from policy changes have been dramatic. As of 31 August 2007, 31 new cogeneration SPP projects under firm contracts, have submitted applications for sale of electricity to EGAT, with a total proposed sale of 2,416 MW, which far exceeded the targeted amount (1,600 MW). Therefore, EGAT had to temporarily close the power purchase from cogeneration SPPs from 31 August 2007. Selections were made based on capability and costs of the power system in purchasing power from the SPP, fuel availability and feasibility of finding electricity and steam users by each SPP. At the end of 2007, 16 cogeneration facilities under SPP program was selected with total generating capacity of 1,663 MW and total sale of electricity into the grid of 1,314 MW. The biggest impediment to new SPPs is probably availability of natural gas supply

The Request for Proposals (RFP) from SPPs using renewable energy, other than MSW, wind and solar energy, to bid for the “adder” was issued on 1 May 2007. Nine proposals were received on 1 August 2007, with a total proposed sale of 435 MW. On 12 October 2007, the proposal evaluation was finalized, with 7 SPPs selected accounting for a total proposed sale of 335 MW and installed capacity of 458 MW. The selected SPPs are obliged to sell electricity to the grid by 2012 with an “adder” of 0.295 baht/kWh. All the projects are based on bagasse, paddy husk and woodchips as other biomass projects are normally small and come under the VSPP program.

The most remarkable response has come from the VSPPs. By the end of June 2008, 442 VSPPs have submitted applications to sell 1,858 MW of power into the grid. These include VSPPs already commissioned before the new regulation, and projects reclassified from SPPs. However, there are around 300 new projects with total sale of about 1,500 MW as the original projects are fairly small with total sale of only about 200 MW. Among these 442 projects, 435 are renewable energy projects with total sale into the grid of 1,825 MW while the other 7 projects are cogeneration projects using natural gas or coal as fuels with one project being a district cooling facility rather than the usual cogeneration projects which sell electricity and steam.

## Table 3: Summary Status of SPP and VSPP Projects

| SPP: April 2008<br>VSPP: June 2008 | Projects Approved | | | Projects in Operations | | |
|---|---|---|---|---|---|---|
| | **Number of Projects** | **Gen. Capacity (MW)** | **Sale to Grid (MW)** | **Number of Projects** | **Gen. Capacity (MW)** | **Sale to Grid (MW)** |
| **Fossil Fuels** | **53** | **5,783** | **3,408** | **27** | **2,690** | **1,673** |
| **SPP** | 46 | 5,632 | 3,374 | 26 | 2,680 | 1,670 |
| **VSPP** | 7 | 151 | 33 | 1 | 10 | 3 |
| **Non-Conventional Energy** | **329** | **2,422** | **1,557** | **130** | **1,252** | **594** |
| **SPP** | 40 | 950 | 536 | 31 | 721 | 382 |
| **VSPP** | 289 | 1,472 | 1,021 | 99 | 531 | 212 |
| **SPP-Mixed fuel** | **4** | **476** | **233** | **4** | **476** | **233** |
| **Total Non-Conventional** | **333** | **2,898** | **1,790** | **134** | **1,728** | **827** |
| **Grand Total** | **386** | **8,681** | **5,197** | **161** | **4,418** | **2,500** |

Note: Figures for SPP projects may be lower than those in earlier publication due to reclassification into VSPPs.

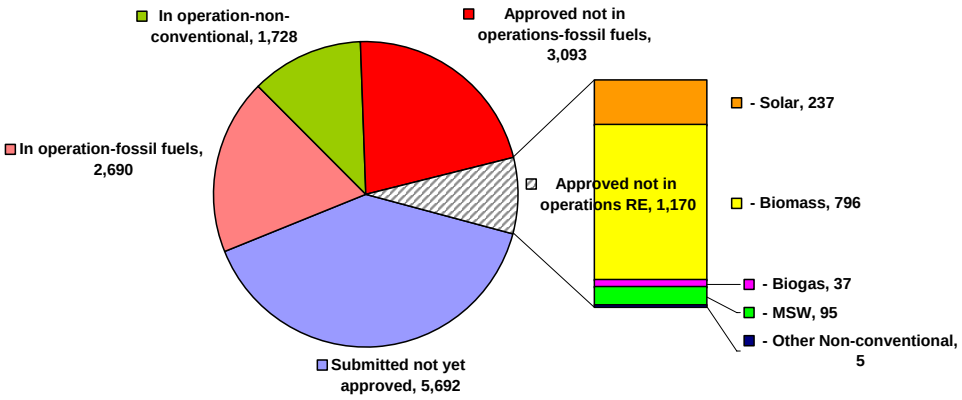
The "adder" has produced the intended result as fuel choice for the new VSPPs has been diverse. Nineteen MSW projects have been submitted with total sale of 97 MW while 3 MSW VSPPs are already in operation – two landfill gas and one anaerobic digestion system. Unusual types of biomass are being used in VSPPs, for example woodchips from plantation, palm wastes from palm oil factories, corn cob, rice straw, coconut fiber, biogas from waste water, and solar energy from "solar farms". The sizes also vary with some very small VSPPs of less than 100 kW, for example from micro-hydro projects or biogas from pig farms.

Although renewable energy being proposed in the new VSPPs is more diverse, future potential of other biomass still exists, such as corn cob, rice straw, sugarcane leaves, cassava rhizome and emptied palm bunches. A study is now being undertaken on the effective collection system and management of these types of biomass scattered here and there. In addition, biogas generation from industrial wastewater is becoming very popular as industrial operators have realized that it is better than the former wastewater treatment system, both in terms of environmental impact and economic effectiveness as energy is obtained as a very valuable by-product.

It is interesting to note that with the "adder" of 8 baht/kWh and establishment of PV factories in Thailand in the past few years leading to the rapid decline in the local price of solar cells, solar farms are mushrooming as 155 projects have already been submitted to sell 892 MW to the grid (excluding roof top PV). Two of these solar PV farms are already in operations, and a few more will be commissioned in the next few months. It remains to be seen whether all these projects will materialize especially the solar thermal/concentrating solar panel (CSP) projects.

Meanwhile a lot of work is progressing on preparations of wind power projects. Thailand's wind potential is not great, but so far 6 projects have been submitted with total sale of 20.6 MW These projects are either located near the sea (Songkla, Nakorn Sri Thammarat, Smutsakorn, Chonburi) or on mountain tops (Petchabun). It is likely we will see a few more proposals of larger wind farms submitted by the end of 2008 with capacity of 20-30 MW each. The policy has also revived the hydroelectricity program that has been dormant for a decade. Work has started on a number of both on grid and off grid mini and micro projects by government agencies (namely EGAT, MoE and PEA) on 15 mini-hydro projects and 65 micro hydro projects (including refurbishment and expansion). Total new capacity is expected to be about 112 MW.

**Generating Capacity of SPPs and VSPPs (MW)**
**(as of June 2008)**

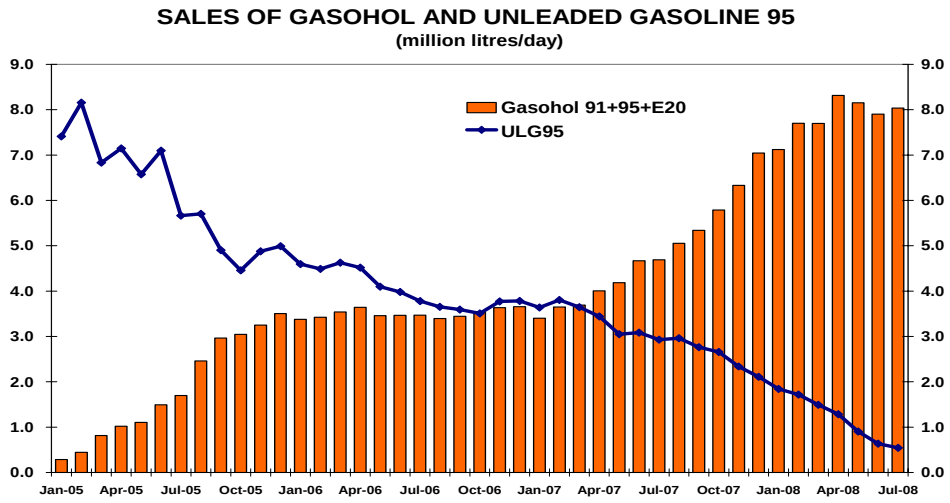



## Biofuels and Natural Gas in Vehicles

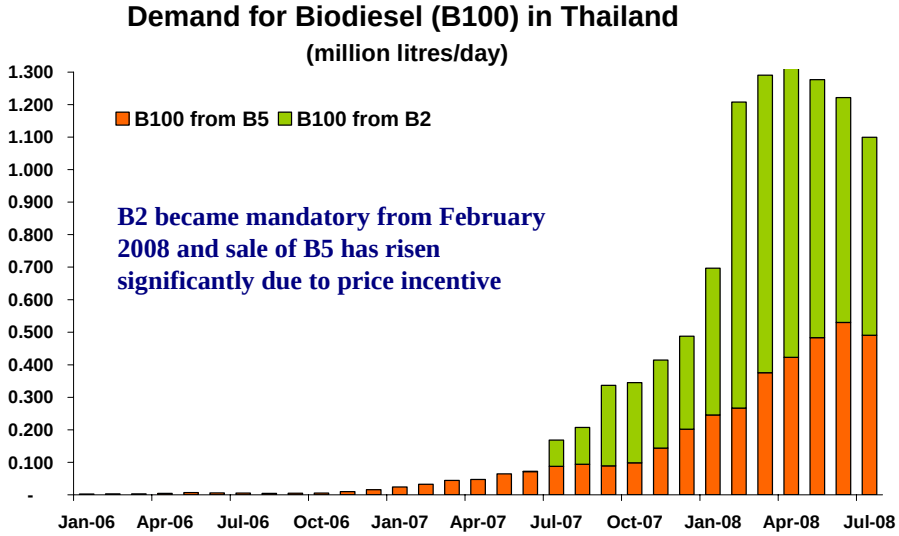
With net agriculture exports accounting for 5.9% of GDP and natural gas being the most important indigenous energy resources, it is only natural that Thailand should be promoting the use of biofuels and natural gas in vehicles to replace gasoline and diesel. Although Thailand had required either MTBE or ethanol to be blended with premium gasoline (95 RON) for over a decade in order to lower emission of carbon monoxide from vehicle exhausts, it was not until 2003 that oil companies began to market E10 premium gasoline (gasohol blended from 10% ethanol and 90% gasoline with octane number of 95 RON). This was due to the rise in the world oil price together with the provision of excise tax incentive which made E10 1.50 baht per litre (5-6%) cheaper than premium gasoline, investment promotion incentives provided to manufactures of ethanol, and heavy promotion by the government. E10 sale initially rose rapidly to reach 17.4% of premium gasoline sale in December 2005, but started to stagnate from the beginning of 2006 onwards while the promotion of ethanol production caused a surplus of ethanol supply to develop. The slow down in sale of E10 was due to consumer perception that E10 caused underperformance in vehicles, insufficiently clear information regarding types of vehicles capable of using E10, the price differential being too small as the net benefit was only 3% if lower heating value of gasohol was taken into account, and the relatively high price of ethanol charged by ethanol manufacturers. The Surayud government immediately implemented a number of policy changes from the end of 2006. The first and most important was the pricing policy whereby the oil fund levy for normal gasoline was gradually increased to a level

substantially higher than the levy on gasohol (which also helped to speed up debt payment of the fund), and a benchmark price was established for the ex-factory price of ethanol based on CIF price of Brazilian ethanol price. The latter immediately lowered the ex-factory price of ethanol by about 20%. The lower ex-factory price together with the lower level of oil fund contribution for E10 effectively increased the differential between the normal gasoline and E10 prices from 1.50 baht per litre to 4.00 baht per litre in November 2007. The second measure undertaken was to indefinitely postpone the previous government's policy to end the sale of premium gasoline by the end of 2006 as there were still many cars which required normal premium gasoline. However, an intensive education campaign was launched to provide information and assurance for motorists. Oil companies were asked to provide guarantees; and automobile companies were asked to provide assurance and warranty to customers, and narrow down the list of cars and motorcycles which are not capable of using gasohol. The government also provided additional price incentive for the refineries, and sought cooperation from oil companies to market E10 regular gasoline as regular gasoline accounted for over 60% of gasoline sale. A higher marketing margin was allowed for gasohol to encourage service stations to sell gasohol rather than the normal unleaded gasoline. Later in 2007 the government also announced a reduction in excise tax in new cars capable of using E20 (which is a blend of 20% ethanol and 80% gasoline) for new cars produced from January 2008. At the same time additional pricing incentive was provided for E20 and cooperation from oil companies were sought for sale of E20 from January 2008 onwards. Discussion between the government, ethanol producers, oil companies and automobile manufactures also started on the future plan to introduce E85 as Thailand should have enough agricultural raw materials for all gasoline vehicles to eventually run on E85, but a sufficient amount of time is required for the automobile and oil industries to adjust.

Biodiesel B5, which is a blend of 5% methyl ester (B100) and 95% normal diesel, has been on sale since 2005. Thailand also allowed the sale of "community" biodiesel which is lower quality B100 made from a number of feedstocks, particularly used cooking oil. The "community" biodiesel is normally used in simple agricultural machineries and use in vehicle is not advisable. Despite the rapid increase in the production capacity of B100, particularly those using palm oil as feedstock, sale of B5 remained very low during the period 2005-6. In 2006 the sale of B5 amounted to 0.12 million litres per day compared with total diesel sale of 50 million litres per day which was equivalent to only 6,000 litres per day of B100 consumption. This was due to unclear pricing policy, unclear standards and enforcement of B100 standards, and refusal by automobile companies to provide warranty for vehicles using B5. At the end of 2006 the Surayud government introduced a number of measures to boost the sale of biodiesel. A benchmark was established for the ex-factory price of B100 based on the price of palm oil and methanol – the main raw materials for B100 production. This resulted in a 25% increase in the price of B100 which encouraged more investment in B100 production, but the oil fund had to be used to provide a subsidy to oil companies so that B5 could be sold at 0.70 baht per litre lower than normal diesel. This subsidy is intended to be temporary and eventually it is hoped that the biodiesel industry would become competitive in the same way as the ethanol industry. In 2007 the government also issued a policy to require all diesel fuel to be B2 in 2008 allowing a period of about one year for all related parties to make adjustments. Clearer and stricter standards were issued for B100, B2 and B5 and they were actually enforced which provided sufficient assurance to automobile companies to provide warranty. The automobile manufactures eventually agreed that all diesel vehicles in Thailand could run on B5. Mandating B5 as the normal grade for diesel would require 2.5 million litres per day of B100, and there is clearly insufficient amount of raw palm oil or other feedstock. The government, therefore, provided soft loans for the expansion of oil palm plantation and yields with preliminary target of mandating B5 by 2011.



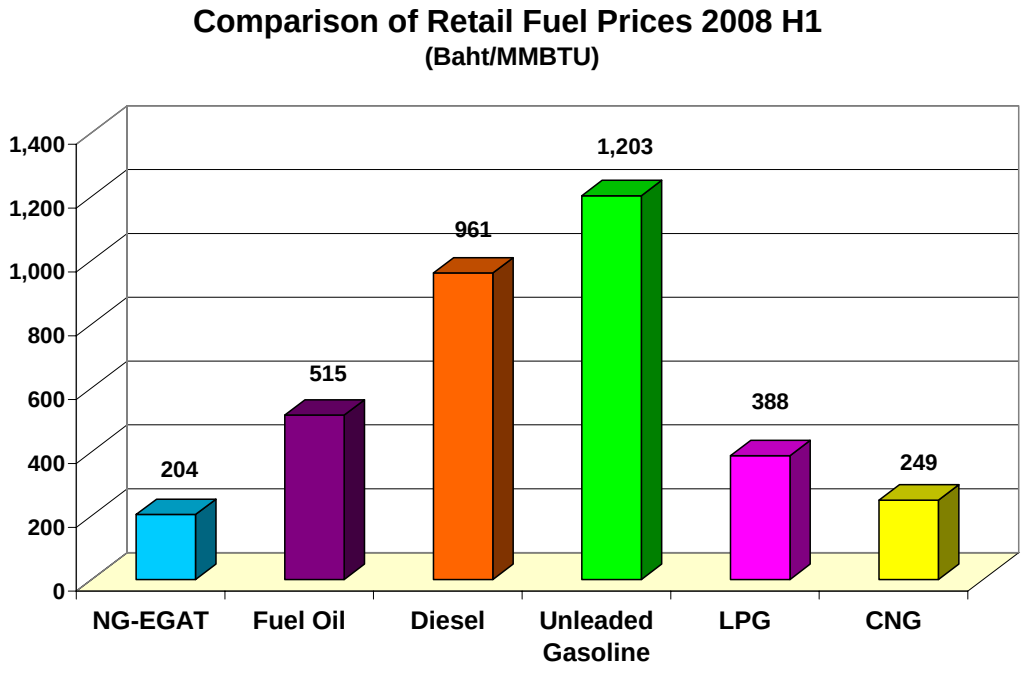

Responses from these policy changes were dramatic. The sale of E10 rose from 3.5 million litres per day in 2006 to reach 7.0 million litres per day in December 2007. During the first 7 months of 2008 the average sale of E10 averaged 7.8 million litres per day with 24% consisting of regular E10. The sale of E20 which began in January 2008 reached 92,000 litres per day in July 2008. The sale of premium gasoline dropped from 6.1 million litres per day in 2005 to 0.54 million litres per day in July 2008 with two major oil companies having ceased the sale of premium gasoline completely. Although the sale of gasohol has stagnated in recent months as the total demand for oil dropped, the tax reduction on gasohol at the end of July 2008 (thereby increasing price differential to 8.90 baht/litre) should boost gasohol sale to reach the target of 12 million litres per day by the end of 2008. By 2009 it is expected that all vehicles which are capable of using gasohol would be using gasohol which means the share of gasohol would be around 75% of gasoline sale and would translate into ethanol demand of 1.5 million litres per day. On the other hand, B2 became mandatory on 1 February 2008 with B5 being an alternative grade for motorists with a slightly lower retail price. Since diesel users are much more price sensitive than gasoline users, the sale of B5 rose from 0.12 million litres per day in 2006 to 9.8 million litres per day in July 2008. With B2 becoming compulsory in February 2008, total demand for B100 reaches 1.16 million litres per day during the first 7 months of 2008. The only constraint to B5 is now the sufficiency of raw materials. With the gradual increase in production of palm oil expected in the next few years, the target for making B5 mandatory by 2011 should be accomplished.



There is still a surplus of ethanol which is exported. Given the relatively low Brazilian ethanol price, the domestic ex-factory price of ethanol in Thailand was recorded at 17.41 baht/litre during the first half of 2008 which was 3% lower than the ex-refinery price of premium gasoline adjusted for differential in heating value. The ethanol industry which was initially subsidized by the government is now able to stand on its own feet. It is hoped that in the near future the biodiesel industry will also become competitive with diesel fuel. Although the price of B100 is still subsidized, the differential between B100 price and diesel price has declined substantially from 16.4 baht per litre in January 2008 to 6.7 baht per litre in July 2008.

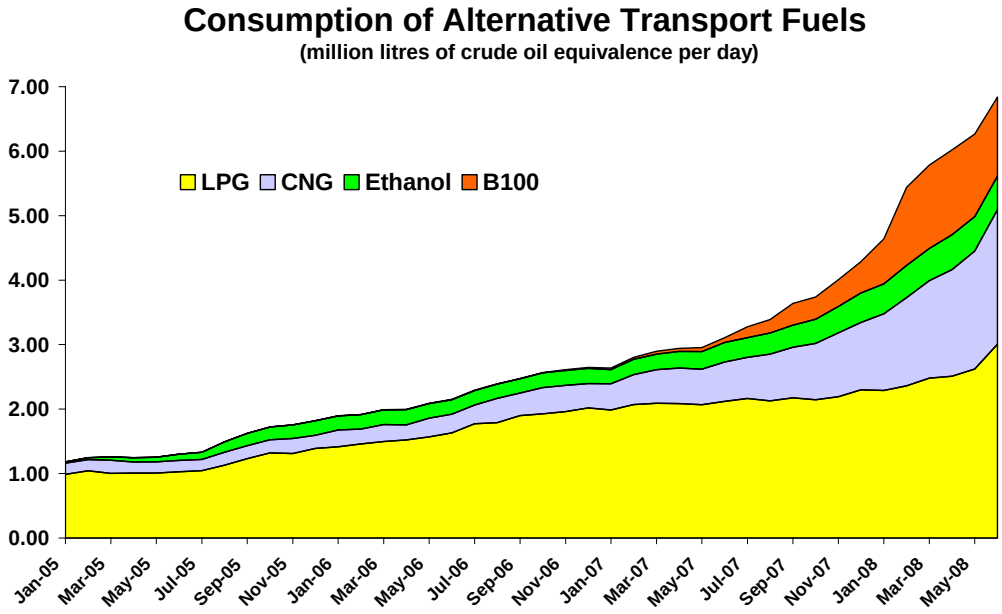
"Community" biodiesel has also been very popular. Although there are no reliable data for the consumption of "community" biodiesel, there is now a shortage of used cooking oil and the price of used of cooking had tripled over the last five years.

In 2007 Thailand consumed 3,421 million cubic feet per day (MMCFD) of natural gas with 26% being imported from Myanmar. The long term contracts with various concessionaires which partially link the well-head prices to the world price of fuel oil have caused a large divergence between the price of fuel oil (which could be considered as the substitute for natural gas in power generation) and Thailand's average natural gas price. For instance in January 2000 the price of natural gas at EGAT's power plants was 37% lower than the price of fuel oil, but with the 243% rise in the world price of fuel oil between January 2000 and December 2007 the average gas price was 60% lower than the price of fuel oil in December 2007. This provides an enormous financial incentive for the sale and consumption of natural gas in vehicles. Various incentives provided by the government ranging from the provision of soft loans and direct subsidy for conversion, exemption of excise tax on natural gas used in vehicles (whereas diesel fuel faces taxes and oil fund levy of 10-20%) together with ambitious targets for establishment of NGV filling stations all over the country have led to a rapid conversion by various kinds of vehicles to natural gas, particularly taxis, buses and trucks. During the period 2005-7 consumption of natural gas in vehicles rose from 7 MMCFD in 2005 to 37 MMCFD in December 2007. It further rose to 60 MMCFD during the first 7 months of 2008 which is equivalent to 1.68 millions litres per day of crude oil equivalence or 2.4% of gasoline and diesel demand.



LPG could be considered as alternative energy as 60% of Thailand's LPG supply comes from the indigenous natural gas and has a much lower production cost (approximately US$330-360/ton) than imported LPG (around US$900/ton as of June 2008) or LPG produced by oil refineries. LPG is an economic option for gasoline vehicles with sufficiently high mileage like taxis, but the subsidization of LPG makes it financially attractive for nearly all gasoline vehicles. This has led to rapid increase in the sale of LPG in vehicles. In particular, as the prices of gasoline and diesel rose rapidly during the first half of 2008 conversions became widespread to the extent that diesel pickup trucks started to change the whole engines so they could use LPG; and motor cycles, boats and other kinds of machineries started to convert to LPG. Without LPG price subsidy there would still be a fairly rapid conversion from gasoline, but probably less than in the present situation which has already caused Thailand to become a net importer of LPG again for the first time in 14 years.

As of June 2008 the consumption of the four alternative transport fuels (ethanol, biodiesel, CNG, LPG) amounted to 6.8 million litres of crude oil equivalence per day and have replaced 10.3% of gasoline and diesel demand compared with 2.0% in 2005.




## Towards Energy Sustainability

The force of financial incentive is remarkable, particularly when combined with the provision of technical advice and other forms of assistance to lower the technological risk in the initial period. Given the progress of the SPP and VSPP programs, the target to increase the use of renewable energy for power generation from 2,061 MW at present to 3,276 MW in 2011, or an increase of 1,215 MW, is likely to be exceeded.

Natural gas and biofuels are also expected to make further penetration into the market for gasoline and diesel over the next decade. The rapid rise in their consumption during the past years is just the beginning, but it requires consistent and comprehensive policy strategies which take into account the interests of all related parties: consumers, oil companies, biofuel manufactures, farmers, the automobile industry, the government, and research institutes. Sufficient amount of time for adjustment and fair transition path for all related parties are required. Ignoring any group would lead to failure or problems in implementation. Various constraints must also be acknowledged, taken into account and resolved: technical capability of

old cars in using gasohol and E85, limitation in the speed of expansion of palm oil production, future rise in the price of natural gas, and distorted pricing structure of LPG. Although E85 will be made available in 2008, the consumption will be negligible as there are only a few cars which are capable of using E85. It will not be until 2011 that E85 will begin to have a clear impact as the domestic automobile industry will be able to manufacture E85 vehicles. Eventually all gasoline vehicles should run on E85, but this will take more than a decade and would require a significant increase in crop yield or second generation ethanol. Mandating B5 is a reachable goal by 2011 but mandating B10 will require a substantial increase in oil palm yield and planted area which has to be undertaken without encroaching on forest areas or development of other oil crops as competitive as palm oil. Rapid expansion of natural gas infrastructures is required to support natural gas vehicles. Although there has been severe shortages of CNG supply and filling stations over the period 2007-8, but this is really due to the success of the program as a very large number of heavy duty diesel vehicles have converted to natural gas. These problems are expected to eventually disappear by 2009 and the consumption of natural gas in vehicles should rise to over 350 MMCFD by 2011. In the medium term the problem will be how to divert the supply of natural gas from the power sector to the transport sector as other more economical fuels exist for power generation. LPG will remain a serious problem as long as the government is unable to raise domestic retail price to reflect the true cost. This price distortion will have increasingly more impacts on other alternative energy, particularly ethanol and CNG, and the longer it persists the more difficult it is to correct. It is expected that by 2020 the substitution of gasoline and diesel by biofuels, natural gas and LPG would increase from 8.1% during the first half of 2008 (equivalent to 5.8 million litres of crude oil) to 29% (equivalent to 34 million litres of crude oil) in 2020.

So far Thailand has been successful to a certain extent in reducing her dependence on imported oil from various measures implemented in the past few years, particularly abolishment of oil price subsidy and the promotion of renewable energy, as we have seen the share of oil in total commercial energy consumption falling from 47.3% in 2004 to 41.5% in 2007, while net oil import has fallen by 14.6% in volume over the same period. The promotion of cogeneration, distributed generation and renewable energy, biofuels and natural gas in vehicles together with other policies to diversify from fossil energy should allow Thailand's share of oil in total primary energy consumption to fall further to 33.6% in 2011. Clearly, this is far from ideal as far as Thailand's energy security is concerned. In order to further reduce Thailand's dependence on imported oil and emission of greenhouse gases, other strategies must be pursued at the same time and must not be ignored, particularly energy efficiency in buildings and factories, energy efficiency in the transport sector (eg. hybrid cars), shift in mode of transportation from roads to rails, power purchase from hydroelectric projects in neighbouring countries, and the introduction of nuclear power in the long run. Management of the energy sector must also be further streamlined and improved. This should be accomplished by the new Power and Natural Gas Regulator recently established under the Energy Industry Act which became law on 12 December 2007.

With the right policy mix and more effort on all types of alternative energy, the worst case is that Thailand should achieve the targets stipulated in the latest power development plan: to raise the share of alternative energy in electricity generation from 6.5% on 2008 to 16.6% in 2015 and eventually 37.3% in 2021. This will also reduce Thailand greenhouse gas emission from the power sector from 2018 onwards.

Policies adopted by Thailand allows a number of objectives to be achieved at the same time: strengthening energy security of the country by reducing energy imports and promoting indigenous energy resources, competitive energy price for sustained economic growth, and providing her contribution in reducing the global emission of greenhouse gases.

## Table 4: Status of SPPs as of April 2008 by Fuel Types

| Energy Type | Number of Projects | Installed Capacity (MW) | Sale to Grid (MW) |
|---|---|---|---|
| **SPP in Operations** | | | |
| **Non-Conventional** | **31** | **721.1** | **382.3** |
| - Bagasse | 11 | 273.6 | 81.5 |
| - Paddy Husk | 5 | 57.3 | 46.8 |
| - Black Liquor | 1 | 32.9 | 25.0 |
| - MSW | 1 | 2.5 | 1.0 |
| - Waste & Flared Gas | 2 | 21.0 | 7.7 |
| - Mixed Biomass & others (1) | 11 | 333.8 | 220.3 |
| **Fossil Fuel** | **26** | **2,680.2** | **1,670.2** |
| - Natural Gas | 21 | 2,277.6 | 1,465.2 |
| - Coal | 4 | 392.2 | 196.0 |
| - Fuel Oil | 1 | 10.4 | 9.0 |
| **Combination** | **4** | **476.0** | **233.0** |
| - Waste Gas/Coal | 1 | 108.0 | 45.0 |
| - Black Liquor/Coal | 1 | 40.0 | 8.0 |
| - Eucalyptus Bark/Coal | 2 | 328.0 | 180.0 |
| **Total Projects in Operation** | **61** | **3,877.3** | **2,285.5** |
| **New SPP projects** | | | |
| **- Bagasse** | | | 4.0 |
| **- Paddy Husk** | 5 | 39.8 | 33.5 |
| **- Mixed and Flared Gas** | | | 6.0 |
| **- Mixed Biomass** | 4 | 189.6 | 110.0 |
| **Sub-total New Non-Conventional Projects** | **9** | **229.4** | **153.5** |
| **- Natural Gas** | 20 | 2,952.1 | 1,704.0 |
| **Total New Projects** | **29** | **3,181.5** | **1,857.5** |

Note: (1) mixture of bagasse, paddy husk, eucalyptus bark, woodchips, palm waste or cassava rhizome.

Source: Thailand's Energy Ministry

## Table 5: Power Purchase from VSPPs as of June 2008

| Fuel Type | Applications | | | In Operations | | |
|---|---|---|---|---|---|---|
| | Number | Installed Capacity (MW) | Sale to the Grid (MW) | Number | Installed Capacity (MW) | Sale to the Grid (MW) |
| **Conventional Fuel** | | | | | | |
| - Coal | 4 | 124.0 | 21.0 | 1 | 9.5 | 3.0 |
| - Natural Gas | 3 | 26.7 | 12.4 | 0 | 0 | 0 |
| **Sub-total** | **7** | **150.7** | **33.4** | **1** | **9.5** | **3.0** |
| **Non-conventional Fuel** | | | | | | |
| **- Solar** | 219 | 928.4 | 892.7 | 37 | 1.72 | 1.69 |
| Solar PV Roof Top | 64 | 0.72 | 0.71 | 35 | 0.148 | 0.148 |
| Solar PV Farm | 60 | 320.3 | 288.2 | 2 | 1.57 | 1.54 |
| Solar Thermal/CSP | 95 | 607.3 | 603.8 | 0 | 0 | 0 |
| **- Wind** | 6 | 20.6 | 20.6 | 0 | 0 | 0 |
| **- Biogas** | 497 | 62.0 | 52.0 | 16 | 16.6 | 10.5 |
| Animal Wastes | 14 | 3.17 | 2.77 | 8 | 1.60 | 1.33 |
| Industrial Waste Water | 35 | 58.8 | 49.3 | 8 | 15.0 | 9.2 |
| **- Biomass** | 137 | 1,335.1 | 757.4 | 42 | 509.4 | 197.0 |
| Paddy Husk | 45 | 406.5 | 319.1 | 9 | 49.3 | 41.1 |
| Bagasse | 31 | 602.8 | 175.8 | 24 | 423.3 | 135.3 |
| Woodchips | 23 | 145.6 | 123.2 | 0 | 0 | 0 |
| Palm Wastes | 16 | 89.9 | 65.4 | 4 | 23.0 | 12.9 |
| Rice Straw | 8 | 3.09 | 2.9 | 3 | 1.64 | 1.46 |
| Corn Cob | 4 | 26.0 | 21.5 | 1 | 0.16 | 0.135 |
| Coconut Fibre | 4 | 25.5 | 21.2 | 0 | 0 | 0 |
| Other Biomass | 3 | 31.0 | 22.2 | 1 | 12.0 | 6.2 |
| **- Biodiesel** | 1 | 0.025 | 0.025 | 0 | 0 | 0 |
| **- MSW** | 19 | 109.9 | 97.1 | 3 | 3.22 | 2.45 |
| **- Hydro** | 4 | 5.16 | 5.13 | 1 | 0.04 | 0.03 |
| **- Wind** | 2 | 0.33 | 0.33 | 0 | 0 | 0 |
| **Sub-total** | **435** | **2,461.1** | **1,825.0** | **99** | **531.0** | **211.7** |
| **Grand Total** | **442** | **2,611.8** | **1,858.4** | **100** | **540.5** | **214.7** |

Source: Thailand's Energy Ministry