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Towards a sustainable energy future—exploring current barriers and potential solutions in Thailand

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Abstract Renewable energy is considered an indispensable basis of sustainable energy systems as electricity generation from renewable sources results in low emissions of greenhouse gases compared to fossil fuel based electricity and contributes to sustainable development. However, effective strategies and conducive institutional settings are needed for advancement of such clean electricity systems. Although Thailand, as a nation, has a huge potential for renewable energy utilization, its total amount of electricity generation from renewables is relatively small and could be enlarged substantially. Lack of policy mechanisms, institutional development and financing exist as major barriers for Thailand in this regard. Investigation of the nation's current energy strategy implementation shows that relevant energy and development policies are at different stages of implementation and institutional settings are continuously evolving. This paper argues that further significant efforts could be made towards advancement of renewable electricity and thus achievement of energy sustainability in Thailand. Resource planning, effective policy and institutions, focussed planning for energy sustainability and implementation of the Clean Development Mechanism (CDM) under the Kyoto Protocol could facilitate further advancement of renewables for the nation.

Keywords CDM · Sustainable energy · Renewable · Policy · Thailand

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1 Introduction

Use of renewable energy sources is considered an indispensable basis of sustainable energy systems (Lund 2006). Renewable energy systems[1] provide nearly emission-free electricity compared with fossil fuel energy systems and offer additional benefits.[2] However, efficient management of energy systems including the advancement of renewables and appropriate decision-making with respect to strategies and institutional settings is also necessary economically, socially and environmentally (Schenk et al. 2007).

As a newly industrialized nation with a fast growing economy, Thailand could benefit from development and implementation of sustainable energy systems. They would assist in meeting its fast-growing energy demand, addressing potential scarcities of fossil fuel supply and ensuring social and energy security. As a basis for policy development, a comprehensive understanding of Thailand's current energy systems including renewable or socio-technical[3] systems and their governance in the Thai geo-political context is essential. However, much of the existing literature related to sustainable energy development in Thailand has focused on the technical and financial aspects of renewable energy systems including potential, opportunity and barriers for biomass and biogas energy (Prasertsan and Sajjakulnukit 2006); the impacts of biomass use and taxes in electricity generation (Santisirisomboon et al. 2003); implications of energy demand management for renewable energy in Thailand (Tanatvanit et al. 2003) and sustainable energy development strategies in rural Thailand via use of improved cooking stoves and small biogas digesters (Limmeechokchai and Chawana 2007). Also, a range of policy-oriented literature exists that discusses renewable policy initiatives in Thailand including indicators for sustainable energy development (Todoc et al. 2005); laws in Thailand promoting renewable energy (Sitdhiwej 2005) and Thailand's energy conservation program and the role of renewables (Pichalai 2007). Thus, to date, there has been little research that analyses the barriers and policy aspects relating to facilitation of a sustainable energy strategy for Thailand.

Also, the role of renewable energy in climate change mitigation for Thailand has not been considered by researchers even though removal of barriers for renewable energy projects to enable greenhouse gas emission reduction in developing nations has been highlighted as an important area for investigation (Gilau et al. 2007). In addition, little research exists on the role of the Clean Development Mechanism (CDM)[4] of the Kyoto Protocol (UNFCCC 1998) in facilitation of sustainable energy development in the Thai context.

In order to bridge these gaps, the research presented in this paper involves investigation of the issues surrounding a sustainable energy future for Thailand, and in particular, the

[1] Renewable energy systems interchangeably refer to renewable and sustainable energy systems in this paper unless mentioned otherwise. They are also referred to as socio-technical systems. Renewable energy includes wind, small hydropower, biomass, biogas and solar etc. Biomass is categorized as renewable energy.

[2] Additional benefits include: income generation; improved livelihood, communication and often facilitation of basic needs.

[3] For example, wind power and solar assisted systems are socio-technical systems, where policy instruments are required to motivate support and accelerate learning processes (i.e. learning-by-doing; learning-by-using; learning-by-interacting).

[4] CDM is a flexible mechanism under the Kyoto Protocol (Article 12). The Kyoto Protocol entered into force on February 16, 2005 after nearly eight years of negotiations. CDM gives industrialized nations the opportunity to finance greenhouse gas mitigation projects in developing nations with the aim of contributing to sustainable development while also helping industrialized nations meet their greenhouse gas emission reduction commitments (UNFCCC 1998).

potential role of CDM in advancement of electricity generation via renewables. In this regard, the paper first reviews Thailand's energy situation in relation to the nation's economy. Environmental concerns associated with energy use are also discussed. This is followed by an analysis of Thailand's current energy strategies and institutional settings. The final part of the paper examines sustainable energy strategies—both discussing barriers and giving recommendations for the future.

2 Methods and materials

A case study approach has been used for this research (Yin 1994). Assessment of renewable energy policy in Thai geo-political context has been carried out as an example of a newly industrialized nation's approach towards achieving energy sustainability. The methods used for this research included: collecting data in the field, desk-top assessment of literature and interaction with key agencies and organizations. These are employed in order to perform a systematic assessment of documentary evidence regarding Thailand's energy situation, governance and institutions; evaluation of the role of CDM with regard to advancement of renewable electricity and assessment of the barriers that constrain development of renewables in the Thai context. Interaction with representatives from government agencies, non-government organizations, research institutions and CDM project developers[5] currently active in Thailand was carried out during field research in 2006 and 2007.[6]

Some Thai sustainable energy issues that have been raised in the paper lack reliable and comparable data. All the energy, economy, environmental and social statistics in this paper are quoted or derived from the most recent available data. Unfortunately, in some cases, the only available data one from the late 1990s because more recent energy information for Thailand either has not been aggregated in some cases or publicly released in others. To ensure authenticity of gathered data, cross-comparison was carried out among different datasets and the most reliable data have been incorporated in this research paper. Thus, the important issues addressed in this article are representative of sustainable energy development trends in Thailand. This incompleteness of data for decision-making provides indications of the magnitude of the task facing Thailand if a sustainable energy future is to be pursued and achieved.

3 Economy, energy situation and environmental concerns

Thailand's energy future and potential for energy sustainability are linked with economic and environmental concerns. Aspects of the economy are briefly introduced below while the energy situation and potential for renewables are covered in more detail as background to Thailand's current renewable energy progress.

[5] Face-to-face meetings were limited to only two CDM project developers since preference was given to such projects that had received a Letter of Approval (LoA) from the Designated National Authority (DNA) of Thailand for CDM and were at an operational phase. During the first quarter of 2007, only seven projects had received LoA from the Thai DNA.

[6] This is due to fact that Internet based resources usually do not provide all the required information/data. Also data from such resources can raise issues of authenticity. Moreover, accessing information/data from off-site can be very time consuming and often unsuccessful. Field research was carried during the first quarters of 2006 and 2007.

3.1 Economy

With an area of 513,000 km^2 and a population of about 64 million in 2004 (ADB 2005a, b), Thailand has one of the fastest growing economies of the developing Asian nations. Despite the fact that the mid- to late-1990s saw the strength of the economy plunge after Thailand's overvalued currency fell precipitating a regional financial and currency crisis. In 2004, Thailand's per capita GDP was US$ 2544, which was an increase of 23% compared with per capita GDP in 1992 (ADB 2005a, b). This upward economic development trend is also expected to continue for 2007–2008 (ADB 2005a, b). The financial crisis during late 1990s did halt energy sector growth with positive consequences for emissions of pollutants, but only temporarily as recovery started in 2000. Thailand's energy consumption rate grew at a ratio of 1.4:1.0 in relation to the nation's economic growth during 1997–2002 (Hayes 2004). The upward trends in energy demand from the early 2000s together with environmental concerns about fossil fuel energy use indicate that a change of Thailand's current strategic approach towards sustainable energy development is necessary.

3.2 Energy situation and potential for renewables

Thailand has limited fossil fuel reserves, mainly about 1240 million tonnes of coal and 345 Gm^3 of natural gas (ACE 2002). Oil reserves only account for 200 million barrels (ACE 2002). Around 50% of commercial energy is imported into Thailand to meet demands for transportation fuel and electricity generation (Prasertsan and Sajjakulnukit 2006). The electricity sector in Thailand is heavily dependent on fossil fuels as Thailand uses 74% of its natural gas supply for electricity generation (Nakawiro and Bhattacharyya 2007). Although fossil fuels are expected to remain as the major source of commercial energy consumption in Thailand during the next few decades (MOE 2003), such energy resources may become very expensive due to supply constraints and accelerated demand.

In contrast to its fossil fuel constraints, Thailand has abundant renewable energy sources. Since the early 2000 renewable energy has continuously contributed to the nation's energy supply at a proportion of around 17% (Prasertsan and Sajjakulnukit 2006). In terms of electricity generation from renewables, a total of 2940 MW of hydropower (7% of total electricity generation) generating capacity is currently installed in Thailand (EIA 2005). Thailand also plans to build a further 2400 MW of hydropower capacity in the future (EIA 2005). Biomass is the most promising renewable and around 1977 MW of biomass technologies were implemented by 2006 (DEDE et al. 2006). This amount represents about 18% of total technical potential (DEDE et al. 2006). Also by 2006, 30 MW of solar PV technologies were implemented in Thailand (DEDE et al. 2006). In contrast, based on a 2006 estimation, less than 1 MW of wind turbine capacity was installed nationally (DEDE et al. 2006). Currently about 44 MW of small-hydropower technology has been implemented in Thailand (DEDE et al. 2006).

The technical potential for renewables in Thailand has been estimated to be around 60 GW by researchers of the DANIDA-PRET[7] project (PRET 2006a, b). Out of this technical potential for renewables, over 80% is seen as coming from solar and around 8900 MW from biomass (PRET 2006a, b). Table 1 summarizes the renewable energy

[7] DANIDA (Danish International Development Agency) – PRET (Potential Renewable Energy Technologies) refers to a bilateral project carried out between Danish Ministry of Foreign Affairs and Department of Alternative Energy Development and Efficiency (DEDE) of Ministry of Energy (MoE).

Table 1 Estimated potential for renewable energy sources in Thailand

Technologies	MW
Municipal solid waste	533
Biomass back pressure, 1 MW	113
Biomass back pressure, 5 MW	182
Biomass combined cooling and power	85
Biomass condensing, 20 MW	4241
Biomass condensing, 10 MW	2535
Biomass condensing, 5 MW	1833
Biogas electricity generation	251
Mini hydro (200 kW–6 MW)	287
Micro hydro <50 kW	–
Wind farm, 20 MW	1438
Solar PV large scale	49295
Solar PV residential	–
Total	60793

Source: PRET 2006a, b; –, data is not available

potential for Thailand. Most of these renewable energy resources in Thailand are still untapped, particularly for renewable electricity generation.

3.3 Environmental concerns

Use of both fossil fuels and renewables can cause impacts on the environment and society. Increased emissions of CO_2 and severe air quality impacts especially in urban areas due to emissions (from pollutants other than greenhouse gases) are major environmental concerns associated with fossil fuel use in Thailand. Impacts with regard to air quality together with other negative environmental impacts associated with advancement of renewables in Thailand, are discussed below.

3.3.1 CO_2 emissions

During the 4-year period (2000–2004), Thailand's CO_2 emissions increased by about 27% to 146 million tonnes of CO_2 emitted in 2000 (MOE 2004). This was mainly due to increased emissions from the transportation sector and rapid industrialization. According to recent projections, this upward trend of CO_2 emissions could lead to a four-fold increase by 2020 (Karki et al. 2005). The electricity generation sector alone contributed about 38% of CO_2 emissions in 2004, which was slightly less than the sector's emissions in 2000 (39%) (MOE 2004). Although, Thailand accounted for only 0.7% of world's total emissions of CO_2 in 2001, both Thailand's energy intensity and carbon intensity[8] levels have increased significantly over the past 15 years (EIA 2005). This upward trend of CO_2 emissions could potentially be reduced via further application of renewables in electricity generation[9] (see Section 4).

[8] Energy intensity – units of energy per unit of GDP; carbon intensity – unit emissions of carbon dioxide per unit of GDP.

[9] Renewable energy use in the transportation sector via biofuels is only addressed briefly in this research paper when it is relevant to other areas of renewables implementation.

3.3.2 Air quality impacts

Air quality impacts are often regarded as one of the most important environmental issues that Thailand is currently facing. Use of fossil fuels in both transport and electricity generation results in emissions of air pollutants such as CO, SO_2 and NO_x. As air pollutants from fossil fuel fired electricity generation are not seen to be significant in Thailand due to modern emission controls (Thanh and Lefevre 2000), most Thai environmental policies and measures have been focused on reducing air pollutants from the transportation sector. Some progress has been made with, for example, use of catalytic converters to control CO and NO_x emissions; phasing out of leaded gasoline by the beginning of 1996; as well as adaptation of the European Union's emission standards in 1995 (Todoc et al. 2005).

3.3.3 Environmental and social impacts associated with renewables

Renewables, although having positive benefits environmentally, also can have detrimental environmental and social impacts. A variety of negative environmental impacts, for example, loss of agricultural lands, natural habitat and social impacts have been associated with hydropower development in Thailand. As a result, public protests have been made against the construction of new hydropower dams within Thailand[10] (Yu 2003).

Other negative environmental impacts recognized in Thailand include disposal of lead-acid batteries from the widely used solar photovoltaic systems (Kaufman 2000) and air pollutant emissions from biomass such as CO and TSP (Total Suspended Particulates) which are high due to lower efficiency and incomplete combustion of biomass-fired electricity generation plants[11] (Santisirisomboon et al. 2001; Santisirisomboon et al. 2003).

4 Current sustainable energy strategies

4.1 Thai energy policy and planning and legal instruments

Thailand's energy strategies to date have focused on providing sufficient energy services for the nation's economic development while allowing for environmental protection. The 1992 Energy Development and Promotion Act, which replaced the 1953 National Energy Act (Sitdhiwej 2005), was introduced in response to the high energy demand during the 1980s and early 1990s. Currently, all energy development and promotion including renewables in Thailand are administered under this Act. Renewable energy development strategies are embedded in the 1992 Energy Conservation and Promotion Act and the 2003 Energy Strategy for Thailand's Competitiveness outlined the share of renewable energy development planned a decade later. Under this Act, the framework for Thailand's Energy Conservation and Promotion (ENCON) Program was established (Sajjakulnukit et al. 2002). Arguably, the ENCON Program has been instrumental in facilitating growth of renewables in Thailand since its inception (Pichalai 2007). The ENCON Program includes

[10] As a result, Thailand has started developing hydropower projects in neighbouring nations such as in Lao PDR and Myanmar (Yu 2003). This raises concerns that high environmental and social costs due to hydropower development will result in these nations.

[11] Advanced gasification systems with efficient control of emissions could reduce the higher air pollutant emissions.

Table 2 Renewable electricity development targets

Renewable energy sources	Existing in 2006 (MW)	Reported target in 2007 (MW)	Target in 2011		
			RPS (MW)	Incentives (MW)	Total (MW)
Biomass	1977	162.4	–	823	2800
Hydro	44	18	78	34	156
Solar PV	30	0.2	–	25	55
Wind	1	3	1	108	110
Municipal solid waste (MSW)	4	1	–	96	100
Biogas	5	1	–	25	30
Total	2061	185.6	79	1111	3251

Source: PRET 2006a, b

under its auspices the Renewable Energy Development Program[12] in its third implementation Phase (2005–2011)[13] of being implemented (Pichalai 2007).

The 2003 Energy Strategy for Thailand's Competitiveness outlined the specific targets for the share of renewable energy in final energy consumption of 8% in 2011 and 10% by 2020 moving from 0.5% in 2002 (PRET 2006a, b). Specific targets for renewable electricity generation from each renewable source are given in Table 2.

In order to achieve this ambitious target, the Government of Thailand devised the following policy measures (MOE 2003):

(i) Establish regulations for, or legal enforcement of, the Renewable Portfolio Standard (RPS) for new power plants, i.e. 5% of their generation capacity must be generated by renewable energy;
(ii) Devise incentive measures encouraging purchase of power generated by renewable energy, e.g. feed-in-tariffs, provision of tax credits, privileges and subsidies from the Energy Conservation Promotion Fund (ENCON Fund);
(iii) Support research and development on renewable energy sources and exploitation for which Thailand has a high potential such as solar, micro-hydropower, wind and biomass; and
(iv) Encourage participation and partnership of local communities in decision-making about renewable energy fuelled power plants.

Recognizing the potential and importance of biomass, the Thai Cabinet approved a new Energy Strategic Plan with very aggressive targets for biomass-based energy[14] in 2005

[12] The Renewable Energy Development Program focuses on five areas including: promotion of the use of biofuels, especially gasohol and biodiesel as transportation fuels; promotion of renewable energy utilization for electricity generation; promotion of renewable energy utilization for heat generation; policy study and research and development on renewables potential in Thailand; and human resources development in the field of renewables (Pichalai 2007).

[13] The Phase 1 (1995 – 1999) and Phase 2 (2000 – 2004) of the ENCON Program have been implemented. Overall reduction of 883 MW of energy demand by replacing of 5447 GWh of electricity and 430 litres of crude oil accounted for a saving of over US$22.2 million per year (Pichalai 2007).

[14] Although electricity generation from biomass is not competitive with other fossil fuel generated electricity due to its high capital cost (Santisirisonboon et al., 2001), biomass has been set as a prime target for renewable electricity among the different renewable energy sources for electricity generation.

Table 3 Roadmap of gasohol and bio-diesel development

Gasohol roadmap	Bio-diesel roadmap
Phase 1 (2004–2006):	Phase 1:
Replacement of MTBE (Methyl Tertiary Butyl Ether) by ethanol	Introduction of bio-diesel (5% bio-diesel with diesel or B5) in targeted areas (Bangkok and the south) by 2007
Specification development for Gasohol 95 (10% ethanol in all types of gasoline)	
Phase 2 (2007–2012):	Phase 2:
By 2012, all petrol consumed will be gasohol 95 by law	Introduction of B5 through out the nation by 2011
Ethanol production will be increased to 3 million litres per day by 2011.	
	Phase 3:
	Mandatory B10 (10% bio-diesel with diesel) through out the nation by 2012

Source: Adapted from Gonsalves (2006)

(DEDE et al. 2006). The specific biomass-based energy targets under this Plan include: reducing 25% oil for the transportation sector by 2009 with use of natural gas, gasohol and bio-diesel; increasing contribution of bio-diesel to 8.5 million litres per day (10% of diesel consumption by 2012) and transforming the agricultural sector into a modern energy supply base. The Government of Thailand has devised a 'roadmap' of gasohol[15] and bio-diesel development and promotion in Thailand (Gonsalves 2006) to combat transportation energy dependency on fossil fuels and emission reduction challenges. Table 3 shows details of this roadmap of gasohol and bio-diesel development.

According to the Thai gasohol roadmap, preliminary distribution of gasohol started in January 2007 and from 2008 promotion of gasohol 91 will be made nation wide (Pichalai 2007). A number of government support mechanisms have been introduced to facilitate the gasohol roadmap including lower price set of gasohol (3.75 US cents/l) compared with octane 95 gasoline; investment promotion for fuel-ethanol production plants; reduction of import and excise taxes for flexible-fuel vehicles (FFV) and provision for soft loans to support domestic manufacturing of FFV (Pichalai 2007). Regarding bio-diesel, Thailand has been pursuing its bio-diesel roadmap with targets to replace 10% of diesel consumption by 2012 by bio-diesel and production of 8.5 million litres of bio-diesel per day by that time (Pichalai 2007). However, limitation of raw materials for bio-diesel production, e.g. raw palm oil[16] is seen as major barrier that may prevent immediate increase in bio-diesel production (Pichalai 2007). In response to this, a major initiative by the Government is to increase palm oil plantations by 0.8 million hectares by 2009 (Pichalai 2007).

Other policy measures in favour of renewables include privatization of energy generation—via a scheme of encouraging independent power producers (IPPs) and small power producers (SPPs); pricing policy; tax reduction incentives; investment support for renewables and emission standards (Sajjakulnukit et al. 2002). Investment support for renewables has included government provision of 50% and 30% of capital costs for solar and micro-hydro projects, respectively, under the SPP programme (TEENET 2004).

[15] Gasohol is a biofuel product also referred to as E-10, which is the mixture of ethanol and octane 91 at a ratio of 1 to 9.

[16] Other raw material include coconut oi, used cooking oil, various oil plants, etc.

4.2 CDM in Thailand to date

Another strategic approach relates to Thailand's national climate change strategy with reference to the Kyoto Protocol. This includes facilitation of management of greenhouse gases emission reduction activities particularly in the energy sector of Thailand. Thailand ratified the UN Framework Convention on Climate Change (UNFCCC) in December 1994 and the Kyoto Protocol in August 2002. Although Thailand has considerable potential for sustainable energy projects which could be developed under the CDM scheme of the Kyoto Protocol, until now only 28 projects[17] have received Thai Designated National Authority (DNA) approval[18] and around 20 projects are in the pipeline. However, only five projects have been registered as CDM projects for implementation to proceed. Appendix 1 provides details of approved CDM projects by the Thai DNA (as of 10 March 2008).

Biomass-based electricity generation projects under CDM only account for less than 2% of total potential for biomass-based electricity generation in Thailand and this represents about 19% of the biomass-based electricity generation target by 2011. The electricity generation from these projects would result in an emission reduction of 0.8 million tonnes of CO_2 per year, which only account for less than 0.5% as projected in Thailand's Initial National Communication to UNFCCC[19] (MOST 2000). To compare, CO_2 emission reductions from the energy sector were estimated to be about 974 million tonnes during the 2000–2020 period of which supply side options accounted for 85% (Timilsina and Shrestha 2006).

Thailand's early initiatives on CDM have been characterized by a slow Thai approval process as host nation. However, there is potential for a large number of very significant renewable energy projects under the CDM scheme. For example, it has been estimated that an ethanol programme in Thailand could lead to up to 4 million tonnes of CO_2 reductions by 2012 and could be economically attractive under the CDM scheme (Amatayakul and Berndes 2007). To date, although Thailand has great potential for renewables such as solar, small-hydro and municipal solid waste, only biomass-based project activities have been encouraged under CDM schemes. However, the prevailing risk associated with the Kyoto Protocol after the first commitment period and issues associated with afforestation/reforestation and forestry projects under CDM in Thailand appears to have had a dampening effect on CDM implementation recently.

[17] The first seven prompt start projects were approved by the Cabinet Resolution on 30 January 2007, followed by eight project activities on 28 August 2007 (Cooper 2007). The additional 13 projects were approved under the New Thailand Greenhouse Gas Management Organization (TGO) as of 10 March 2008. Among the 28 project activities, nine projects will produce electricity from biomass combustion, sixteen projects will generate electricity from biogas. See details in Annex 1.

[18] DNA of any nation is the focal point for UNFCCC communication regarding climate change and greenhouse gas emissions. A Letter of Approval (LoA) is issued for a project activity that comply all CDM requirements by the DNA. The LoA is an essential document when a project activity seeks registration by the CDM Executive Board and witnessed during validation by the Designated Operational Entity (DOE). CDM project cycle consist stages of validation, registration, monitoring, verification, certification and issuance of CERs according to CDM methodologies and procedures.

[19] This is the only National Communication from Thailand to UNFCCC. In this study, the emissions of CO_2 from burning of biomass are discounted from the total amount of CO_2 emissions (total emission 127 Mt after discounted emissions from biomass) from the energy sector, following IPCC guidelines for national GHG inventories.

5 Assessment of sustainable energy strategic directions for Thailand

Lack of adequate policy frameworks, institutional settings, financing, technological development, human capacity and slow diffusion rates of new technologies have been reported as challenges to deployment of renewable energy technologies in developing nations (Painuly 2001; Yu 2003). Other developing nations' specific barriers include lack of required infrastructure—roads, maintenance and operating instruments, and transportation (Gilau et al. 2007) and limited social acceptance, namely socio-political, and community and market acceptance, is also seen as constraining factor in achieving renewable energy targets in many jurisdictions (Wustenhagen et al. 2007). Malicious damage has been recognized as a new impediment for adoption of renewable energy technologies in industrialized nations, for example, in Australia, which may potentially spread to developing nations (McKenzie and Howes 2006).

Accordingly, the key barriers affecting energy from renewables—particularly from biomass—are due to non-technical rather than technical issues (Rosch and Kaltschmitt 1999). Challenges to the advancement of renewables in Thailand include policy and institutional aspects, technology, finance and investment, information and knowledge, public support as well as realizing externalities. These are discussed in detail below.

5.1 Policy aspects

There have been no direct legislative or regulatory guidelines developed to date that are specifically designed for promotion of sustainable energy in Thailand. Also, current regulatory and policy frameworks with respect to advancement of renewables currently do not coordinate with overall energy sector development in Thailand (DEDE et al. 2006). Instead, Thailand has devised specific renewable resource base initiatives, such as for example, Thailand's aggressive targets for biomass-based energy systems and its bio-fuels strategy for the transportation sector. Also policy measures are biased towards energy systems with relatively large-scale and low electricity generating costs (Prasertsan and Sajjakulnukit 2006). There is a lack of focus on policy measures towards small-scale and higher cost renewable electricity generation technologies, for example, policy on biogas focuses only on large systems (1000 m^3 per unit) (Prasertsan and Sajjakulnukit 2006). Further contextual factors, changing objectives, political priorities and the influence of political actors, and resource constraints all affect policy performance and it is even more difficult to judge progress towards a goal when no specific targets have been set (Lipp 2007). Additionally, the success of policy implementation depends largely on existing implementation capacity and efforts to enhance this (Gan et al. 2007).

One possible sustainable energy support policy mechanism for Thailand could be the Renewable Portfolio Standard (RPS).[20] RPS is a quota system that requires electricity supplies to source a certain proportion of their electricity from renewables and has been implemented in 38 jurisdictions of which eight are national governments (e.g. Australia, UK, Japan) (Lipp 2007). Generally, RPS is favoured by free market proponents who prefer leaving technology choice and price unregulated. This leads to the situation that only mature technologies will be promoted. Although Thailand has devised RPS as a policy measure for advancement of renewables, however, functioning of RPS in the Thai context is yet to be implemented. Currently biomass-based technologies are preferred under this

[20] also known as the Renewable Obligation in the UK.

scheme. However, to ensure compliance, an obligation or quota system is needed with provision of penalties for not meeting the target.

Other measures such as, a Feed-in-Tariff (FIT)[21] have been shown to be effective for meeting multiple objectives compared with the RPS approach (Flamos et al. 2008). However, it should be noted that a FIT alone was not enough for promotion of renewable electricity in the case of Denmark and Germany (Lipp 2007). Another approach, a quota system in the form of tradable green certificates[22] has been operational in Sweden and has been effective in promoting bio-fuels (Wang 2006). Also, environmental taxes and tax relief as an environmental bonus often are used to promote renewables, for example, for the advancement of biomass-based heating in Sweden (Wang 2006).

In this context, Thailand lacks imposition of a mix of such policy mechanisms to support renewables.

5.2 Institutional settings

Energy activities span across a number of institutions in Thailand from political institutions to project implementing agencies as shown in Appendix 2. This has hindered the performance of the energy sector in Thailand due to differing and often overlapping policies and legislation governed by a diverse range of agencies and ministries that are associated with energy activities including renewables. This has often resulted in poor coordination among them and especially with the private sector (Prasertsan and Sajjakulnukit 2006). Such lack of coordination between different levels of government also has been observed to be present in industrialised nations with regard to energy development (Wang 2006).

Thailand still lacks a separate government Ministry that functions and oversees as a policy implementing arm for renewables in Thailand. Such institutions exist in other settings, for example, the Ministry of New and Renewable Energy in India (Ghosh et al. 2002). Initially, the Thai Department of Energy Development and Promotion (DEDP) under the Ministry of Energy was established as the lead agency for energy development, but DEDP was renamed as the Department of Alternative Energy Development and Efficiency (DEDE) in 2002, and its roles and responsibilities since then have covered clean energy generation and consumption activities as well as being the nation's sole agency for renewable energy development.

Further institutional change and lack of appropriate institutional settings have often dampened the pace of renewable energy development. For example, Thai electricity producers, which historically were state-controlled monopolies, are being partially privatized[23] (EIA 2005; Mulugetta et al. 2007; Uddin et al. 2006). Prior to recent restructuring,[24] the electricity supply industry was characterized by vertically integrated electricity generation and transmission via the Electricity Generating Authority of Thailand

[21] By guaranteeing a fixed price based on the learning curve associated with a particular technology, the Feed-in-tariff (FIT) can support various technologies at varying stages of development. All eligible projects are guaranteed grid access and a certain price for the electricity under FIT scheme.

[22] Combining obligations for consumers to use green electricity with certification of green production - advantages of such systems include: competition and cost effectiveness.

[23] However, moves to privatize EGAT were dramatically cancelled in March 2006 due to a court decision where the Judge deemed the sale to be entangled in conflict of interest which potentially could create an unfair monopoly for the new owners (Mulugetta et al. 2007).

[24] Industry reform, deregulation, liberalization and restructuring have all been used to describe the general process of electricity generation and retailing. Here, the authors prefer the term restructuring to 'reform'.

(EGAT).[25] Additionally, as mentioned previously, Thailand has experienced slow progress of renewable electricity projects under the CDM of the Kyoto Protocol due to constraints in its institutional framework and the approval procedures for CDM. However, realizing the challenge of climate change issues and in particular management of CDM issues, a new organizational structure has been established in Thailand (see Appendix 3). During the last quarter of 2007, the very new greenhouse gas and CDM institution named the Thailand Greenhouse Gas Management Organization (TGO)[26] was established as a public authority to act as the DNA for the CDM Secretariat Office. This has been seen as more effective by CDM developers involved in establishing projects in Thailand compared with Thailand's previous complex and bureaucratic CDM institutional setting (Cooper 2007). However, functional CDM institutions and simplified CDM approval procedures by host nations do exist in other settings, for example, the CDM institution that has been established in Bhutan (Uddin et al. 2007). Additionally, with respect to CDM schemes, lack of financial assistance in designing CDM activities including capacity building has been observed as a problem in Thailand.

5.3 Technological development

Technical barriers associated with renewables in Thailand have resulted from lack of standards and know-how associated with systems and equipment for a range of energy sources (Prasertsan and Sajjakulnukit 2006). Additionally, with regard to CDM projects, assessment of technology needs depends on nation's domestic institutional capacity (Gaast et al. 2008). This is a particular issue for renewable energy technology-importing nations such as Thailand due to lack of capacity building and availability of human resources with appropriate knowledge. For example, wind, solar photovoltaic and biomass technologies have a much steeper 'learning curve' compared with fossil-based technologies according to the International Energy Agency (IEA) (IEA 2000; Owen 2006). Also technical barriers exist particularly with advanced technologies, for example with biomass gasification and advanced solar photovoltaic cells, which are still at very early stages in the market. Also, their development and commercialization face challenges due to the complex link between technology adoption and economies of scale. This means that the unit investment cost could be lower for these technologies when the technologies are mature and implemented bulky; the unit cost of produced electricity consequently be lowered.

Also, from entire systems perspective of innovation, lack of coherence and integration in the design of policy measures can lead to failure particularly between the stages of demonstration and pre-commercialization and between pre-commercial and commercial development of any renewable energy technology (Allen et al. 2008). In the Thai context, development of some renewable energy technologies remains mostly in research, development and demonstration stages (RD&D), for example, with wind energy development (Uddin et al. 2006). Unlike fossil fuel technologies, the efficiency and applicability of renewable energy technologies is very site-specific and depends on very heterogeneous natural conditions. Accordingly, their development should integrate site specificity. For example, although Thailand has a high potential for solar energy, development of solar assisted technologies such as solar assisted refrigeration requires sufficient support and

[25] The current situation is that the EGAT as a state enterprise is responsible for electricity generation, transmission and distribution of electricity.

[26] As a result of the Royal Decree on Thailand Greenhouse Gas Management Organization (Public Organization) Establishment B. E 2550 (2007).

wide market dissemination for the economic feasibility of such systems (Pongtornkulpanich et al. 2008).

5.4 Finance and investment

Advanced and new technologies for electricity generation especially from renewables are capital intensive and thus associated with a high risk in investment. In particular, in Thailand financing and investment are among the major barriers. In order to enhance financial support by the Thai Government, an ENCON Fund[27] was established under the ENCON Program to provide working capital including financial grants or support to promote energy conservation, energy efficiency and renewable energy development activities (Pichalai 2007). While the ENCON Fund has provided initial support for renewables, Thailand still lacks target-oriented policy initiatives to enhance subsidies and tax provision in advancing of renewable electricity, which have been implemented in other settings. For example, in Sweden, investment support is operational for about 25–35% for wind electricity generation (>60 kW), up to 15% investment subsidy for small-scale hydro-electricity generation schemes, and support of US$625/kW of installed electricity capacity for new cogeneration or combined heat and electricity (CHP) production plants (Korner 2005; Wang 2006). Also, emission taxes levied especially on fossil-based heating systems have encouraged biomass-based cogeneration in Sweden (Wang 2006). Another example is Brazil where a programme called PROINFA (Programa de Incentivo a Fontes alternatives) has been successful in providing fiscal incentives for grid-connected wind, small hydro and biomass thermoelectric plants (Cavaliero and Da Silva 2005; Goldemberg et al. 2004). Thailand has already devised implementation of Renewable Portfolio Standard (RPS), as discussed previously; however, initial success of a market mechanism such as RPS depends on the political, administrative and socio-economic conditions of its specific geo-political context (Reiche and Bechberger 2004; Winkler 2005).

5.5 Information and knowledge networking

While overall energy related information is available from relevant Thai institutions, information on renewable energy programmes and their environmental aspects is not readily available in Thailand. The nation lacks comprehensive energy information outreach facilities and also coordination among different institutions is a problem. These are important issues because effective knowledge networking and effective communication between government institutions and local people are seen as a first step to encourage further market penetration of renewable energy systems (Nguyen 2007). In addition, a knowledge management system focusing on provision of technological know-how, including, for example, installation, operation and maintenance of renewable energy technologies, should be put in place for users. This could be extended with information on existing grid systems, examples of decentralized energy systems and successful case examples of rural energy applications. This may have a multiplier effect among Thai users of renewable energy technologies as well as project developers. Also, it should assist in

[27] The ENCON Fund was created by imposing a levy at a rate of Bath0.04/litre (US$0.00105/litre) as a one-off in 1998 on sale of petroleum products, e.g. gasoline, diesel, kerosene and fuel oil (Pichalai 2007). Additional sources for this fund include surcharges on power consumption, government subsidies and remittances from members of the private sector in the nation and investors from abroad, and the interest accruing to the ENCON Fund (Sajjakulnuki et al. 2002).

identifying baselines[28] for potential CDM projects. An example of this type of knowledge management system exists in Vietnam where information about baseline for grid-connected renewable electricity generation project is available for CDM project developers (Tuyen and Michaelowa 2006).

5.6 Community support and social acceptance

Lack of community support has been a further barrier that exists in Thailand. Factors influencing socio-political and community acceptance are increasingly recognized as being important for understanding the apparent contradictions between general public support for renewable energy innovation and the difficulties in realization of specific projects (Wustenhagen et al. 2007). Misperceptions about renewables among the Thai people have created barriers for some renewables projects. For example, opposition to a rice husk electricity plant occurred in central Thailand due to beliefs about the devastating role that acid rain[29] from the plant would play in destroying crops (Prasertsan and Sajjakulnukit 2006). Also, strong protests against hydropower development have occurred in Thailand due to severe environmental and social impacts experienced from earlier projects after construction of dams (Yu 2003). On the demand side, energy supply restructuring policy has not received strong support from the public as Thai labour unions in general oppose the policy due to concern about insecurity of future jobs and social impacts (Prasertsan and Sajjakulnukit 2006). Social acceptance in the form of community opposition has also strongly impacted afforestation projects under the CDM scheme in Thailand.

5.7 Externalities of electricity generation and vulnerability

It is estimated that the damage costs associated with combustion of fossil fuels, if internalized into the price of the resulting output of electricity, could lead to a number of renewable energy technologies being financially competitive with electricity generation from coal-based plants (Owen 2006). Even with today's technology conditions and processes for costing projects, current market conditions and taking into account externalities,[30] combined cycle natural gas technology would have a significant financial advantage over both coal and renewables (Owen 2006). To date, assessment of externalities in the Thai electricity generation context is slim, but damage costs related to the human health impacts of electricity generation in Thailand have been assessed. They are relatively small, but not negligible, ranging from US$0.006 to US$0.05 per kW (Thanh and Lefevre 2000). In comparison with fossil fuel based electricity, electricity generation from solar energy has negligible environmental externalities and should have positive social benefits for Thailand (NEPO/DANCED 1998) considering its greenhouse gas neutrality. Biomass also has significant advantages compared with fossil fuel based electricity generation in Thailand due to its sustainable supply (NEPO/DANCED 1998). Ideally, however, in order for renewable electricity to be more competitive, the price of fossil fuel based electricity should internalize its external costs. This issue is not unique to Thailand alone.

[28] Here baselines refer to GHG emission baseline scenarios.

[29] Acid rain is due to excessive sulphuric and nitrogenous gases emissions from human-induced sources.

[30] Costs borne by the governments, including direct subsidies, tax concessions, indirect energy industry subsidies (e.g. the cost of fuel supply security) and support of research and development costs, are not externalities (Owen, 2006). They do, however, distort markets in a similar way to negative externalities, leading to increased consumption and hence increased environmental degradation.

As discussed previously, currently, and in the future, energy supply in Thailand will be vulnerable to the limitations of supply of fossil fuel resources. Electricity generation in Thailand is heavily dependent on natural gas followed by coal. However, high dependence on natural gas for electricity generation raises concerns about the security of energy supply in Thailand. For example, a 10% change in natural gas price could result in a 3.5% change in electricity tariff (Nakawiro and Bhattacharyya 2007). These have often raised concerns regarding fossil fuel based electricity generation in Thailand. They may result in renewables being implemented more seriously as an energy source for the nation in the future.

6 Areas for sustainable energy policy enhancement

This paper has discussed the challenges associated with sustainable energy development in Thailand. A number of potential solutions in order to overcome barriers to implementation are discussed below. Policy innovations and reforms directed towards achieving energy sustainability are highlighted together with important policy aspects including resources planning, the role of CDM and focussed planning for energy sustainability.

6.1 Solutions to overcome barriers

6.1.1 Policy development

Although Thailand lacks explicit legislative or regulatory guidelines towards the advancement of renewables, renewable energy development strategies are embedded in the 1992 Energy Conservation Promotion Act and refined strategies and goals were set in the 2003 Energy Strategy for Thailand's Competitiveness. However, effective modalities and appropriate incentive mechanisms need to be implemented. Although energy policies adopted by the Thai Government to date have been in the right direction, the pace of implementation has been slow. Recommended approaches are bottom-up approaches, e.g. off-grid or community-based application of renewables to facilitate meeting the national renewable electricity target, and investment subsidies and encouraging private sector participation should be continued and encouraged.

One very positive policy innovation has been the Thai bio-fuels strategy which has embarked on producing roadmaps for alternative fuels in the transportation sector. While the success of this strategy will depend on effective institutions and policy settings, the bio-fuel strategy has already provided guidance for development of useful steps towards transport energy sustainability in Thailand.

6.1.2 Institutional innovation

While institutional reform in Thailand has been moderately successful on the supply side, the Ministry of Energy (MOE) as an energy policy institution and the Department of Alternative Energy Development and Efficiency (DEDE) have both made progress in implementing renewable energy programmes. However, more concerted coordination in monitoring and evaluation among concerned Ministries and Departments could facilitate nationwide renewable activities towards reaching renewable electricity targets. This is particularly important when considering CDM project activities. The Thailand Greenhouse Gas Management Organization (TGO) has been active in coordinating CDM activities among different ministries and various departments in Thailand. Also, supply side institutional reform should be scrutinized with a view to greater private participation. Accordingly, it is very important that a dedicated Thai renewable energy institution should be established in order to enhance coordination among relevant institutions and stakeholders.

6.1.3 Advancement of technological development

To advance technological developments, implementation of site-specific renewable energy technologies as demonstration projects should be emphasized in Thailand, for example, introduction of tailored solar PV and biomass-based electricity systems. Also the quality of equipment maintenance standards should be improved. This is especially important for a nation where technology use is diverse. Advancement of technology should be assured with financial and technical assistance during the early penetration of renewable technologies in order for them to successfully enter the market and create stakeholder acceptance.

6.1.4 Finance and investment measures

Several finance and investment measures would encourage further growth of renewables in Thailand. A target-oriented investment subsidy scheme should be established for renewable energy technologies. For example, solar PV and biomass-based technologies should be partially or fully financed initially. Emission taxes on fossil-based electricity generation may be considered to provide this support. This should foster renewable energy applications and biomass-based cogeneration especially in the industrial sector where there is provision for captive electricity generation, e.g. use of waste heat for generation of electricity. The implementation of a Renewable Portfolio Standard (RPS) is another measure that should be adopted and should be devised in such a way that renewable electricity generators have price certainty and ensure participation by the small-scale energy players. Furthermore, financial assistance could be usefully directed towards capacity building for CDM implementation.

6.1.5 Information hub

Responsible Thai authorities could institutionalize a knowledge hub—possibly based on the Internet—that would assist technology users as an information resource for installation, operation and maintenance of new and existing renewable energy technologies. Such an information and knowledge hub could be the responsibility of EGAT or MOE. Also, information via Internet regarding the electricity grid network could also be made accessible by users or project developers when designing renewable projects including CDM projects. Such an information network could be operational under the Thai CDM DNA.

6.1.6 Stakeholders including public participation

Effective participatory processes could lead to more successful implementation of renewable energy technologies in Thailand. For example, adequate stakeholder participation, and not just consultation, during renewable energy project design should be sought. Another possible opportunity could be community-based small-scale renewable energy applications. Also, engaging the public when considering decentralizing energy supply systems or constructing a hydro dam could foster understanding of environmental and social benefits and costs and contribute to reduction of emissions of greenhouse gases.

6.1.7 Internalization of external costs

In order to make renewable electricity more competitive, the cost of electricity from fossil-fired systems ideally should take into account external environmental and social costs. Also social benefits and reduction in greenhouse gas emissions as positive externalities should be taken into account when conducting cost-benefit analysis of renewable energy technologies. One possible approach could be to gradually reduce or eliminate government subsidies towards fossil fuel based electricity systems.

6.2 Policy directions towards energy sustainability

6.2.1 Resources planning

Thailand's current economic growth has resulted from industrialization and associated increases in energy demand. Fossil fuels are expected to continue to dominate in commercial energy consumption during next few decades in Thailand though potential risks exist due to resource constraints, their environmental impacts and price volatility. Although Thailand possesses great potential for renewables, to date renewables have been exploited only to a small extent. Renewable resource plans should focus on exploitation of Thailand's significant untapped resources. For example, target-oriented renewable energy planning with a specific focus on solar energy use could be put in place. Also, facilitation of CDM schemes could be integrated into national development planning.

6.2.2 Role of CDM

Thailand is currently experiencing the early stages of the CDM operational process and interest in CDM projects remains low (Mulugetta et al. 2007). While the national government must play a central role in facilitating the renewables, some renewable energy technologies will not be able to go ahead because of financial constraint despite improved implementation circumstances—e.g. a below-benchmark internal rate of returns. CDM could support these technologies in Thailand as it could demonstrate new technologies to make stakeholders more familiar and could generate extra revenues (based on CO_2 credits) to lift the internal rate of return above the benchmark level. Additionally, capacity building and efforts to enhance interest in CDM project development should be prioritized. Although the potential for CDM project activities is limited to small-to-medium scale, Thailand has potential for a programmatic CDM approach (Weiss et al. 2008), for example, to support implementation of the national ethanol programme for transportation sector (Amatayakul and Berndes 2007). However, such programmatic approaches are still limited due to lack of tailored methodologies for such a CDM programme of activities. There is therefore an urgent need for Thailand to explore methods for development of such activities. Thailand has clearly seen a trend in biomass-based CDM project activities. While the methodologies are already in place for biomass-based schemes, potential solar and hydropower-based project activities also could be explored. From an institutional arrangement perspective, the Thai DNA should enhance collaboration with other relevant Thai institutions for CDM development and further assist in building the capacity of relevant stakeholders. In essence, CDM schemes should be considered as an incentive and an opportunity for renewable electricity generation and sustainable development. In this regard, general capacity building and also efforts to enhance CDM projects should be prioritised.

6.2.3 Focussed planning towards sustainability for the national interest

The Thai King decreed that the philosophy of *Sufficiency Economy* or the *Middle Path of Development* should be a guiding principle of national development and management for Thailand (Taplin et al. 2008). The main principle of this approach to development is the adherence to a middle path in all aspects of social interaction at individual, family and community levels including energy sustainability aspects. However, modelling carried out under this sufficiency economy scenario has resulted in projections of only 14% of renewable energy sources to be used in total primary energy supply by 2050 and an increase of energy import dependency from 50% in 2000 to 80% in 2050 (Shrestha et al. 2007). This is mainly because of the burden of high initial costs and the lower plant load factor[31] of renewable energy technologies used for electricity generation and the intermittent nature of renewable resources. Although Thailand possesses visionary thinking and guiding principles towards sustainable development via its Sufficiency Economy approach, further strategic thinking is needed if Thailand is to become an energy independent nation. A vision for a sustainable energy strategy should be articulated as a part of the nation's Sufficiency Economy thinking.

7 Conclusions

Based on assessment of Thailand's renewable energy strategy and institutions, a number of barriers to a sustainable energy future for the nation have been identified. Areas for renewables' policy enhancement have been discussed in order to overcome such impediments towards sustainable energy development. However, this paper reveals that the prospect of achieving energy sustainability for Thailand in its current position is questionable. However, the introduction of renewables is somewhat in transition so there may be grounds for a more optimistic future outlook. Aspects of the current situation include the following:

(i) Thailand's initiatives on the advancement of renewables and thus reducing dependency on fossil fuel are somewhat stagnant strategically. There is a lack of stringent policy measures and Thai institutional settings are often fragile and too immature to respond to market demand, for example in the case of CDM.
(ii) Two major challenges with regard to the inclusion of renewable energy strategies in Thailand's sustainable development should be resolved. One challenge is to internalize the external cost of fossil fuel electricity and integrate a high share of intermittent renewable energy resources into the national electricity system. A second

[31] Plant load factor is defined as the ratio of actual plant operating time to the total hours of an year.

is to include renewable transportation fuel in the national energy strategy. While Thailand has been successful in defining a bio-fuel roadmap, it is however, yet to scale up the activities with long-term commitment to broader energy sustainability.

(iii) CDM should be taken up as an incentive instrument in terms of sustainable energy development. Thus, effective operation of CDM institutions and further refining of national CDM strategies is important. The emerging CDM approach of programmatic CDM activities should be taken into consideration especially regarding disseminating nationwide renewable energy applications such as solar PV technologies. Further, a fine balance needs to be struck between the spirit of CDM, as encapsulated in its mandate to promote sustainable development in nations such as Thailand and its economic benefits. Thailand should seriously consider approval of those projects which are deemed beneficial from the viewpoint of sustainable development.

(iv) There is potential for a relatively large-pool of sustainable energy projects in Thailand that can reduce emissions of greenhouse gases and foster sustainable development once barriers are removed. If Thailand does take up the initiative to advance renewables and to move towards sustainable energy development its experience could be replicated and adopted in other national settings. Learning from Thailand's sustainable energy development planning and implementation could then be a possible avenue for other nations.

(v) Although global trends towards development of a sustainable energy future in most nations are very patchy, there are sufficient initiatives—renewable energy targets and emissions reduction policies—to create momentum for change. Thailand is yet to find its stand in such global moves.

(vi) A nation on the up-swing towards renewables like Thailand would be well served to heed the lessons on energy sustainability emerging from industrialized nations via focusing on policy design features that have been successful, and otherwise, for meeting the range of policy objectives and challenges for those nations.

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Appendix 1

Table 4 CDM project activities in Thailand

Project title	Status	Technologies	Capacity MW	Emission reductions* (t CO_2e)
Registered projects				
A.T. Biopower Rice Husk Power Project in Pichit	Registered	Biomass to energy	22	70,772
Phu Khieo Bio-Energy Cogeneration Project (PKBC)	Registered	Biomass to energy	41	102,493
Dan Chang Bio-Energy Cogeneration Project (BCBC)	Registered	Biomass to energy	41	93,129
[a]Rubber Wood Residue Power Plant in Yala	Not proceed	Biomass to energy	20.2	60,000
Khon Kaen Sugar Power Plant	Registered	Biomass to energy	30	61,449
Korat Waste to Energy	Registered	Biogas to energy	5	310,843
[b]Ratchaburi Farms Biogas Project	De-bundling the project and requested for 3 LoAs	Biogas to energy	2.22	100,380
Projects under validation				
Surat Thani Biomass Power generation Project in Thailand	Received LoA validation	Biomass to energy	9.95	173,359
[c]Surin Electric Power Company	Received LoA	Biomass to energy	10	–
Wastewater Treatment with Biogas System in a Stretch Plant for Energy and Environment Conservation in Nakom Ratchasima	Received LoA validation	Biogas to energy	Nil	21,733
Wastewater Treatment with Biogas System in a Stretch Plant for Energy and Environment Conservation in Chachoengsao	Received LoA validation	Biogas to energy	Nil	20,449
Northeastern Starch (1987) Co. Ltd.	Received LoA validation	Biogas to energy	0.7	27,321
Chumporn Applied Biogas Technology for Advance Wastewater Management	Received LoA	Biogas to energy	Nil	23,436
Natural Palm Oil Company Limited	Received LoA	Biogas to energy	1	17,533

Table 4 continued

Project title	Status	Technologies	Capacity MW	Emission reductions* (t CO_2e)
Jaroensompong Corporation Rachathewa Landfill Gas to Energy Project	Received LoA validation	Landfill gas	1	99,139

Sources: Adapted from Cooper (2007)

* Emission reductions in metric tonnes of CO_2 equivalent per annum that are based on estimates provided by the project participants in PDDs (validated PDDs for registered project activities and un-validated PDDs for projects other than registered status)

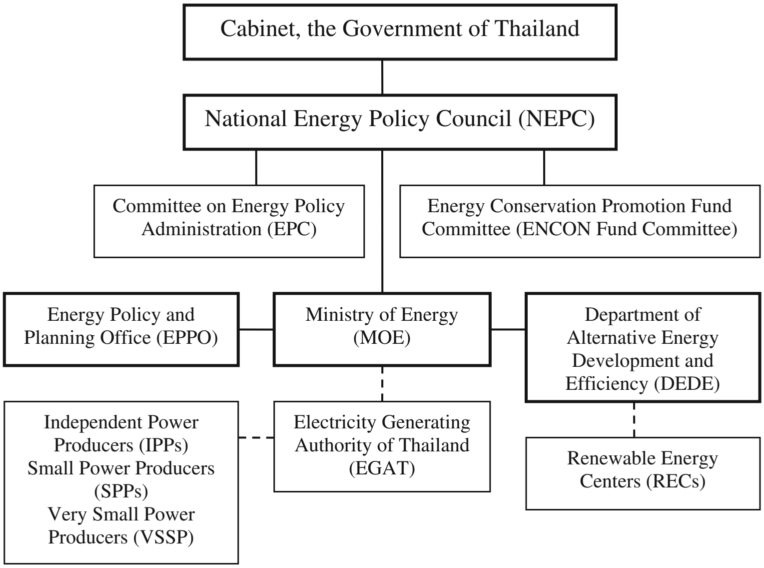
[a] This project has been implemented under Global Environment Facility (GEF) so cannot be registered as CDM though a LoA has been issued based on a preliminary application to the Thai DNA

[b] This project has received a LoA from the Thai DNA;however, as it does not meet the criteria as small-scale CDM project, it needs to de-bundled in three separate projects and applications made for three LoAs separately

[c] No information is available on the UNFCCC website, information on LoA approval and capacity were obtained from the Thai DNA

Appendix 2

Current organizational structure of Thailand's energy sector management



Source: Adapted from Pichalai (2005)

NEPC: the National Energy Policy Council (NEPC) was established under the 1992 Energy Development and Promotion Act, under the Cabinet of the Government of Thailand (Pichalai 2005). The NEPC is responsible for formulation and overseeing of energy policies and plans.

EPPO: the Energy Policy and Planning Office (EPPO) was established to function as a secretariat of the NEPC.

EPC: To enhance efficient management, the Energy Policy Committee (EPC) was established to assist work with the NEPC (Pichalai 2005).

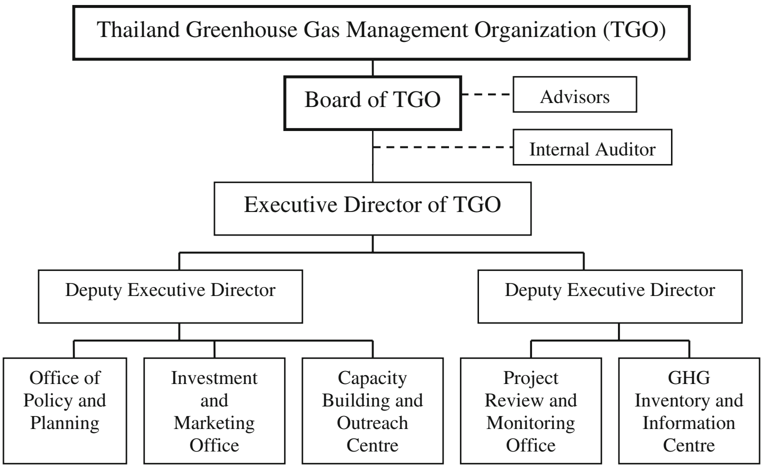
ENCON Fund Committee: The Energy Conservation Promotion Fund Committee was established to assist the NEPC with the Energy Conservation Promotion Fund (ENCON Fund)

MOE: The Ministry of Energy (MOE) as a sole agency responsible for energy activities was established and empowered under Sections 5 and 26 of the 2002 State Agency Organization Act (Sitdhiwej 2005).

Renewable energy institutions, EPPO and Department of Alternative Energy Development (DEDE), are the sole government agencies responsible for renewables in Thailand's energy sector. Renewable Energy Centres (RECs) under the DEDE demonstrate and promote renewables in local communities. The Electricity Generating Authority of Thailand (EGAT) is responsible for decentralized electricity generation from renewables. Other players include independent power producers (IPP); small power producers (SPP) and very small power producers (VSPP).

Appendix 3

CDM organizational structure in Thailand



Source: Adapted from Cooper (2007).

MONRE: The Ministry of Natural Resources and Environment (MONRE) acts as the Designated National Authority (DNA) to the UNFCCC and is responsible for approval of greenhouse gas emission reduction projects including renewable energy projects under the CDM of the Kyoto Protocol.

ONEP: The Office of Natural Resources and Environment Policy and Planning (ONEP) acts as the DNA secretariat. ONEP acted as the national focal point for the UNFCCC and coordinates CDM activities in Thailand until beginning of 2007. However, due to constraints in the institutional framework and the approval procedures for CDM, ONEP proposed establishment of a new institution for climate change and CDM as the CDM Institution in Thailand. Realizing the challenges of climate change issues and in particular management of CDM issues, the Thai Cabinet agreed to proceed the 'Royal Decree on Thailand Greenhouse gas Management Organization (Public Organization) Establishment B.E. 2550 (2007) and the 'Order of the Prime Minister on Climate Change B.E. 2550 (2007) (Cooper 2007).

The National Committee on Climate Change: The National Committee on Climate Change Policy was established under the Order of the Prime Minister on Climate Change B.E. 2550 (2007) issued in June 2007 and is chaired by the Thai Prime Minister. This comprises relevant Ministries and experts are responsible for overall climate change issues.

Climate Change Coordinating Office: the Climate Change Coordinating Office under the ONEP serves as a secretariat to the National Committee on Climate Change Policy.

TGO: The newly established Thailand Greenhouse Gas Management Organization (TGO) under the Royal Decree on Thailand Greenhouse Gas Management Organization (Public Organization) Establishment B.E. 2550 (2007), serves as a secretariat for the DNA. TGO reviews greenhouse gases mitigation projects including CDM and provides associated services.

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