Small Scale Biomass CHP Projects - Improving the Framework Conditions for CDM in Thailand

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Abstract: *This paper discusses a CDM project located in an industrial park, Navanakorn, in Thailand. It concerns a small scale biomass Combined Heat and Power plant (CHP) with supply of district heating, and it outlines the potential benefits obtained by this transitional energy supply system compared to the existing baseline situation. The project has yet to be implemented, but is here suggested on the basis of thorough analysis of a community of SMEs. The case study illustrates that SMEs' heat demands can be reduced significantly and met by using biomass waste from the local community. To support the implementation and disseminate the project idea in Thailand, the paper suggests a whole range of supportive policy recommendations to overcome implementation barriers, and identify the most influential stakeholders. The paper concludes, among other things, that the Federation of Thai Industries should take the lead in promoting the implementation of biomass CHP within industrial parks in Thailand. The Ministries of Energy and Industry should thus map the energy consumption patterns within the Thai industries and identify available biomass waste within and outside the industrial parks. Finally, the paper stresses the need for stronger governance in relation to climate change initiatives in Thailand.*

Keyword: *Clean Development Mechanism (CDM), Sustainable development, Thailand, Policy recommendations, Stakeholder identification, Combined Heat and Power (CHP), Co-generation, Biomass waste.*

1. Introduction

1.1 Outline of CDM Project Activities Globally

The Clean Development Mechanism (CDM) is one of three market based mechanisms included in the Kyoto Protocol, and focuses on the transfer of carbon credits from developing to developed countries. A second mechanism is the Joint Implementation (JI) mechanism which focuses on emission reductions in both countries; typically a developed country and a country in transition (e.g. Eastern European countries). Finally, a third mechanism is the Emissions Trading Scheme (ETS) that allows companies etc. within the EU to trade credits between each other (UNFCCC, 2011).

In this paper we concentrate on the CDM which concerns the implementation of projects reducing greenhouse gas emissions in developing countries. These reductions are then transferred to the developed world to meet their emissions reduction commitments under the Kyoto Protocol.

Currently more than 5,600 CDM projects are in the pipeline worldwide, with a total amount of 2,700 million expected Certified Emission Reductions (CERs) to be issued by the end of 2012 (UNFCCC, 2011a). By 2012, the share of expected CERs coming from projects dealing with industrial gases will decrease to 26 %, whereas 'renewable energy' and 'energy efficiency/fuel switch' will increase their shares to 36 % and 18 % respectively (UNEP Risø, 2010).

1.2 Focus of this Paper

The emphasis of this paper is on promoting CDM projects to be implemented within industrial communities of Small and Medium Sized Enterprises (SMEs)[1]. The paper describes the project idea concerning an industrial park in Navanakorn, and the paper outlines the benefits that could be achieved. We claim that such projects could assist a transition of the energy supply system if widely disseminated within the Thai manufacturing sector. This would be a substantial additional benefit of this type of CDM project, and not a formal CDM requirement. The purpose of this paper is thus to point out relevant policy recommendations, and to identify important stakeholders who can support the implementation of the suggested project.

The Navanakorn CDM project relates to the implementation of biomass combined heat and power (CHP) plants which employ district heating. It is envisioned that a single energy facility would supply power and heat to several industries in the industrial park, and would substitute the use of fossil fuels in many smaller individual boilers, and the supply of power from the national grid with a high fossil fuel mix.

The present paper is a follow up on an earlier paper (Lybæk, 2008) in which the technical issues related to the design and implementation of the proposed energy supply system were presented in detail. Based on thorough technical, economic and resource/waste related studies in the case area, undertaken over a period of seven years, it was concluded that such a system could be developed and provide various benefits (economic, environmental, etc.) for the local community. Thus, this paper only provides a short summary of the benefits obtained by developing such an energy supply system, as its main focus is on how to enhance the framework conditions for implementing such projects in Thailand. Thus, we concentrate on policy recommendations and stakeholder identification in supporting such future energy supply systems.

1.3 The Energy Situation in Thai Industries

Globally there is an emerging need for the implementation of more renewable energy technologies and systems, Thailand is no exception. Co-generation, CHP, already exists in Thailand, usually implemented under the Small Power Producers' (SPP) scheme which lies outside the CDM framework. The aim has been to supply energy to large agro-industries (for example the processing of palm oil, rice and sugar), which are located in remote areas. Co-generation plants which fall under the SPP scheme (up to 90 MW) are also to be found within industrial parks in Thailand. These plants are fuelled by natural gas or coal and supply high quality energy, thus steam, to nearby industries that have a high demand for this type of energy.

However, co-generation plants based on *biomass waste* have yet to be introduced into industrial parks. Such plants could supply low quality energy, thus district heating, to communities of SMEs with a relatively high percentage of their energy demand being hot water rather than steam (thus below 100 degrees C.). On average, 65 % of the heat demand in wood, pharmaceutical and food manufacturing SMEs requires hot water and not steam (Lybæk, 2004).

Close to 40 % of the industrial output in Thailand measured by GDP is produced by around five million SMEs primarily located within approximately 80 industrial parks (Pongvutitham, 2010). These types of industries therefore account for a significant amount of the total energy consumption of the industrial sector. Within this sector 'manufacturing' is one of six sub-sectors (agriculture, mining, manufacturing, construction, residential, commercial and transportation sector) which account for 37 % of the total energy consumption in Thailand, or 24,195 ktoe (thousand tonnes of oil equivalent). The energy types consumed in this sector are coal, renewables, electricity, petroleum products, and natural gas (DEDE, 2008). Compared to the manufacturing sub-sector, the agriculture, mining, construction, and transportation sub-sectors for instance consume 3,446, 121, 105 and 23,097 ktoe respectively. Thus, the energy consumption seems relatively high within the manufacturing sub-sector which primarily consists of SMEs.

The manufacturing sector in Thailand emits around 40 million tons of CO_2 annually (DEDE, 2008). The claim here is that 36 % energy savings could be obtained if projects like the one proposed at Navanakorn are implemented, thus lowering CO_2 emissions considerably. Except from a few industrial parks consisting primarily of large scale petro-chemical companies (e.g. in Map Tha Phut), most industrial parks in Thailand are a mix of different SMEs (Lybæk, 2009), and thus very similar to the one studied. This enhances the possibility of replicating the results from the case study to other industrial parks, using the programmatic CDM approach emphasised later in this paper.

1.4 Biomass Waste from Industries

Previous studies in Thailand indicate that large amounts of biomass waste from the manufacturing sector could be used as fuel, but mainly are discharged or re-used inefficiently (most often for heat-only production in boilers; see Lybæk, 2008). The actual amount of and energy potentials from biomass waste generated by SMEs industries are not systematically identified or mapped.

The waste varies in type and quantity and can, for instance, be composed of wood residues from furniture industries (wood pieces or saw dust), residues from the production of food (dry sludge, different solid fractions) and various types of residues from pharmaceutical industries, (fermentation sludge, bio-oil) (Lybæk, 2008).

The use of and knowledge about biomass waste from the agricultural sector in Thailand, are, on the other hand, relatively high. Analyses estimate that the energy potentials from biomass waste amount to 7,000 MW (EPPO, 2003), with biomass (bagasse, rice husk, wood chips), municipal waste and biogas accounting for 3,700 MW (EPPO, 2008). As mentioned earlier, rice, sugar and palm oil mill residues are already used for energy production in co-generation plants within the Small Power Producers scheme (Holm, 2009).

As the amounts and character of the biomass waste from SMEs industries varies quite a lot, it is rarely used efficiently for energy production. *If* actually used for energy purposes it is mainly converted in small individual boilers (heat-only), but most often it is discharged with the ordinary waste collection or donated as animal feed (Lybæk, 2004). Therefore, a joint biomass CHP plant could be a better way of using the waste for energy purposes, as it will be collected and mixed from many sources making the quantity larger and improving the combustibility of fractions with low heat value. The energy production will also be composed of both power and heat. Thus, the CDM project we propose in this paper suggests that Thailand adapt to biomass CHP supplying low quality district heating to SMEs. The technology can rely on domestic (not imported) biomass waste as fuel and has the capacity to produce *both* power and heat, which usually are generated separately in such types of industries today.

There are, however, challenges in relation to the profitability of implementing such energy supply systems, and in this respect this paper addresses the CDM procedure as a helpful input to such investments. If CDM however fails as a future mechanism, the biomass CHP with district heating must still be promoted in developing countries as a means to provide more efficient energy production and consumption in this part of the world. Thus, the above problem area leads to the following research question:

1.5 Research Question

What are the benefits of, and how can the implementation of biomass CHP with district heating be supported in a community of Thai SMEs, through an identification of relevant policy recommendations and influential stakeholders?

2. Methodology

Navanakorn is located 45 km north of Bangkok. At this site we suggest the implementation of a small scale biomass CHP plant distributing district heating to nearby industries. The aim is to create a joint energy supply system within Navanakorn, making it possible to phase out the use of fossil fuels used in individual boilers for heat-only production, as well as large amounts of fossil fuel used for national power production (in Thailand the fuel mix is mainly natural gas, petroleum, lignite, hydropower and renewables). A more detailed and thorough description of the proposed CDM project can be found in Lybæk (2004; 2008) and in Lybæk & Jacobsen (2009).

In order to answer the research question this paper will ***firstly*** provide a short description of research findings, ***secondly*** elaborate on the *benefits* of the energy system proposed in Navanakorn so as to illustrate its relevance as a CDM project. ***Thirdly***, we then provide *supportive* policy recommendations and identify important stakeholders to facilitate the implementation of the energy supply system proposed.

In doing this, we distinguish between ***market*** and ***non-market*** approaches to conditions having impact on the CDM project proposal, as well as on other potential CDM projects at different levels. A market approach is for instance to identify the biomass waste generators (farmers, municipalities, industries etc.) and to engage them in the use of biomass for energy production. A non-market approach concerns how to establish such conditions and thus to enhance the framework conditions for collecting the biomass waste in order for it to be converted efficiently in a CHP plant. Behind the market and non-market approach specific stakeholders exist, each of them having either ***influence*** or ***no influence*** on improving the conditions for CDM in Thailand. The policy recommendations, as well as the identification of stakeholders capable of supporting future CDM project activities, will be pointed out as explained below.

As illustrated in Table 2 in the final section, the methodology applied has firstly been to identify **what impacts CDM projects.** For instance, in sections 4.1 & 4.2 in the planning phase we have identified that 'biomass fuel' and supply of 'appropriate technology' are important elements in this phase, named the Project Design Document (PDD) phase. Thus, by means of the analysis conducted in Section 4, relevant **policy recommendations** are made for how to improve the conditions for CDM in this phase. Hence, relevant 'industrial and agricultural waste policies' could thus strengthen these conditions (non-market), as well as provide enhanced focus on and support to various 'waste generators' (market). **Influential stakeholders** are identified and project carriers pointed out. This continues with an identification of what impacts CDM projects have in the CDM *'implementation phase'*, and in the CDM *'operation phase'* with policy recommendations and influential stakeholders likewise being identified. The above analysis will enable an answer to the research question posed, which is illustrated in Table 2 in the final section.

3. Presentation of Thai Case Findings and Potential Benefits

3.1 Resource Optimization within Industrial Parks

Before summarizing the findings from Navanakorn we briefly present two Figures (1 and 2) illustrating the idea of resource optimization that can be applied within industrial parks, which interact and connect with the outside community from where biomass fuel can be supplied to the Parks.

The figures concern the 'connected' energy supply system (the suggested CDM project proposal), as opposed to the 'disconnected' energy supply system (the existing situation or 'baseline'). In the 'disconnected' energy supply system (see Figure 1) there are no interrelations between the industries located within the industrial parks, and no or limited interrelations between the industries and the surrounding community. The fuel supply is based on individual consumption of fossil fuels converted in boilers and supply of power from the national grid. The efficiency of the energy system is relatively low and highly fossilized. Discharges of waste go primarily to landfills, or to other companies within or outside the community for inefficient re-use (Lybæk, 2009).

In the 'connected' energy supply system (Figure 2) the fossil fuel inputs are substituted by biomass waste from industries located within the industrial park, as well as from various waste generators located outside the Park. This could be agricultural residues or biomass residues from vegetable markets or organic waste from households located in the municipality or province, etc. An interrelation between industries is established, as the former individual energy supply is converted to a joint energy supply system based on distribution of power and heat from a biomass CHP plant located inside the industrial park.

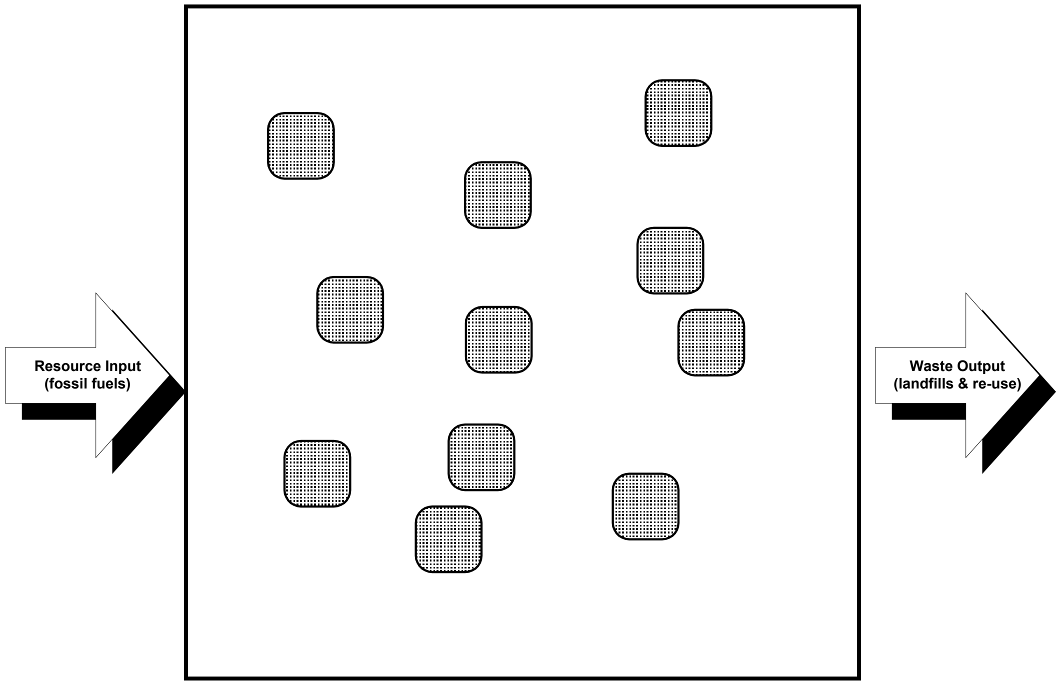

Figure 1: *'Disconnected' energy supply system among industries located within an industrial park. Squares indicate that the industries are not connected (Source: authors)*

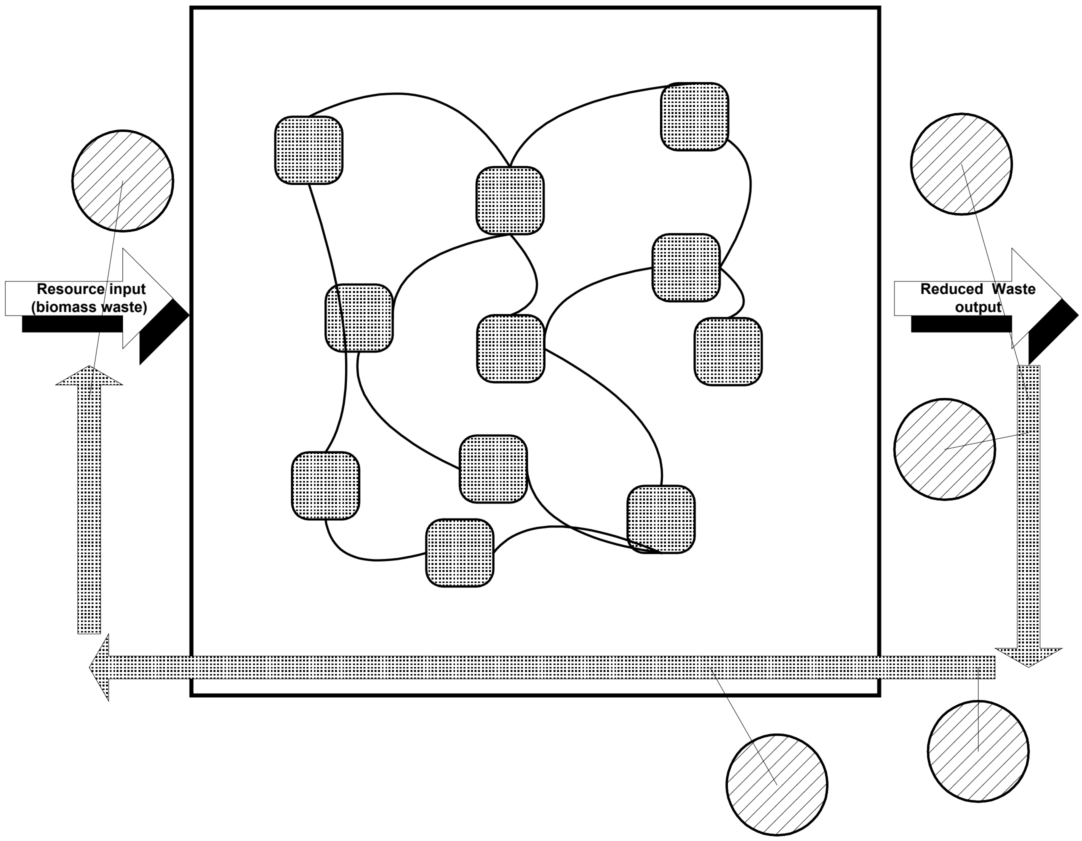

Figure 2: *'Connected' energy supply system between industries located within an industrial park. Squares indicate the connected industries and circles the supply of external biomass waste to the park (Source: authors)*

Thus, the biomass resources are collected from within and outside the industrial park, and converted in a decentralised CHP technology inside the Park. The 'connected' energy supply system provides many benefits for the local community as indicated briefly above. In the following a real case study emphasising the above will be presented.

3.2 Navanakorn Industrial Park

Navanakorn consists of approximately 250 manufacturing industries located in four industrial zones within the Park, and the number of industries is constantly increasing (Sasindran, 2007; Navanakorn, 2008). There are many types of industries located in Navanakorn, such as food, medical and furniture industries, electronically and assembly industries. Few of them are large scale businesses, i.e. having more than 2,000 employees, but mostly SMEs with less than 500 employees (Lybæk, 2004; Navanakorn, 2008).

The ***baseline situation*** (existing energy supply system) for the six SMEs case industries in the food, wood and chemical line of business located within Navanakorn is illustrated in Figure 3. They all rely on the supply of fossil fuels in the form of power from centralised Thai power plants transmitted on the national grid, as well as on fuel oil (bunker oil) for heat-only production in individual boilers (except from Rockwood who produces process heat by means of power only). The efficiency of the energy supply system is relatively low, as it is based on a separate production of power and heat (heat-only boilers and power supply from the national grid). The efficiency of centralised power plants in Thailand is also relatively low (Greasen & Footner, 2006).

As indicated in Figure 3, valuable resources are transported out of Navanakorn (see the large arrow in Figure 3), as the collected biomass waste primarily goes to landfill or to other outside sectors for inefficient re-use leading to increased transportation; hence emissions of methane (CH_4) and CO_2. Other Thai provinces receive the landfill waste from Pathum Thani today, as only limited spatial areas can be found for waste disposals in the province (Lybæk, 2004).

The ***CDM project activity*** (energy supply system undertaken transition, by means of a biomass CHP with district heating), seeks to exploit local resources within Navanakorn and minimise the flow of unsustainable materials (fossil fuel based energy) *inside* the Park. It also seeks to prevent valuable resources from the area to be discharged or re-used inefficiently *outside* the Park. The energy system suggested thus relies on a local self-supply scheme in which industrial biomass waste are used as fuel in a CHP technology, which distributes power and heat to *several* (here six) SMEs connected to a district heating network. Local agricultural biomass waste, or other sources of clean organic waste, can also be supplied in order to increase the amount of biomass fuel.

As the consumption of steam mainly takes place at Imperial, and to a lesser extent at B.B. Snacks, it is possible to cover the process heat demands in the remaining industries solely by district heating (hot water, not steam). This means that energy savings are obtained both in quality (from 'steam' to 'hot water') and in quantity (by the reduced amount of energy which it is necessary to produce in order to cover the energy demands) (Lybæk, 2004; Lybæk, 2008; Lybæk & Jacobsen, 2009; Lybæk, 2009).

Thus, from the district heating network, the industries now extract heat at different temperatures - according to their specific demands - by means of heat exchangers and individual service lines. Back-up energy will be provided individually by the existing fossil fuel boilers installed at the industries, or collectively by a stand-by natural gas boiler. As the distances between the industries are relatively short (defined by the industrial park boundaries), the costs of applying district heating networks along the roadside to industries - composing the heat-market - are quite feasible (for thorough technical details and feasibility study see Lybæk (2004)).

3.3 Potential Benefits

The benefits obtained by applying this transitional biomass CHP technology with district heating between several SMEs in Navanakorn are as follows:

Saved expenses will be achieved as the industrial biomass waste from Navanakorn now will be used as fuel for energy production instead of fossil fuels for heat-only production and purchase of power from the national grid. This will lead to economic gains (or saved expenditures) for participating industries, as energy expenses pose a higher and higher cost on the manufacturing sector in Thailand (Møller, 2009). Also, costs related to waste handling can be

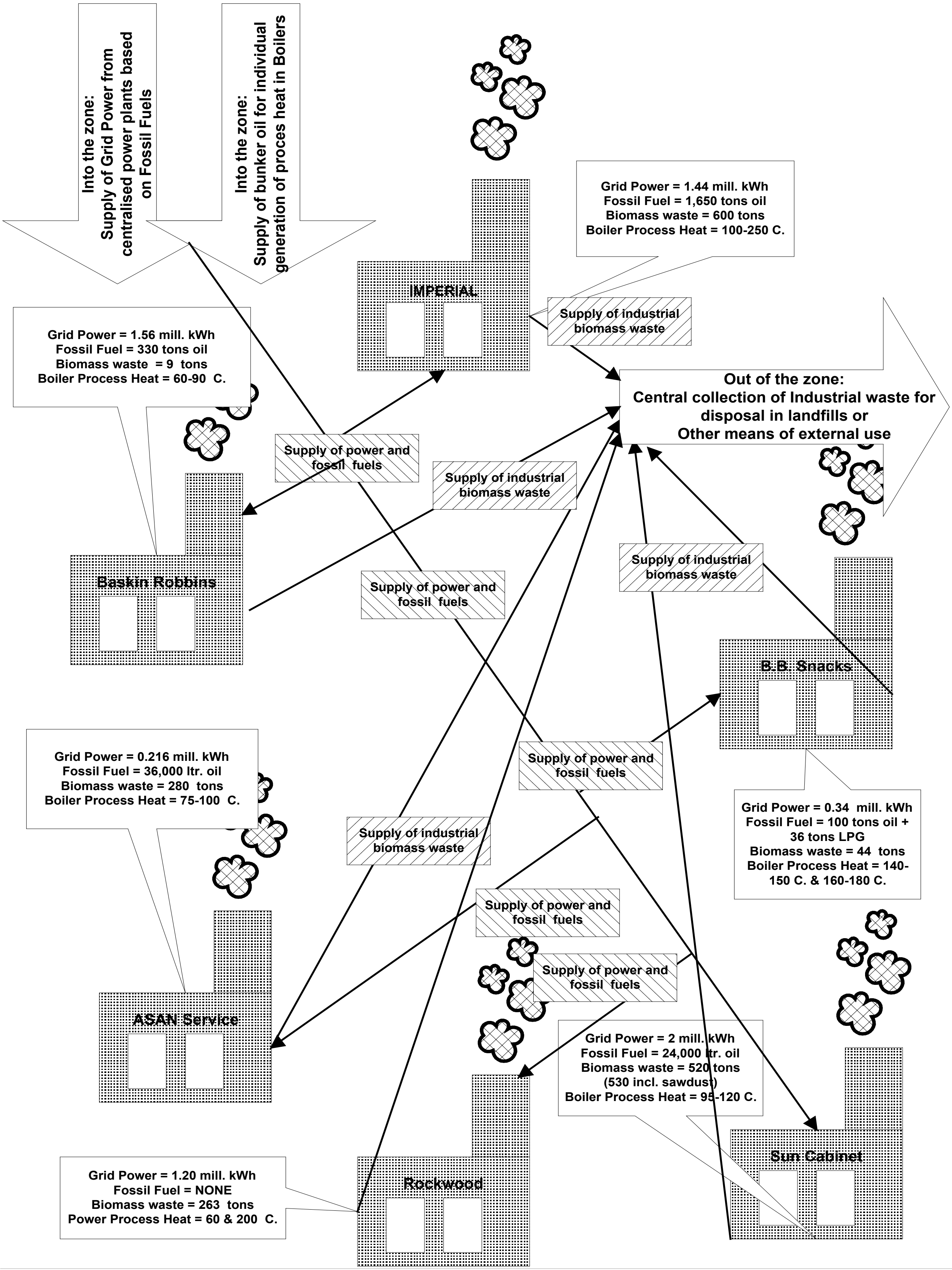

Figure 3: *Baseline energy supply system ('disconnected' system) (Source: data collection and calculation by Lybæk, 2004 & 2009)*

reduced or eliminated, as the biomass waste will be used within the park instead of being transported to landfills by external waste handling companies (Lybæk, 2004).

New businesses opportunities can thus emerge and create new value chains in the local community. Biomass waste, previously regarded as an expense for local industries, will become a resource and be used as fuel for generating valuable energy, i.e. power and heat. If surplus heat is generated, it could be sold to nearby industries, or/and surplus power can be transmitted to the grid creating extra income for participating industries. Local farmers can supply agricultural wastes to the energy plant and thereby receive extra income, and also receive farmland fertiliser (bottom ash) from the energy plant, substituting costly fabricated products.

Optimization related to the ***materials chain***, are as follows: Biomass disposals in landfills leading to methane emissions, which pose a big pressure on local governments, can now also be terminated. Avoided CO_2 emissions from transportation of biomass waste out of Navanakorn (for illegal dumping or to authorised landfills), or for external re-use (if any) elsewhere, can also be obtained. Burning of for instance rice straw on agricultural land also lead to CO_2 emissions and local air pollution etc., and if left to decay it will cause emissions of methane to the atmosphere. These emissions can also be avoided when implementing the project proposal. Thus, CO_2 emissions emitted along the materials chain, as illustrated above, are stopped/reduced by implementation of the suggested CDM project proposal using the biomass waste as fuel.

As far as the ***energy chain*** is concerned the following optimization will occur: CO_2 emissions can be avoided from extraction, transportation and final consumption of fossil fuels for both power (from centralised power plants) *and* heat production (from individual boilers). The project proposal is thus based on a very efficient local production and consumption of power and heat, on applying energy efficiency, and on improved manufacturing processes (process integration and cascading of energy), as well as on conversion from steam to hot water. By means of the district heating network, improvements are obtained by the cascading of energy from Imperial to B.B. Snacks and from Imperial to the district heating network, and again, from the network to the industries connected to it.

From the case it is thus calculated that the quantity of energy (heat supply) necessary to produce, can be lowered significantly: from 17,200 MWh/year to 11,000 MWh/year (a 36 % reduction) with the supply of biomass waste equalling 18,400 MWh/year (a more thorough description of the new energy supply system can be found in Lybæk; 2008; Lybæk & Jacobsen, 2009). The biomass waste in this case study example is converted in a cost effective biomass CHP plant with district heating and a capacity of 2.6 MWtotal. Apart from reductions in emissions of SO_2 and NO_x, the proposed energy system can contribute 28,100 tons of CO_2 emission reductions yearly, when including all the activities along the material and energy chains outlined above (Lybæk, 2009).

The ***job opportunities*** include approximately 10 "construction jobs" (short term), and 7 "maintenance & operation jobs" (long term) will be created as *direct jobs* (see background calculations in Lybæk; 2009). These estimations are based on the type and size of the specific energy plant in MW installed capacity etc., which reflects the construction period and the labour necessary to run and maintain the plant (see Heaver & Del Chiaro, 2003; Kjær, 2006). Direct jobs normally lead to the creation of *indirect jobs* and is in the scale of 2 to 4 times the direct jobs (Kjær, 2006), which should be added to the above.

In the Thai context the job opportunities connected to such projects might be even higher, as jobs connected to for instance maintenance and operation probably would be more labour intensive compared to other parts of the world. An example would here be local farmers' collection of agricultural residues to be supplied to industrial parks for efficient energy production.

4. Identifying Policy Recommendations and Influential Stakeholders

4.1. Biomass Fuel

The biomass fuel depends on the supply options, the quality, and the price of raw materials, etc. These prices are connected to the waste policy and regulation in Thailand, as well as to potential taxes and disposal fees put on waste, etc. For industries using their own biomass waste as fuel, the 'biomass fuel' is free (but setting up a large collection system will off course have a price), and lead to savings for industries. Waste management costs will decrease with the proposed transition of the energy supply system (see policy recommendations in Table 2 in the concluding section).

Waste from ***residential and manufacturing sectors*** is usually collected by the local tambon's (municipals) and transported to landfill areas and dumped (Lybæk, 2004). These activities pose an increasing problem for the tambon's, as spatial land for developing landfills are getting difficult to locate. This means that the waste is transported over increasingly long distances (Ibid.), or illegally dumped at riversides or burned uncontrolled (Parasnis, 1999). The practical collection of the waste is normally the responsibility of the tambon's in which the industrial parks are located, and the overall responsibility for pointing out appropriate areas for landfill areas are the Province in which the industrial park is situated (Lybæk, 2004).

The Ministry of Industry's (MoI), Department of Industrial Works (DIW), is responsible for industrial waste management in Thailand, including industrial, commercial and household wastes from Industrial Estates or Zones[2]. They authorise industrial waste being moved from one place to another to be for instance re-used in both Industrial Estates and Zones, but their actual waste management is limited to a small number of private Industrial Zones. The Industrial Estate Authority of Thailand (IEAT) is responsible for the management of wastes etc. in Industrial Estates (Sombutsiri, 2007), which constitutes the majority of industrial parks in Thailand. Both DIW and IEAT are thus important stakeholders when it comes to the supply of biomass wastes from industrial parks and to facilitate the proposed CDM project within such sites (Ibid.; Sutiratana, 2008).

In Pathum Thani Province waste from the ***agricultural sector*** primarily consists of large quantities of rice straw being burned on the fields, which hence pose a great potential as fuel supply to local industrial parks. Unlike other kinds of biomass residues (rice husk and rice ash of which the latter is used in the cement industry, etc.), rice straw is not yet exposed to any kind of competitive use that puts a price on it (Praphakornkiat, 2007). Thus, as the pressure for appropriate waste management increases in Thailand, due to the many problems related to industrial, residential and agricultural wastes, various stakeholders will be interested in finding more local and sustainable waste management solutions. This could include stakeholders in the central administration, just as more local stakeholders responsible for waste disposals will be increasingly interested in finding new solutions, emphasised below.

4.1.1 Actions by Influential Stakeholders

The ***industrial waste policy (non-market)*** can be supported as follows: Within the industrial parks, especially DIW could support the supply of biomass for energy production, by a quick approval of applications for moving waste (for re-use as fuel.). DIW could also strengthen the regulation on industrial wastes to limit the amounts of biomass wastes being discharged, and encourage reuse inside the industrial parks. This should be done in collaboration with IEAT, which is in charge of the majority of industrial parks in Thailand. At the municipal and provincial level both Takhlong Municipality and Pathum Thani Province can play a role in supporting the supply of biomass wastes for energy purposes within Navanakorn.

Takhlong Municipality could set up higher demands for waste collection from industries located within the Park, as to prevent valuable biomass discharges. Presently, biomass waste is discharged with the normal wastes, and therefore ends up in landfills or dumped on unauthorized land. Takhlong Municipality could set up a scheme in which industries would have to pay a fine for discharging valuable biomass wastes. This would act as an incentive for separating the waste, and thus facilitate appropriate re-use of the waste.

Another possibility is to examine the present re-use of biomass wastes, and thus evaluate and suggest other means of re-use, preferably within the industrial parks. Some of the industrial biomass waste from Navanakorn is, for example, transported far away, and re-used quite inefficiently in other manufacturing business. In case industries (see Lybæk, 2008 for detailed information on Imperial, Sun Cabinet and Rockwood) almost all the biomass waste was transported outside the industrial park and re-used for production of heat-only elsewhere, or simply discharged.

As more than 250 industries are located in Navanakorn, it is very likely that large amounts of biomass waste undertake such inefficient re-use (if any) elsewhere. Such analysis could increase the amounts of biomass available within Thai industrial parks, and the mapping could be undertaken by Pathum Thani Province, DIW and IEAT jointly. The outcome of the analysis could be a strengthening of the industrial waste regulation by DIW, prohibiting outside re-use of biomass waste, if 'inside' more efficient options are available. The willingness for industries to participate in resources exchanges - thus to adopt a more appropriate use of their waste - would hopefully also emerge when they see or are informed about the financial gains from the project proposal.

The ***agricultural and energy policy (non-market)*** could be supported as follows: Takhlong Municipality can set up a collective system for agricultural biomass wastes (as for instance rice straw), which could be distributed as fuel to industrial parks nearby. The latter proposal must be initiated in co-operation with Pathum Thani Province and the Ministry of Agriculture and Co-operatives. In order to increase the amount of agricultural biomass waste, the Ministry of Agriculture and Co-operatives could ban the burning of agricultural biomass waste on the fields, which would act as an incentive to participate in the collective system (Sutiratana, 2008). Local farmers in Pathum Thani Province can thus supply agricultural residues to the energy facility, supported by the local authorities just mentioned. This would create an extra income for farmers in the community and enable that biomass residues are re-used efficiently. With the growing prices on fossil fuels there should be room for poor farmers obtaining favourable prices for their agricultural residues.

The Ministry of Agriculture and Co-operatives could also, in partnership with the Ministry of Energy, make analyses of the possibilities for setting up production of energy crops to be distributed to the industrial parks in Thailand. According to EPPO there are thousands of acres of land in Thailand not being used for any purpose. This land is owned by the Thai government, and is referred to as 'wasteland'. EPPO is very positive towards growing energy crops on these areas, with regards to a future supply of biomass for energy production in Thailand (Opatvachirakul, 2008), but so far no initiatives have been taken in this direction (Opatvachirakul, 2009).

→ [3] Influential stakeholders for the two aspects above are Department of Industrial Works under Ministry of Industry, Ministry of Agriculture and Co-operatives, Ministry of Energy, Pathum Thani Province and Takhlong Municipality (see Table 2 for sum-ups).

The ***waste generators (market)*** are here industrial parks such as Navanakorn in which industrial biomass wastes and household waste etc. are generated. It is also the municipal and province which contributes to biomass waste generation through household waste, residues from fruit and vegetable markets, and waste from commerce, etc. Waste generators are also farmers generating relevant biomass residues outside the industrial parks.

→ Influential stakeholders regarding this aspect are Navanakorn, Takhlong Municipality, Pathum Thani Province and local farmer etc.

4.2 Appropriate Technology (supply)

A next step in the production process upon a transition of the Thai energy supply and consumption is the implementation of appropriate technology, as it impacts CDM. Thus, appropriate energy technologies should be manufactured in Thailand, and to promote this a 'technology demand' can be created. This could be initiated by the central administration through an industrial energy program targeting industries in Thailand located within the industrial parks.

4.2.1 Actions by Influential Stakeholders

As far as the ***national policies (non-market)*** the following initiatives can be applied;

Master Plan: To support technology demand new national policies for supply and use of district heating could be introduced. This could be initiated by a two step Master Plan for 'Energy Efficiency and District Heating' in the manufacturing sector in Thailand. The focus should be on energy efficiency and conversion from steam to hot water demands. This first phase - implementation of energy efficiency within industries - would constitute the platform for a second phase, in which biomass CHP technologies with district heating could supply efficient energy to industries located within industrial parks. Such National Program's should be initiated by the Ministry of Energy and approved by the Cabinet.

CERs ADDER: The above initiative could be supported by a CERs 'ADDER' (Thai term for feed-in tariff) for projects dealing with energy efficiency. Thus, more CERs generated per reduced emission unit coming from energy efficiency, could act as an incentive for implementing the first phase of the two steps Master Plan.

→ Influential stakeholders regarding this aspect are Ministry of Energy in Thailand.

To support this type of CDM project, it is also important to identify ***local & foreign manufacturers of energy technology and equipment (market)***. Many producers of boilers exist in Thailand, as for instance Bangkok Industrial Boilers, Thai K. Boiler, Thai Steam Boiler, Banpong Boiler, STPI Boiler and Hansa Boiler International etc. (Møller, 2008a; Sutiratana, 2008). As far as their efficiency is concerned, two manufacturers in particular can be emphasised, namely Bangkok Industrial Boilers and Hansa Boiler International, of which the latter previously has co-operated with Babcoc Borsig from Berlin, and has a large market share in Thailand for solid fuel boilers and for plants producing thermal energy for industrial use (Møller, 2008a). Bangkok Industrial Boilers or/and Hansa Boiler International could, for example, join forces with Vølund, and start up a domestic production of efficient biomass boilers in Thailand. Vølund has experience with such kind of joint ventures' from Malaysia, where they have established a private partnership with a Malay manufacturer of boilers for the palm oil industry.

Danish manufacturers of district heating pipes, as for instance Løgstør and StarPipes could also establish such joint partnership with a relevant Thai stakeholder. This could for instance be a company named Tor Nam Thai, which produces un-insulated PVC pipes for energy supply (Sutiratana, 2008). Local manufacturers of heat exchangers for the appropriate transmission of heat from the district heating network to industries requiring process heat, already exist in Thailand. Genesis, produces efficient heat exchangers in their factory in Rayon, south east Thailand, at ¼ the price of imported heat exchangers from for instance Finland (Salam, 2008).

Establishing steam turbine manufacturing in Thailand is unlikely to be feasible, as the resource base (knowledge connected to producing this kind of technology) is limited. Import from the nearby Singapore is an option, as quite efficient German steam turbines are manufactured there under license (Møller, 2008b). Alternatively, the steam turbines can be supplied by Chinese manufacturers. The efficiency of the technology might then be compromised, but the purchase prices lower (Møller, 2008a).

→ Thus the influential stakeholders in this area are: Genesis, Bangkok Industrial Boilers, Hansa Boiler International, Tor Nam Thai, Vølund, StarPipes and Løgstør.

4.3 Technology Efficiency and Investment Costs (development)

This issue largely depends on the maturity of technologies (technical reliability and energy efficiency), which tend to increase with increased market size (technology demand). Increased technology demand normally initiates competition between suppliers, thus possibilities for product innovation, followed by price reductions (lower investment costs). The latter can also be obtained by outsourcing the manufacturing process.

4.3.1 Actions by Influential Stakeholders

As suggested briefly in the section above, appropriate technology supply can be established by several suppliers in Thailand, based on joint ventures between foreign and Thai manufacturers. Danish companies, such as Vølund and Løgstør Pipes, could join forces with Thai industries, like Bangkok Boilers to produce efficient energy technology. Thus, we suggest establishing ***mega-suppliers of appropriate technology & a supply-park of materials and goods (market)***. A local or regional supply-park could evolve around the mega-suppliers, producing spare parts, materials and goods to support the production. Thus, the majority of the value chain stays in Thailand instead of being transferred to developed countries in the North. Technology efficiency is hence obtained through a joint venture manufacturing scheme, and the investment costs reduced as the manufacturing process are placed where the technology demand is situated, and as it takes place in a developing country (cheaper labour, materials etc.). Observations point to the fact that technologies produced in developing countries can lower the total production costs significantly compared to production costs in the North (Quaak, 1999).

The joint ventures between Danish and Thai companies can be facilitated by the Thai Chamber of Commerce and the Royal Danish Embassy in Bangkok. They could initiate the identification and facilitate establishment of collaboration between relevant technology manufacturers' in Thailand and Denmark, to create mega-suppliers and supply-parks for manufacturing of CHP with district heating in Thailand (Mukdasathien, 2008). The Federation of Thai Industries (FTI) can also assist in setting up such supply systems in Thailand. They could facilitate this by setting up a committee to establish a forum, which will initiate this development through relevant activities (Prakitsri, 2008).

→ Influential stakeholders regarding this aspect are therefore the Royal Danish Embassy in Bangkok, the Federation of Thai Industries and the Thai Chamber of Commerce.

Efficient energy production and consumption of energy: Energy efficiency can also be supported by ***national policies/initiatives (non-market).*** As already mentioned, governmental programs etc. can be used to initiate a market; to create a technology demand that can lead to a supply of appropriate energy technology. The efficiency of implemented technology can then be enhanced by the transfer of know-how from the North through joint ventures with local companies, and the investment costs decreased by locating the production of the technology in developing countries. Governmental actions supporting the implementation of such technologies can be established by increasing the demands for an efficient production and consumption of energy.

We suggest that a feed in tariff is developed for heat consumption, similar to the 'ADDER' feed-in tariff for power. The only difference is that the size of the ADDER is calculated as heat being *used* in a manufacturing process (either inside or outside the company), and not only as being *distributed* as in the case of power to the grid. This could be calculated as m^3 consumption of heat compared to the total amount of heat produced on the CHP plant. If the consumption of heat is high (amount of m^3 heat usage) the economic contribution from the feed in tariff increases correspondingly.

A feed in tariff can act as an incentive to use the generated heat instead of wasting it, or to use limited amounts. It will also, very importantly, create an incentive to locate CHP plants where a potential heat market exists, as for instance in industrial parks. The old regulation requiring 10 % use of generated heat (not in force any longer), could also be reintroduced. A demand of 20-25 % re-use will surely act as an incentive to find means of using the generated heat.

Another way to support efficient production and consumption of CHP is to require that biomass CHP plants in Thailand make use of generated heat, which is presently only required on fossil fuel CHP plants. This will also act as incentives to locate the CHP plants near a potential market or optimise the internal use of heat. Prior to such activities, information about energy efficiency etc. should be disseminated to industries to impact their behaviour.

→ Influential stakeholders regarding this aspect are thus Ministry of Energy in Thailand.

Conducting Project Identification Notes (PINs): In order to select appropriate CDM projects, Thailand should not wait for bilateral or multilateral projects to evolve, as the project developers connected to these projects not necessary looks at the future development options for Thailand; they might be more interested in quick projects leading to high CERs generation. Thailand should therefore initiate CDM project activities by themselves, thus establish unilateral project activities, and thereafter sell the CERs to buyers on the market. In this way Thailand can ensure that sustainable development goals are reached, and that a platform for a future industrial manufacturing of energy technologies are 'thought-into' the development options for the country in an early stage.

Thus, the Thailand Greenhouse Gas Management Organisation (TGO) should promote the biomass CHP technology as potential CDM projects in Thailand. This could be done by creating a one-stop PIN-shop (project identification notes), offering already identified biomass CHP projects to potential investors. Such a project pipeline, identifying biomass CHP projects in Thailand, also makes it possible to implement the CDM projects as bundled activities, which *could* make the project attractive for investors.

Activities could also be taken by buyers of CERs - such as power companies in Denmark - wanting Thailand to benefit more from the CDM activities in the country. Setting up a biomass CHP plant as a sort of 'CDM demonstration plant', could pave the way for more projects like this by involving e.g. The Danish Embassy. Or a combination of the two approaches described above can be applied, using the Danish demonstration plant, as a showcase for the Thai project pipeline developed.

Develop CDM Methodology: Another important issue is the development of an appropriate - and by the Executive Board approved - methodology for this type of project. It would be a major barrier for this type of project if a methodology cannot be developed and approved, and thus act as a technical guideline for implementation of such projects. Previously, several methodologies dealing with CHP and district heating (named distributed energy) have been rejected. The baseline issue has been difficult to prove in such type of projects.

Thus, we suggest that Thai TGO and/or the Danish Embassy, with assistance from relevant consultants, develop a methodology that can be used for such types of project in Thailand. With both PINs and methodologies worked out, some major obstacles for such types of projects could be eliminated.

→ Influential stakeholders regarding this aspect are thus Thailand Greenhouse Gas Management Organisation (TGO), and the Danish Embassy in Bangkok.

Standard policies - ***national & international technology standards (non-market & market)*** - like for instance certain demands for energy efficiency standards of biomass technologies or manufacturing equipment etc., can also speed up the development and implementation of technologies. This can be either national or international standards putting pressure on producers of biomass technologies or manufacturing equipment. The European standards (10 % PES) for CHP plants (European Commission, 2004) can for example be categorised as standard policy required by the Thai government, whereas for instance standards on energy technology set forth by the ISO are international standards.

In Thailand, it is the Thai Industrial Standard Institute (TISI) who sets up standards for technology efficiency, and they also co-operate with the international ISO. So far they have not required any standards for industrial boilers etc., but efficiency standards have been applied on, for instance, air-condition appliances (Sutiratana, 2008). TISI, in co-operation with for instance the Thai Environment Institution (TEI), carries out Green Label Schemes, by which certified product can bear green labels. This is a measure to reduce pollution in the environment as well as to encourage manufacturers to use clean technology (TISI, 2008). In Thailand, TISI should set up higher standards for the most commonly applied technologies within the manufacturing sector, using unsuitable high amounts of energy.

→ Influential stakeholders regarding this aspect are therefore the Industrial Standard Organisation, ISO, and the Thai Industrial Standard Institute dealing with international and domestic standards respectively.

The technology development also depends on the ***public R&D in renewable energy technology (non-market)*** invested in the specific technology. It therefore depends on the level of both public and commercial R&D activities in general. Under the Ministry of Science and Technology (MOST) in Thailand, several public organisations conduct research activities connected to renewable energy technologies and energy efficiency (Sutiratana, 2008). National Science and Technology Development Agency (NSTDA) and Thailand Institute of Scientific and Technological Research (TISTR) are, for instance, two governmental organisations who work to research, promote and disseminate knowledge about efficient technology implementation in Thailand (NSTDA, 2008; TISTR, 2008).

→ Influential stakeholders regarding this aspect are Ministry of Science and Technology, thus the National Science and Technology Development Agency and Thailand Institute of Scientific and Technological Research.

4.4 Financial Conditions

The possibilities for obtaining loans or other means of commercial financing have a great influence on the implementation of biomass technologies as well as efficient manufacturing equipment. If the biomass fuel price is high, grants and subsidies limited and the selling price of power and heat low, then the financial conditions are difficult for biomass technologies. And further, if public policies (lack of appropriate standards, no soft loan, shortage of other incentives, etc.) do not support the implementation of efficient manufacturing equipment, it can be difficult to obtain favourable loans unless the pay-back period is extremely short.

4.4.1 Actions by Influential Stakeholders

The ***commercial financial support (market)*** can be supported by Thai banks, as for instance The Thai Military Bank that has a long tradition for financing the implementation of renewables. They also engage in financing CDM projects, for example through the International Finance Corporation of Thailand (IFCT) (Sutiratana, 2008). Also Siam Bank has been very engaged lately in supporting CDM projects in Thailand (Cooper, 2009).

→ Influential stakeholders are here the Thai Military Bank and Siam Bank.

Transactions costs (market) for smaller CDM projects they tend to be relatively higher than for larger projects. This, off course, poses a barrier for the implementation of smaller projects with a relatively low generation of CERs, but is often superior when it comes to its contribution to sustainable development in local communities (IGES, 2006). Several initiatives like '*Bundled CDM projects*' as well as *'Programmatic CDM'* (pCDM) can be applied (UNFCCC, 2009). The latter can be very useful for the CDM project emphasized here, as the conditions for replicating the project to other industrial parks in Thailand are very likely. The CDM project developers decide which types of projects to develop, and whether they will apply a bundled or pCDM approach or not. The Designated National Authority (DNA) in Thailand, named TGO - can, however, promote and assists the project developers in using these types of project implementation tools, in order to promote these concepts in the future. The Thai TGO is in charge of CDM project implementation in relation to sustainable development criteria's and rules, etc.

→ Influential stakeholder is here the Thai project developers, the Designated National Authority, as well as the Thailand Greenhouse Gas Management Organisation (TGO).

4.5 Technology Maintenance & Operation

This must take place by skilled and trained Thai craftsmen. A supply-park of such services will have to be established, in order to service the technologies manufactured by the mega-suppliers.

4.5.1 Actions by Influential Stakeholders

The ***training activities (non-market)*** should be done through a collaboration between Ministry of Labour (Dept. of Technical Labour Development) and King Monkut Institute of Technology (Sutiratana, 2008), and possibly also other relevant Thai governmental organisations under the Ministry of Energy (DEDE & EPPO) and academia (AIT).

→ Influential stakeholders are here Ministry of Labour, King Monkut Institute of Technology, Asian Institute of Technology, Ministry of Energy.

The establishment of a ***supply-park of services (market)*** should be commenced by the stakeholders also initiating the mega-suppliers and the supply-park of materials and goods (i.e. the Royal Danish Embassy in Bangkok, FTI and the Thai Chamber of Commerce).

→ Influential stakeholders are the Royal Danish Embassy in Bangkok, Federation of Thai Industries and the Thai Chamber of Commerce.

4.6 Public Subsidies

In the following, relevant financial programs by the Thai government will be highlighted emphasising public subsidies. The conditions for power and heat sales will be dealt with in the next section. The subsidies mentioned below are not based on a thorough analysis of all options available, but the most important in Thailand and thus provides an example of public subsidies available.

4.6.1 Actions by Influential Stakeholders

The Thai government has set up two financially supportive public programs for activities that can help the country in moving in a more sustainable direction when it comes to energy production and consumption; the ENCON Fund and NSTDA Program.

As far as relevant ***Financial support (non-market)*** for the CDM project proposed the following sources are available in Thailand (for further readings see

IGES (2006)):

- Ministry of Energy (MoE), EPPO (manage the 'Voluntary Program' under the ENCON Fund),
- Ministry of Energy (MoE), DEDE (manage the EERF Fund under the ENCON FUND),
- Ministry of Science and Technology (MOST), NSTDA Investment Centre (NIC) (manage the NSTDA Program),

→ Influential stakeholders in distributing more economic resources to CDM projects are Ministry of Energy hereunder EPPO, DEDE and NSTDA and NIC.

4.7 Power Selling Price

The power selling price also impacts CDM projects if the project proposal generates surplus energy to be sold on the grid to power companies (grid connected power sale). The selling price of biomass power normally depends on the price of conventional electricity and the bargaining force of suppliers against buyers, unless special conditions are established. This can, for instance, be a higher selling price for biomass produced power compared to conventional power (e.g. an ADDER / feed-in tariff), or fees put on conventional power production. If the power is solely transmitted to industries located in industrial parks (as in Navanakorn), the price for borrowing the grid - the "wheeling fee" - is also important, and must be evaluated against establishing an individual grid connection in the area, which will increase the total capital costs of the CHP plant (Lybæk, 2004).

4.7.1 Actions by Influential Stakeholders

Also important is the ***regulation of power market (non-market)***. To promote the production of power based on domestic renewable energy sources, the Thai government has introduced a subsidy (feed in tariff) for power generation based on biomass. Biomass waste in particular receives attention, which is beneficially when setting up an energy supply system based on industrial biomass wastes.

The Thai government has also introduced favourable power selling conditions for biomass based power, as they have increased the size of the plants allowed to sell power to the national grid (from 1 to 10 MW). This has increased the number of units capable of selling power to the grid, just as regulatory frameworks now assure that they can rely on power sales to the grid. Waste for power production must derive from the following sources:

- *"Waste or residues sources directly from agricultural activities or industrial production processes (e.g. rice husk; bagasse and wood chips);*
- *Products derived from waste and residues from agricultural and industrial production processes, such as biogas derived from wastewater, biogas from an agricultural process, and refuse-derived fuel (RDF);*
- *Garbage (e.g. municipal waste);*
- *Sources of wood biomass (e.g. tree plantation)"* (IGES, 2006 p. 82)

→ Influential stakeholders regarding the aspect above are the Thai Ministry of Energy (MoE).

Power companies (market) are also an important stakeholder in Thailand. Access to the national power grid has previously and still is an obstacle for renewable energy technologies in Thailand. It is the project owner - and not the Electricity Generating Authority of Thailand, EGAT - that has to pay for the connection to the grid, which can be high for small projects. It can also be problematic that the 'power purchase agreements' still must be approved by EGAT for individual energy projects (Sutiratana, 2008). Access to the electricity grid within the industrial parks is also regulated by EGAT. Here, a 'wheeling fee' can thus be put on the use of the power supply networks, which will add costs to the project proposal. Alternatively, a locally owned grid can be laid out underground to avoid such expenses (this is off course not without costs).

→ Influential stakeholders are here primarily Electricity Generating Authority of Thailand.

4.8 Heat Selling Price

The heat selling price also impacts CDM projects, and normally, at least in a European context, it depends on the competition between network companies, as well as on the level of district heating network expansion in the EU, thus the availability or access opportunities. If heat is to be used, not only within individual industries generating process heat, it is necessary to establish district heating networks connecting several industries (to establish a heat market). The selling price of heat will thus be the substituted costs of buying the commercial heat previously used in for instance boilers, i.e. fuel oil, natural gas, coal etc..

4.8.1 Actions by Influential Stakeholders

The ***regulation of heat market & demand / market for heat (non-market & market)*** is another important issue. The options for selling heat depends on the possibilities of setting up district heating networks for the external use of heat, which again depends on the political priorities, and whether the use of 'waste-heat' and thus CHP has priority. The Thai government gives priority to heat production, in it's strive for reaching the renewable energy targets set forth. A target of 3,851 ktoe of heat production has been established (Opatvachirakul, 2009), and it is thus likely that CDM projects addressing this issue will be met positively by various stakeholders including governmental organisations.

Another initiative can be applied by the Industrial Estate Authority of Thailand, IEAT. They can - when planning the design of new industrial parks or when retrofitting old ones - place district heating pipes in the soil in advance in order to prepare for later expansion of collective energy supply. If it is difficult to dimension on forehand, an alternative is to install only the service lines in advance. As mentioned, power supply grids can also be laid out underground in the industrial parks, to avoid the use of EGAT transmission lines.

→ Influential stakeholders are here Ministry of Energy and Industrial Estate Authority of Thailand.

5. Conclusion

In this paper we have answered the following research question:

What are the benefits of, and how can the implementation of biomass CHP with district heating be supported in a community of Thai SMEs, through an identification of relevant policy recommendations and influential stakeholders?

We will elaborate on some important conditions for implementing the type of CDM project proposed in this paper. Table 1 summarizes the ***benefits*** obtained by implementing the biomass CHP plant with district heating in a community of SMEs, here suggested as a future type of CDM project in Thailand. As shown, not only environmental benefits are achieved all along the materials and energy chain, but new business opportunities are also developed that can benefit more marginal groups in the Thai society. This is obtained as new value chains emerges (supply of agricultural residues to the energy facility, bottom ash as fertiliser on farmland, direct jobs at the plant). As such, the sustainable development contribution from the project is high. Apart from the benefits outlined in Table 1, the proposed CDM project can help Thailand in its transition towards a more sustainable energy production and consumption, as it provides CO_2 reduction activities all along the materials and energy chain and thus improves the possibilities of reaching long term changes within the manufacturing sector in Thailand.

Adapting the proposed CDM project in Thailand however requires that relevant policy recommendations are put forward, and that appropriate stakeholders assist in facilitating it. The CDM project can thus be ***supported*** by influential stakeholders or 'project carriers'. Table 2 outlines the identified policy recommendations to support the implementation of biomass CHP with supply of district heating in Thailand within the framework of CDM. It also points to the most important stakeholders in achieving this.

Table 1: *Summary of benefits caused by the project proposal in Navanakorn Industrial Park (Source: authors)*

Benefits caused by the project proposal; biomass CHP with district Heating
The project proposed is placed in Navanakorn and targets six SMEs in food, wood and chemical industries. The biomass CHP technology with district heating will be implemented in an industrial area, where industries are located close to one another. This implies that favourable conditions for exchanges of materials and energy within this area are present, and that a more decentralised energy supply system can be developed. This can lead to the following benefits for the local community: *Saved expenses on:* • Power and fuel oil purchase; • Present waste handling costs; *New business opportunities:* • Sale of power and heat; • Sale of ash as farmland fertiliser; • Use of local biomass waste as fuel; • Local farmer's etc. supply of agricultural residues;
Due to various activities along the materials and energy chain, 28,100 tons of CO_2 emissions will be avoided annually, from the following sources: *Materials chain:* • Transportation of waste; • Inefficiently (if any) re-use outside the site; • Biomass decay in landfills; • Biomass decay or burning on farmland; *Energy chain:* • Grid power and individual fuel oil consumption (also lower SO_2 & NO_x); • Extraction and transportation etc. of the above; *Instead the following has improved the energy chain in Navanakorn:* • Production of biomass power *and* heat (applying 18,400 MWh/y fuel); in • A cost effective biomass CHP technology with district heating (2.6 MWtotal); • Process integration and cascading of energy; • Energy efficiency; hereunder • Supply of low quality energy instead of high quality energy (from steam to hot water; from electricity to hot water); leading to • 11,000 MWh/y of primary heat demand down from 17,200 (36 % reduction);
To increase the job opportunities from the project proposal, emphasis is on supply of biomass residues, as the employment effect is highest: *Direct jobs:* • 10 'Construction jobs' are here estimated (short term), and • 7 'Maintenance & Operation jobs' estimated (long term); *Indirect jobs:* • Direct employment lead to min. 2-4 times the indirect employment;

Table 2: *Summary of policy recommendations and stakeholder identification (Source: authors)*

	What impacts CDM Projects?	Policy Recommendations		Influential stakeholders (or 'project carriers')
		Non-market	Market	
PROJECT DESIGN DOCUMENT	**Biomass fuel (supply, quality and price of raw materials)** **(4.1)**	Industrial waste policy; Agricultural and Energy policy	Waste generators;	DIW; IEAT; Ministry of Agriculture and Co-operatives; MoE; Pathum Thani Province; Takhlong Municipality; Navanakorn industrial park; Takhlong Municipality; Pathum Thani Province; Local farmers etc.;
	Appropriate technology (supply) **(4.2)**	National policies (Master Plan & CERs 'ADDER')	Local manufactures of energy technology and equipment Foreign manufactures of energy technology and equipment	MoE Genesis Bangkok Industrial Boilers Hansa Boiler International Tor Nam Thai (In joint venture with) Vølund StarPipes/Løgstør/
PROJECT IMPLEMENTATION	**Technology efficiency & investment costs (development)** **(4.3)**	National policies & initiatives (Efficient production and consumption of energy & Conduction of PINs & Develop Methodology National technology standards Public R&D in renewable energy technology	Mega-suppliers of appropriate technology Supply-park of materials and goods International technology standards	Royal Danish Embassy in Bangkok FTI Thai Chamber of Commerce MoE TGO Royal Danish Embassy in Bangkok TISI ISO MOST (NSTDA & TISTR)
	Financial conditions **(4.4)**	pCDM & Bundling	Commercial financial support Transaction costs	Thai Banks (Thai Military Bank or Siam Bank) Project Developers TGO
PROJECT OPERATION	**Technology maintenance & operation** **(4.5)**	Training activities	Supply-park of services	Ministry of Labour & KMIT AIT EPPO DEDE Royal Danish Embassy in Bangkok FTI Thai Chamber of Commerce
	Public subsidies **(4.6)**	Financial support		EPPO DEDE NSTDA Investment Center (NIC)
	Power selling price **(4.7)**	Regulation of power market	Power companies	MoE EGAT
	Heat selling price **(4.8)**	Regulation of heat market	Demand / market for heat	MoE IEAT

6. Perspectives

What are the conditions for achieving the targets set forth in this paper? Which important planning conditions did we not consider in this work? We have chosen to focus on two important elements in this discussion, namely 'drivers for action' (macro-level) and 'social capital' (micro-level), which will be emphasised below.

'Drivers for action' are here understood as initiatives taken by governments or organisations which establish a certain pressure downwards in the societal hierarchy - regional and local governments, industries and businesses, etc. - enabling that financial resources and regulations support combating of climate change. Such pressure could for example lead to emission reduction targets put on the manufacturing sector in Thailand, and thus for the Ministry of Energy and Industry to adopt some of the ideas outlined in this paper to increase the energy efficiency and limit the CO_2 emissions from this sector. Engaging the industrial parks in this work would be natural, as the majority of Thai manufacturing industries are located within such sites. From here local provinces, municipalities, industries and agriculture would need to be a part of the climate change efforts, thus including stakeholders at all levels.

The United Nation and the Kyoto Protocol are thus interpreted as important drivers for achieving the supporting policy frameworks for CDM in Thailand, as suggested in this paper. Currently, the future of CDM is however unsure due to limited achievements under the COP 16 Cancun meeting in December 2010. The pressure from the international society is therefore weak, leaving the national states to manage by themselves and not requiring specific actions or targets to fulfil. Thailand has not been a 'fast mover' when it comes to accepting CDM projects and approving the implementation of this flexible mechanism. Without pressure, or drivers, from governing organisations (e.g. UNFCCC) there is genuine risk that Thailand will lower their interests in CDM and focus on other types of renewable energy expansion, as for instance hydropower import and the use of nuclear energy. It is thus very important that the drivers are re-established and re-enforced and thus that the international governance become stronger.

The above issue is also connected to the 'social capital' in Thailand. It is questionable whether local stakeholders in Navanakorn (company owners, municipalities etc.) will be able to develop the type of energy system we propose. The companies and local authorities do not have the skills and organisational knowledge to develop such a project. Thus, in the initial phase governmental authorities, NGOs and academia etc., at many different levels, must be included in the project until a certain knowledge base, or network, is developed among the stakeholders (Lybæk, 2004).

Notes

1 Manufacturing industries with less than 250 and more than 50 employees (European Commission, 2010).

2 A distinction is made here between privately managed Industrial Zones and national managed Industrial Estates, of which the latter are by far the majority.

3 The arrow indicates that the text is summing up the above analyses in relation to influential stakeholders.

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