

## How to Enhance the Sustainable Development Contribution of Future CDM Projects in Asia - Experiences from Thailand

Lybæk, Rikke Bak

*Publication date:*  
2009

*Citation for published version (APA):*  
Lybæk, R. B. (2009). *How to Enhance the Sustainable Development Contribution of Future CDM Projects in Asia - Experiences from Thailand*. Roskilde Universitet.

### **General rights**

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain.
- You may freely distribute the URL identifying the publication in the public portal.

### **Take down policy**

If you believe that this document breaches copyright please contact [rucforsk@ruc.dk](mailto:rucforsk@ruc.dk) providing details, and we will remove access to the work immediately and investigate your claim.

# How to Enhance the Sustainable Development Contribution of future CDM Projects in Asia

## *- Experiences from Thailand*



**Post doc. dissertation, 2009**  
**Assistant Prof. Ph.D., Rikke Lybæk**



**Department of Environmental, Social and Spatial Change  
(ENSPAC)  
University of Roskilde, Denmark**

## ***Abstract***

This study addresses how to increase the sustainable development contribution of future Clean Development Mechanism (CDM) projects, by developing a Manual with guidance on how to pursue this in Asian countries in general. The Manual will assist project developers, regulating authorities, national states and carbon credit buyer's, etc. in implementing and supporting the creation of more sustainable future CDM projects. The CDM project activity proposed in this study will for instance increase the energy supply security in Asian countries, contribute to improved income generating opportunities related to the project, and support the implementation of an efficient renewable energy technology, that can assist Asian countries in transforming their energy supply systems; thus '*biomass Combined Heat and Power (CHP) with supply of district heating*'.

The CDM project activity proposed in this study try to revolve the present project-based focus on CDM, and seek to include CDM project implementation in the energy supply system of a whole community; not only in one single standing industry. Small and Medium Sized Enterprises (SME's) located within the many Industrial Parks in Asia are hence selected as targets for the implementation of the biomass CHP technology, due to the availability of biomass waste within and outside these areas. The close location of industries within the Industrial Parks also provides a valuable market for heat, which otherwise are discharged in many tropical Asian countries. Exchanges of materials and energy can thus be applied between the industries and the surroundings, leading to many benefits for the local community.

Based on thorough studies of potential Thai 'CDM-industries', and relevant framework conditions for CDM within Thailand, elements for a Planning Guide and Policy Recommendations are extracted from the Thai context. The Planning Guide developed is hereafter exercised on a Thai case study area - Navanakorn Industrial Promotion Zone - illustrating its applicability, and demonstrating the environmental and Green House Gas (GHG) related benefits when applying the tool on a local community of SME's.

To support the usability of the Planning Guide, and to support the implementation of CDM projects based on biomass CHP with district heating, some overall Institutional & framework conditions are also addressed in the Manual. Based on the Policy Recommendations extracted throughout the study, as well as on an identification of what impacts CDM projects along the production process, influential stakeholder are identified. These stakeholders are 'carriers' of the changes necessary to pursue, in order to promote the implementation of more sustainable CDM projects in future Asia. A final issue addressed by the Manual is how to start up this development, and suggestions are put forward to which stakeholders to initiate the proposed development within the Industrial Parks in Asia.

### **Front page photos: Author, Thailand, Marts 2009**

Top left: "Sima 2", *Biogas from Starch Plant, Chachoengsao.*

Top right: "Nongbua pig farm Biogas" - *Collection of manure, Ratchaburi.*

Bottom left: *A.T. Biopower Rice Husk Plant, Pichit.*

Bottom right: "Siam Cement" - *The cooling tower, Kaeng Khoi.*

# Table of contents

<b>Chapter 1; Introduction</b> .....	p.7
1.1 Project context .....	p.7
1.2 Focus of the study .....	p.7
1.3 EU and Danish climate change policies .....	p.8
1.3.1 EU National Allocation Plans.....	p.8
1.3.2 EU Emission Trading Scheme.....	p.8
1.3.3 EU Linking Directive .....	p.9
1.4 CDM Outline.....	p.9
1.4.1 Present CDM governance and emerging needs .....	p.9
1.5 Energy and materials use in Asia.....	p.10
1.5.1 Thailand at a glance .....	p.11
1.5.1.1 CDM implementation in Thailand.....	p.12
1.6 Purpose of the study .....	p.13
1.7 Research question.....	p.14
1.8 Outcome of the study .....	p.14
1.8.1 Applicability.....	p.14
1.9 Structure of the study.....	p.15
<b>Chapter 2; Methodology</b> .....	p.18
2.1 Introduction .....	p.18
2.1.1 Research design .....	p.18
2.2 Analytical platform .....	p.18
2.2.1 Analytical optic .....	p.18
2.2.2 Sustainable Development Concepts Part I.....	p.20
2.2.3 Sustainable Development Concepts Part II .....	p.20
2.2.4 Elements to be addressed by the sustainable development concepts.....	p.21
2.3 Creating sustainable development concepts .....	p.22
2.3.1 The Triangle (inner circle) .....	p.22
2.3.1.1 Input/output model.....	p.25
2.3.1.2 Technological options.....	p.26
2.3.1.3 Applying the ‘Triangle’ on the ‘Input/output model’ and on the ‘Technological options’ .....	p.27
2.3.1.4 Sum-up on sustainable development concepts (Part I.).....	p.28
2.3.2 Framework conditions (outer circle) .....	p.29
2.3.2.1 Sustainable development .....	p.29
2.3.2.2 The DAC-principles .....	p.30
2.3.2.3 Applying the ‘DAC-principles’ on the Thai CDM context.....	p.31
2.3.2.4 Sum-up on sustainable development concepts (Part II.) .....	p.32
2.4 Research in Thailand .....	p.33
2.4.1 Previous research experiences.....	p.33
2.4.2 Fieldwork .....	p.34
2.4.2.1 Interviews and presentations.....	p.34
2.4.2.2 Case industries.....	p.34
2.4.2.3 CDM project visits/interviews.....	p.34

<b>Chapter 3; Background data</b> .....	p.35
3.1 Waste generation .....	p.35
3.1.1 Food industries .....	p.35
3.1.2 Wood industries .....	p.35
3.1.3 Chemical industries.....	p.36
3.2 Energy consumption.....	p.36
3.3 Appropriate areas.....	p.40
3.4 Discussion .....	p.41
3.5 Extraction of elements for the Manual.....	p.42

<b>Chapter 4; Thai CDM policies and institutional set-up etc.</b> .....	p.44
4.1 Institutional set-up .....	p.44
4.1.1 Institutional development in the approval of CDM in Thailand .....	p.44
4.1.1.1 Historic review .....	p.44
4.1.1.2 First CDM projects to be approved in Thailand .....	p.45
4.1.1.3 New approval procedure.....	p.45
4.2 Thai sustainable development requirements .....	p.46
4.2.1 National Sustainable Development Strategy .....	p.46
4.2.2 Thai “Sustainable development Criteria’s” for CDM .....	p.47
4.2.3 Gold and Crown Standard .....	p.48
4.2.4 Comments .....	p.48
4.3 Discussion .....	p.49
4.4 Extraction of elements for the Manual.....	p.50

<b>Chapter 5; CDM potentials in Thailand</b> .....	p.52
5.1 GHG emissions in Thailand.....	p.52
5.1.1 Sector identification .....	p.52
5.2 Potential resources and technologies .....	p.53
5.2.1 Technology identification.....	p.53
5.2.2 Resource identification.....	p.53
5.3 The Thai Government’s focus of CDM projects .....	p.54
5.3.1 Comments .....	p.54
5.4 Past and present governmental actions on energy .....	p.55
5.4.1 Renewable energy targets and energy efficiency.....	p.55
5.4.1.1 Historic review .....	p.55
5.4.1.2 Present targets .....	p.57
5.4.2 Support for renewable energy implementation.....	p.58
5.4.2.1 The future of SPP co-generation in Thailand? .....	p.59
5.4.3 Comments .....	p.60
5.5 Discussion .....	p.60
5.6 Extraction of elements for the Manual.....	p.62

<b>Chapter 6; Industrial metabolism and options for transforming the energy supply</b> .....	<b>p.64</b>
6.1 Industrial metabolism .....	p.64
6.1.1 Food industries .....	p.64
6.1.1.1 ASAN Service.....	p.64
6.1.1.2 B.B. Snacks.....	p.65
6.1.1.3 Baskin Robbins.....	p.67
6.1.2 Wood industries.....	p.68
6.1.2.1 Sun Cabinet.....	p.68
6.1.2.2 Rockwood .....	p.69
6.1.3 Chemical industries.....	p.70
6.1.3.1 Imperial Industrial Chemicals .....	p.70
6.1.4 Sum-up .....	p.71
6.2 Energy saving techniques and systems.....	p.71
6.2.1 Efficient processing equipment - internal processes .....	p.72
6.2.2 Process integration - external and internal processes .....	p.75
6.2.3 Sum-up .....	p.77
6.2.4 Sustainable local energy systems.....	p.78
6.3 Discussion .....	p.78
6.4 Extraction of elements for the Manual.....	p.79

<b>Chapter 7; Enhancing development opportunities</b> .....	<b>p.81</b>
7.1 CO <sub>2</sub> emissions caused by different options proposed.....	p.81
7.1.1 Different options for CO <sub>2</sub> displacement .....	p.81
7.1.2 Comments .....	p.85
7.1.3 Options for transforming the energy supply system.....	p.85
7.1.3.1 ‘The transformation process’ .....	p.85
7.1.4 The interests of case industries .....	p.86
7.2 Discussion .....	p.87
7.3 Extraction of elements for the Manual.....	p.88
7.4 Revolving the development effect of CDM projects.....	p.89
7.4.1 Upgrading the energy supply .....	p.89
7.4.1.1 Industrial energy supply .....	p.89
7.4.1.2 Upgrading .....	p.89
7.4.2 Revolving development opportunities .....	p.90
7.4.2.1 Profile of the value chain in developing aid .....	p.90
7.4.2.2 Suggestions for a new distribution chain .....	p.91
7.4.2.3 Market expansion .....	p.92
7.4.2.4 Employment opportunities and biomass technologies .....	p.93
7.4.2.5 Costs of technologies .....	p.94
7.5 Discussion .....	p.94
7.6 Extraction of elements for the Manual.....	p.95

<b>Chapter 8; Planning Guide, PDD elements and case example</b> .....	<b>p.96</b>
8.1 Part I.A.: Planning Guide .....	p.96
8.1.1 Introduction .....	p.96
8.1.2 Step 1: ‘Choice of industries and areas’ .....	p.98
8.1.3 Step 2: ‘Resource studies in industries and local community’ .....	p.100
8.1.4 Step 3: ‘Energy audit/studies in industries’ .....	p.103
8.1.5 Step 4: ‘Technology options’ .....	p.104
8.1.6 Step 5: ‘Local manufacturing of efficient energy technology’ .....	p.106
8.2 Part I.B.: Extraction of PDD elements .....	p.108
8.2.2 Sum-up on PDD extractions .....	p.108
8.3 Part II.: PDD case example; Navanakorn Industrial Promotion Zone (II.) .....	p.109
8.3.1 Applying the PDD elements on the case .....	p.109
8.3.1.1 General description of project activity (#A) .....	p.109
8.3.1.2 Calculation of GHG emission by source (#E) & Environmental impacts (#F) .....	p.113
8.3.1.3 General description of project activity (#A) .....	p.120
8.3.1.4 Opportunities connected to technology .....	p.124

<b>Chapter 9; Institutional &amp; framework conditions for Thai CDM</b> .....	<b>p.128</b>
9.1 Biomass fuel price.....	p.130
9.1.1 Actions by influential stakeholders.....	p.131
9.2 Appropriate technology (supply) .....	p.132
9.2.1 Actions by influential stakeholders.....	p.133
9.3 Technology efficiency and investment costs (development) .....	p.134
9.3.1 Actions by influential stakeholders.....	p.134
9.4 Financial conditions .....	p.137
9.4.1 Actions by influential stakeholders.....	p.137
9.5 Technology maintenance & operation.....	p.139
9.5.1 Actions by influential stakeholders.....	p.139
9.6 Public subsidies.....	p.139
9.6.1 Actions by influential stakeholders.....	p.139
9.7 Power selling price.....	p.141
9.7.1 Actions by influential stakeholders.....	p.142
9.8 Heat selling price .....	p.143
9.8.1 Actions by influential stakeholders.....	p.143
9.9 Institutional & framework conditions.....	p.143

<b>Chapter 10; Generic Manual</b> .....	<b>p.145</b>
10.1 Answer to the research question .....	p.145
10.2 How to begin? .....	P.146

<b>References;</b> .....	<b>p.150</b>
--------------------------	--------------

# Chapter 1; Introduction

## 1.1 Project context

This study emphasise on enhancing Asian countries' energy supply security and on how to establishing a more decentralised energy supply system based on local biomass resources. The Clean Development Mechanism (CDM) is only one way of achieving energy supply security and promotes a more decentralised energy supply. CDM can, however, not be the sole driver in this development, and the absence of an actual energy planning strategy in Thailand currently makes it difficult to reach sustainable changes in the energy system.

Mainly quantitative targets are put forward and overall directions of how to achieve these targets, by for instance energy planning are rarely addressed in Thailand. New ways of thinking and implementing CDM projects are however emerging, like the programmatic CDM (pCDM) approach. The pCDM approach can be useful in Thailand, as it could integrate and establish an alternative energy planning frame for the project based CDM approach currently applied.

One element of this study is to help Thailand to utilise the waste heat from power production; thus to implement biomass CHP with supply of district heating. This is sought promoted in the Industrial Parks in Thailand with supply of district heating to local Small and Medium Sized industries (SME's) constituting the heat market. I recognise, however, that CDM projects can be implemented outside Industrial Parks where the heat market is limited and the focus on power production alone is the situation. In such cases more focus could be given to converting waste heat to cooling, thus substituting the power use for air-conditioning in Thailand. Power consumption for air-conditioning in the business and residential sector accounts for approximately 50 % of the total use of power in Thailand (Møller, 2009).

A last issue in this project context is the question concerning the future EU policies on climate change, which could make it difficult for member countries to purchase carbon credits in developing countries. The majority, if not all, CO<sub>2</sub> reductions would possible have to happen within the EU itself in the future. This would undermine the purpose of this study, but not the proposals on how to establish sustainable renewable energy projects in Asian countries. The future EU frame for carbon credit transactions are currently unknown, but the guidance in this research study on how to develop projects with high sustainable development contribution, can always be applied, with or without carbon credit transactions.

## 1.2 Focus of this study

This study discusses how CDM would be able to better support sustainable development by means of a generic Manual that will provide guidance for projects developers, national states, buyers of carbon credits and other relevant stakeholder, on how to enhance and integrate concepts of sustainable development in future CDM projects. This also includes an outline of important policy recommendation and institutional conditions to enhance the framework for future CDM project implementations'.

The importance of the above is clear, as many developed countries in the world emphasise strongly on CDM to assist them in complying with their carbon emission targets. It is therefore important that good 'CDM governance' is put in place, with visions for host



countries - exceeding that just appropriate transactions of carbon credits take place - in which CDM to a higher extent contributes to sustainable development where implemented.

## **1.3 EU and Danish climate change policies**

The Kyoto Protocol from 1997 states that EU member countries are obliged to lower their CO<sub>2</sub> emissions by 8 % before 2012 compared to the 1990-level (UNFCCC, 2005). According to the EU burden sharing agreement, the EU member countries have committed themselves to a differentiated level of reduction, taking into consideration the varying ‘starting points’. Denmark has committed itself to achieve a 21 % reduction in CO<sub>2</sub> emissions between 2008 and 2012 compared to the 1990-level (Energistyrelsen, 1999).

The Danish Government has decided to make use of the ‘flexible mechanisms’ of the Kyoto Protocol - Joint Implementation (JI) and Clean Development Mechanism (CDM) - in order to comply with their CO<sub>2</sub> commitments (EU Commission, 2003). As a result of this the Danish Government signed a Memorandum of Understanding (MoU) in 2003 with the Thai Government, in which it was agreed that Denmark could buy carbon credits (CER’s<sup>1</sup>) from Thailand through CDM projects. The Danish Government thus planned to spend approximately DKK 100 million yearly in purchase of carbon credits from CDM projects in developing countries (Danish Energy Authority, 2004), as for instance Thailand, Malaysia, South Africa, China and Indonesia (DANIDA, 2004).

### **1.3.1 EU National Allocation Plans**

In order to achieve cost-effective carbon reductions, the EU has decided that large CO<sub>2</sub> emitters (companies and EU-member states) should be able to use the market mechanisms, and thus let their share of the reduction happen where it is most economically feasible. To obtain this goal large emitters of CO<sub>2</sub> are allocated emission allowances through NAP’s<sup>2</sup>, according to their past historic emission benchmarked against similar productions and national reduction goals. The companies covered by NAP’s are thus responsible for approximately 46 % of the total carbon emissions within the EU (CO<sub>2</sub> emitted by larger industries and energy producers etc.), whereas the responsibility for the remaining emissions (CO<sub>2</sub> emitted by agriculture, smaller industries/energy producers and traffic, etc.) are passed on to the individual national states within the EU (Directive 2004/101/EC).

### **1.3.2 EU Emission Trading Scheme**

The EU emission trading scheme involves more than 10,000 European companies, which each is given an allowance to emit a certain amount of CO<sub>2</sub>. Before each new commitment period the emission allowances are reduced. Companies emitting more CO<sub>2</sub> than their allowances must either lower their emissions or buy EAU’s<sup>3</sup> from other companies under the scheme. If the companies emit more than their stock of allowances, they will have to pay a fine (Directive 2004/101/EC).

---

<sup>1</sup> Certified Emission Reduction

<sup>2</sup> National Allocation Plans

<sup>3</sup> Emission Allowance Units

### 1.3.3 EU Linking Directive

In order to make the trading scheme more flexible and cheaper to comply with, the European Commission has decided upon a 'Linking Directive'. As the name implies, the Directive links the EU emission trading scheme with the flexible mechanisms of the Kyoto Protocol. The Linking Directive allows companies to buy CER's from CDM projects and ERU's<sup>4</sup> from JI projects in order to meet their emission targets. Thus, not only national states like Denmark but also companies can make use of CDM and JI in their effort to meet CO<sub>2</sub> commitments. There are close to 400 Danish companies covered by the NAP's (Energistyrelsen, 2005).

As Denmark will be able to continue its CO<sub>2</sub> emissions through purchase of CER's from for instance Thailand, it is important that this transaction leads to benefits for the Thai society. It is thus essential that Denmark apply CDM in an appropriate manner leading to *sustained environmental and social benefits* in the countries addressed by the mechanism.

## 1.4 CDM outline

At present (May 2009) 1,596 CDM projects have been registered by the Executive Board (EB) of the UNFCCC and another 202 is in the process of registration. Top countries by CER's issued are China, India, South Korea, Brazil and Mexico. More than 76 % of the global CER's that are issued, are based on mitigation of industrial gasses (F-gas and N<sub>2</sub>O reduction projects), primarily from CDM projects in China. Only a minority of the CER's deals with 'renewable energy', only approximately 13 %, and 'energy efficiency' & 'fuel switch', approximately 5 %<sup>5</sup>. Looking at the number of projects implemented, however, only approximately 2 % of the projects deals with industrial gasses - coming from a few projects only - whereas renewable energy projects account for 64 % (UNEP Risoe, 2009).

Apart from the 1,596 already registered CDM projects more than 3,100 new projects are currently in pipeline, which are expected to generate in total 1,343 million CER's before 2012. The share of the expected CER's coming from projects dealing with industrial gasses until 2012 will eventually decrease to 25 %, whereas 'renewable energy' and 'energy efficiency' & 'fuel switch' will increase its share to 37 % and 19 % respectively (UNEP Risoe, 2009).

### 1.4.1 Present CDM governance and emerging needs

Some CDM projects are implemented as end-of pipe solutions dealing with non-carbon gasses, like the above mentioned industrial gas projects in China. These projects are not *energy projects* dealing with renewable energy or energy efficiency, and their contribution to sustainable development in local communities are non existent (Stehr, 2006). Other CDM projects actually dealing with renewable energy, lacks the capacity to produce and consume the generated energy efficiently; most often the heat.

In many cases this is caused by inappropriate use of the energy inside the companies themselves, or outside in nearby communities due to the remote location of many such projects. This is for instance the case in some CDM projects in Thailand dealing with biomass in which stand-alone locations of these projects – in combination with a limited internal use of

---

<sup>4</sup> Emission Reduction Units

<sup>5</sup> Compared to CDM projects developed by the Danish Government with a share of 65 % and 2 % respectively (Danish Ministry of Energy, 2008).

the generated heat - leads to energy waste and thus relatively low efficiency. Hence, due to a limited 'outreach' of these projects, their contribution to sustainable development in local communities in Thailand are unfortunately quite limited (CDM project site visits Thailand, 2009).

CDM projects dealing with sustainable development, renewable energy and energy efficiency etc. in *local communities* must therefore be stronger addressed in the future. Not in large industries who can finance such initiatives by themselves, but in smaller industries where the energy consumption all together are highest, and where financial needs are required for a transformation of the energy supply system (Fenhann, 2006). CDM projects focusing on sustainable development, however, tend to generate few CER's, and opposite, projects generating large amounts of CER's seldom comply successfully with sustainable development issues (IGES, 2006).

It is in my opinion necessary to address *both* issues in future CDM projects; to develop projects that generate large amounts of CER's, and at the same time contribute to sustainable development. Such projects must contribute to the majority of the future CER's generated, as to comply with the targets set forth in the Kyoto Protocol, which states that:

*"The purpose of the Clean Developing Mechanism shall be to assist Parties not included in Annex 1 in achieving sustainable development"* (UNFCCC, 2005 p.4).

Future CDM projects must therefore involve aspects such as high carbon emission reduction, access to energy and security of energy supply, and lead to an overall transformation of the energy supply systems. Thus, the projects cannot primarily be qualified by the amount of CER's generated (Schlup, 2005), but must embrace the following issues:

- Enhance the future energy supply security, through less dependence on imported fossil fuels; hereunder
- Intensify the use of domestic renewables in energy production;
- Develop decentralised energy supply systems in local communities;
- Enhance the environmental benefits in local communities;
- Implement 'transformative' renewable energy technologies; that
- Lead to new employment opportunities and local income distribution; and if possible
- Revolve the value chain (more profits stay in the South instead of being transferred to the North);

These aspects of sustainability will speed up the needed transition towards sustainable development in developing countries, which is much needed. This becomes evident when looking at the approaching development of many developing countries, emphasised below.

## **1.5 Energy and materials use in Asia**

It is estimated that the demand for energy will rise dramatically in Asian countries within the next decades, as the industrial output continues to grow in this region. By the year 2025, this part of the world is expected to account for as much as 55 to 60 % of the global industrial output of goods and products (Garmichael & Rowland, 1998). This dramatic development puts great pressure on energy demands in the region, and will result in developing countries by-passing OECD countries in energy-related CO<sub>2</sub> emissions before 2025. Today, developing

Asia account for a net oil import of 45 %, which is expected to increase to 72 % in year 2030 (IEA, 2007).

As their own production of oil decrease in the same period, Asian countries will become more dependent on oil and gas imports from a few countries, like the Middle East and Russia (IEA, 2007). As oil and gas prices increase, Asian countries are expected to intensify their share of the global coal consumption, from the present 45 % to 80 % in 2030. As the energy consumption in Asia thus becomes highly fossilized - with higher shares being coal - CO<sub>2</sub> emissions and air pollutants as for instance SO<sub>2</sub> will become increasingly problematic (IEA, 2007).

### **1.5.1 Thailand at a glance**

Previously, Thailand's energy demand was mainly covered by biomass resources, as for instance wood fuel and charcoal used in household cooking stoves, or in the manufacturing sector for thermal energy production. But the changes in lifestyle, and economic growth during the 1980's and 1990's, have included Thailand in the globalised economy. Many industries during that period gave up using biomass for internal energy production. Today, this has lead to a large reduction in the use of biomass for energy, not only in industries but also in private households (Thai-Danish Co-operation on Sustainable Energy, 1999).

In combination with growing quantities of industrial and household waste, this has lead to intensified problems in locating appropriate landfill areas for the increasing amount of wastes in Thailand. As a consequence, some industrial waste are burned uncontrolled or openly dumped and left to decompose naturally, causing air pollution, hygienic problems and threatens to contaminate ground water capacities and the natural life (Parasnis, 1999 & Sutiratani, 2008). Again, other types of wastes are transported by road over increasing distances in order to find spatial room for landfill development. This is for example the case in Pathum Thani Province (case province of this study), in which high quantities of industrial and household waste from the community puts pressure on allocating land for landfills (Lybæk, 2004).

Not only the intensified use of materials to increase the industrial output (the goods), which leads to a problematic waste disposals, is of concern in Thailand. The projected energy capacity expansion is expected to increase by more than 25,000 MW within approximately a decade, leading to an installed capacity of 52,829 MW in 2019 - up from 27,788 MW in 2007 (EGAT, 2007). In the "National Power Development Plan", this capacity expansion is expected to be covered by domestic and imported natural gas, nuclear power and coal imports (Ibid.). The share of renewable energy is however also expected to increase in coming years, and energy efficiency obtained by means of the ENCON-Fund also assists in lowering the total energy demand (Holm, 2009).

Thus, even though the projected capacity expansion is lower that previous expected, the power sector in Thailand is primarily constituted of inefficient converting technologies. To cope with the demand, old and outdated power plants - those especially fed by fuel oil, petroleum and lignite etc. - are not replaced by more modern and efficient technologies, as for instance combined cycle gasification technologies (CCGT) fed by natural gas or modern biomass applications.

Some analyses estimate that biomass for energy purposes has a potential of 7,000 MW in Thailand (EPPO, 2003), and therefore can cover more than 25 % of the existing capacity installed. These estimations are primarily made from biomass wastes coming from the extracting part of agricultural activities and from large scale agricultural processing of crops etc., as for instance rice,- sugar and palm oil mills. They do not include biomass wastes from other types of Thai manufactures, nor SME's.

The energy potential of biomass waste in Thailand would thus be higher, if these resources were included as well. More than 90 % of the Thai industrial output is produced by SME's (Parasnis, 1999). It is therefore to be expected that a future increase in industrial activities, and the corresponding increase in CO<sub>2</sub> emission, will come from these types of industries.

Biomass technologies are already implemented within manufacturing industries in Thailand. Almost all sugar mills have for example implemented technologies based on combined heat and power (CHP), incinerating the industry's biomass wastes and generation steam in the process of doing so. Previously, the efficiency of the applied technologies was quite low and often compensated for by use of fossil fuels as a supplement, even though the energy production from biomass waste could cover the internal energy demands. In some cases, the technologies were deliberately set to a low efficiency (energy output) in order to incinerate all the biomass waste generated, hence solving an industrial waste problem (EC-ASEAN COGEN, 1998). Also, agricultural industries having sufficient quantities of biomass waste *and* a demand for internal process heat, did previously not always apply CHP technologies.

Do to the Small Power Producers (SPP's) and Very Small Power Producers (VSPP's) scheme in Thailand, which allow the industries to sell power on the grid for a favourable price - together with a feed-in tariff for utilisation of certain types of renewables for energy production - the above situation is now changing. More focus is now on using biomass resources for energy production in more modern and efficient technologies (Holm, 2009).

### **1.5.1.1 CDM implementation in Thailand**

As opposed to other countries in Asia, as for instance China, India and Malaysia, Thailand has only recently started approving CDM projects. According to the Deputy Executive Director of the Thai Designated National Authority (DNA) Ms. Prasertsuk Chamornmarn, Thailand is not especially interested in CDM. However, the financial support from the mechanism is welcomed as a support to the private sector, in their transition towards a more environmental friendly means of production (Chamornmarn, 2008).

Former Prime Minister Taksin Shinawatra previously stated that Thailand does not need the financial resources from CDM. As a businessman, he was said to be pro American, and as the USA has not ratified the Kyoto Protocol, Mr. Taksin followed this direction in his policies (Salam, 2008). Previously, CDM was also perceived by the Thai central administration as a new form of colonialism, which it would be advisable to avoid (Phonthiwisutwathee, 2008). This viewpoint does not exist any longer (Ibid.), but Thailand has to some extent been reluctant to implement the mechanism efficiently. This has fortunately changed with the establishment of the Thailand Greenhouse Gas Management Organisation, TGO, who recently scaled up their staff by 300 % from the initial amount (Holm, 2009).

This is very positive as all countries in Asia must adapt to energy production and consumption leading to lower CO<sub>2</sub> emissions, in which CDM project implementation is one means of achieving this. The challenge in Thailand is therefore to connect CDM even further to visible

and tangible benefits that will speed up the implementation of CDM projects in the country, which *could* ensure that the mechanism enjoys full penetration in Thailand. By focusing on increasing the *sustainable development contribution* of future CDM projects, this study will try to speed up the implementation of such projects in Thailand.

## 1.6 Purpose of the study

CDM in its present form has failed to deliver a transformation of the energy supply system in Thailand, and can merely be viewed as a static instrument for transfer of CER's from a developing to a developed country. Thus, it is a case-by-case approach in which different CDM projects are approved and implemented, without addressing any overall strategy for transforming the energy supply system in the country. Therefore, CDM is applied as a single project-based mechanism, which lacks the support from energy planning initiatives in Thailand. In general CDM projects also has shortcomings in contributing to environmental and social impacts with long term benefits, and is therefore met by intensified critique as these 'side-effects' rarely are implemented. Focus on environmental and social impacts is therefore often regarded as an optional task, or a 'side-effect', rather than something that qualifies or enhances the projects (WWF, 2004 & Dishon, 2008).

The CDM projects currently applied therefore equals a 'single factor' -or 'linear thinking' approach, that lacks a more cyclic path of direction in which materials and energy flows are exchanged for more sustained environmental benefits. The overall purpose of this study is thus to develop a tool, which can help in transforming the energy supply system in Thailand at the community level, and develop means for applying more energy efficient manufacturing processes within Thai SME's. This can for example be achieved by integrating different production chains, by substituting and re-using materials and energy between industries located in a community, by implementing efficient manufacturing equipment and by applying process integration.

This study will propose how CDM can become this dynamic mechanism with actions on how to approach such improvements - not only at the single industrial level but in communities as well - and propose on how CDM to a higher degree can support sustainable development where implemented. This could lead to more sustained production changes and materials and energy substitutions that would increase the overall efficiency of resource consumptions'. This would again support the development of a more self sustained domestic energy production, less sensitive towards energy fluctuations (accessibility/price) and other external factors; thus increase the energy supply security.

The purpose of this study is also to improve the possibilities for reducing CO<sub>2</sub> emissions from CDM projects even further, by addressing as many aspects as possible having influence on emission reductions when looking at the production process (the materials and energy chain) of Thai manufactures. I will address materials and energy saving opportunities using a *systemic approach*, emphasising on possibilities for implementing biomass technologies, efficient manufacturing equipment and process integration in a community of SME's. Studies of the framework conditions, will, on the other hand, highlight which types of policy, capacity building and institutional strengthening etc. there must be applied, and by whom, in order to enhance the sustainable development contribution of future CDM projects.

## 1.7 Research question

*How can the sustainable development contribution of future CDM projects be enhanced, using Thailand as a case study, and developed into a generic Manual with guidance on how to pursue this in Asian countries?*

## 1.8 Outcome of the study

### *The Manual*

The conclusion of this study will be a **generic Manual** on how to address a transformation of the production and consumption of energy in Asian countries, by improving the conditions for CDM project implementation. The Manual will thus provide guidance on how to enhance the sustainable development contribution of future CDM projects in these countries. It will suggest a Planning Guide on how to implement CDM projects with a high sustainable development contribution (Chapter 10, Figure 10 A), and it will illustrate the potential benefits when actually following the steps of this Planning Guide (Chapter 10, Figure 10B). To strengthen the usability of the Planning Guide, the Manual will suggest Institutional & framework conditions (Chapter 10, Table 10C), which can strengthen and support the actual use of the Planning Guide.

### *Planning Guide*

Suggestions to the Planning Guide will be extracted throughout this study from the Thai context, and become a guideline on how to implement future CDM projects in Asia with a high sustainable development contribution, and will be connected to relevant stakeholders. The Planning Guide will address the implementation of a renewable energy technology posing many development opportunities for Thailand; the 'biomass CHP with district heating'. The Planning Guide will elaborate on and identify important aspects to be included in the Project Design Document (PDD) in future CDM project preparations'.

### *Policy Recommendations (Institutional & framework conditions)*

Policy Recommendations is also extracted throughout the report from the Thai context, which will become a part of the proposed Institutional & framework conditions supporting the implementation of future CDM projects in Asia. Apart from the 1) Policy Recommendations just mentioned, the Institutional & framework conditions will contain an identification of 2) What actually impacts CDM projects along the production process, and which 3) Influential Stakeholders that are capable of changing or impacting on these.

### 1.8.1 Applicability

The study will generate knowledge on how to enhance the sustainability of future CDM projects, by an optimisation of the materials and energy use within Thai manufactures. Thailand act as a case for the study, but the overall results (the generic Manual) can be applied on other Asian countries. These countries are also interesting for Denmark when it comes to purchase of carbon credits, as for instance Indonesia and China. As the industrial structure in many of these countries is quite similar to that in Thailand, it is very likely that the Manual, or parts of it, can be adopted in these countries as well. This study will thus contribute to generic knowledge which national states, project developers, carbon credit buyers and host countries, etc. can adopt, when assessing which type of CDM projects to implement or support. The

Manual can thus be adopted in other European countries and companies, and thus become an overall guidance of how to approach a qualification in the use of CDM.

## **1.9 Structure of the study**

### **Chapter 1; Introduction**

The first chapter outlines the project frame and the overall emphasis of the study undertaken. It questions the present CDM governance and describes the need for changes in the focus of future CDM projects. Focus is on higher energy supply security, use of biomass resources and implementation of transformative renewable energy technologies, etc. The relevance of such changes in Thailand, as well as in Asian countries in general, is hereafter addressed. At the end of the chapter, the research question is posed and the outcome of the study described. Finally, the structure of the study is outlined.

### **Chapter 2; Methodology**

This part of the chapter outlines the methodological approach taken in this study. The chapter shortly describes the overall research design applied in the study, and then proceeds to present and eventually develop an Analytical platform for the study. The Analytical platform consists of two sets of sustainable development concepts (Part I. & II.) developed in this chapter, which pose a frame from which extractions of elements for the Manual are exercised throughout the report. The sustainable development concepts will be applied on the Thai context in relation to potential CDM-industries and relevant Thai CDM frameworks. At the end of the chapter, I describe how previous studies in Thailand have formed the present study, and how the fieldwork has been conducted in Thailand.

### **Chapter 3; Background data**

To enhance the sustainable development contribution of future CDM projects, this chapter identifies what kind of projects to focus on in Thailand; what type of energy to substitute and in which industries and locations this would be most appropriate. The chapter first elaborates on a theoretical selection of appropriate CDM-industries in accordance with their waste generation and its usability as energy source. It also shows the consumption of and type of energy flow through these types of industries. The purpose of this chapter is thus to identify in which industries, and in what parts of the energy chain and industrial manufacturing processes, it is favourable to pursue improvements. This chapter also describes in which locations (physical areas) to exercise the implementation of future CDM projects in Thailand. At the end of the chapter extraction of elements for the Manual will be outlined.

### **Chapter 4; Thai CDM policies and institutional set-up**

Options for enhancing the sustainable development contribution of future CDM projects are in this chapter identified through analysis of the national CDM policies in Thailand. It identifies and suggests on means to strengthen the above, by looking at the chosen direction of the Thai CDM policies. This is for instance done by evaluating the sustainable development criteria's set forth for CDM up against the national sustainable development strategy in Thailand, and by suggesting on how to strengthen and prioritize the sustainable development criteria's. At the end of the chapter extraction of elements for the Manual are exercised.



## **Chapter 5; CDM potentials in Thailand**

This chapter identifies in which sectors and what resources and technologies, Thailand has chosen to focus on in their future CDM development, and eventually suggest on means for improvements. It will identify which sectors in Thailand emit the highest quantities of Green House Gas (GHG), and briefly looks into projections in the future emissions. The possibilities for implementing CDM projects in Thailand, hereunder whether the proposed projects are in line with the resource potentials found are hereafter identified.

After this, analysis of whether the national strategies correspond to the resource potentials, and whether the Thai GHG abatement is placed on the most important sectors, are conducted. Also here, the purpose is to increase the sustainable development contribution of future CDM projects. Extraction of elements for the Manual will also here be exercised at the end of the chapter.

## **Chapter 6; Industrial metabolism and energy supply transformation**

This chapter emphasise on options for setting-up more sustainable means of production and consumption within Thai manufacturing industries. First an identification of the materials and energy throughputs (industrial metabolism) within the case industries will be conducted. The overall purpose of this is to identify if relevant biomass waste is generated, and to expose the energy consumption patterns within the case industries. After this, I will outline which energy saving techniques and systems it is possible to implement given the specific context, hereunder how to apply efficient processing equipment and process integration. At the end of the chapter I will identify and discuss, which of the Technological options (Option B or C) it is most appropriate to implement in the given context. This will lead to extractions of elements for the Manual.

## **Chapter 7; Enhancing development opportunities**

Enhancing the sustainable development contribution of future CDM projects are here sought obtained, by identifying how to increase the CO<sub>2</sub> emission reduction potentials of such projects, thus elaborating further on the ‘Technological options’ presented in Chapter 2. The chapter will also suggest on a ‘transformation process’ of the energy supply system, proposing that also a suggestive development of the energy supply system can be applied.

The second part of this chapter will focus on how to create more value in developing countries as to increase the *development opportunities* connected to CDM implementation. Focus will for instance be on which type of energy technologies to implement, according to their employment effects and market expansion possibilities, etc. It will also be on how to establish mega-suppliers of energy technology and how a supply-park can evolve around these suppliers. At the end of the chapter extraction of elements for the Manual are exercised.

## **Chapter 8; Planning Guide, PDD elements and case example**

Chapter 8 firstly presents the Planning Guide, which is based on extraction of Planning Guide elements from throughout the study; now arranged in a logical planning order including extractions of PDD elements. The second part of the chapter thus exemplifies the use of the Planning Guide applying the PDD elements on a Thai case; Navanakorn Industrial Promotion Zone. The implementation of and benefits from applying the biomass CHP with district heating in the case area, are thus outlined at the end of the chapter.

## **Chapter 9; Institutional & framework conditions for Thai CDM**

All 'Policy Recommendations' identified throughout the study are integrated into strategies for strengthening the overall Institutional & framework conditions in Thailand, presented in this chapter. Apart from the 'Policy Recommendations' this chapter outlines 'What impacts CDM projects' along the production process, and which 'Influential stakeholders' can change or impact on this; thus CDM project carriers.

## **Chapter 10; Generic Manual**

The generic Manual in the last chapter outlines the findings of this study, and thus enables an answer to the research question repeated here. Some means of suggestion are finally given to how to commence the development proposed in the generic manual in Asian countries.

# **Chapter 2; Methodology**

This chapter will elaborate on the methodological approach applied in this study, in order to enable an answer to the research question posed earlier on. It firstly describes the overall research design applied in this study. Then it proceeds to emphasise on the analytical optic of the study and the development of an analytic framework, with focus on the integration of different conceptual concepts for creating an 'Analytical platform'. This platform will consist of two sets of concepts for sustainable development, which will be presented and developed further in this part of the study. At the end of the chapter, I describe how previous studies in Thailand have formed the approach taken in this study, and how fieldtrips etc. have been conducted.

## **2.1 Introduction**

### **2.1.1 Research design**

The overall research design applied in this study can be described as a triangulation between theory, empirical data - interviews and company visits - and primary/secondary literature (Yin, 1999). The outcome of this study will thus be a result of this triangulation developed into a conceptual tool - a Manual - which can be used by project developers, host countries and buyers of carbon credits, etc. In order to develop the Manual, I have applied a case study - several multiple embedded case studies - in which potential Thai 'CDM-industries' have been studied (Yin, 1999).

The case industries have thus acted as objects for materials and energy savings as well as substitutions, in which different options for appropriate transformation of the local energy supply has been identified. I have selected case industries located in one of Thailand's many Industrial Parks, as to benefit from the close location of industries and thereby possibilities for setting up exchanges of materials and energy ('external metabolism') within these sites. The industrial structure in Thailand is thus beneficially when it comes to applying exchanges of materials and energy within such areas.

## **2.2 Analytical platform**

In the following section, I describe the methodological approach of this research project, and then proceed to establish the Analytical platform for the study in Section 2.2.2 that follows.

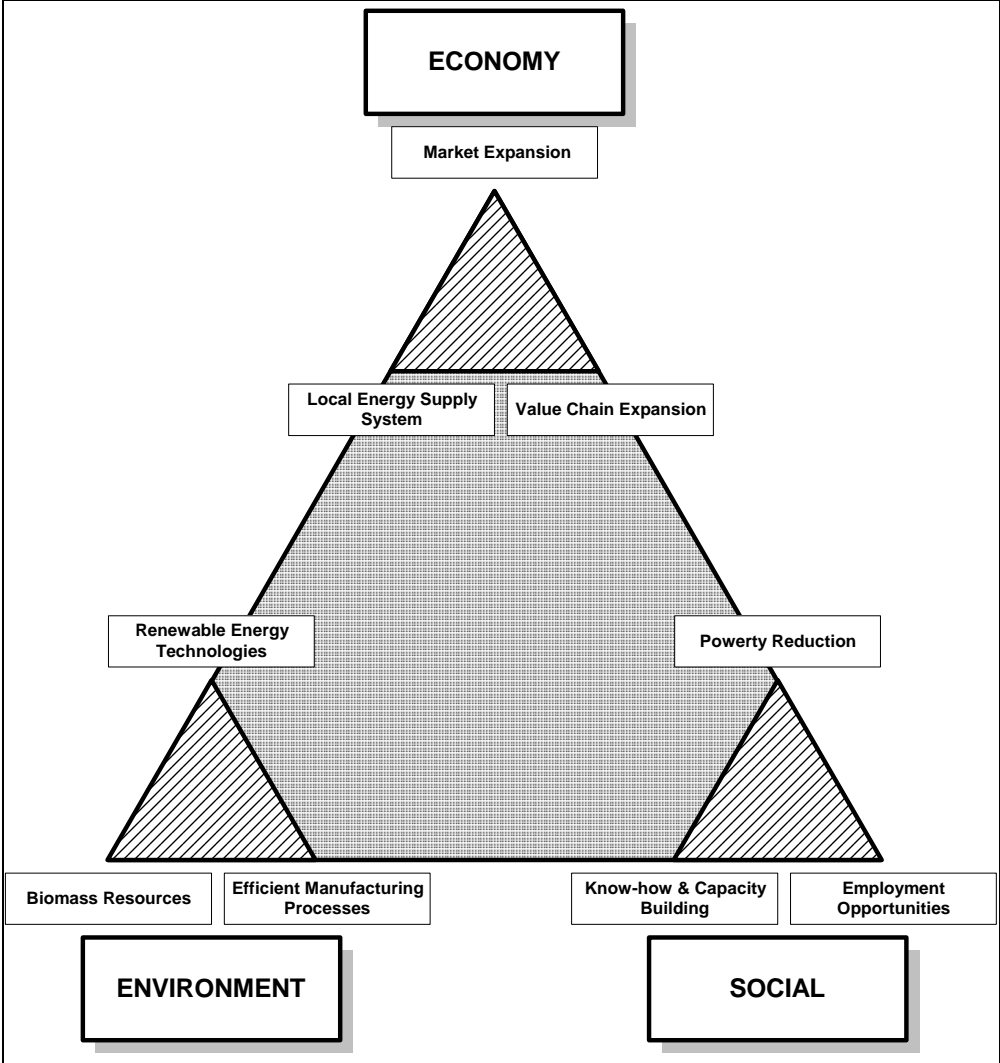
### **2.2.1 Analytical optic**

Figure 2A below illustrates some of the important issues that will be outlined and discussed in this research project, as a consequence of the Analytical platform and thus extractions of sustainable development concepts. The underlying optic of the Analytical platform developed in this chapter, are a classical understanding of sustainable development as containing the elements depicted in Figure 2A; namely 'Economy', 'Environment' and 'Social' issues (WCED, 1987).

Thus, under the ‘Social’ element this study discuss poverty reduction and employment opportunities related to technology implementation, and how transfer of know-how and capacity building can establish the ground for more knowledge-based jobs in Thailand. Elements concerning the ‘Environment’ discuss which renewable energy technologies to adopt in Thailand for more efficient conversion of the biomass resources available; from both industry and other relevant sources as for instance agriculture etc. To make the resources consumption within the manufacturing sector in Thailand more efficient, the study also elaborates in how to apply and implement technical changes and process optimisations, etc.

The above is important for further discussions of the ‘Economy’ elements, in which a sustainable local energy supply system are proposed for a case study area. How this energy system can contribute to enhance the local economy is thus discussed by means of a value chain expansion in the community. The final step of such value chain expansion, are an actual Thai manufacturing scheme of the renewable energy technology pointed out for the case areas. Further, discussions of how to -and options for expanding the market for this technology will be addressed. Additional discussions to those mentioned above will also be outlined in this study. Also, the cross line between the elements in the figure below, are in this analysis not applied as rigid as illustrated in the figure.

**Figure 2A: Analytical optic**



Source: Own figure

## 2.2.2 Sustainable Development Concepts Part I.

The Triangle illustrated in Figure 2B below consists of three elements being a) Dematerialisation / Decarbonisation, b) Energy Efficiency, and c) Industrial Ecology. These elements all together create a framework on how to use and re-use resources (materials and energy), how to limit the use of resources in general, and how to comply with energy efficiency and materials substitutions. The triangle focuses on the ‘materials and energy chain’ (‘production process level’) of creating concepts for sustainable development, illustrated by the *Inner Circle*. These concepts will form the extraction of elements to the Planning Guide, and thus become part of the Project Design Document (PDD) and eventually included in the generic Manual. The above elements thus stretch out a set of overall concepts for sustainable development on the ‘production process-level’.

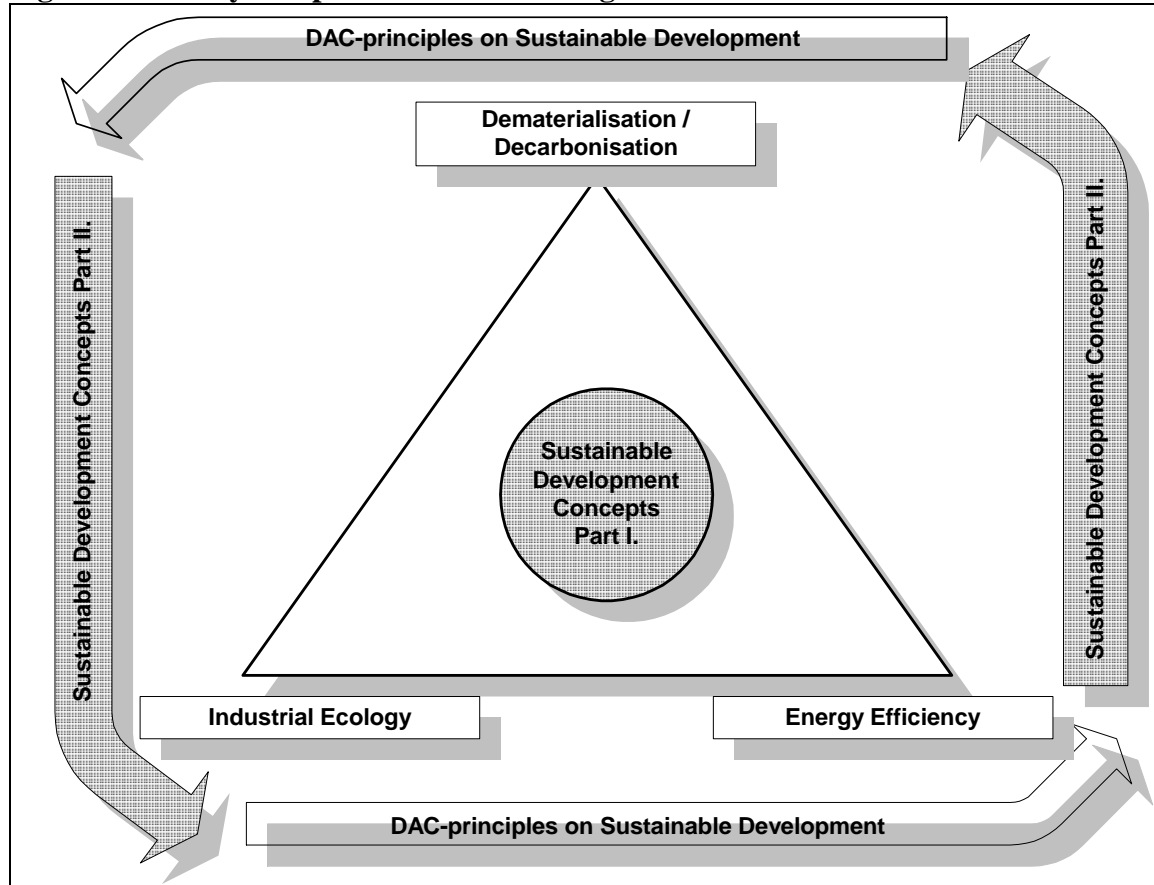
## 2.2.3 Sustainable Development Concepts Part II.

The *Outer Circle* (see Figure 2B) also focuses on framework conditions as means of creating concepts for sustainable development. Here, these concepts will form the extractions of elements for the Planning Guide - together with Policy Recommendations emphasised below - and finally be included in the generic Manual. Many framework conditions influence the possibilities for enhancing CDM projects. Suggestions will be outlined on how to improve these conditions, by pointing to for instance relevant policies and stakeholders capable of supporting more sustainable means of production and consumption in Thailand.

At the institutional level relevant suggestions for capacity building and changes in the priorities of Thai CDM relevant organisation, will be proposed. The above elements thus stretch out a set of overall concepts for sustainable development on the ‘strategic level’, which will act as an analytical platform in the study.

The usability of the Planning Guide will be supported by appropriate Institutional & framework conditions, which develop some favourable overall parameters for implementation of CDM projects in Thailand. Emphasis is thus on identifying ‘*What impacts CDM projects?*’ connected to planning, implementation and operation of such projects, followed by relevant activities supporting each of the phases just mentioned above. A special focus is here given to the ‘*Policy Recommendations*’ proposed throughout the study (incentives, laws and regulation etc.), and whether they can - if implemented - support an enhancement of CDM. Emphasis is also on identifying ‘*Influential Stakeholders*’ in Thailand, who can influence on the Policy Recommendations proposed and the conditions for CDM implementation at different stages of the production process, implying that relevant ‘project carriers’ are pointed out.

**Figure 2B: Analytical platform - The Triangle**



Source: Own Figure

## **2.2.4 Elements to be addressed by the sustainable development concepts**

The sustainable development concepts, described above and developed below, will be used throughout this research to evaluate and to suggest future strategies and priorities, in order to strengthen the sustainable development contribution of future CDM projects in Thailand. They will be applied on relevant areas that can help to achieve this development, as exemplified below.

The sustainable development concepts (Part II.) will first of all be applied with the purpose of identifying in which part of the energy production and consumption it is most favourable to set up an alternative energy supply in Thailand. Thus, what type of energy to substitute and in which industries and locations this would be favourable to pursue. The sustainable development concepts (Part II.) will hereafter be applied on the Thai CDM policies, as to identify and suggest on means to strengthen the sustainable development contribution of future CDM projects in the country. To evaluate whether the chosen direction of the Thai CDM priorities are appropriate, analysis of the sectors, resources and technologies pointed out in Thailand, are conducted. Suggestions will be proposed on how to strengthen the sustainable development contribution of future Thai CDM projects, given this identification, by applying the sustainable development concepts (Part II.).

Hereafter an identification of different options for setting up local biomass energy systems, based on internal or external re-use of materials and energy throughputs in Thai case industries, are exercised. A prioritisation of these options is hereafter applied, by bringing in the sustainable development concepts (Part I.), as a turning point for selecting the most appropriate energy system. Suggestions are thus given to which technical improvements to focus on in general, when preparing for or implementing the selected energy system. How to support this implementation even further is thus discussed and suggested upon next, by increasing the value chain connected to future CDM projects. This can, for instance, be done by setting up a domestic technology manufacturing scheme, and include the local population more in operating CDM energy facilities. Thus, the sustainable development concepts (Part II.) are applied, with the purpose of increasing the overall development effects of future CDM projects in Thailand.

## 2.3 Creating sustainable development concepts

### 2.3.1 The Triangle (inner circle)

Departing from the Triangle (Figure 2B above), the following section will describe the content of the elements; 1) Dematerialisation / Decarbonisation; 2) Industrial Ecology and 3) Energy Efficiency. At the end of the section the elements will be discussed up against a simple *Input/output model* for industrial manufacturing, and in relation to different *Technology options* outlined. The purpose is to extract sustainable development concepts for the analytical framework, illustrated by the *Inner Circle* in Figure 2B.

#### ***Dematerialisation***

*“Broadly, dematerialisation refers to the absolute or relative reduction in the quantity of materials required to serve economic functions. Lower material use would reduce the amount of waste produced, limit human exposures to hazardous materials, and conserve landscapes. It can also extend the life of non-renewable resources by using less material per unit product, enabling greater productivity from the same primary input”* (CH4org.uk/glossary).

Dematerialisation has for many years been of importance for manufacturing businesses and extensive research in the topic has been conducted. Car and aircraft manufactures are examples of businesses where research on how to limit the use of materials (steel and consequently gasoline), and at the same time strengthen the product performance, have been applied. Also soft can producers have achieved business advantages by dematerialising efforts, when developing light weight aluminium cans with one-third the density of the formerly used steel products (Wernick et. al., 1996).

In the energy sector dematerialisation emphasise on using less material to produce the same or even additional energy services. Dematerialisation in the energy sector can be obtained by implementing more efficient technologies, converting the same amount of raw materials into ‘more energy’. It can also be obtained by using ‘secondary energy’ emerging from the primary energy production. This is for example the case on Danish CHP Plants distributing district heating to households, hereby making use of a ‘by-product’ (hot water/steam), which normally would have been discharged (this is the case in for instance Thailand). District

heating thus dematerialise the use of oil and natural gas in Danish households and office buildings etc. for on-site production of heat.

At the household level it is also possible to dematerialise the amount of materials required to generate energy services, by for instance using fluorescent light bulbs instead of traditional bulbs. This results in a reduction in fuel consumption at the power plant. Dematerialisation can also be applied when re-using materials instead of drawing on virgin raw materials, which become increasingly scarce. It can be applied in the manufacturing business where re-use of certain materials in the production process can be obtained, taking of pressure on virgin materials.

In manufacturing businesses generating heat or steam for internal process use, dematerialisation can be obtained by re-using 'waste' heat or steam instead of discharging it. This limits the pressure on fuel consumption. In the energy sector, re-use can among others be applied by the above mentioned district heating scheme, or by use of combined cycle technologies using 'waste steam' in an additional cycle for higher energy output. Thus, some activities contain a duality as both dematerialising and decarbonising the use of materials.

### ***Decarbonisation***

*“Decarbonisation is the switch from heavy carbon fossil fuels, such as coal, to lower carbon fossil fuels, such as oil and gas, and to eventually carbon free sources, such as nuclear power, renewable energy sources and hydrogen power” (CH4org.uk/glossary).*

The focus of decarbonisation is - as opposed to dematerialisation which focuses on quantities versus yields - to emphasise on the transition towards the use of non-fossil fuels, as for instance renewable energy sources, like biomass, wind or solar energy etc. CDM is directly connected to this element and is designed to aid in the transformation of the energy supply towards the use of renewables and enhanced energy efficiency etc. with the purpose of lowering the content of carbon in the energy supply.

Decarbonisation and dematerialisation can go hand in hand understood in the sense, that a transformation of the energy sector not necessarily have to lead to intensified pressure on virgin raw materials - due to intensified use of for instance biomass - in order to decarbonise the energy system. By focusing on *efficient* use of biomass resources, already extracted and used in industrial processes, it is possible to both dematerialise and decarbonise the energy supply system. In Thailand, as in many other developing countries, valuable biomass resources from the manufacturing sector are often discharged as wastes, but *could* contribute with significant value if re-entering the production process as for example biomass fuel (Lybæk, 2004).

### ***Energy Efficiency***

*“Energy efficiency refers to the amount of energy that is used to carry out a particular task such as keeping a building warm in winter or generating electricity from coal. The more energy efficient something is, the less energy it needs to complete the task. Energy efficiency measures can be as simple as fitting draft excluders to doors and windows or technical fixes such as converting power plants into co-generation plants” (CH4org.uk/glossary).*



Energy efficiency - or Demand Side Management (DSM) - is here related to optimisations in industrial activities undertaken by manufacturing businesses etc. Energy efficiency is as such all aspects of technical solutions and process changes leading to reduced consumption of energy in materials processing, or increased industrial output (goods) by the same amount of energy use. Energy efficiency can be applied on the manufacturing sector, both using and producing energy, as well as on the traditional energy sector, i.e. on power plants.

Energy efficiency can be influenced by many factors and can vary quite dramatically between manufacturing businesses, and even between manufactures in the same line of business. Lack of energy efficiency is often caused by outdated technologies (the design and age of equipment), by chemical and mechanical parameters that keeps the production process in a certain track, or simply by means of inadequate maintenance and operating practices. Energy efficiency is also, in this context, understood as enhanced processing of materials so as to avoid product failure (damaged goods which will be discharged). Such enhancement can also add to the overall efficiency of materials processing and lower the consumption of energy and materials related to producing the goods.

### ***Industrial Ecology***

*“In a biological ecosystem some of the organisms use sunlight, water, and minerals to grow, while others consume the first, alive or dead, along with minerals and gases, and produce wastes of their own. These wastes are in turn food for other organisms, some of which may convert the wastes into the minerals used by the primary producers, and some of which may consume each other in a complex network of processes in which everything produced is used by some organism for its own metabolism.*

*Similarly, in the industrial ecosystem, each process and network of processes must be viewed as a dependent and interrelated part of a larger whole. The analogy between the industrial ecosystem concept and the biological ecosystem is not perfect, but much could be gained if the industrial system were to mimic the best features of the biological analogue”* (Frosch & Gallopoulos, 1989 p.74)

Industrial Ecology is a conceptual frame in which an industry is understood, not only in isolation from the surrounding environment, but as a part of it. The aim of Industrial Ecology is to optimise the total materials cycle from virgin materials to final product or service. Theories of Industrial Ecology are inspired by traditional biological ecology and studies concerning the interactions that determine the distribution and abundance of organisms. The above definition of Industrial Ecology by Frosch and Gallopoulos describes, in my opinion, the core of the concept very satisfactory. Many other proposals on a definition have been put forward during the last decade or so (see N. Gertler, 1995 p. 79 & B.R. Allenby, 1999 p. 40 & E.A. Lowe et. al., 1997 p. 3).

The core concept of Industrial Ecology is to minimise throughputs of resources in industrial processing's, to enhance internal activities to avoid waste generation, and thus to end up with a system in which solar radiation is the only throughput of resources. As stated by Frosch and Gallopoulos this is a much idealised vision for manufacturing processes, but never the less important when creating energy systems striving for sustainability. In the following, I will

therefore briefly describe how this evolution takes place in a biological interpretation, so as to inspire the discussions on sustainability in manufacturing processing's.

L. W. Jelenski and others describe the earliest life forms on earth as being limited and characterised by large amounts of resource available. Not only were resources unlimited, but waste disposal opportunities were also unlimited. Life on earth was so limited that disposals of waste had practically no environmental impacts on the earth capability to maintain it. L. W. Jelenski and others describe the system, in which materials flow from one stage to another being independent of all other flows, as a *linear materials flow*. As the biological system evolves and resources becomes more limited, it becomes to resample biological ecosystems knows as biotopes.

Now life forms becomes more interlinked and depended upon each other; it becomes more cyclic as waste from one organism is re-used as a resource by other organisms. The materials throughput into, and wastes out of, the ecosystem are quite limited compared to the linear materials flow described above. This *quasi-cyclic materials flow* is thus superior to the linear materials flow, but in the long run not sustainable due to the direction of the flow.

The evolution continues and a new enhanced system evolves - the *cyclic materials flow* - in which resource throughputs are limited and solely consists of solar radiation. Likewise, external waste generation are completely terminated, due to the organisms of the system working together and their metabolism evolutionally adopting to each others output/input needs. The efficiency of this system is high due to limited environmental impacts: no resource extraction and waste generation.

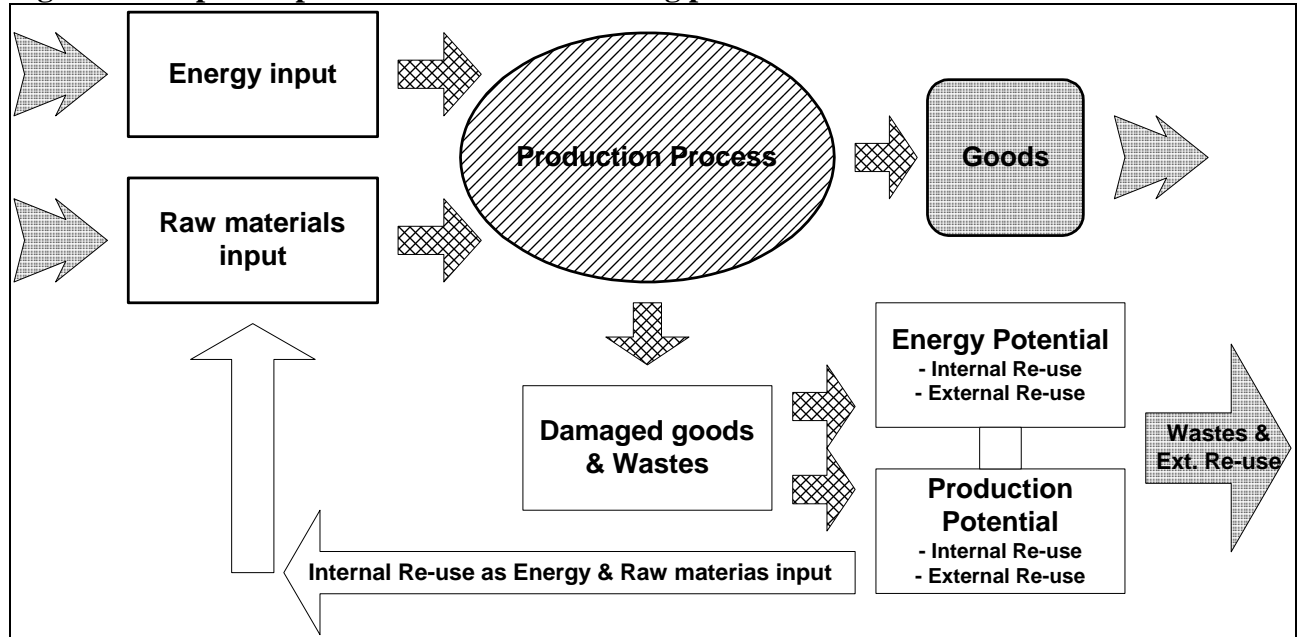
L. W. Jelenski and others thus suggest that industrial activities should try to mimic the latter system in order to pursue sustainability in manufacturing activities. Can industries manage to perform practices that are cyclic - or even establish cyclic flows of materials within the entire industrial ecosystem - industrial manufacturing will become more efficient and lead to reduced environmental impacts, with less pressure on resource extraction's as well as reduced consumption of energy and waste generation (Jelenski et. al., 1991).

### **2.3.1.1 Input/output model**

Figure 2C below illustrates, that materials throughput lead to industrial activities ending up as product output (goods). In this production process some resources like energy and raw materials disappears, due to production failures or discharges as wastes or energy losses. Parts of the waste will have an *energy potential*, which can be re-used for energy production internally (by the same manufacturing industry) or externally (by another or more manufacturing industries). The amount of waste with an energy potential can be reduced, if optimisations in the production process occur, etc.

Another part of the waste will have a *production potential* also appropriate for re-use either internally or externally. Some types of wastes can have a combined energy and production potential, as for example wood wastes. Given the quantity of internal re-use, a certain amount of output (apart from the final goods) will evidently occur, leading to either external re-use or actually discharges as wastes.

**Figure 2C: Input/output model of manufacturing processes**



Source: Own figure

### 2.3.1.2 Technological options

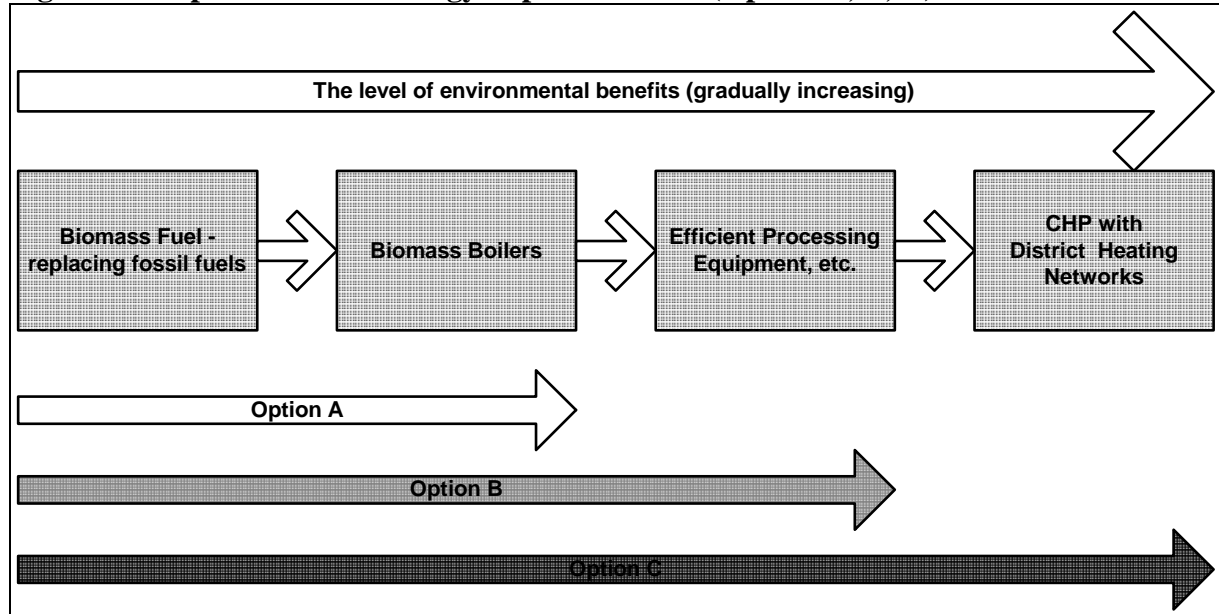
The technological options (Option A, B and C) shown in Figure 2D below, illustrates how environmental benefits can be obtained in the supply of energy to the industrial sector in Thailand at different levels. The lengths of the arrows indicate the level of environmental benefits, and at which level it is assessed, but also the increasing complexity of achieving these benefits. The specific activities related to each steps - or option - are described below:

*Option A* focus on possibilities for implementing individual biomass boilers, substituting the use of presently applied fossil fuel boilers in Thai industries. The environmental benefits solely relates to phasing out the use of fossil fuels, and substituting it with local biomass resources. Thus, the energy consumption will remain the same, but the energy supply will be decarbonised through the use of biomass waste.

*Option B* origin from the same approach as above, but the implementation of efficient processing equipment is also emphasised, leading to lower overall energy consumption and use of biomass resources (decarbonisation & dematerialisation) compared to Option A. Energy efficiency is achieved by means of applying more efficient manufacturing equipment, implying reduction in the total amounts of energy required. The complexity of the system increases, as technical aspects and means of processing must undertake changes.

*Option C* increases the environmental benefits even *further* by setting up a collective energy supply system based on a biomass CHP Plant, distributing district heating to industries participating in the network, using local biomass resources. The individual boilers are phased out, and the supply of energy is undertaken by a joint or collective system (which includes one large single biomass boiler). Supply of process heat is mainly based on hot water (not steam) in order to dematerialise the energy system, and the energy is sought re-used through process integration and cascading of energy in order to avoid energy wastes.

**Figure 2D: Options for technology implementation (Option A, B, C)**



**Source: Own figure**

Minor changes in processing equipment are a precondition for establishing Option C, as the supply of process heat are based on hot water (through supply of district heating of temperatures below 100 °C. Surplus electricity can - if any - be transmitted to the national grid. The complexity of this system is higher compared to the latter two, but the environmental benefits much more comprehensive.

### **2.3.1.3 Applying the ‘Triangle’ on the ‘Input/output model’ and on the ‘Technological options’**

#### ***Input/output model:***

To comply with the three elements composing the Triangle (Figure 2B), it is evident that the energy production must be based on resource throughputs decarbonising the energy supply originating from solar radiation (as for instance biomass). Likewise, throughput of raw materials must limit extraction of virgin materials, so as to dematerialise the pressure on scarce natural resources. To comply with this, the use of biomass waste already extracted and used in a previously production process must be prioritised. This limits the pressure on virgin materials (energy and raw materials), but also the size of the linear materials flow out of the system (wastes).

In order to limit the resource extractions related to energy and raw materials input, the production process must also be as efficient as possible, leading to low amounts of damaged goods and wastes. The ‘organisms’ of the production process must, in other words, ‘consume’ the resource input as efficient as possible, due to an enhancement of the ‘internal metabolism’ of the materials use. This will lead to limited waste generation and a more cyclic production process will be developed with higher product output (goods).

Enhanced ‘internal metabolism’ can be obtained by technical optimisations, as for instance implementation of modern biomass boilers (heat production) or biomass CHP technologies (power & heat production) for efficient conversion of biomass resources. Also, by switching from steam to hot water use, and by applying more effective pumps-, heat exchangers- or

vacuum technologies etc., this can be obtained. Finally, by applying more efficient processing equipment leading to improved utilisation of raw materials, and by process integration and substitution to more appropriate materials for lowering energy requirements in processing activities etc., this can also be achieved.

At the single industry level it is, however, seldom sufficient to rely on the industry's own biomass wastes for complete coverage of internal energy needs. It can therefore be convenient to re-use the biomass efficiently in another industry, or opposite, to make use of other industry's biomass waste. This approach can also be applied on energy discharges in the form of for instance hot water or steam (process heat). By establishing cyclic flows of materials (material and energy) connecting different industries, the cycle of re-use expands and the foundation for 'external metabolism' occurs. This will again reinforce the potentials of limiting the linear materials flow out of the system.

#### ***Technological options:***

In relation to the issue of biomass waste mentioned above, Options C (the biomass CHP with district heating) has the capacity to use all types and amounts of biomass waste generated, and are capable of supplying steam and heat at many temperature levels. This technology thus has the capacity to initiate a verity of materials and energy exchanges in the local community. Option C can thus be described as an 'Industrial Ecology Engine', applying a technological option with many potential benefits for the Thai society.

The superiority of Option C, compared to Option A and B, also lies in the fact, that a large CHP technology is much more efficient than smaller individual boilers producing heat-only (see Section 7.1.1, Chapter 7). The collective system, which the district heating network form, also enables the re-use of a 'waste product', namely cooling water from the power production, which normally are discharged by cooling towers in Thailand, as well as in other Asian countries due to lack of heat markets.

From a sustainability point of view it is thus beneficial to select Option C, as it embraces the elements of the Triangle to a very high extend. In the specific context, however, it is necessary to identify which types of energy 'transformation process' the industries can and are willing to pursue. It might be necessary to pursue Option B in the initial stages of an energy supply transformation, and then later on convert to Option C. A transformation process must therefore be identified, with the purpose of creating possibilities for a continuous evolvment of the local energy supply system, and to avoid options that can act as barriers for a development of the energy system later on.

#### **2.3.1.4 Sum-up on sustainable development concepts (Part I.)**

***On the 'production process-level' (the material and energy chain) CDM enhancement can be obtained by:***

- (1) Seek use of '***already processed biomass wastes as fuel***' for energy production;
- (2) Preferably select biomass, and if possible already processed biomass waste, as raw materials input;
- (3) '***Optimise the production process in regards to the use of energy/materials***', by:
  - Implement '***efficient biomass converting technologies***', like efficient biomass boilers or preferably CHP technologies (Option C);

- Seek ‘*use of hot water instead of steam*’ in processing activities, as the latter requires relatively more resource input to produce;
- Apply ‘*process integration*’ lowering the use of energy (quantity/quality);
- Use production methods lowering energy demands (materials substitution);
- Implement ‘*efficient manufacturing equipment*’ leading to reduction in materials/energy use;
- (4) Establish ‘*internal/external re-use of energy/materials*’, by:
  - Apply ‘*re-use of resources where the environmental benefits are highest*’;
  - Seek ‘*re-use where the resources are used most appropriately*’;

## 2.3.2 Framework conditions (outer circle)

This section describes a set of strategic principles given by the OECD (DAC), which can increase the level of and path towards sustainable development in developing as well as in developed countries. These principles will lead to another set of concepts for sustainable development, which will be used to strengthen relevant institutional and framework conditions for enhancing CDM projects. Some examples of this can be strengthening of public subsidies, better financial conditions for renewables, higher energy efficient standards on technology and stronger national energy policies in general (Kjær, 1998). Also aspects as appropriate institutional set-up and capacity building of relevant Thai institutions working with CDM frameworks are important.

### 2.3.2.1 Sustainable development

#### *Sustainable Development*

Sustainable development is often defined as: "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It is a principal aimed, not only at the environment, but also the economy and our society as well. Sustainable development shares the benefits of economic activity across all sections of society, to enhance the well-being of humans, protect health and alleviate poverty. It involves patterns of production and consumption that can be pursued into the future without degrading the human or natural environment*" (CH4org.uk/glossary).

The OECD / DAC offers a definition of sustainable development focusing on the strategic level, which is appropriate for this study, as it addresses issues of framework conditions and possibilities for improvements. Sustainable development is thus interpreted as:

*“A co-ordinated set of participatory and continuously improving processes of analysis, debate, capacity strengthening, planning and investment, which integrates the economic, social and environmental objectives of society, seeking trade offs where this is not possible”* (OECD, 2001, p.16).

### 2.3.2.2 The DAC-principles

The DAC-principles on sustainable development emphasise, as mentioned, on strategic principles, which must be pursued when seeking sustainability. Experiences show that there are many common features of good practice when pursuing sustainable development. The principles outlined below thus have universal relevance, and as such address both developing and developed countries efforts in achieving sustainable development. By integrating the principles into a country's mainstream strategic planning process, the outcome will lead to more lasting impacts towards sustainable development (OECD, 2001). Based on the report: "Strategies for sustainable development - The DAC Guideline" from 2001, some key principles for sustainable development are put forward in the following:

**People-centred:** Effective strategies emphasise on people-centred approaches, seeking long-term benefits for marginalised or disadvantaged groups in the society.

**Consensus on long-term vision:** Planning is more likely to succeed if long term visions are pursued with timeframes that all stakeholders agree upon. It is, however, also a necessity that short and middle term aspects of planning can be dealt with in an appropriate manner, so as to obtain the goals of the long term vision. It is important to seek agreements and support for the vision by diverse political parties, so as to comply with changes in the political situation. The vision is more likely to survive if it is based on a broad political agreement.

**Comprehensive and integrated:** Strategies should seek to integrate economic, social and environmental aspects where possible. Where integration of these aspects cannot be fully obtained, it is necessary to conduct trade-offs (negotiate). Such trade-offs or negotiations must hold the overall optic of the rights, and possible future needs, of generations to come.

**Comprehensive and reliable analysis:** In order to point out relevant areas of priorities, it is important that the present situation is analysed thoroughly. Here the use of local expertise and knowledge in analysis and information gathering is emphasised, as well as on including the perceptions of different stakeholders in the planning.

**High-level government commitment and influential lead institutions:** As mentioned above, commitments are essential if political or institutional changes are to appear, but financial allocations, as well as responsibility for implementation, must also be clearly defined.

**Build on existing processes and strategies:** Sustainable development strategies should be build on existing planning processes, and not be the result of a new planning paradigm. By using the existing system, it enables complementarily, coherence and convergence between different planning polities and frameworks.

**Effective participation:** Participation is essential for sustainable development strategies to occur, and both central governmental involvement as well as multi-stakeholder processes is required, for instance by local/regional authorities, the private sector and civil society as for instance developers, universities, NGO's etc. This requires good information and communication skills, as well as transparency and accountability.

**Link national and local levels:** Sustainable development strategies should focus on an iterative process between the national level and the decentralised level. The overall political, financial, legislative etc. issues should be dealt with at the national level, whereas issues dealing with detailed planning, implementation, monitoring and evaluation are important focus areas at the decentralised level.

**Develop and build on existing capacities:** Strategies can in the initial phase build on a country's existing capacity, and if needed later on, support a necessary capacity enhancement as part of the strategy process. Strengthen skills and capacity is emphasised, both within and outside governmental institutions.

### 2.3.2.3 Applying the 'DAC-principles' on the Thai CDM context

In the following, I have elaborated on the DAC principles for sustainable development as to integrate them into an *enhanced* Thai CDM context, with the purpose of creating concepts for sustainable development.

(1) Enhanced CDM must to a higher degree take a '*people centred*' approach, understood as the evolvement of a more local/regional chain of beneficiaries, following the projects. Such approach can be developed by using biomass resources from the community, supplied by various local stakeholders creating new job opportunities locally, and minimising waste problems in the community. New types of jobs can also be established in the process of manufacturing efficient renewable energy technologies, and in implementing advanced processing equipment leading to local knowledge creation and higher skilled jobs.

(2) Thai CDM enhancement must preferably be a result of '*consensus on long-term visions*', and as such, regarded as a common good for the Thai society. If not, institutional, - financial and political frameworks for setting up long term visions, with appropriate short and middle term planning objectives, must be strengthened. Specific actions here could for instance be formulation of governmental programs or plans in which CDM is an integrated part of the national policies, and regarded as a means of obtaining policy goals in Thailand. This could for instance be targets (National Master Plans) aiming at increasing the energy efficiency within Thai industries, in which CDM could support these targets.

(3) Whether or not CDM is '*comprehensive and integrated*', and thus adopted into Thailand's economical, environmental and social understanding etc., are likely to be exposed by the country's explicit requirements to CDM projects. This is given by the sustainable development criteria's for CDM projects formulated by the Thai DNA. If the level of comprehensiveness and integration is low, it is likely that very vague formulated CDM criteria's are formulated, when it comes to economic, environmental and social aspects.

(4) CDM projects must be based on '*comprehensive and reliable analysis*' showing the potentials for implementing project activities. Such analysis could identify the type of CDM projects to focus on when looking at the Thai production process (materials and energy chain), and identify in which parts of it CDM project implementation could be beneficially. The analysis could also point to the most appropriate sectors and industries for CDM and identify available resources and technological options.



(5) Enhanced CDM must enjoy *'high-level government commitment and influential lead institutions'* will have to support the mechanism, in order for it to sustain or become a more powerful mechanism. The Thai DNA could for instance play a more active role in project identification and implementation. This will show commitment and high engagement from a Thai CDM lead institution.

(6) CDM must also *'build on existing processes and strategies'*, as for instance on other policies in the country connected to development goals. It could for instance be whether or not the CDM criteria's is build on or relates to the Thai 'National Sustainable Development Strategy'. Or further, whether or not the national energy policies etc. correspond to the targets set forth for CDM project development.

(7) CDM enhancement is more likely to occur if the projects are based on sound principles of *'effective participation'*. In the Thai situation, this especially addresses the local/regional level, but also the governmental level. I find that 'effective participation' is participation by the *most important* stakeholders connected to a project, and not just any stakeholder, as it will hamper the decision making process. Effective participation includes stakeholders who can influence CDM at various levels along the materials and energy chain connected to the projects.

(8) The interconnection between the local level, the provincial administrations and the central administrations - or *'the link between national and local levels'* - can also support a CDM enhancement. There must, for instance, be correspondence between the national policies and the actual potentials for CDM implementation at the community level. Therefore, national CDM policies should be based on the options given at the local level. If large potentials for applying energy efficiency at the local level are identified, governmental actions should be established, by for instance setting up relevant programs and targets, etc. This will enhance the link between the administration levels.

(9) It is important that enhanced CDM are *'developed and build on existing capacities'* in Thailand. A local technology manufacturing scheme, for instance, must therefore rely on an identification of local knowledge, and options for further development of the local capacities. This can, for example, be through partnerships established between energy technology manufactures from the North, upgrading the technologies manufactured in the South. It can also be an identification of additional training need for workers operating/constructing energy technologies, placed in already established institutions in Thailand.

#### **2.3.2.4 Sum-up on sustainable development concepts (Part II.)**

*On the 'strategic level' CDM enhancement can be obtained by:*

- (1) *'People centred'*: Use biomass resources from the community in future CDM projects, as to strengthen local beneficiaries;
- (2) *'Consensus on long-term visions'*: Set up appropriate national policies and visions for CDM, by relevant authorities etc. at different levels;
- (3) *'Comprehensive and integrated'*: Strengthen the sustainable development criteria's to establish higher integration between environmental, social and economical issues;

- (4) *‘Comprehensive and reliable analysis’*: Use local/regional knowledge in identifying the conditions for CDM project implementation, as for instance in determining the potential sectors, resources, and technologies etc. to focus on;
- (5) *‘High-level government commitment and influential lead institutions’*: Support implementation of CDM project activities through relevant commitment by CDM lead institutions;
- (6) *‘Build on existing processes and strategies’*: Identify if CDM initiatives are based on existing processes and strategies in the country, and set up means to improve these;
- (7) *‘Effective participation’*: Seek effective participation in CDM project activities, by relevant stakeholders with influence on all levels of the materials and energy chain connected to the projects;
- (8) *‘The link between national and local levels’*: Establish connection between the national policies etc. and the actual CDM potentials in local communities;
- (9) *‘Develop and build on existing capacities’*: Identify the existing technology capacities, and set up actions for how to increase the performance of the technologies, and how to train skilled workers using local institutions, etc.

## 2.4 Research in Thailand

### 2.4.1 Previous research experiences

I have previously worked with Thai industries and studied possibilities for setting up CHP with district heating in an Industrial Park North of Bangkok. The idea of setting up supply of district heating in tropical countries with no demand for heat, is very interesting as a vision for the future energy supply in Asia, and an important element to achieve sustainability in supply of energy in this part of the world. As the traditional Nordic heat markets (households etc.) do not exist, the heat markets must be ‘developed’ or ‘discovered’. But how can this be established in tropical countries? From this question the idea of ‘establishing’ heat markets within the industrial sector in Thailand arose, which has been the focus of my Ph.D. thesis.

From this research I have learnt, that extensive environmental benefits can be obtained when industries are located close to one another, enabling mutual sharing of resources (energy or/and wastes). I have thus chosen to continue to focus on Industrial Parks *and* biomass CHP in this study, as to benefit from the close location of industries and the options for setting up sustainable energy systems in such areas. I have also chosen to continue working with Thai industries generating clean biomass wastes, as for instance food, - wood and chemical industries. Emphasis on these types of industries enhances the possibilities for using the industries own biomass waste as fuel in local energy systems, together with other local or regional biomass resources.

The present focus is therefore not specifically to examine possibilities for implementing CHP with district heating in Thailand, but merely to take the knowledge from the Ph.D. thesis along in this study, and interpret the establishment of such energy systems as the ‘conclusion’, when pursuing sustainable energy production and consumption in Thailand. In this study, biomass CHP with district heating is thus interpreted as the ‘full package’ of environmental benefits, which can be obtained through future CDM projects. Therefore, focus is on how CDM can be enhanced to support the implementation of biomass CHP with district heating, as to benefit from the economic contribution posed by the mechanism in the transformation of the energy supply system in Thailand and in Asia in general.

## **2.4.2 Fieldwork**

The outcome of the generic Manual conducted in this study, builds on an iterative research approach involving many different Thai stakeholders. This approach is described below:

### **2.4.2.1 Interviews and presentations**

During the first fieldtrip to Thailand I have collected empirical data from various private persons, organisations and institutions. In brief these were for instance stakeholders within the Thai central administration, NGO's, Academia, CDM project developers, CDM project owners, etc. (a list of all interviewees from each of the years 2007, 2008 and 2009, can be found in the reference list at the end of the report). These stakeholders provided me with valuable knowledge to conduct a draft Planning Guide and to come up with relevant Policy Recommendations etc. In the second fieldtrip, I presented the Planning Guide and received feedback and critique from the stakeholders again, and the Institutional & framework conditions took form. On this background I revised the previous work done once more, and at the third fieldtrip I presented the final Manual for the most relevant Thai stakeholders.

### **2.4.2.2 Case industries**

Apart from the stakeholders mentioned above, I have also conducted interviews and presented results in case industries located in Navanakorn Industrial Promotion Zone. It has been very important for me to establish CDM project proposals that the manufacturing industries in Thailand actually wanted to participate in. This contact has thus been very valuable for the outcome of this research.

### **2.4.2.3 CDM project visits/interviews**

Moreover, I have visited and interviewed the managers/owners of six Thai CDM projects, located widespread throughout Thailand. The projects were all very different, but primarily based on the biogas technology. Two projects were identical, namely two plants both making biogas from tapioca. Below is a list of the plants visited:

“*Sima 2*”, Biogas from Starch Plant, Chachoengsao = Production of biogas from tapioca.

“*Nongbua pig farm Biogas*”, Ratchaburi = Production of biogas from pig manure.

“*A.T. Biopower Rice Husk Plant*”, Pichit = Power production from rice husk shells.

“*Siam Cement*”, Kaeng Khoi = Energy efficiency.

“*Jaroensompong Landfill Gas*”, Rachathewa = Landfill gas from municipal waste.

“*CYY Biopower*”, Korat = Production of biogas from tapioca.

## Chapter 3; Background data

To enhance the sustainable development contribution of future CDM projects it is important to identify what kind of projects to focus on. Thus, which type of energy to substitute and in what industries and locations, this would be most appropriate. This chapter first elaborates on a theoretical selection of certain industries in accordance with their waste generation and its usability as energy source, and show the consumption of and type of energy flow through these industries. The purpose is to identify in what industries, and in which parts of the energy chain and industrial manufacturing processes, it is most beneficially to make improvements. The chapter also describe in which locations (physical areas) to exercise the implementation of future CDM projects.

At the end of the chapter, I will bring in relevant sustainable development concepts (Part II.) as a turning point for the discussions. Based on the findings in these discussions, the chapter will extract elements that will become part of the Planning Guide (Chapter 8), as well as Policy Recommendations, which will become part of the Institutional & framework conditions (Chapter 9). Eventually they will be integrated into the generic Manual (Chapter 10).

### 3.1 Waste generation

In order to work with industries in which the generated waste can become a part of either internal or external re-use, I have chosen to work with industries generating biomass wastes unlikely to be contaminated. *Food, - wood and chemical industries* are therefore selected, as they represent branches in which relatively clean biomass waste are identified (Lybæk, 2004). At the same time they represent a relatively large percentage (50 %) of the total energy consumption in the industrial sector as a whole (Ibid.), which could make improvements in these lines of businesses very visibly. These types of industries are thus appropriate future 'CDM-industries'. The following section identifies relevant biomass waste within food, wood and chemical industries.

#### 3.1.1 Food industries

Food manufacturing is based on processing of livestock and agricultural raw materials into goods for either intermediate or final products for humans or animals. Most food producing industries generates solid or liquid wastes appropriate for energy production, as for instance grease/fat, oil, intestinal parts from animals, waste from vegetable processing, proteins and fruit juices, etc. Grease products are obtained by fat separation and collection systems in the production process, whereas flotation sludge is obtained by flotation techniques, which separate and collect the organic materials as sludge. This happens by a mechanical skimming of the liquid surface (Energistyrelsen, 1991). Flotation sludge consists of large amounts of grease and proteins that are very suitable for digestion, but can also be incinerated when pre-dried (Lybæk & Møller, 1999).

#### 3.1.2 Wood industries

Wood manufacturing (production of furniture, etc.) is based on turning wood products into different kinds of goods, as tables, chairs, sofa sets, beds and office furniture's, etc. It

normally consists of the processing of chip boards; plywood's; MDF plates; hard wood (noble or ordinary) and laminate products etc. The wood wastes is a mix of saw dust, small wooden parts (cut offs) and damaged goods. Depending on previous process activities - for instance whether inorganic lacquers are being used or not - wood producing industries generates a clean and dry wood waste product, that produce relatively low particulate emissions when incinerated (Lybæk, 2004).

### 3.1.3 Chemical industries

Chemical or pharmaceutical manufacturing is based on transformation of organic and inorganic materials by chemical processes, and the formulation of either intermediate -or final products. Products based on *chemical synthesis* generate waste that consists of reaction -and reactor bottom waste, not appropriate for further re-use (US EPA, 1997). In products based on *natural product extraction* the waste consists of spent raw materials like plants or roots, whereas it in *fermentation* products consists of filter cakes and production sludge, etc. Waste from natural product extraction and fermentation products can be re-used for energy purposes, either by digestion or incineration when pre-dried (Lybæk, 2004).

## 3.2 Energy consumption

The following sections elaborates on the energy consumption in food, - wood and chemical manufacturing industries, as to assess in which parts of the production process it is most beneficially to make improvements. Data on energy supply in the Danish context is based on "Teknologikatalog - Energibesparelser i Erhvervslivet", Energistyrelsen, 1995. The energy supply data can differ quantitatively in the Thai context, but the manufacturing processes undertaken by these industries are quite similar (Lybæk, 2004). The following description of food manufactures will include an argumentation of the chosen figures and numbers, when assessing energy losses and inefficiencies etc., whereas these will be excluded in the presentations that follow.

### *Food industries*

Energy footprints in the food manufacturing line of business are illustrated in Figure 3A below. The **power supply** input accounts for 4,517 TJ annually, which correspond to a primary energy consumption of 12,906 TJ with an average efficiency of 35 % on Thai central power plants, fuelled by petroleum, diesel, oil, coal and natural gas (of which the latter has the highest share). On power plants fuelled by natural gas or on combined cycle plants the efficiency is higher, but due to the emerging energy demand in Thailand all available energy supply technologies, as well as fuel types, are being used (Lybæk, 2004).

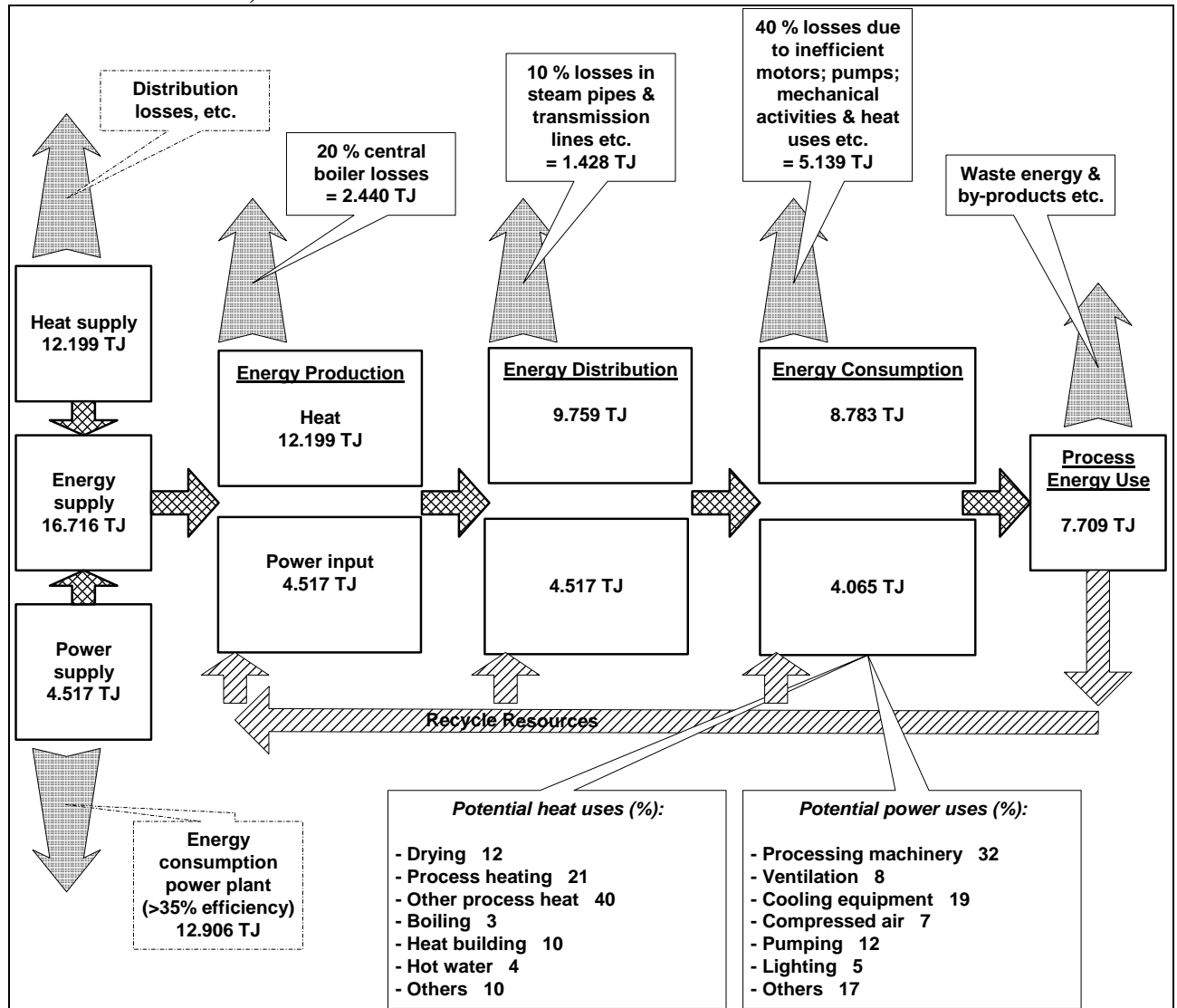
On the **heat supply** side 12,199 TJ ( $9,759 \cdot 1.2$ )<sup>6</sup> are consumed by food manufacturing industries - when adjusting for the use of fossil fuels for combustion in boilers instead of supply of district heating - and primarily consists of natural gas, liquid petroleum gas (LPG), fuel oil (bunker oil) or coal, etc. in the Thai context. In the Danish context the fuel supply is mainly covered by district heating, whereas this type of energy is not available in Thailand. The total energy supply input thus amounts to 16,716 TJ annually.

---

<sup>6</sup> Boiler efficiency of set to 80 %.

In the *energy production* part of industrial manufacturing the heat supply is converted by means of different technologies, as for instance steam and water heat boilers. The efficiency of boilers varies dramatically depending on the type of fuel supply, boiler age and the level of maintenance. An efficiency of 80 % is however applied as average for all kinds of boilers utilised (US DOE, 2006). In food manufacturing industries this correspond to energy losses equal to 2,440 TJ annually (20 % of the heat supply). In some cases, however, the energy use takes place directly in processing activities without a prior energy production process. This can for instance be frying activities that use gas directly in the processing of food.

**Figure 3A: Food industry (Case industries B.B. Snacks & ASAN Service & Baskin Robbins)**



Source: Own figure

The heat and power supply now undertakes *energy distribution* in which it is lead to the actual processing of raw materials for food production purposes. In the systems carrying power and heat to production processes and technical equipments, an estimate of 10 % losses occur in traps, valves and steam pipes as well as in electric transmission lines (US DOE, 2006). This is a very moderate estimate as figures between 10-40 % losses in these activities are observed (Ibid.). As a result of 10 % losses in energy distributions another (976+452) 1,428 TJ of energy in lost in the production process.

When the energy supply reaches the **energy consumption** stage of the manufacturing process, it undertakes different means of use depending on the type of food produced. In general terms the heat supply will be used for heating, drying and boiling purposes, etc. The power supply will be used in processing machinery, ventilation, pumping and lighting, and in cooling equipment. Energy losses in these activities are reported to be between 5-90 % depending on the actual processes (US DOE, 2006). A moderate estimate of 40 % losses in energy consumption is thus applied, which leads to (3,513+1,626) 5.139 TJ energy discharges due to process inefficiencies.

The actual **process energy use** amount to 7,709 TJ, which at the most equals (7,709/16,716\* 100) 46 % of the primary energy input, excluded the energy consumption on central power plants. With the moderate estimate of energy losses made, it is very likely that only 2/5 of the energy supply (40 %) end up as useful energy. But not even this factor might be accurate;

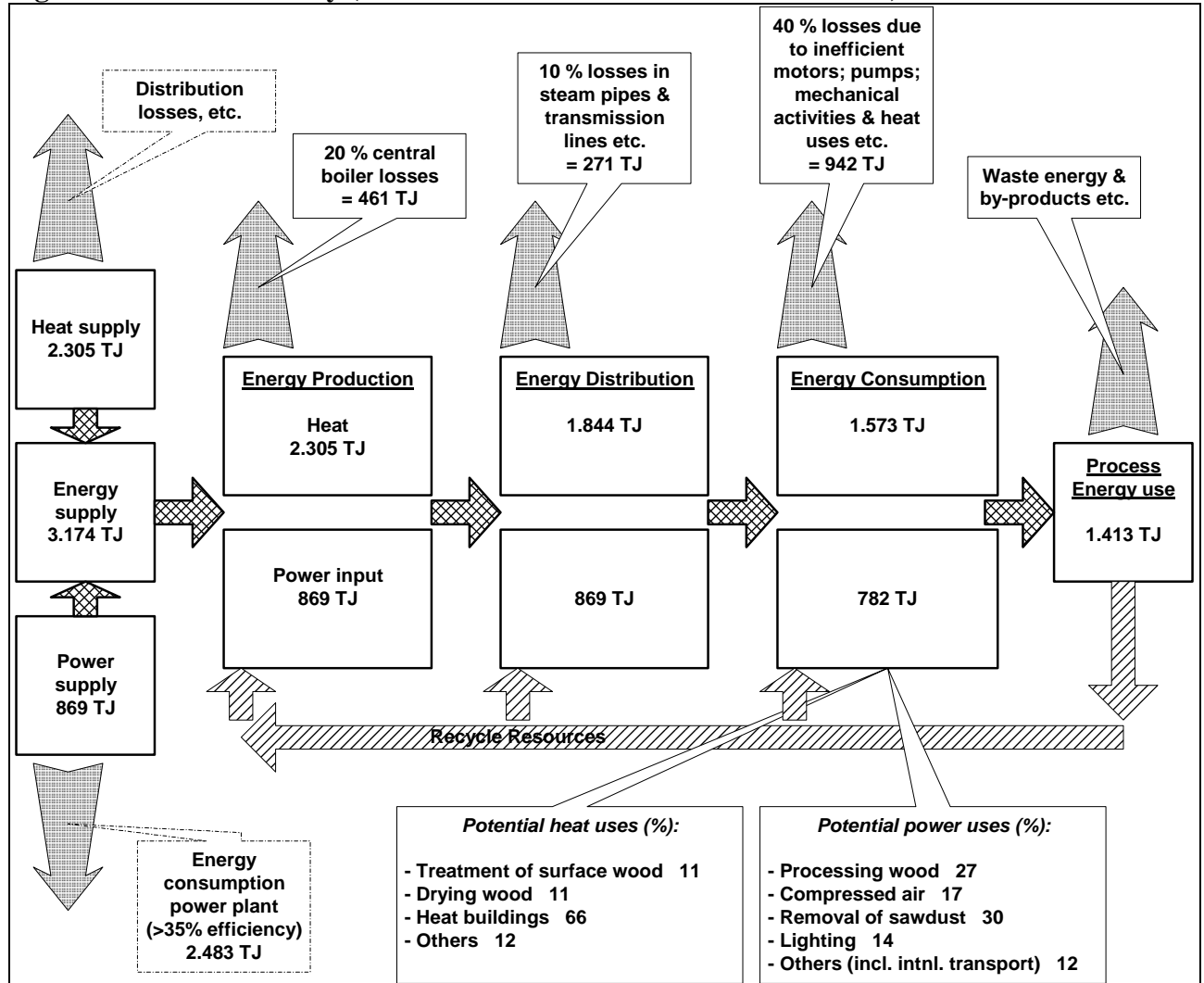
The process energy use is however rarely completely efficient, as waste energy - in the form of hot water or steam - often appears, as well as other by-products. To what extent these materials are being re-used or discharged are difficult to assess, but they could re-enter the production process at different levels as illustrated in the figure. **Recycle of resources** could be obtained in process heat (steam and water based heat) and re-used directly in the energy consumption part of the production, by implementation of for instance heat exchangers and thus re-used in the same production process. It could also re-enter the energy distribution system and supply energy services to other production activities. On a general level, process heat temperatures could also be lowered by technical changes (from steam to hot water), so as to limit energy throughputs, and thus the quality of unavoidable energy waste. By-products could on the other hand be re-used in the energy production phase (internal or external) for energy purposes.

### **Wood industries**

Figure 3B below illustrates the energy footprint of the wood manufacturing industries producing furniture's, etc. The **power supply** equals 869 TJ annually which correspond to 2,483 TJ primarily fuel supply on central power plants. The **heat supply** is based on oil, gas, coal and wood wastes totalling 2,305 TJ annually. **Energy production** leads to energy losses equal to 461 TJ annually due to boiler inefficiencies, and losses in steam pipes and transmission lines due to **energy distributions**, lead to another (87+184) 271 TJ of energy discharges. Finally, losses in **energy consumption** lead to energy wastes corresponding to (629+313) 942 TJ. These energy losses occur due to the use of heat for treatment of surface wood, drying wood and for heating up buildings. Losses due to power consumption happen by processing of wood, compressed air, removal of sawdust and lighting, etc.

As for the food manufacturing industries the final **process energy use** are relatively low, compared to the energy input, and accounts for 45 %, thus 1,413 TJ annually. The level of internal **recycle of resources** in this line of business is relatively high compared to food, - and chemical industries, depending on the specific production processes undertaken, and normally consists of wood waste used for process heat generation (heat-only) or for re-use in the actual production process.

**Figure 3B: Wood industry (Case industries Sun Cabinet & Rockwood)**



Source: Own figure

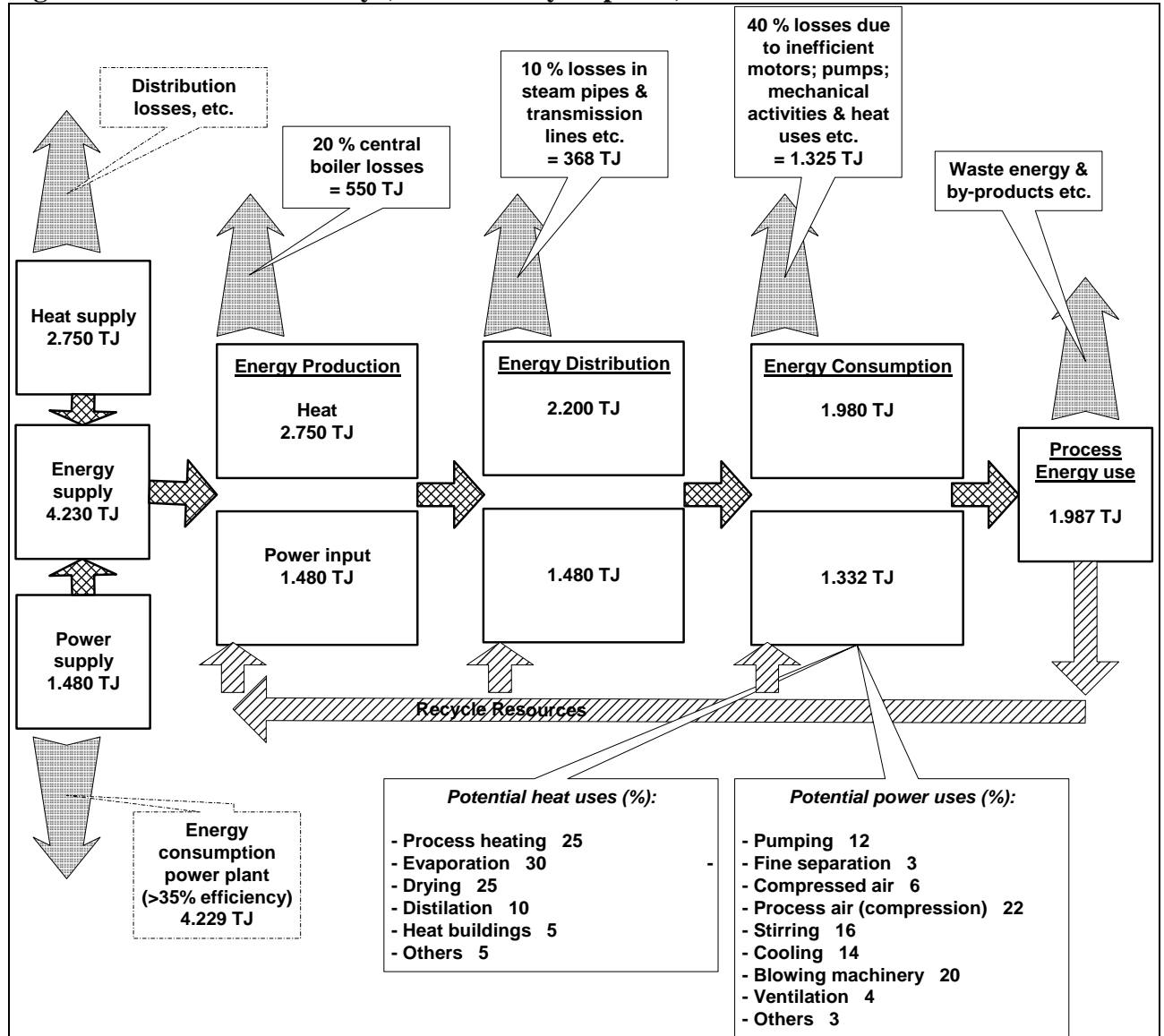
### Chemical industries

In chemical manufacturing industries, illustrated by Figure 3C below, the **power supply** equals 1,480 TJ per year, which requires an energy supply of 4,229 TJ on centralised power plants. The **heat supply** amount to 2,750 TJ and primarily consists of gas, oil and supply of district heating in the Danish context (1,870 TJ from fossil fuels and 704 TJ from district heating - the latter multiplied by 1.2 for boiler conversion) Thus, a total of 4,230 TJ annually enters the chemical industries. In the **energy production** phase 20 % losses due to boiler inefficiencies happens, which amounts to 550 TJ per year. Also here **energy distribution** leads to discharges of valuable energy, equalling (220+148) 368 TJ.

Losses due to **energy consumption** in processing activities are caused by process heating, evaporation, drying, distillation and heating up building, etc. Likewise, power losses are caused by pumping, fine separation, compressed air, process air (compression), stirring, cooling, blowing machinery and ventilation activities, etc.



**Figure 3C: Chemical industry (Case industry Imperial)**



Source: Own figure

All together these inefficiencies lead to discharges of (792+533) 1.325 TJ annually, leading to a final *process energy use* of 1,987 TJ, equal to a 47 % efficiency in the total energy supply, excluded the primarily power supply as well as other losses. As for food and wood industries this factor is evidently too high and the actual use of resources quite unsatisfactory. Options for *recycle of resources* could be applied, as for instance re-use of energy at different temperature levels in other parts of the manufacturing process.

### 3.3 Appropriate areas

As described in the introduction, I have selected Industrial Parks in Thailand as the physical areas in which an optimisation of the production process of Thai manufactures - through a transformation of the energy supply system - are sought established. This is due to the facts that industries are located close to one another in these areas, enabling 'external industrial metabolism', thus exchanges of materials and energy between industries.

The close location of industries thereby pose an option of implementing district heating networks, and thus supply district heating to industries within the area. In this way the industrial sector can act as the ‘heat market’, which the households constitute in Denmark. Many appropriate industries are located in these areas, when it comes to biomass waste generation (Lybæk, 2004).

There are approximately 70-80 Industrial Parks in Thailand, of which the majority are operated by the Thai Government through the Industrial Estate Authority of Thailand (IEAT). A few private Industrial Zones also exist operated by private stakeholders, but the regulatory framework is, however, identical.

This type of industrial structure is relatively common in Asia, as many of the world’s 12,600 Industrial Parks, are located in this part of the world (GTZ, 2000). Moreover, this type of industrial structure is constantly being expanded in Asia, as new Industrial Parks see the light every year. It is therefore important to focus on these areas, as improvements in energy and materials consumption in Asia could enjoy large scale implementation inside these areas. They could thus become a strong tool in achieving a more sustainable production and consumption within the manufacturing industries in Asia.

It would therefore be appropriate if future Industrial Parks - or when retrofitting existing - could take into account the possibilities of creating options for exchanges of energy and materials between industries. This could be ‘matching’ the industries in special district within the Park in accordance with their waste generation and consumption of energy, or by putting down district heating pipes in the soil. It could also be to establish a local power supply grid within such sites, in order to avoid conflicts with and high wheeling fees from the national or local power company.

### 3.4 Discussion

As described above, Industrial Parks are appropriate sites for optimising the production process of Thai manufactures, just as industries located in such areas could act as both biomass waste generators and heat markets. Especially food, - wood and chemical industries are identified as target ‘CDM-industries’ and thus for strategies dealing with materials and energy exchanges and production optimisations’.

As emphasised in Section 3.2 above, optimisations’ in food, - wood and chemical industries are required all along the materials and energy chain (production process): In the primary fuel supply from central power plants, in conversion of fuels in individual boilers, in distribution systems, in various processing activities, and in options for better use of resources in the final production step when the goods are produced.

Thus, the ‘*comprehensive and reliable analysis*’, outlined in Section 3.2 above, point out that three areas of the production process stand out, as leading to relatively large energy losses and thus materials consumption, discussed below:

- Inefficient supply of energy from centralised power plants;
- Energy wastes in processing activities;
- High costs connected with energy production and consumption;

The efficiency of Thai power plants is quite low, as combined cycle gas turbines, coal fired steam turbines and gas turbines only reaches efficiencies of 41 %, 30.4 % and 25.4 % respectively (Greasen & Footner, 2006). The inefficient Thai power plants call for conversion to CHP at the centralised level, increasing the overall efficiency of energy production. As traditional heat markets constituted by the households in Denmark are non-existent in Thailand, this option is difficult to apply at the centralised level in Thailand.

Local biomass CHP technologies implemented in Thai Industrial Parks with a demand for heat, are however more likely to be developed. But, an actual conversion of centralised Thai power plants to CHP would not change the fact that fuel consumption would rely on fossil fuels. Such fuel switch is more likely to be established on smaller plants implemented in local communities.

High discharges of valuable energy in processing activities are an emerging area of optimisations', as the losses in this part of the production process are extremely high. The efficiency of some of the applied technologies in this part of the production is very low. The thermal efficiency of for instance compressors can be as low as 10-20 %, pumps and fans 55-65 %, and processing equipment as for instance grinders, 10 %. Likewise, use of high qualitative process heat (steam) is not always a necessity in manufacturing processes, thus low qualitative energy by means of hot water could easily be applied.

A fuel switch strategy in Thailand would be very advisable to pursue, when looking at the energy costs connected to fuel consumption in the country. In 2008 Thailand's energy expenditures reached USD 45 billion, which is equal to almost 23 % of the GDP. Of this amount USD 29 billion were used on energy imports accounting for 14.5 % of the GDP. In total energy imports make up for 60 % of the total energy consumption in Thailand (Suksumek, 2008), and thus pose a significant risks for the industrial sector.

Thus, in the case of Thailand it will *firstly* be beneficial to reduce the energy waste in processing activities by implementing more efficient manufacturing equipment. *Secondly* to primarily focus on efficient converting technologies like the CHP technology, as the latter reduce the demand for cost full and inefficiently generated power on centralised fossil fuelled power plants. Thus, *thirdly* to make optimisations all along the materials and energy chain (the production process).

## **3.5 Extraction of elements for the Manual**

### **Planning Guide elements**

- Identify Industrial Parks, or relevant industrial areas, in witch industries are located close to one another;
- Point out the food, - wood and chemical industries located relatively close to one another in the Industrial Parks, who is to become the main 'CDM-industries';
- Preferably make improvements all along the materials and energy chain, as to increase the overall efficiency of the production process and to avoid fossil fuel consumption;

## **Policy Recommendations**

- To enhance the possibilities for distributing power and heat to industries located in Industrial Parks in Thailand, I suggest that district heating pipes are placed in the soil when establishing new ones, or when for instance retrofitting or adding to old ones. This could also include putting down power supply in the soil, for facilitating on-site transmission of power, without being dependent on the national grid. In this way the Industrial Parks in Thailand will be prepared for a future transformed energy supply system based on shared energy facilities;

## **Chapter 4; Thai CDM policies and institutional set-up**

In this chapter options for enhancing the sustainable development contribution of future CDM projects are identified, through analysis of the Thai national CDM policies etc. Thus, how Thai CDM criteria's comply with national sustainable development targets set forth, and whether new standards for CDM approval will have impacts on the future CDM project implementation in Thailand. Suggestions to strengthen the Thai policies are thus put forward. In the discussion at the end of the chapter, I will bring in relevant sustainable development concepts (Part II.) as a turning point for the discussions. Based on these discussions, I will extract elements for the Planning Guide and Policy Recommendations, to be integrated into the Manual.

### **4.1 Institutional set-up**

#### **4.1.1 Institutional development in the approval of CDM in Thailand**

##### **4.1.1.1 Historic review**

Thailand signed the United Nations Framework Convention on Climate Change (UNFCCC) in June 1992 and ratified the convention in December 1994, which entered into force on the 28th of March 1995. The Kyoto Protocol was signed in February 1999 and ratified on the 28th of August 2002. On the 10th of September 2002 the Thai Government agreed upon a resolution in which the importance of climate change problems was recognised, and support from the Government was formulated towards projects lowering GHG emissions in Thailand. With an option of using CDM in this process, the Thai Government decided that each CDM project should be submitted to the Cabinet for individual approval (Bratasida, 2006).

A Cabinet resolution on the 1st of July 2003 established the 'National Committee on Climate Change' chaired by 'Minister of Natural Resources and Environment' (MONRE), as well as the 'National CDM Board' chaired by the permanent secretary of MONRE. MONRE was furthermore appointed to be the Thai CDM DNA. In 2004, however, MONRE transferred the assignment of conducting all relevant work on climate change and CDM to the 'Office of Natural Resources and Environmental Policy and Planning' (ONEP). ONEP then became the national focal point for CDM and was to coordinate and structure the CDM operations' in Thailand, and act as the DNA secretariat to MONRE (IGES, 2006).

The different departments of ONEP, and particularly the '*Climate Change Coordinating Office*', were playing an important role in designing the content of the Thai CDM policy. The Climate Change Coordinating Office was drafting all the procedures and criteria's necessary for adopting CDM, like the national policy on climate change and CDM, as well as appropriate institutional frameworks, etc. The purpose of the latter was to facilitate and assure that Thai CDM projects lead to sustainable development, in accordance with the 'national sustainable development strategy', as well as to 'public and community benefits', 'technology transfer' and 'capacity building' (IGES, 2006 & Puvacharoen, 2005).

Apart from ONEP and MONRE the following institutions were participating in designing the Thai CDM framework: 'The Cabinet', the 'National Environmental Board' (NEB) and the 'National Climate Committee on the United Nations Framework Convention on Climate Change' (NCUNFCCC):

The '*National Environmental Board*' (NEB) thus gave recommendations on CDM project approvals to '*The Cabinet*'. NEB is an inter-ministerial body at Cabinet level, and has since 1992 - with the introduction of the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (NEQA) - been represented by all major ministries. NEB is chaired by the deputy Prime Minister (the acting Prime Minister), with ONEP being the secretariat of the Board. The implementation of the 1992 NEQA enhanced the role of NEB to be the highest policy making body in Thailand on environmental issues (IGES, 2006). The 1992 arrangement was an attempt to empower NEB in order to make ministries respect the decisions made by the Board (Lybæk, 2004).

The '*National Climate Committee on the United Nations Framework Convention on Climate Change*' (NCUNFCCC) was established in 1993 as a result of the ratification of the UNFCCC, but later closed down due to the Governmental restructuring in 2000. In July 2003 it was, however, decided to re-establish the NCUNFCCC, now as a sub-committee under NEB, with the minister of MONRE acting as chair of the Committee. The main duties of the NCUNFCCC were to coordinate the country's climate change strategy and follow up on the implementation of the UNFCCC. It also advised on issues related to the convention to the Thai Government and developed national policies on climate change. Some 20 organisations, including Governmental bodies, business associations, universities, NGO's and private sector experts etc., were represented in UNFCCC. As it was established as a sub-committee under the NEB, ONEP acted as the NCUNFCCC secretariat (IGES, 2006).

#### **4.1.1.2 First CDM projects to be approved in Thailand**

On the 30th of January 2007 and after several years of hesitation, Thailand finally approved the first batch of CDM projects consisting of seven projects, and within a month they approved another batch of projects. The first seven CDM projects in Thailand were: Dan Chang Bio-Energy Co-generation Plant in Suphan Buri, Phu Khieo Bio-Energy Co-generation Plant in Chaiyaphum, AT Biopower Rice-husk fuelled Plant in Pichit, Rubber Wood Residues Power Plant in Yala, Khon Kaen Sugar Power Plant, Korat Waste to Energy project and a Pig farm biogas project in Ratchaburi (Bangkok Post, 2007). So far (May 2009) Thailand has issued 75 Letters of Approval (LOA) and currently has 22 CDM projects in pipeline. In total 16 projects have been cleared by the Executive Board (EB) of the UN, which adds up to a total of 4.76 Mt CO<sub>2</sub> equivalents annually (Ward, 2009).

#### **4.1.1.3 New approval procedure**

As mentioned above, Thailand previously approved the projects on a case by case approach at '*The Cabinet*' level. The project proposals were first hand to be reviewed by NEB, who made recommendations to the proposals. This procedure, however, met critique by private sector stakeholders, as they regarded it as a complicated and discouraging approval procedure (IGES, 2006). Thus, the CDM approval procedure has now been changed.

A re-organisation of the approval procedure has thus been established in Thailand; namely the ‘National Committee on Climate Change Policy’ (June 2007) and the ‘Thailand Greenhouse Gas management Organisation’, TGO (July 2007), of which the latter is a public organisation now serving as the Thai DNA. The TGO thus receives the Project Design Document (PDD), the Environmental Impact Assessment (EIA) or Initial Environmental Report (IEE) from the project developer. Within three working days the PDD must be delivered to the concerned Ministry for comments, and within 15 working days it must be returned to the TGO with relevant comments. After a review on the comments, and in the case of approval, the TGO Board issue a Letter of Approval (LOA) to the CDM project proponent, and the UNFCCC will be notified about the project (TGO, 2008).

The Thai CDM activities have been managed by the Thailand Greenhouse Gas Management Organisation (TGO) since July 2007 and onward (TGO, 2008). With this new organisation of the DNA it is expected that the project approval procedure will be limited to 30 working days, but max. 180 days (Cooper, 2009). Thai project developers, however, do not expect that a 30 day’s approval procedure will be realised, but very much welcome a shortening in the existing procedure’s (Visukamol, 2008 & Watanatada, 2009).

## 4.2 Thai sustainable development requirements

An enhancement of the CDM project approval procedure in Thailand, must include an examination of whether the specific projects comply with the goals for sustainable development set forth in the ‘National Sustainable Development Strategy’ for the country. The content of this strategy will be presented below (Section 4.2.1), followed by the TGO’s ‘Sustainable Development Criteria’s for CDM projects in Thailand’ (Table 4A):

### 4.2.1 National Sustainable Development Strategy

Eliminate *poverty* through sustained economic growth, by the following strategies:

- Green productivity and national competitiveness (industry, agriculture, tourism and services);
- Energy security (supply, production, consumption, etc);
- Fiscal sustainability and public debt;
- National savings;
- Development and transfer of technology;

Enhance *environmental security*, by the following strategies:

- Management of water and air quality;
- Waste management;
- Integrated planning and management of natural resources;
- Biodiversity conservation;

Create a *knowledge-based society*, by the following strategies:

- Education and continuous learning;
- Innovation systems;
- Preservation of national heritage and traditions;

- Improve public health (access rights; quality of public health system);
- Limit crime and drug abuse;

Ensure *good governance*, by the following strategies:

- Law enforcement;
- Public participation and equity;
- Regional and international co-operation; (Lohsomboon, 2006)

#### 4.2.2 Thai “Sustainability Development Criteria’s” for CDM

**Table 4A: Sustainable Development Criteria’s from the Thai DNA, TGO**

Sustainable Development Criteria/Indicator for CDM projects in Thailand	
<b>1. Natural Resources and Environment Indicators</b>	
<b>1.1 Environment Indicators</b>	
1) Reduction of Green House Gas Emissions as specified in the Kyoto Protocol. 2) Reduction of air pollutant emissions in compliance with air quality standards i.e. NO <sub>x</sub> , HC, PM10, SO <sub>2</sub> , CO, O <sub>3</sub> , VOC’s, Dioxin. 3) Noise pollution (in compliance with government standard). 4) Odour pollution (in compliance with government standard). 5) BOD loading in waste water (in compliance with government standard). 6) Waste management. 7) Soil pollution (in compliance with government standard). 8) Groundwater contamination. 9) Reduction of hazardous waste.	
<b>1.2 Natural Resource Indicators</b>	
10) Water demand and efficiency of water usage. 11) Soil, coastal and river bank erosion. 12) Increase in green areas under the project’s initiative (in accordance with provincial green areas statistics). 13) Ecosystem diversity. 14) Species diversity 15) Use/import of GMO and/or alien species in the projects site.	
<b>2. Social Indicators</b>	
1) People’s participation (assessed by the level of participation being organized). 2) Activities promoting social development, culture, and ‘sufficiency economy’ philosophy. 3) Workers health and surrounding community health.	
<b>3. Development and/or technology transfer Indicators</b>	
1) Technology development. 2) Post project implementation plan or post crediting period plan as outlined by the project. 3) Capacity-building.	
<b>4. Economic Indicators</b>	
1) Increasing income of stakeholders: 1.1 Increasing income of the workers. 1.2 Increasing income of other stakeholders, such as increases in income of farmers through selling raw materials to the project. 2) Energy: 2.1 Use of alternative energy. 2.2 Energy efficiency. 3) Increase in usage of local content.	

Source: TGO (2008)



### 4.2.3 Gold and Crown Standard

The Thai CDM projects has so far to a large extent been approved by means of the Gold Standard, with the purpose of enhancing the sustainable development contribution of the projects. Some CDM projects in Thailand have, however, been accused of damaging the local communities more than benefiting them (Point Carbon, 2009). Thus, the Thai TGO has decided to develop their own set of approval procedure for CDM projects, called Crown Standard, which is expected to be launched in 2010 (Ward, 2009).

This standard focuses very much on the specific energy facilities, but also on the surrounding community. The main difference from the existing procedure is that none of the evaluation criteria's (indicators) must have a negative score. As the system works now, some of the evaluation scores can be negative, as long as the total sum of scores are positive. Also the majority of the scores must come from 'Natural recourse' and 'Environment', and there must be at least one positive score in the remaining indicators; 'Social', 'Technology' and 'Economy'. The Crown Standard implies, just as for the Gold Standard, a higher price of the CER's generated (Ward, 2009).

The Crown Standard can, according to the Thai TGO, contribute to a community's economy by:

- Generating employment;
- Technology transfer and capacity building;
- Foreign exchange benefits;

The social contributions of the new standard may include the following:

- Income supplement;
- Providing energy to energy-poor populations;
- Benefiting marginalised populations environmentally (i.e. reduced pollution and resource degradation);

Environmental benefits of Crown Standard projects may include:

- Reduction of hazardous waste;
- Increasing ecosystem diversity;
- The promotion of 'green areas' defined as any vegetated land managed according to sivilculture<sup>7</sup> and landscape principles; (Document hand-out TGO, Marts 2009)

### 4.2.4 Comments

I find the TGO's Sustainable Development Criteria's (Table 4A above) very truthful to the National Sustainable Development Strategy (Section 4.2.1), as many identical elements are included, as for instance the public participation dimension, the economic, - environmental and social dimension, as well as the technological dimension.

---

<sup>7</sup> Refer to afforestation/reforestation projects. These types of projects, with added benefits of sustainable development, may also be considered under the Crown Standard. The Thai TGO is in the process of establishing guidelines for CDM forestry projects (Ward, 2009).

I sympathise with the latter dimension on ‘technology development’ (# 3 in Table 4A), as it not only focus on appropriate ‘technology import’ but on ‘technology development’. Thus, the focus is not merely on imports, as a means of applying more sustainable energy technologies in Thailand. Also possibilities for supporting ‘technology development’ locally are in focus, and not only through manufacturing and provision of spare parts and maintenance of technology imported from the North. Compared to earlier sustainable development criteria’s from the Thai DNA (ONEP, 2006), focus on the ‘local content’ has been intensified (this is explicitly formulated in # 4 in Table 4A above).

Any specific focus or direction of a domestic ‘technology development’ scheme is, however, not explicitly formulated or required in the criteria’s, but could be a way of strengthening the technology dimension even further. This could be technology from the North made in Thailand on licence, occupying skilled Thai workers. This would improve both the social and economical dimensions even further. As for the new Crown Standard such focus or direction is also not formulated, and as such, the new standard does not indicate a future more active role by Thai stakeholders in supporting a domestic technology manufacturing scheme.

Another issue, which I sympathise with, is the income distributing element put forward in the economic criteria’s, requiring that CDM projects benefit local farmers/workers through for instance supply of materials and sale of products (could be supply of agricultural residues, etc.). Again, more focus could explicitly be given to income distribution to marginal groups in the Thai society, hereby including them in the country’s future CDM project development. The Crown Standard, however, elaborates on this issue by explicitly addressing marginalised people as a target for environmental benefits due to future CDM projects. More focus should, however, be given also to including the marginalised people in the value chain following CDM project implementation.

Hence, potential technologies embracing the above - options for setting up domestic technology manufacturing *and* a higher income distribution to marginalised groups in the Thai society - are thus *not* identified in the existing or in future sustainable development criteria’s set forth by the TGO.

## 4.3 Discussion

The following assessment of the Thai CDM policies is not based on an analysis of whether the policies actually have penetrated the Thai society, but merely on a discussion of how the policies are formulated. It is obvious, that many of the criteria’s mentioned in Table 4A, face difficulties in being adopted in the Thai society, as for instance the social indicators.

Thus, on the paper, the current Thai policies on CDM are very much in line with the overall national policies for the country development, as formulated in the ‘National Sustainable Development Strategy’. The actual formulation of Sustainable Development Criteria’s for Thailand is thus very much in accordance with the Governmental policies, as they are offspring’s of the ‘National Sustainable Development Strategy’. The Thai CDM policy therefore *‘builds on existing processes and strategies’*, which is beneficially.

The Thai Sustainable Development Criteria’s are also, on the paper, *‘people centred’*, as they focus on enhancing the social, economical and environmental conditions for the Thai people at the community level, by for instance promoting the use of local biomass resources for energy production. By proposing that benefits from the projects are spread to the community,

and by emphasis on employment and income opportunities, it seems to set the Thai people in centre of development. Some suggestions to strengthen the people centred approach, can, however, be initiated:

As mentioned earlier, I find the requirements for ‘technology development’ insufficient, as focus on employment and income opportunities - connected to specific technologies that actually *could* be manufactures in Thailand - not are explicitly formulated. The only requirement connected to this criteria’s is to ‘develop/import technology’, of which the first has highest priority (TGO, 2008a). Thus, more specific criteria’s for the direction or technology track of the specific ‘technology development’ in Thailand should be formulated, based on existing capacities in the country and followed by ideas for spreading the technologies in Thailand (this will be the focus of Chapter 7).

On the paper, the Thai Sustainable Development Criteria’s also emphasise, that participation by many different local stakeholders are important. ‘*Effective participation*’, however, require local stakeholder involvement at all levels of the materials and energy chain connected to the project; From potential stakeholders capable of supplying biomass fuel to the CDM project activity, to domestic manufacturing of energy technology or parts of it, to stakeholders providing technical maintenance etc., and finally to stakeholders consuming the energy services produced by the project activity. Effective participation can thus assist in expanding the income distribution connected to CDM project activities (this will be the focus of Chapter 7).

The level of ‘*comprehensiveness and integration*’ of the Thai Sustainable Development Criteria’s, are, in my opinion, quite strong. The integration of social, environmental and economic issues in the formulated criteria’s is well developed, and seems to enjoy equity. If, however, the projects could become a platform for technology manufacturing *and* include marginal groups of people in wider income distribution, the level of ‘comprehensiveness and integration’ of Thai CDM projects would become stronger. This will be highlighted below:

To achieve the benefits mentioned above, some means of institutional strengthening, or a more proactive profile of the Thai DNA, must be applied. ‘*High-level government commitment and influential lead institutions*’ should be developed around the CDM regime, to make the Thai DNA more active in pointing out relevant CDM technologies, and identify potential CDM projects embracing the sustainable development criteria’s put forth - hereby laying the foundation for a CDM technology track. The Thai DNA must thus be proactive in pointing out potential technologies embracing the development goals. In this case it could be options for domestic technology manufacturing connected to higher income distribution to marginal groups in the Thai society. The DNA could make a portfolio of project activities, which project developers and others could work with.

If Thailand can identify such project activities, it would show ‘*consensus on long-term visions*’ for the country, when it comes to the overall CDM development for the future, and it could facilitate project developers in their search for relevant CDM projects. In this way Thailand *could* act proactive, identifying projects by themselves that lives up to national sustainable development criteria’s, as opposed to the situation where the DNA is waiting for project developers to come up with project ideas, and thus setting the scene.

## **4.4 Extraction of elements for the Manual**

### **Planning Guide elements**

- Include relevant local stakeholders in the project in order to enhance the benefits of the project activity in the local community. This can be relevant stakeholders at all levels of the materials and energy chain connected to the project activity, etc.;
- Select technologies that can establish a platform for local technology manufacturing, *and*;
- Enhance the income distribution to marginal groups in the society;

### **Policy Recommendations**

- Establish a more proactive Thai DNA setting up project ideas complying to sustainable development criteria's, and pointing out favourable CDM project activities to focus on for project developers;

## **Chapter 5; CDM potentials in Thailand**

To enhance the sustainable development contribution of future CDM projects, this chapter will identify which sectors, resources and technologies Thailand has chosen to focus on in their CDM development, and eventually suggest on means for improvements. This chapter therefore identifies the sectors in Thailand emitting the highest quantities of GHG, and briefly looks into projections in the future emissions. The possibilities for implementing CDM projects in Thailand, hereunder whether the proposed projects are in line with the resource potentials found are hereafter identified. After this, I will analyse if the national strategies corresponds with the resource potentials, and whether the Thai GHG abatement are placed on the most important sectors.

As for the previous chapters, I will bring in sustainable development concepts (Part II.) at the end of the chapter, as to enable extraction of elements for the Planning Guide. Also Policy Recommendations will be extracted to become a part of the Institutional & framework conditions later on, and finally included in the generic Manual.

### **5.1 GHG emissions in Thailand**

#### **5.1.1 Sector identification**

More than two-third of the GHG emissions in Thailand come from emissions of CO<sub>2</sub> and the remaining one-third from methane. More than half of the CO<sub>2</sub> emissions come from the 'energy sector', which steadily increase both in relative and absolute terms, indicating that larges potentials for GHG abatement can be found in this sector (Todoc, 2004). The remaining GHG emissions come from the following sectors: 'agricultural', 'land use change & forestry', 'industrial', and 'wastes' (Todoc, 2004 & TGO, 2008).

In a study conducted by the Asian Development Bank (ADB) 'Asia Least-cost Greenhouse Gas Abatement Strategy: Thailand' from 1998, GHG emissions from the 'energy sector', and especially the sub-sectors 'power generation' and 'manufacturing', is expected to increase relatively more than the remaining sub-sectors by the year 2020 (ADB, 1998).

The Government of Switzerland and the World Bank's 'National CDM Strategy Study', expects the 'energy sector' to increase its CO<sub>2</sub> emission from approximately half of the total output in Thailand to around two-third by 2020 (ERM, 2002). Presently, the 'energy sector' in Thailand emits approximately 180.6 million tons of CO<sub>2</sub> equivalents per year, separated as follows:

Power Production 71.62, Transportation 53.21, Manufacturing 39.73, Others 10.80, and the Residential & Commerce sub-sector 5.31 (Puvacharoen, 2005). It is estimated that the 'energy' and 'waste' sectors will generate as much as 400 Mt CO<sub>2</sub>e per year by 2020, and thus account for more than 75 % of the total GHG emissions in Thailand by then (IGES, 2006).

## **5.2 Potential resources and technologies**

### **5.2.1 Technology identification**

In the ADB's study mentioned above, the following GHG reduction options in the energy and sub-sectors in Thailand were found to have a large mitigation potential, as well as economic benefit for the Thai society:

- Co-generation in the industrial sector;
- Increase in the oil boiler efficiency in the industrial sector;
- Application of efficient motors in the industrial sector;
- Utilisation of cleaner fuels;
- Lighting efficiency program in the residential and commercial sectors;
- Air conditioner efficiency program in the residential and commercial sectors;
- Refrigerator program in the residential sector;
- Increase in fuel economy of automobiles; (ADB, 1998)

The 'National CDM Strategy Study' points out the following areas as especially interesting for Thailand in the energy and sub-sectors, when it comes to implementation of CDM projects:

- Production process improvements;
- Combustion efficiency improvements;
- Boiler, steam trap and chillers' retrofit; (ERM, 2002).

Based on the literature review of the main sectors for CDM implementation in Thailand, it can be summarised that the most important potentials were found in the industrial sector (being one of several energy-sub sectors in Thailand) embracing the following:

- Improvements in the energy efficiency of industrial manufacturing;
- Improved efficiency in the productivity of production processes;
- Utilisation of cleaner fuels; (IGES, 2006).

### **5.2.2 Resource identification**

The 'National CDM Strategy Study' also point to the following resources, as appropriate for CDM project development:

- Biomass (biogas & biofuels);
- Solar;
- Waste to energy; (ERM, 2002).

This research study's focus on potential CDM projects in Thailand, with emphasis on energy efficiency in the industrial sector and use of biomass wastes, are therefore in line with suggestions put forward by ERM (2002) and others, as a result of in depth country studies. In the next section the actual Thai CDM priorities are outlined.

## 5.3 The Thai Government's focus on CDM projects

The Thai TGO gives the following priorities to CDM projects, which currently focus on the 'energy sector':

### *I. Energy Development*

- *Project for the use of bio-energy such as ethanol and bio-diesel, and biogas from farm and industrial wastewater.*
- *Project for the conversion of industrial waste into energy.*
- *Project for the use of renewable energy sources such as solar, wind and small hydro-power systems.*

### *II. Energy Efficiency*

- *Project for increasing the efficiency of combustion and steam generation.*
- *Project for increasing the efficiency of cooling systems.*
- *Project for increasing the efficiency of energy usage in buildings.*
- *Project for changing the types of fuel consumption to produce energy.*

### *III. Environment*

- *Project to convert waste into energy.*
- *Project to convert waste into bio-fertilizer.*

### *IV. Projects to increase transport efficiency.*

### *V. Industrial Process*

- *Project that can lead to the reduction of greenhouse gas emissions" (TGO, 2008: p. 5-6).*

### 5.3.1 Comments

The above priorities of the Thai DNA indicated that the 'energy and sub-sectors' have been given the largest focus when it comes to CDM project development. Emphasis of the CDM projects are GHG emission reduction's in the energy sector - both in the supply and demand side - and potential CDM projects are thus: 'energy production, transformation and consumption', by both power producers and industrial manufacture's. The priorities also indicate that both technical and resource related consideration has been taken, when selecting the focus areas of CDM project development. The 'waste sector' is for instance considered an important player in developing such projects, just as appropriate means of technology implementation is expected to lower the energy consumption.

The private sector in Thailand is sought engaged in reducing GHG emissions by various means, as for instance by using renewable energy sources and industrial/residential wastes in an effort to substitute fossil fuels. This political motive is not solely based on GHG abatement priorities, and the resource potentials of the country, but also on security of energy supply.

In regards to the TGO's project priorities, more focus should explicitly be given to combustion of biomass waste and co-generation as potential CDM projects. Under 'Energy Development' the topic being closest to biomass waste incineration is; *Projects for the conversion of industrial waste into energy*. This under-priority of biomass waste incineration and co-generation can also be seen by the CDM projects actually implemented in Thailand, which to a large extend are biogas projects based on tapioca and pig farm manure, with only few of these being co-generation plants (TGO, 2009).

## 5.4 Past and present governmental actions on energy

### 5.4.1 Renewable energy targets and energy efficiency

#### 5.4.1.1 Historic review

Thailand has established political actions supporting energy efficiency, production of power from renewable energy sources and promoted private sector participation in energy development. The country has for instance introduced incentives and enforced mandatory measures to facilitate the implementation of the 1992 'Energy Conservation Promotion Act'. Following this Act, Thailand has set-up and implemented a 'DSM & EE Program'<sup>8</sup>, including a Standards and Labelling Program (Wantawin, 2003).

In 1993 Thailand implemented the *first phase* of its 'DSM & EE Program' (running from 1994-1998 & 1998-2001), targeting a reduction of 238 MW peak demand: 1,427 GWh of power production and 1.06 million tons of CO<sub>2</sub> emissions in the following five years. Ultimo 1998 the program had lead to peak demand cuts of 503 MW and energy savings of 2,345 GWh (OEPP, 2000). As of September 2001 the program had lead to a 651 MW cut in peak demand and energy savings amounting to 3,665 GWh.

The first phase of the program consisted of six major sub-programs: The Residential Program, Commercial/Governmental Building Program, Industrial Sector Program, Load Management Program, Energy Conservation Attitude Promotion Program, and finally Monitoring and Evaluation Program. The focus of the first three programs was energy efficient appliances, hereunder especially lighting equipment, as well as efficient refrigerators-, air-conditioners and motors (Wantawin, 2003 & NEPO, undated).

For the *second phase* of the program the Government formulated another five-year 'DSM & EE Program' (running from 2002-2006). Promotion of energy efficiency and load management technologies - like cost reduction in SME's and standardization of energy use in the social sector as well as in corporations - were additional initiatives in this phase. Targeted energy savings in phase two of the program was a 632 MW cut in peak demand and 2,508 GWh of energy savings, corresponding to a CO<sub>2</sub> emission reduction of 1.85 million tons by the end of 2006 (Wantawin, 2003 & NEPO, undated).

As part of the standard program, six electrical appliances: refrigerators, air-conditioners, motors, CFL's, fluorescent lamps and ballets, were subjects to enforced minimum energy performance standards. The Government estimates that some 3,200 GWh and 660 MW of power could be saved by these activities. On top of that, guidelines and incentive schemes for a more effective energy labelling of the products mentioned above, were examined for implementation by the Thai Government (Todoc, 2004). As of March 2006 the 'DSM & EE Program' had reduced the peak power demand in Thailand by more that 1,300 MW (Bijoor & Greacen, 2007). The figures for peak demand cuts emphasised above, must be compared to an installed capacity in Thailand of almost 28,000 MW as of 2007 (EGAT, 2007), with a 2.5 % increase until ultimo 2008 (Suksumet, 2008).

---

<sup>8</sup> Demand Side Management & Energy Efficiency



A *third phase* was launched in December 2006 under the (by then) interim Thai Government expected to run from 2007 until 2011. It was based on a revision of the 2002-formulated ‘Strategic Plan for Energy Conservation 2002-2011’, set up under the former Prime Minister Taksin Shinawatra (Opatvachirakul, 2007). The ‘*DSM & EE targets*’, as well as the ‘*Overall National targets*’ for renewable energy in Thailand posed by this plan, will be emphasised below:

The ‘Strategic Plan for Energy Conservation 2002-2011’ aimed at de-coupling economic growth and energy consumption, by reducing the energy elasticity from 1.4:1.1 by the year 2007, and increase the share of ‘new & renewable energy’ in the fuel generation mix of ‘commercialised renewable energy’ from 0.5 to 8.3 % by year 2011. With ‘traditional renewable energy’ accounting for 11 %, the total share of renewable energy in Thailand would be 19 % by year 2011 (DEDE, 2006). The higher share of renewable energy - replacing the use of petroleum - was expected to lower the demand for imported fossil fuels and help to reduce the GHG emissions, especially in the two largest *consumption* sectors: manufacturing and transportation (IGES, 2006).

‘*DSM & EE targets*’: The targets for energy efficiency was lowered by 2,660 ktoe<sup>9</sup> in the revised plan (as of December 2006) compared to the original, with a total implementation of energy savings amounting to 7,694 ktoe in 2011. The two main areas in which to reach this target were ‘industry’ and ‘transport’, and only to a minor extend ‘DSM’. The targets for energy efficiency in industry had increased, while the targets for transport had declined quite a lot making the great difference. Apart from the devaluation of transport, enhanced focus on *industrial energy use* were the main difference between the original and this revised plan (Document hand-out EPPO, 2007).

‘*Overall National targets*’: When it came to alternative energy implementation the revised plan posed a slight increase in the targets set out compared to the original strategy, thus 2,299 ktoe of additional alternative energy was planned to be implemented. This increase, however, only came from the use of NGV (Natural Gas Vehicle), and did therefore not pose a real contribution to renewable energy implementation. Thus, the actual target for renewable energy implementation came down from 7,530 ktoe in the original plan to 6,962 in this plan (Document hand-out EPPO, 2007).

The largest contribution to the targets set out were incentives for renewable energy ‘power’ and ‘heat’ production, which were expected to reach 1,033 and 3,851 ktoe respectively in year 2011 (down from 1,443 and 4,001 compared to the original strategy). Also, the production of biofuels would contribute to the overall targets (Document hand-out EPPO, 2007). The decrease in the ‘power’ targets primarily came from the termination of the Renewable Portfolio Standard (RPS), which previously had determined that 5 % of the capacity of a conventional power plant in addition should be implemented as renewable energy (Nuntavorakarn, 2007). Targets for both ‘power’ and ‘heat’ were primarily expected to be obtained through the use of biomass, and lead to a total implemented capacity of (3,660 ktoe + 940 ktoe) 2,800 MW in 2011 (Document hand-out EPPO, 2007).

The means to reach the targets were a mix of different incentives, as for instance feed in tariffs to promote renewable power production, and enforced regulation and penalties to enhance the production of ‘steam’, thus CHP (see section below). Initiatives dealing with

---

<sup>9</sup> Kilo tons of oil equivalent (10\*10\*10 tons of oil equivalent) = 42.24 GJ

actual monitoring and technical optimisations in industries were also applied. Studies focusing on palm oil mills had the objective to increase the sales of power to the grid quite dramatically, by using more efficient technologies in combination with improved use of the generated biomass waste (they only use the fibres now, not the fruit bunch etc.). Ten industrial branches were, moreover, included in studies of how to make the internal production and consumption of heat more efficient (Sutiratana, 2007).

Compared to the original 'Strategic Plan for Energy Conservation 2002-2011' the revised edition was slightly more modest in its ambitions for energy savings and renewable energy implementation. The focus was, however, on industries and the production and consumption of 'heat' based on the use of biomass.

#### **5.4.1.2 Present targets**

A *revised third phase* (2007-2011), has been approved by the Cabinet as of December 2007, after the Thai Government selection in the fall of 2007. This plan has a target of achieving 7,820 ktoe of energy savings, which is an increase from the former plan. The focus of 'DSM & EE' strategies in this plan still emphasise on 'industry' (3,190 ktoe), 'transport' (3,413 ktoe) and only to a minor extent on 'DSM' (1,217 ktoe) (Document hand-out EPPO, 2008). The above targets will lead to energy savings of 10.8 % in 2011, but have recently been revised to a 20 % target in 2022 primarily emphasising on the industrial and transportation sectors (Suksumek, 2008). In the industrial sector this target will among others be achieved by the following initiatives:

Approximately one third of the target for 'biomass for heat production' - equal to 1,220 ktoe - is expected to be obtained by means of CHP production, and primarily by two types of industries; SME's and larger industries (Opatvachirakul, 2008). This is expected to happen as SME's convert from fossil fuel boilers to biomass boilers, and as they modify their existing boilers or invest in new technology. On larger industries it is expected to happen as co-firing of biomass and coal, like for instance on cement industries (Ibid.). 'Biomass for power production' also includes small scale biogas plants, and especially organic waste from municipalities, hospitals, cantinas and department stores etc. are targets for this development. 300 such small scale biogas plants are thus planned to be implemented in coming year (Opatvachirakul, 2009).

Promotion of Energy Service Companies (ESCO) will also be emphasised in Thailand to lower the economical burden for the industrial sector in transforming their energy supply. Revolving funds and taxes will likewise be supported to speed up the implementation of energy efficiency in Thai industries (Suksumek, 2008).

The overall targets for renewable energy implementation are now 9.2 %, as opposed to the previous 8.3 %, leading to a total of 6,688 ktoe of renewables in 2011 (down from 6,962 ktoe in the previous plan), and 2,170 ktoe of NGV in 2011 (down from 2,867 ktoe in the previous plan). As energy savings are expected to be effectuated at the same level, the total savings are higher in the 'revised third plan' compared to the previous.

Renewable energy 'power' and 'heat' production is expected to reach levels of 1,047 ktoe and 4,035 ktoe respectively, which is an increase from the previously targets of 1,033 and 3,851 ktoe respectively. Of all renewables, the selected fuels are primarily 'biomass' (941 ktoe) for power production, and 'biomass' (3,660 ktoe) and 'biogas' (370 ktoe) for heat production (Document hand-out EPPO, 2008). The new Thai aim for the year 2022 increases the use of renewable energy to the end user, to 20 % of total energy consumption (Suksumek, 2008).

## 5.4.2 Support for renewable energy implementation

In 1992 Thailand launched the *Small Power Producer (SPP)* regulations, with the purpose of promoting power production from renewable energy and co-generation facilities in the private sector. It thus applied to both CHP projects, usually converting fossil fuels as natural gas or coal, as well as to renewable energy projects. In 1998, however, Thailand changed the SPP regulation to not include fossil fuel CHP SPP's. Critique was put forward questioning the plant's contribution to clean and efficient CHP production. In order to qualify as an SPP, the energy plant would have to use 10 % of the generated waste steam, and to achieve an overall plant efficiency of 45 % (Greacen, 2007a). These figures for CHP were, indeed, not ambiguous, as the average power output of a conventional CCGT operated in Thailand are in the same level. A penalty system was implemented for SPP's failing to meet the 10 % steam requirement (Opatvachirakul, 2007).

SPP is divided into 'firm' and 'non-firm' contracts based on their supply and capacity to deliver energy services to the grid, and the payment they received reflects this. Primo 2009 'firm SPP' receive THB 2.56/kWh, while 'non-firm SPP's receive THB 2.10/kWh (EPPO, 2008). Under this program 60 firm and non-firm SPP's are currently (ultimo 2008) selling power to the grid with a total generating capacity of 3,889 MW and with 2,286 MW of energy sales to EGAT. Of these projects 30 are based on renewable energy, 26 on fossil fuels - primarily natural gas and only to a minor extend coal - and 4 on mixed fuels (EPPO, 2008). Another 68 firm and non-firm SPP's, have signed contracts of power supply and yet another 90 SPP's has received Notification of Acceptance (NoA) for future power supply. Of the latter 40 projects are based on renewable energy, 46 on fossil fuels - primarily natural gas/coal - and 4 on mixed fuels (EPPO, 2008).

In 2002 the *Very Small Power Producers program (VSPP)* was enforced, allowing capacity sales of up to 1 MW to be sold on the national grid (power export through 'net-metering'), to facilitate implementation of smaller renewable energy projects in Thailand (Todoc, 2004). Until then only relatively large renewable energy SPP's had been implemented with an average size of 18 MW (EPPO, 2008). The VSPP regulation stipulates that the Thai distribution companies - MEA & PEA - must purchase power from VSPP at the same price, as they pay for power purchase from EGAT (approximately 80 % of the retail price) (Todoc, 2004).

As opposed to the SPP regulation there is no 'firm' and 'non-firm' arrangement for VSPP's, but they receive higher payment during peak periods (and lower during off-peak). VSPP received THB 3.8/kWh during peak hours (9 am to 10 pm), and THB 2.00/kWh during off-peak hours (weekends, holidays and night-time) (Greacen, 2007b). In a period of four years - from 2002 to 2006 - 97 VSPP were registered with a total installed capacity of 16.8 MW (EPPO, 2008). Due to the small scale size of VSPP projects, the actual impact of the regulation has so far been quite limited compared to the SPP's regulation. But variations in the technologies applied, and the type of renewables used are, however, much more comprehensive compared to the SPP's.

In December 2006 the VSPP regulation were, however, revised by the (at that time) Thai interim Government. Several changes benefiting efficient CHP production was launched:

- Firstly, it is now possible (for the first time since 1998) to implement CHP fuelled by fossil fuels. Compared to the former SPP regulation, the new VSPP's requirements on

waste-steam are tightened. CHP Plants who connects under the VSPP program, must prove Primary Energy Savings (PES) of no less than 10 % - compared to separate generation of heat and power - to avoid penalties. The 10 % PES requirement is based on the EU standards for efficient co-generation (see Directive 2004/8/EC). It is therefore an enhancement of the requirements compared to the use of only 10 % steam, as set out in the former regulation being relatively easy to comply to.

- Secondly, the size of VSPP's has been increased 10 fold, as projects up to 10 MW can be approved now. This means that the power export on the grid to MEA and PEA can be as high as 10 MW.
- Thirdly, a power subsidy (feed in tariff) for renewable energy has been introduced (an 'ADDER'), which depends on the type of renewable energy used by the VSPP producers (NetMeter.org, 2007). The ADDER was revised in the spring of 2009, increasing the payment received compared to the previous ADDER. The feed in tariff is added to the payment of each kWh produced as outlined above.

**Table 5A: Feed in tariffs (THB/kWh) as of 2009**

<u>Biomass:</u>	
Installed capacity < 1MW	0.5 THB/kWh
Installed capacity > 1MW	0.3 THB/kWh
<u>Biogas:</u>	
Installed capacity < 1MW	0.5 THB/kWh
Installed capacity > 1MW	0.3 THB/kWh
<u>Waste:</u>	
Landfill	2.5 THB/kWh
Thermal process	3.5 THB/kWh
<u>Mini-hydro:</u>	
Installed capacity 50 kW - < 200 kW	0.8 THB/kWh
Installed capacity > 50 kW	1.5 THB/kWh
<u>Wind:</u>	
Installed capacity < 50 kW	4.5 THB/kWh
Installed capacity > 50 kW	3.5 THB/kWh
<u>Solar:</u>	8 THB/kWh

**Source: Own table after EPPO, 2009**

#### 5.4.2.1 The future of SPP co-generation in Thailand?

In 2007 the Thai Government opened for *Independent Power Producers (IPP)* bidding with a target of 3,200 MW installed capacity, which was increased to 4,400 MW for only four projects:

- Two coal fired projects were approved:  
Map Tha Put: 660 MW & Chacherngsao Province: 540 MW.
- Two gas fired projects were approved:  
Saraburi: 1,600 MW & Chacherngsao Province: 1,600 MW (Nuntavorakarn, 2008).

In August 2007, the Thai Government received a larger number of applications (2,400 MW to be exact) for SPP's established as co-generation plants (Greasen, 2008). The applications exceeded the allowed 500 MW SPP based on co-generation, which was set as a target roof (NEPC; resolution 5/2550). As the Government had received a large number of IPP biddings they made it clear, that they would not allow more the 500 MW from SPP. Later that year, however, the Thai government agreed to allow implementation of 4,000 MW SPP based on co-generation - but not more than that (NEPC; resolution 8/2550).

### 5.4.3 Comments

The actual benefits of the targets set fourth in the Thai plans for 'EE & DSM', as well as the targets for 'renewable energy implementation' are in my opinion quite limited, as the share of 'traditional renewable energy' at the same time decrease. Thus, the actual increase in the use of alternative energy only account for a very small percentage. A larger percentage of the renewable energy will be converted and produced on commercially basis, which *could* be beneficial when it comes to regulation and incentives, but the overall benefits for the environment is limited.

The national targets and goals for renewable energy implementation and energy efficiency etc. are very much in line with what could be achieved by implementation of biomass CHP with district heating, supplying process heat to Thai industries. The implementation of such schemes could also help in location renewable energy technologies, where there is an actual demand for heat. The biomass CHP with district heating could thus be implemented as SPP's, and enjoy support form the new feed in tariff in Thailand. Here the ADDER on for instance landfill waste is very favourable and it is therefore recommendable to include this type of waste in energy production, as it leads to high economic support.

As far as selecting a direction for the future energy supply in Thailand it is obvious, that Thailand has selected a centralised fossil fuel tract instead of a more decentralised tract based (partly) on renewable energy and CHP production. This is evident when looking at the approval of the coal and gas fired power plants presented above. Even though the SPP's applied for 2,400 MW installed capacity, only 740 MW were finally accepted (Greasen, 2008). Instead, the 4 large centralised and fossilised IPP power plants were accepted. This choice has limited impacts on the Thai people when it comes to income distribution, the use of local biomass resources and to create a better environment in local communities, etc.

## 5.5 Discussion

It is important that the CDM priorities are in line with the sectors and resources most appropriate in the country addressed. Therefore, analysis of GHG emission by sectors, and potential resources for energy production, must be identified. If the local conditions do not match the national policies and targets, it is very difficult to establish a fruitful link between the two levels, nor to reach any positive results. Thus, an identification of potential sectors and biomass resources should be addressed, as to identify where to commence a transformation of the energy supply. Such data must be based on '*comprehensive and reliable analysis*', and could be provided by local stakeholders (as for instance Takhlong Municipality, Pathum Thani Province etc.) and relevant Governmental agencies (as for instance DIW and IEAT etc.) (See more in Chapter 9).

The TGO's focus on the industrial sector in Thailand, as well as on municipal and biomass waste, are very much in line with the potentials given at the community level. Large amount of biomass wastes are discharged in Thailand, so the re-use potentials of this waste is high (Lybæk, 2004), and the second largest emitter of GHG is found to be the industrial sector. Thus, the '*link between the national and local level*', when it comes to identifying and pointing out appropriate sectors and resources for CDM, are established. When it comes to CHP technologies, the link between the two levels can also be found. CHP and incineration of biomass, are, however, not explicitly formulated in the TGO priorities (see Section 5.3). Focus is, however, very much on technologies increasing the efficiency of energy production, as well as on the use of waste in this process, but more focus could be given explicitly to CHP in the TGO priorities.

The focus on 'heat' in the revised plan is, as emphasised earlier, very positive, as it is a recognition of the importance of CHP when pursuing energy efficiency (also when it is based on fossil fuels). There should be more emphasis on efficient production and *consumption* of 'heat', with more focus on *using* the heat produced. If options for using the heat are limited, it makes so sense to increase the output percentage demand of heat produced by VSPP.

In this sense a regulation focusing on the *use* of steam or process heat (heat) are more appropriate, and could be promoted by incentives such as a feed in tariff (ADDER) given per m<sup>3</sup> heat actually *used* as energy service, in for instance industrial manufacturing processes etc. This would at the same time initiate more focus on placing CHP Plants where the demand for heat are present, and in this way avoid projects in which there is no demand for heat, and thereby an inefficient use of resources. In this way focus is placed more on the 'heat-side' of regulation, compared to the present 'power-side' regulation.

The present regulation panelling fossil fuel SPP's for not using the steam, could also apply to biomass fuelled VSPP. It is also possible to re-introduce the regulation requiring a certain amount of the heat to be used. The old regulation required 10 % re-use, but could be increased to for instance 20-25 %. The above initiatives will provide incentive to use the resources more efficient, and enhance the focus on CHP and an appropriate location of such plants.

For enhancing the '*link between national and local level*' and at the same time establish a more '*people centred*' approach in the future Thai CDM development, when it comes to biomass resources, the following should be initiated:

As mentioned earlier some analyses estimate that biomass for energy purposes has a potential of 7,000 MW in Thailand (EPPO, 2003). This potential does not include biomass waste from SME's, but only from the extracting and processing part of agricultural activities. Thus, the potential are larger than the 7,000 MW proposed by EPPO. In order to improve the possibilities for implementing CDM projects in Thailand based on biomass wastes, it is thus very important that the waste is collected and canalised to the Industrial Parks for potential re-use, facilitated by CDM project. If local and national visions for biomass use do not comply with joint actions for re-use, it is difficult to make use of the full potential of the resources which the biomass constitutes.

Possibilities for growing energy-crops in Thailand must be identified, as the country have large areas of 'waste-land' currently not being used (Opatvachirakul, 2008). This would limit the pressure on traditional biomass resources for energy purposes, like rice husk and palm oil

fibres etc. At the municipal and provincial level is it necessary to establish a collective system for biomass waste, as to facilitate the re-use of resources within Industrial Parks.

Thus, it is important that local and national stakeholders participate jointly in this to provide the resources for enhancing the possibilities for implementing biomass based CDM projects. It is also necessary to analyse or monitor the existing re-use of biomass resources within or outside the Industrial Parks in Thailand, as re-use - if any - tend to be quite inefficient (see Chapter 6). If more biomass waste could be collected within the industrial sites, prevented inefficient re-use elsewhere or simply discharges, more biomass CDM projects could be implemented within these locations.

New regulatory means acting as incentives for this could be penalties or fines on industries discharging biomass waste with a re-use potential. It could also be other means of regulatory adjustment, facilitating re-use and internal distribution of waste within the Industrial Parks. Today, this requires permissions and a long administration period, which could act as a barrier for more efficient re-use of the biomass waste within these areas.

As emphasised in the previous section on Thai energy policies (Section 5.4), CDM projects dealing with energy efficiency and the use of biomass waste in Thailand would ***'build on existing processes and strategies'***, because the country has a very long record in actions promoting energy efficiency and demand side management, etc. The CDM priorities are thus very much in line with the overall national energy policies and targets set forth by the Thai Government. It will off source benefit the implementation of CDM projects, if they comply to already established national targets and energy policies, as the specific direction posed by the projects are 'institutionalised' in the society. CDM projects going in a completely different direction would hardly receive the same kind of support.

## **5.6 Extraction of elements for the Manual**

### **Planning Guide elements**

- Examine the different sector's emitting GHG; *and*
- Make projections of the industrial sectors GHG emissions (will it grow in the future?);
- Identify the biomass waste potentials of the country (will it grow in the future?);
- Identify if national policies support actions related to use of biomass waste and efficient energy production and consumption, as important for supporting the CDM project implementation;

### **Policy Recommendations**

- Point out the need for additional regulatory measures that could support the implementation of biomass CHP. This could for instance be feed in tariff supporting generation of heat, by an ADDER per m<sup>3</sup> steam produced and used, by industrial manufactures for instance, or a demand for production of CHP in all energy producing activities (also those based on biomass);
- Re-introduce the demand for heat utilisation from the former 10 % to for instance 20-25%;
- Establish new regulatory measures with the aim of creating incentives for re-use of biomass waste, as opposed to wasting it. Large fines' will improve the stakeholder's

incentives for separating and sorting the waste for later pick up by relevant authorities etc.;

- Strengthen the regulatory frameworks for re-use of materials within Industrial Parks, as this requires permissions and a long administration period today, which could act as a barriers for more efficient re-use of resources within such areas;
- Establish analysis or audits of the character of biomass re-use within or outside Industrial Parks, as to increase the amount available for efficient energy production;
- Identify options for growing energy-crops on the 'waste-land' in Thailand;
- Establish local and regional waste collection of biomass resources with all relevant stakeholders participating;



## Chapter 6; Industrial metabolism and energy supply transformation

This chapter emphasise on the materials and energy throughput in six case industries located in Navanakorn Industrial Promotion Zone some 45 km. north of Bangkok. Focus will be on identifying the ‘industrial metabolism’ in food, - wood and chemical industries. These industries are found appropriate as case CDM-industries due to consumption of relatively large quantities of energy (power & heat), and due to the generation of mainly clean biomass waste appropriate for re-use, either internal (biomass boilers) or external (CHP Plants).

The description of materials and energy throughputs in the case industries which follow, are conducted by means of the simple ‘input/output model’ of a manufacturing process, described in Section 2.3.1.1, Chapter 2. *Energy input* and *Raw materials input* is thus identified, and an assessment of the quantities of *Damaged goods & Wastes* is carried out. A characterisation of the waste is conducted, as having either *Energy -or Production Potentials* for re-use. This is exercised in order to assess the biomass wastes’ usability for energy purpose.

Analysis of the *Production Process* will, however, illustrate the potentials for obtaining improvements in the manufacturing processes undertaken by case industries, which will be exposed by looking into different energy saving techniques and system.

An identification of different options for setting up local energy systems, based on internal or external re-use of materials and energy throughputs in Navanakorn, are thus conducted (See Figure 2D, Chapter 2). A prioritisation of these options is hereafter applied, by bringing in the sustainable development concepts (Part I.), as a turning point for the discussions. Extractions of elements to be integrated into the Manual will her solely be suggestions to the Planning Guide, of what is the most important ways to achieve improvements in the production process of Thai manufactures. Thus, the technical aspects to primarily to focus on for enhancing the sustainable development contribution of future CDM projects.

### 6.1 Industrial metabolism

#### 6.1.1 Food industries

The following section identifies the materials and energy throughputs (industrial metabolism) in case industries, with the overall purpose of identifying if relevant biomass residues are generated, and to expose the energy consumption pattern within the case industries.

##### 6.1.1.1 ASAN Service

###### *Short introduction*

ASAN Service is a Thai/Japanese industry manufacturing soy souse to the Thai market, and imports Japanese whisky, mirin, sake, shochu and ryorishu for further distribution in Thailand. The company was established in 1986 and currently has 50 employees.

###### *Energy input*

Power use equal 300,000 kWh/year, and provides energy to mechanical activities and cooling of fermentation areas. Internal process heat generation leads to consumption of 40,000 litre oil annually, fed into a boiler with a pressure of 1.5 bar, and primarily used for serialisation

purposes. Process heat temperatures are between 75 and 100 °C, but a minor part of the process heat use is also between 30 and 40 °C.

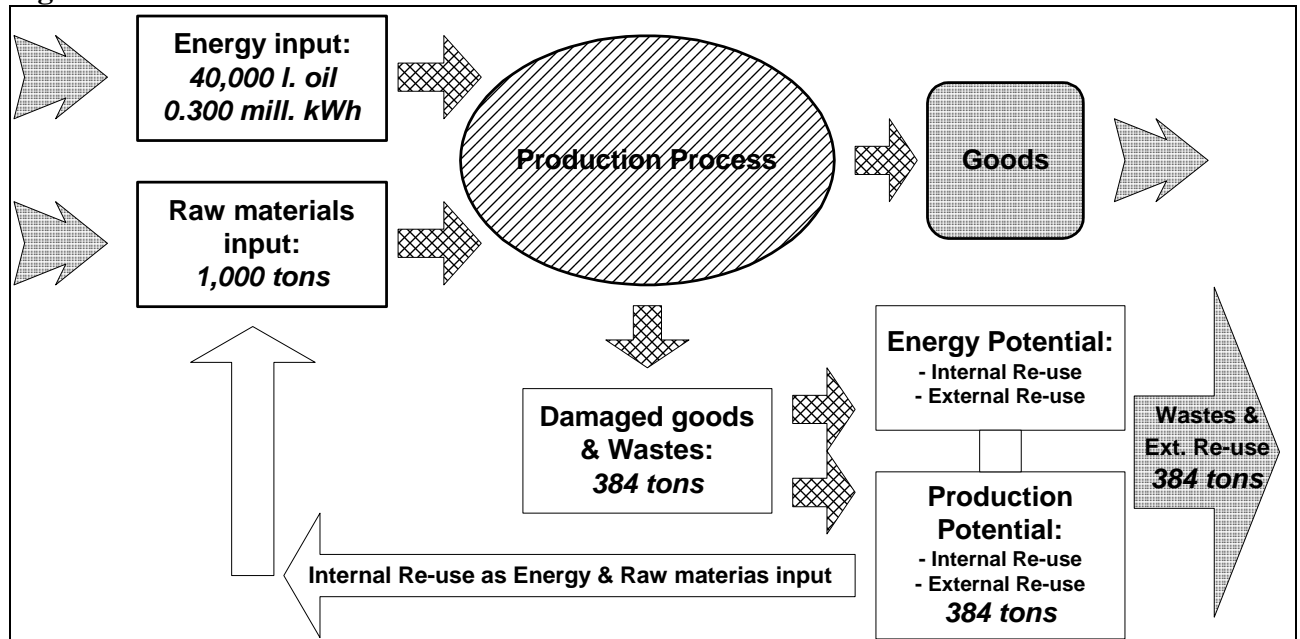
**Raw materials input**

The 1,000 tons of raw materials input annually consists of soy bean, wheat and water, which undergo fermentation processes of six months duration. The yearly output of goods is 960 tons.

**Damaged goods & wastes**

Waste products amounts to 384 tons annually and consists of a protein rich solid substance.

**Figure 6A: ASAN Service**



**Source: Own figure**

**Energy/production potentials**

Currently, the biomass waste at ASAN Service undertakes external re-use as a production potential, by means of animal feed. This re-use is not consequent as the biomass waste just as often is discharged with the waste collection system in Navanakorn, as it is being used as animal feed. The biomass waste has, however, both energy and production potentials. Internal production potentials cannot be applied for this type of waste (cannot re-enter the production process again, as for instance some wood waste can), but both internal and external re-use as energy potential can be established: Internal re-use can be applied by implementing a biomass boiler converting the waste into useful process heat, applying additional waste for complete coverage of heat demands. External re-use can be applied by combustion together with other relevant local biomass resources (All the above information is provided by Mr. Hitoshi Gomi & Mr. Chao Kotiwet, 2007).

**6.1.1.2 B.B. Snacks**

**Short introduction**

B.B. Snacks is a Thai company established in Navanakorn Industrial Promotion Zone in 1982, and currently employees 75 Thai workers. The company manufactures snacks, crispy green

peas, of which 96 % are sold on the domestic market and the remaining, exported to Spain, Holland and England.

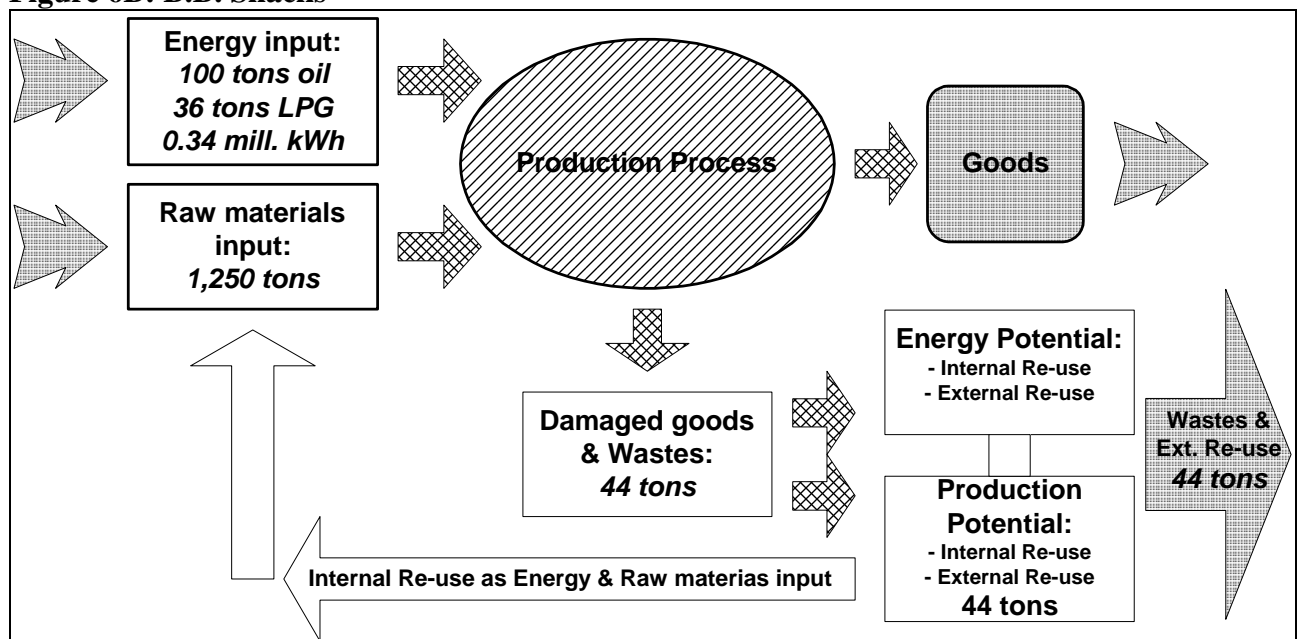
**Energy input**

Energy use equal 100 tons of oil applied in a boiler for process heat generation, which primarily are used for cooking the peas at temperatures between 140 to 150 °C, whereas 36 tons of LPG is used for frying them afterwards at temperatures between 160 to 180 °C. Further, 341,000 kWh of power are used annually for pumping and mixing activities.

**Raw materials input**

Raw materials input consists of 1,000 tons of peas and 250 tons of rice powder annually, as well as small amounts of colour products - the latter two used for coating the peas with different flavours.

**Figure 6B: B.B. Snacks**



**Source: Own figure**

**Damaged goods & wastes**

Approximately 44 tons of biomass waste is generated yearly, which consists of a solid protein rich substance.

**Energy/production potentials**

Generated biomass waste at B.B. Snacks currently undertakes external re-use as a production potential, by means of animal feed. The biomass waste has, however, both energy and production potentials: Internal production potentials cannot be applied, but both internal and external re-use as energy potentials, can be established. Internal re-use can be applied by implementing a biomass boiler converting the waste into process heat, also here applying additional waste for complete coverage of heat demands. External re-use can be applied by combustion, together with other relevant local biomass resources (Lybæk, 2004).

### 6.1.1.3 Baskin Robbins

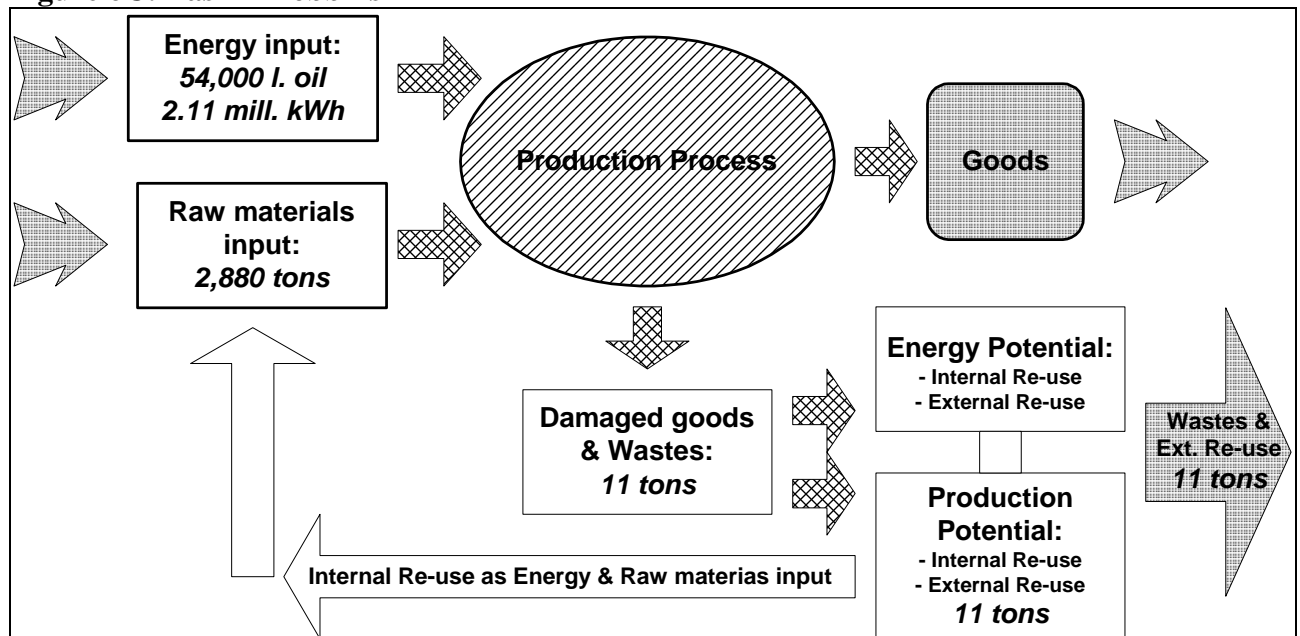
#### *Short introduction*

Baskin Robbins in a Thai manufacturing industry located in Navanakorn Industrial Promoting Zone since 1994. It has 70 employees and produces ice cream and soft ice products for the domestic market. In 2003 it changed its name and organisational structure, to no longer being a joint venture of Baskin Robbins. The company now only pays royalties the American owned company.

#### *Energy input*

The energy use consists of 54,000 litre oil annually for internal process heat generation, which primarily is used in a process heat exchanger (PHE). Process heat temperatures are between 60 to 90 °C. Power use equals 2,110,000 kWh annually and are used for mechanical processes and cooling facilities. Two cooling systems are implemented; one cooling area is minus 30 °C. and another between 0 to 5 °C, the latter for soft ice storage.

**Figure 6C: Baskin Robbins**



Source: Own figure

#### *Raw materials input*

The company use raw materials equal to 1,008 tons per year, which consists of cream, sugar, stabilisation, glucose and skimmed milk. Including water the yearly input is 2,880 tons, leading to the manufacturing of approximately 2,800 tons of ice cream annually.

#### *Damaged goods & wastes*

Around 11 tons of waste is generated annually in the form of production sludge, collected at the WWTP at site, and paper residues of which the latter is sold for re-use. Also 12 tons of ordinary waste is generated.

#### *Energy/production potentials*

Currently, most of the biomass waste at Baskin Robbins is re-used externally, as for instance re-cycling of paper wastes. Sludge from the internal WWTP is discharged together with the ordinary waste (12 tons). The biomass waste has, however, both energy and production

potentials. Internal production potential is not possible, but both internal and external re-use as energy potentials, can be established: Internal re-use can be applied by implementing a biomass boiler converting the wastes into useful process heat, supplemented additional waste for complete coverage of heat demands. External re-use can be applied by incineration. The latter potentials are thus similar to that of ASAN Service and B.B. Snacks (All the above information is provided by Mr. Rastam Benraheem & Mr. Narong Pinyoying, 2007).

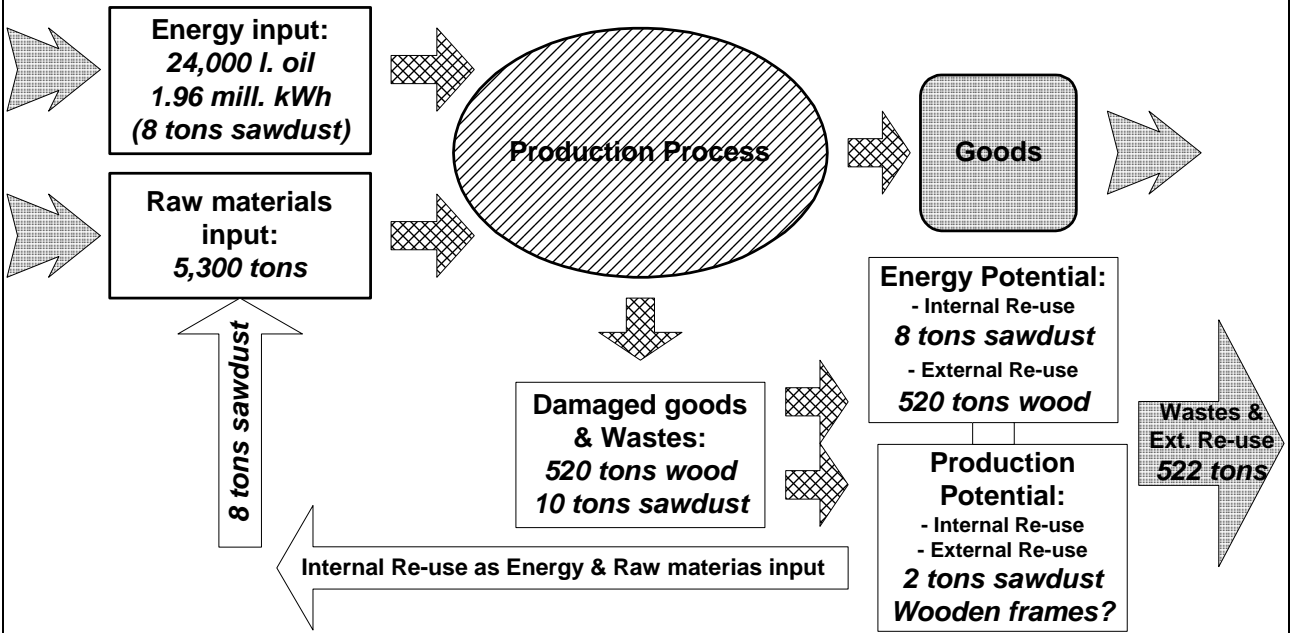
### 6.1.2 Wood industries

#### 6.1.2.1 Sun Cabinet

*Short introduction*

Sun Cabinet was established in Navanakorn Industrial Promotion Zone in 1988 and is a Thai owned company employing 300 people. Almost all (99%) of the wood furniture's are exported to countries like Denmark, Canada, Japan and England etc.

**Figure 6D: Sun Cabinet**



Source: Own figure

*Energy input*

Sun Cabinet use 24,000 litre oil annually in a boiler making process heat at 130 °C, as well as 10 tons of sawdust of which most of it are incinerated in a Stoker boiler making process heat at around 100 °C. The process heat temperatures are between 95 and 120 °C, and provide energy for activities such as pressure and glue hardening etc. Around 1,956,000 kWh annually is also used for providing mechanical activities, compressed air etc.

*Raw materials input*

600 tons of solid wood and 4,700 tons of chip board are being processed at Sun Cabinet, totalling 5,300 tons annually.

### ***Damaged goods & wastes***

10 % of the raw materials end up as waste annually, being wood waste (cut offs and small pieces) equal to 520 tons, and sawdust equal to 10 tons.

### ***Energy/production potentials***

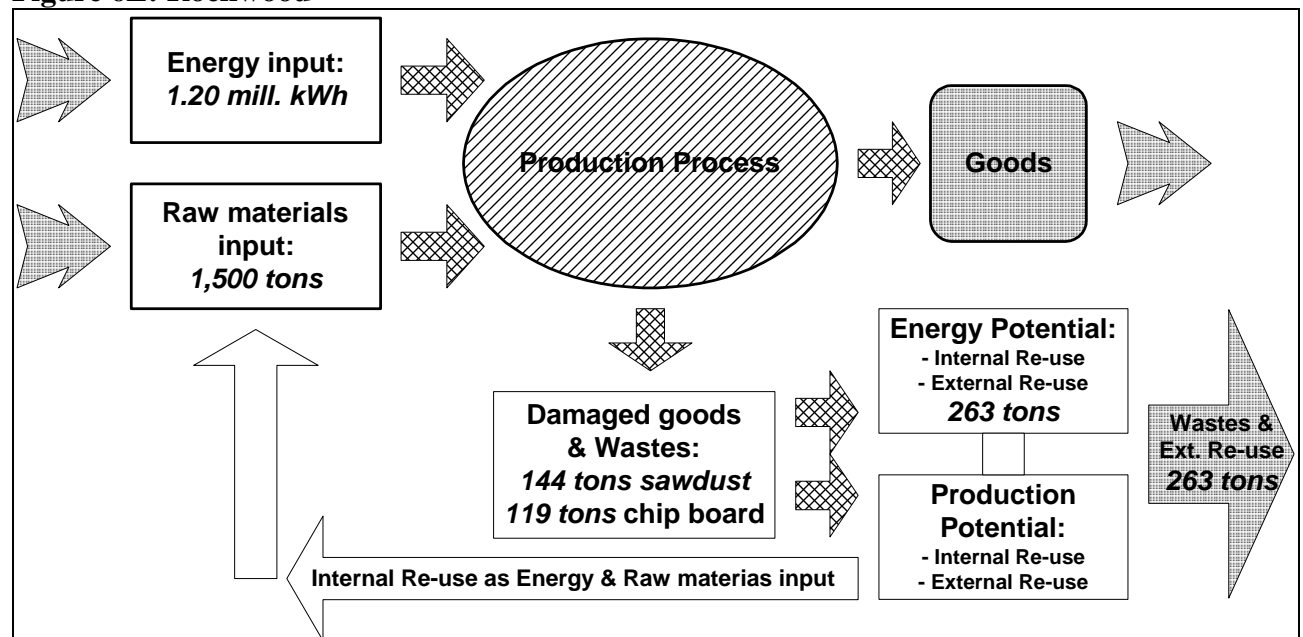
Wood waste primarily undertakes external re-use as energy potential, as most of it is transported to a sister company situated north from Navanakorn, where it is incinerated in the company's boiler for process heat generation (heat-only). Only a minor (unspecified) part of the wood waste is sold to a company making wooden frames. Approximately 2 tons of the sawdust wastes are moreover sold to a company producing incense (Thai offering's for Buddha). The remaining 8 tons of sawdust, are, as mentioned, used in the Stoker boiler for process heat generation. No means of internal re-use as production potential are applied, as for instance construction support material in the manufacturing of furniture's (All the above information is provided by Mr. Somyos Yamtgesorn & Mr. Phayong Sumathi, 2007).

## **6.1.2.2 Rockwood**

### ***Short introduction***

Rockwood was established in 1982 and is a Thai owned industry located in Navanakorn Industrial Promotion Zone. It manufactures' laminate chip board office and home furniture's sold on the domestic marked and employee 180 people.

**Figure 6E: Rockwood**



**Source: Own figure**

### ***Energy input***

1,200,000 kWh of grid power covers the energy demand at Rockwood, and is primarily used for operate machinery's, motors, and to provide compressed air etc. The power supply is also used for generating process heat in an oven hardening applied lacquer, and to provide heat when gluing laminate's on chip boards. The first activity requires process heat temperatures of 200 °C, and the latter temperatures of 60 °C.

### **Raw materials input**

1,500 tons of wood, solely chip boards, are annually processed at the industry.

### **Damaged goods & wastes**

An estimate of 263 tons of wood waste is generated per year, of which the 144 tons are estimated to be sawdust, and the remaining 119 tons smaller pieces of chip boards.

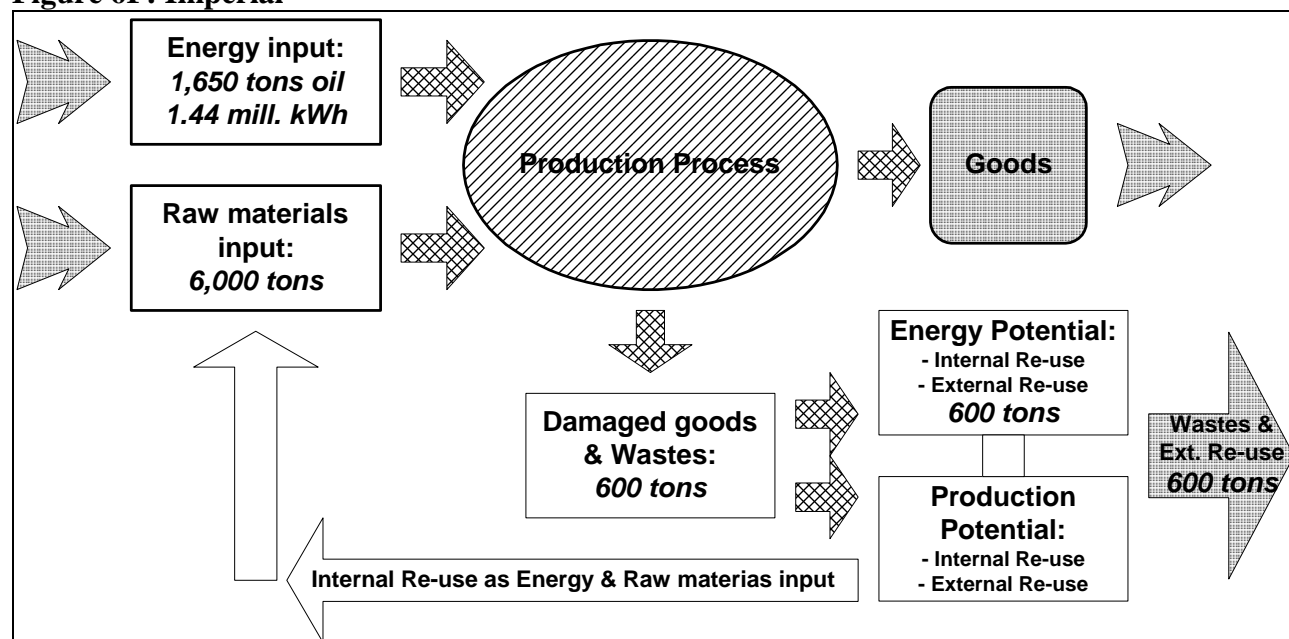
### **Energy/production potentials**

All biomass wastes undertake external re-use as energy potential, as it is used for thermal energy production (heat-only) in a company outside Navanakorn. The waste also has re-use possibilities as production potential (as for instance construction support etc.), as well as options for re-use as energy potentials. The biomass waste is, however, discharged to another production chain, but could have been used more efficiently for energy production *and* consumption locally (Lybæk, 2004).

## **6.1.3 Chemical industries**

### **6.1.3.1 Imperial Industrial Chemicals**

**Figure 6F: Imperial**



Source: Own figure

### **Short introduction**

Imperial is an Indian industry manufacturing fatty acids and glycerine and has been located in Navanakorn Industrial Promotion Zone since 1980. There are 94 people working at the industry and the products mainly cover the domestic market, with a minor export to the US, EU and South Korea.

### **Energy input**

Two boilers at Imperial of Indian origin convert the 1,650 tons of oil consumed annually into process heat, primarily used for heating -, vacuum and reaction purposes, as well as for cleaning reactors and pipes. Process heat temperatures are in the range of just below 100 to

250 °C. Further, 1,440,000 kWh of power are used annually mainly for operating pumping activities at the plant.

#### ***Raw materials input***

6,000 tons of raw materials are used annually, which consists of sunflower, rice bran, rubber, -rape -and cottonseed, and soybean.

#### ***Damaged goods & wastes***

Approximately 10 % of the raw materials end up as waste, which equals 600 tons annually. The biomass waste at Imperial consists of liquid bio oil.

#### ***Energy/production potentials***

Presently, external re-use of the biomass waste generated at Imperial are applied as energy potentials, despite its accuracy as fuel for on-site energy production. Thus, the bio oil is used outside the Industrial Park for thermal energy production (heat-only) by a company manufacturing bricks. The bio oil has no value for either internal or external re-use as production potential (All the above information provided by Mr. A. Sasindran, 2007).

### **6.1.4 Sum-up**

All case industries convert fossil fuels in individual boilers for process heat generation, and rely on power supply from the national grid, i.e. depend on a fossil fuel energy supply system. Only to a minor extend are certain parts of the biomass waste (sawdust) used in the production of heat, and no CHP production are applied within case industries. Most of the waste is thus transported out of the Industrial Park and re-use inefficiently for thermal energy production (heat-only), or used for animal feed. Also large amounts of the waste are discharged with the ordinary waste collection system in the area (Lybæk, 2004). Most of the biomass waste is, however, appropriate for energy production although some of it will have to be pre-dried.

Due to the relatively small quantities of biomass waste generated by some industries, it is necessary to apply additional waste, from within or outside the Industrial Park, to cover internal energy demands. This step is not taken by any of the case industries, who, on the contrarily, transport or/and discharge the biomass waste out of the industrial site.

To comply with the sustainable development concepts (Part I.), it is however important to re-use this waste efficiently, as to lower the pressure on virgin materials through the use of already processed biomass waste. According to these concepts, the biomass waste would be used more efficiently on a CHP technology located within the Industrial Park (more on this issue in Section 6.3).

## **6.2 Energy saving techniques and systems**

In the following, I will analyse which technical aspects that could improve the energy production and consumption within case industries, by focusing on options for implementing 1) *efficient processing equipment* and 2) *process integration*. This will be exercised both on a general level, as well as on a specific level using data and conditions obtained from case industries. Finally, I will identify options for establishing an 3) *sustainable local energy system*.



## 6.2.1 Efficient processing equipment - internal processes

Internal processes are understood as the specific manufacturing equipment used in processing raw materials. It can for instance be machinery processing wood, as for example moulding machines and ovens for drying wood. It can be reactor tanks evaporating liquids in food and chemical industries, as well as cooling -, drying -, pumping and ventilation systems etc. assisting in the processing of raw materials.

### *Wood industries*

In wood industries many technical options can be considered in order to save energy. In the following, emphasis will be on some of the most obvious possibilities for achieving energy savings. When looking at Figure 3B in Chapter 3, it is evident that electricity savings can be beneficial in the areas of Processing wood, Compressed air and in Removals of sawdust. This will be discussed in the following:

When *processing wood*, it is possible to reduce electricity expenses for *ventilation air* activities in wood industries, by implementation of for instance more efficient *local exhaust ventilation systems*<sup>10</sup>. Traditionally, effective elimination of wood chips from moulding and drilling machines<sup>11</sup> has been difficult, as generated chips leave the equipment with high speed, and thus hurled away from the area of ventilation. This inefficiency has led to a need for additional cleaning activities, by for instance using highly compressed air and other means of additional ventilation (DTI Træteknik, 1994).

By implementation of a ventilation air bow<sup>12</sup>, it is possible to avoid these problems, as the equipment is capable of removing generated wood chips more efficient. The ventilation air bow is designed to create an area around the opening of the ventilation point with high air speed, aiming at the ventilation point. This means that chips, which normally are spread to this area, now are forced into the ventilation air bow instead (DTI Træteknik, 1994). The system can lead to electricity savings of 50 %, as well as savings in additional cleaning activities by electricity uses (see below). Moreover, experience has shown that local exhaust ventilation systems also improve the dust content in the air by as much as 32 %. This, again, can lead to improvements in the final products as the wood surfaces finish increases (Ibid.).

Electricity expenditure on *compressed air* activities can also be reduced by as much as 57 %, due to optimisation's in these activities. Polishing and moulding sections, for instance, normally use large amounts of compressed air to conveyor belts and product cleaning activities (Træets Arbejdsgiverforening, 2001). By monitoring the air use in a Danish wood industry, Nitex Møbler A/S, it has been possible to optimise uses of compressed air by:

- Reductions in the overall air compression level of the compressor;
- Optimisation in the compressor control unit;
- Separating the compressed air net in sections to avoid leakage;
- Optimisation of the air intake to the compressor, so air intake temperatures has been reduced;
- Making conveyor belts and product cleaning activities on polish equipment demand-controlled; (Træets Arbejdsgiverforening, 2001).

---

<sup>10</sup> ('lokal punktudsugning')

<sup>11</sup> ('fræse- og boremaskiner')

<sup>12</sup> ('luft-bov')

Energy saving can also be obtained in mechanical *removals of sawdust*, which can be optimised by the utilisation of a Redler transportation system based on a “trough-snail”<sup>13</sup>, as opposed to the more traditional ventilator based transportation system. A Danish wood industry, PLUS A/S, who produces wood fences, has obtained energy saving amounting to 88 % by implementation of the Redler transportation system (Træets Arbejdsgiverforening, 2001). The main reason for energy savings is that the Redler transportation system - as opposed to the ventilator based system - does not move sawdust by use of highly compressed air. Thus, at PLUS A/S, it has been possible to substitute the old 55 kW motor with a new 5.50 kW motor, and reduce energy consumption in effect from 42 kW to 5 kW (Ibid.).

### ***Food industries***

When looking at Figure 3A in Chapter 3 large energy savings can obviously be obtained in the areas of Cooling, Pumping and Ventilation activities. This will be discussed in the following:

Both ASAN Services and Baskin Robbins utilise ***cooling*** in processing activities and for storage purposes. Electricity savings related to cooling/freezing (hereafter cooling) activities can often be obtained by relatively small investments (Pedersen, 1991). Suggestions for areas in which energy savings can be obtained are:

- Adjustment of cooling-demands to the turnover speed of goods in cooling storage facility and use of as high cooling temperature as possible;
- Limiting cooling needs by for instance improvements in insulation;
- Optimisation of the compressor operation;
- Lowering of condensation temperature;
- Effective maintenance of condensation’s;
- Use of natural cooling with dry coolers’; (Pedersen, 1991).

***Pumping*** activities occurs in both Food and Chemical industries, but the share of expenses for this task is in general larger in the food manufacturing industries. Electricity expenses for pumping activities can be reduced by:

- Adjustments to pumping-demands;
- Correct fitting of pumps;
- Regulation principles,
- Optimise the effect of the pump;
- Optimise the effect of the engine; (Pedersen, 1991).

***Ventilation*** (see below).

### ***Chemical industries***

In Chemical industries many technical solutions can be applied in order to save energy. In the following, emphasis will be on some general and obvious possibilities for achieving energy savings in this line of business. When looking at Figure 3C in Chapter 3, it is obvious that electricity savings would be beneficial in the areas of Process air (compression) and in the area of Blowing machinery, Stirring and Cooling activities. This will be discussed in the following section, excluded Cooling activities, as this does not happen at Imperial.

---

<sup>13</sup> (‘trugsnegl’)

When substituting several small vacuum systems in the production process with one single central vacuum system, it can reduce the power consumption for *process air (compression)*. Existing vacuum pumps can be moved to a central facility and interconnected. A piping system can be established, which connects the machines to the central vacuum plant. By doing this, it is possible to reduce the amounts of vacuum pumps in operation, due to a limitation in tick-over periods<sup>14</sup> (Træets Arbejdsgiverforening, 2001). This normally happens on decentralised pumps, in periods where there is no need for them.

At Imperial, however, a vacuum system is applied at different levels depending on the specific batch operated. A vacuum is thus utilised as a process control mechanism, and as such it is difficult to interconnect all vacuum pumps. Decentralised pumps are also often over-dimensioned. In one department processing plastic components in a Danish loudspeaker industry, it has been possible to reduce power expenses in vacuum activities by 54 %, due to the centralising of 4 of 6 vacuum pumps (Træets Arbejdsgiverforening, 2001).

One “low hanging fruit” in the reduction of electricity expenses for operating *blowing machinery and ventilation* activities - here discussed together - is to make uses demand-controlled. It is possible to reduce expenses by up to 50 %, only by shutting down machinery's when the production is closed down (Pedersen, 1991). Some pharmaceutical industries operate ventilation machinery and other ventilation activities at night or in weekends when the industry is closed down, to remove humidity and assure a clean air environment. Experiences show, however, that this activity only is necessary three hours before re-starting the operation, thus further ventilation activities only leads to unnecessary energy uses (Ibid.).

Air intake by blowing machinery and ventilation equipment in general also leads to secondary energy uses, as it - especially in a Thai context - is cooled by air conditioning. Thus, when limiting these activities, it is also possible to save energy resources for either heating or cooling the air intake (Pedersen, 1991). As for wood industries, it is also here possible to limit the overall air intake by optimisations in specific local exhaust ventilation activities, as the general air quality improves by optimisations in the systems.

Other technical solutions for obtaining efficiency in these activities are for instance improvements in the technical design of ventilation channels. If, for instance, high air speed is needed, it is important that the channels system is shaped to match the air pressure, in order to reduce pressure losses and thereby energy expenses. Leakage in and sharp corners in the ventilation channels can lead to unnecessary large energy uses (Pedersen, 1991). Appropriate regulation of the numbers of revolution made by the ventilation machinery, thus air volume, can also save energy resources. Typically, such adjustments can lead to electricity saving of 20 to 50 %. Inlet regulation with guardrail<sup>15</sup> - substituting throttle regulation<sup>16</sup> - can also lead to energy savings of approximately 40 % (Ibid.).

Electricity uses for *stirring* activities can be reduced by optimisations of, for instance, the motor (Pedersen, 1991), or by implementing stirring equipment as for instance propeller's or “worm-screws”<sup>17</sup>, with the capability to mix substances effectively without great electricity uses. As for pumping activities it is important to look at the stirring-demand, and analyse

---

<sup>14</sup> ('ude-tid')

<sup>15</sup> ('ledeskinne')

<sup>16</sup> ('spjældregulering')

<sup>17</sup> ('snegleomrører')

whether stirring activities are over-dimensioned, or for instance can be provided in a shorter period of time with a reduces density. New stirring equipment can lead to significantly energy savings. One Danish pharmaceutical industry has obtained savings in the range of 20 to 40 %, just by implementation of new stirring equipment (Nielsen, 2002).

*Cooling* (see above).

## **6.2.2 Process integration - external and internal processes**

Process integration is here understood as means to develop a more efficient interplay between the manufacturing processes undertaken by the industries; thus how to optimise technical equipment and processes to save energy resources, by combining different energy flows etc. (Nielsen & Hansen, 2006). This will be emphasised in the following, by looking at options for establishing heat recovery systems, and water based heat supply substituting the use of steam. Process integration can be applied at the single industrial level, but also be established as cooperation between several industries.

### ***Sun Cabinet***

The peak heat demands of 120 °C are used for hardening glue in a “glue presser”, when adding laminates on chip board’s. This use of steam can, however, be subsidised with utilisation of lower heat temperatures of approximately 70 °C (Træets Arbejdsgiverforening, 2001). Water based heat can be supplied by means of a biomass boiler or by district heating supply. According to Træets Arbejdsgiverforening, such production change requires a relatively small investment. Heat piping must be prolonged to the “glue presser”, and there must be established storage of glue at temperatures of around 10 °C, as it will be subsidised by a low temperature hardening glue (Ibid.).

### ***Rockwood***

According to experiences obtained in a Danish wood industry, Lyby Møbelfabrik A/S, it is possible to save up to 82 % of the heat expenses by conversion from electricity based process heat to water based process heat in gluing activities. The industry has decreased heat temperatures of 100 °C - made by electricity - to 70 °C, by uses of water based heat supply instead. If the heating system falls out for a period, an electronic system will activate the former electricity based heating system (Træets Arbejdsgiverforening, 2001).

At Rockwood the “glue presser” equipment is operated by electricity and heat temperatures of 60 °C are generated in this process. Thus, Rockwood might benefit from uses of water based heat in the gluing activities. Currently, the peak heat demands of 200 °C are also covered by electricity uses, and happen as the oven for lacquer hardening is heated up. Also here it is possible for Rockwood to decrease heat temperatures by conversion to process heat by water based heat, and prolonging heat pipes to the lacquer oven. In this case it might also be necessary to subsidise the type of lacquer used, in order to obtain a lower hardening lacquer temperature.

Effective insulation, warm caps and adjustments of warm air ventilators in the oven, can assist in lowering heat requirements and make process heating by water based heat effective (Pedersen, 1991). As for Sun Cabinet, Rockwood can also design the system to be operated on electricity in the case of fall-outs. When substituting process heat made by electricity, with process heat supplied by water based heat - and conversion to low temperature hardening

glue/lacquer - it does not impact on the quality of the final product (Træets Arbejdsgiverforening, 2001).

### ***B.B. Snacks***

At B.B Snacks ***boiling*** activities takes place at 140 to 150 °C in large batch reactors or vessels containing the green peas. Depending on the structure of the peas, and whether the vessel creates a closed environment or not, the temperature of the boiling process can possibly be lowered by operating in a vacuum. If such production changes can be implemented, boiling processes can be covered by water based heat only, provided by a biomass boiler or district heating network. If vacuum operation is not possible, the processing of peas can *partly* be built on a water based system; This can be established, as the initial temperature increase (from 25 to 95 °C) is achieved by a water based heat system (a biomass boiler or district heating system), and the remaining temperature increase (from 95 to 140 °C) by the biomass boiler, or possible by ‘waste steam’ from Imperial (see below) (Nielsen, 2002).

Implementation of heat exchangers and re-circulation of hot water between vessels is also an option. “Waste heat” from one vessel can partly heat up new feed-water in the next vessel, where “waste heat”, again, heats up feed-water in the vessel to come etc. “Waste heat” from one vessel can theoretically reach a temperature level of 100 °C, and by heat exchange warm up the water in the next vessel (For reasons of hygiene it is not possible to utilise the same boiling water twice). Peak heat temperatures (95 to 140 °C) are again provided by a biomass boiler or by “waste steam” from Imperial.

This system is superior to the latter above, as it decreases the total energy uses, as providing the lowest heat temperatures (from 25 to 95 °C) by re-circulation of heat and not by uses of water based heat provided by either a biomass boiler or district heating system.

The heat recovery system can also be combined with the vacuum boiling system, where a large part of the energy is recovered and the remaining energy demand covered by a biomass boiler or district heating network (Nielsen, 2002).

A final possibility for obtaining energy savings (not to convert to water based heat) in boiling activities at B.B. Snacks, is to use the heat from the water evaporated in the boiling process. If the vessels consist of a closed environment, water will evaporate at 100 °C, and the heat of evaporation subsequently be recovered in a heat exchanger in which the vapour is condensed. The heat can thus be used for water pre-heating. In case the vessels are not a fully closed environment, the heat recovery will drop because the condensation temperature falls to 70 to 90 °C. Still, both temperature levels can be used for, for example to heat up the feed-water in the vessels (Nielsen, 2002)

At B.B. Snacks, ***frying*** activities are also included in the processing of green peas (at 170 to 180 °C) and this happen by using LPG in a continuous-processing. Also here the development of water vapour occurs, which can be utilised for internal re-use. At the top of the fryer, a ventilation system is installed, through which the vapour disappears. With a heat exchanger it is possible to collect this vapour at perhaps 70 °C for further use in the industry. Currently, such equipment is implemented at B.B. Snacks and used for heating up the oil, in which the peas are fried.

By implementation of all the examples mentioned above, it is in principle possible to save at least 40 to 50 % of total energy uses at B.B. Snacks (Nielsen, 2002). However, practical and economic limits might reduce this number significantly. For a realistic picture it is necessary to make even more detailed energy analysis.

### ***Imperial***

Peak temperatures at Imperial have already been decreased from 400 to 250 °C by operating the process under vacuum. It is unlikely that the temperature demand can be decreased further by this method. Steam accounts for 80 % of the total energy uses in Imperial, and it is thus a significant amount of energy that cannot be converted to water based heat. One strategy can therefore be to utilise the 'waste heat' to cover internal water based heat demands (Nielsen, 2001), accounting for 20 % of total heat use. This will assume that 'waste heat' at the right temperature level is available. Imperial can also receive water based heat from a biomass boiler or district heating network, or/and even supply the network with surplus 'waste heat'. Another possibility is to supply surplus heat (steam) to other industries in the area, as for instance to B.B. Snacks as illustrated above. These possibilities will be emphasised further in the following.

At Imperial, the batch operation happens in reactor tanks or large vessels, in which water evaporates and the specific product are concentrated further and sterilised. In the *top of the reactor*, water vapour is extracted, or given free, on a constant basis. When collecting this energy by implementation of a heat exchanger, it is possible to re-use the energy either internally or externally: For coverage of low temperature heat demands elsewhere or/and for providing hot water to a district heating network. Depending on the vacuum installed (pressure level of the vacuum pump) the temperature of the water vapour can be between 40 and 100 °C (Nielsen, 2002).

At the *bottom of the reactor* it is also possible to extract "waste heat" for further re-use. 'Waste heat' from the heating of reactor tanks at Imperial - by uses of steam at 250 °C - can realistically reach a level of 150 °C (Nielsen, 2002). It is, therefore, a candidate for re-use internally in other parts of the plant, or externally, for export to the water based district heating system, or as steam distribution in separate pipes to for instance B.B. Snacks. Currently, however, this surplus energy is cooled down (lost) and therefore not collected for further uses.

By implementation of the initiatives mentioned above, it is, theoretically, possible to save at least 50 % of the current energy consumption at Imperial. In practice, the realistic energy savings must be expected to be lower. For a complex industry as Imperial, the above mentioned options must be considered systematically and simultaneously. A more thorough process integration study, in which all energy recovery options are exploited, must be elaborated (Nielsen, 2002).

### **6.2.3 Sum-up**

The analysis show, that supply of water based heat can cover energy demands in all case industries, except from certain amounts of process heat demands at Imperial and B.B. Snacks, if relatively simple technological equipment and process changes are applied.

For all industries under one the analysis shows, that substantial energy saving can be obtained when implementing more efficient manufacturing equipment and process integration, etc. Such actions very much apply to the sustainable development concepts (Part I.), discussed below, and will result in substantial savings related to energy production and consumption, if implemented.

## 6.2.4 Sustainable local energy systems

In this section, I will briefly identify which options exist for implementing sustainable energy supply systems in Navanakorn, as opposed to the one already established within the Industrial Park.

### ***Biomass Boilers***

Biomass boilers (Option B) can be implemented in all case industries, and easily cover the demands for process heat at all temperature levels identified. All the biomass waste identified can be incinerated in boilers (some of it must be pre-dried). Each industry will have to apply additional waste in order to cover the internal heat demands, when implementing Option B.

### ***Biomass CHP with district heating***

CHP technologies (Option C) are also capable of converting all biomass waste found in case industries. Production of steam can be applied for coverage of energy demands at Imperial and B.B. Snacks, and for power generation, whereas district heating can supply the remaining industries with water based process heat through a network connecting the industries. The CHP Plant can be a traditional steam turbine plant or a fluidised bed technology. Also here, additional biomass wastes will have to be added in order to cover the energy demands in case industries.

The large size of the CHP Plant, compared to the smaller individual boilers, also enables a more efficient conversion of the liquid bio-fuel from Imperial, as it can be used in an over-heater as combustion support, increasing the temperature level in the furnace. This again means that biomass waste with relatively high moisture content can be incinerated without lowering the temperature in the furnace notable. This leads to higher steam temperatures, and thus a higher power output. The bio-fuel can also be used as a start-up fuel instead of fossil fuels, which normally are applied for quick start-ups (Lybæk, 2004).

## 6.3 Discussion

To comply with the sustainable development concepts (Part I.) formulated in Chapter 2, Options B and C *both* pose an enhancement of the energy supply compared to the presently applied system in Navanakorn, described in Section 6.1 above. However, Options C has many advantages compared to Option B, as emphasised below, drawing on the sustainable development concepts (Part I.) as outlined in Chapter 2 Section 2.3.1.4.

Both energy supply systems (Option B & C) make use of ***'already processed biomass waste as fuel'*** for energy production, as they mainly rely on industrial and agricultural wastes etc. This will lower the pressure on virgin materials (as for instance wood fuel), and phase out the consumption of fossil fuels in general. When it comes to ***'optimising the production process in regards to the use of energy/materials'***, hereunder implementing ***'efficient biomass converting technologies'***, Options C is however much more efficient than Option B. This is due to the fact that power and heat is generated in one process in CHP technologies, and not in two separated processes, as it happens in Option B. Modern biomass boilers can, however, be very efficient in producing heat; but heat only.

Applying '*process integration*' lowering fuel consumption (quantity/quality) is beneficial, as many resources can be saved by doing this. Process integration can be applied within companies for more efficient energy consumption. This can be achieved by implementing vacuum pumps and heat exchangers etc., as mentioned earlier, hereby lowering the process heat temperatures required, and making it possible to use 'waste heat' elsewhere within the company. Companies implementing Option B, can apply these initiatives just as well as those applying Option C. The only difference is that the possibilities for applying external 'process integration', by using the district heating network as means of cascading the energy, not are a possible for companies only applying Option B.

It is also very important to implement '*efficient manufacturing equipment*', leading to reduced materials and energy consumption, such as for instance cooling, pumping and ventilation activities etc. This is, however, not a necessity when choosing the biomass boiler (Option B). It can be implemented without initiating any energy saving techniques and systems whatsoever, leading to a very inefficient but decarbonised production process and consumption of energy. Implementation of biomass CHP with district heating requires, on the other hand, implementation of energy saving techniques and systems, as the supply of heat primarily is distributed as hot water (supply of steam-only will not require any major technical changes, but the efficiency of the system will be lower). As described above, Option C also emphasise on the '*use of hot water instead of steam*', as it reduces both the qualitative energy requirement (from steam to hot water) and quantitative energy requirements (the amount of energy necessary to produce).

When it comes to establish '*internal/external re-use of energy/materials*', Option C is also advantageous, as this can be applied for both power and heat and on several temperature levels. The benefits of supplying heat by means of an external energy supply system, as the biomass CHP with district heating, is evident, as it opens up possibilities for cascading of energy in several steps: Firstly from Imperial to B.B. Snacks, and then from B.B. Snacks to the district heating network. Also 'waste heat' from Imperial, can be re-used through distribution on the district heating network, if not re-used internally. Option B does not imply distribution of heat to industries within the park, as it is based on individual solutions.

Thus, Option C leads to '*re-use of resources where the environmental benefits are highest*'. The CHP technology also improves the possibilities of actually *using* the biomass waste for energy purposes, as the additional waste required must be applied to a joint facility and not to many smaller units, making the first easier logistically. This implies '*re-use where the resources are used most appropriate*'. Alternatively, the biomass waste would have been transported out of the Industrial Park, thus discharged with the normal waste or re-used inefficiently elsewhere.

The analysis above show, that the biomass CHP with district heating (Option C) complies with the sustainable development concepts (Part I.) to a much higher degree, compared to the biomass boilers (Option B). From a sustainability point of view this energy system should be selected.

## **6.4 Extraction of elements for the Manual**

To achieve improvements in the production process of Thai manufactures, the following analysis must be conducted within industries in order to assess the specific options (identified in Section 6.1 and 6.2):



## Planning Guide elements

- *Make materials and energy monitoring in selected industries, here access the:*
  - Amount of power and heat use;
  - Type of production process equipment; and
  - Amount of damaged goods and wastes;
  - Possibilities for applying internal or external re-use of the biomass waste, as either energy or production potentials;
- *Make analysis of efficient processing equipment, here access the:*
  - Internal production processes in wood manufacturing industries, focusing on: Processing Wood, Compresses air, and Removals of sawdust;
  - Internal production processes in food manufacturing industries, focusing on: Cooling, Pumping and Ventilation activities;
  - Internal production processes in chemical manufacturing industries, focusing on: Process air (compression), Blowing machinery, Stirring and Cooling activities;
- *Make analysis of options for process integration, here access the:*
  - Process water: Identify options for operating the manufacturing process under Vacuum, for implementing Heat Exchangers, Recirculation of hot water, and for applying Cascading of steam;
  - Power use: Identify options for converting the use of process heat based on power to process heat based on hot water;

## Chapter 7; Enhancing development opportunities

The first part of this chapter identifies how to increase the CO<sub>2</sub> emission reduction potentials of future CDM projects, and thus how to improve their capability to generate large amounts of CER's. The focus is solely on CO<sub>2</sub> emissions and on an identification of energy systems leading to higher emission reductions, when looking at the different systems proposed in Figure 2D Chapter 2. The section ends with suggestions to a 'transformation process' of the energy supply system, proposing that also a suggestive development of the energy system can be applied.

The second part of this chapter will focus on how to create more value in developing countries addressed by the CDM, as to contribute to higher *development opportunities* in these countries; thus an enhancement of the value chain in the South. Discussions will also be on how to establish mega-suppliers of renewable energy technology and how a supply-park can evolve around such suppliers. Proposals will also be given to which types of energy projects preferably to implement, according to their employment effects and market expansion possibilities, etc. To enhance the sustainable development contribution of future CDM projects, I will, in each part of this chapter, bring in sustainable development concepts (Part II.) for discussion, as to enable extraction of elements for the Planning Guide and Policy Recommendations.

### 7.1 CO<sub>2</sub> emissions caused by different options proposed

The following section elaborates on different consequences when choosing between the technology options, previously outlined, depending on the starting point selected. The section illustrates, that large variations in CO<sub>2</sub> displacement is achieved depending on which GHG abatement option is pursued. This impacts the specific CDM projects capability to achieve large emission reductions and thus the amount of CER's generated.

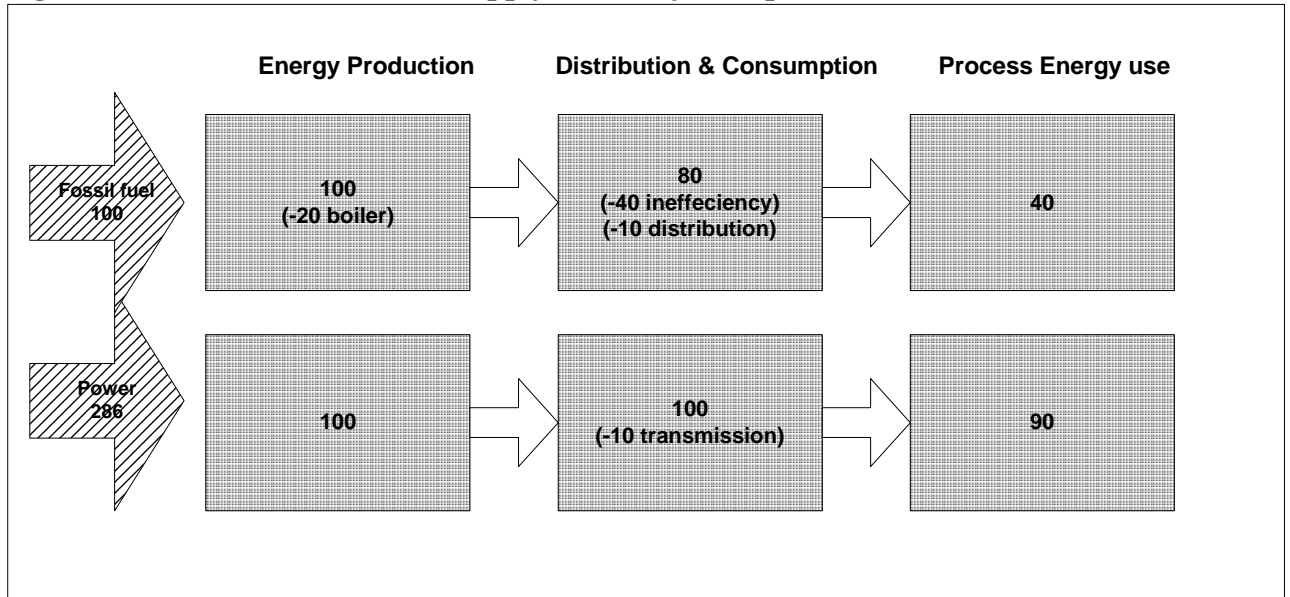
The different options for CO<sub>2</sub> displacements are hereafter discussed in relation to which overall purpose the project developer etc. has, and how the initial choice influence the possibilities for a suggestive development of the energy system at a later stage (energy transformation process). The section ends with a short presentation of the industries point of view (from the case study), when it comes to transforming the energy supply. This is off source a context dependent issue, but also depends on how developers propose the transformation to take place, i.e. the role of industries and their responsibility etc.

#### 7.1.1 Different options for CO<sub>2</sub> displacement

This section will identify which of the Options A to C lead to the highest CO<sub>2</sub> emission reductions. The figures below are simplified models of Figure 3A, 3B and 3C in Chapter 3 (in which the background assumptions for the calculations are described), and show a manufacturing industry's production, distribution & consumption and final use of energy.

The industry below (Option 0) consumes fossil fuel in a boiler to cover heat demands, while power is supplied from the national grid. No means of energy efficiency are applied and energy losses due to inefficiencies are relatively high. This energy supply is similar to the one currently applied in case industries.

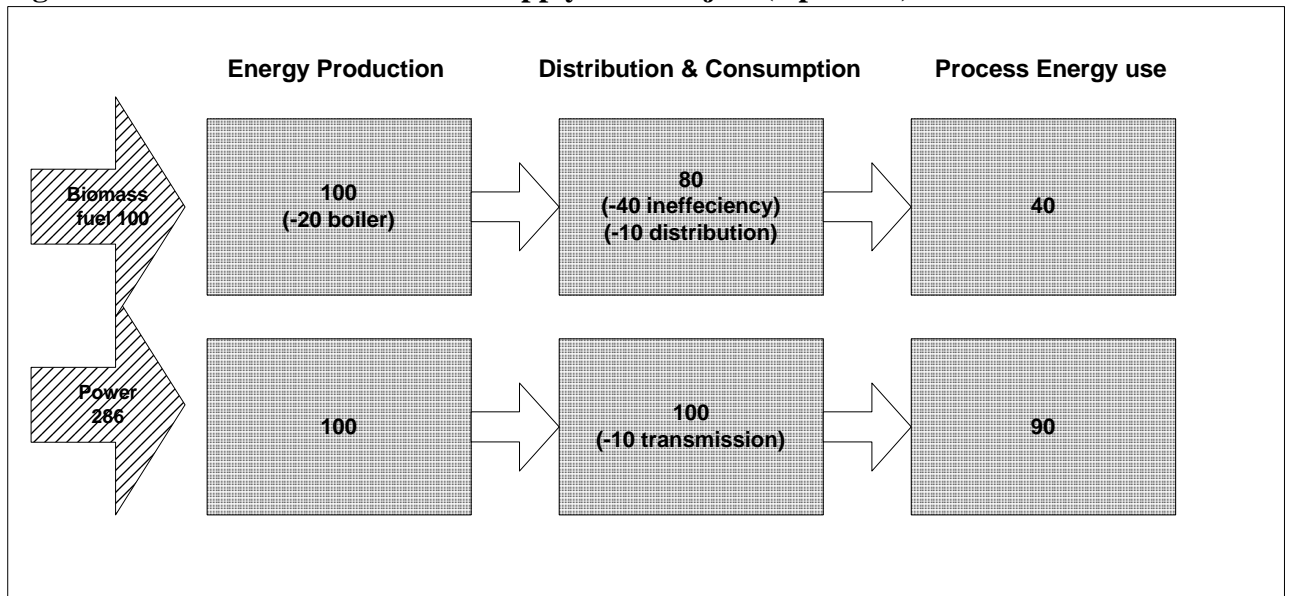
**Figure 7A: Fossil fuel Industrial Supply Side Project (Option 0)**



**Source: Own figure**

CO<sub>2</sub> emissions from the heat supply (100 litre oil<sup>18</sup>) are estimated to (100 litre oil\*39.4 = 3,940 MJ = 3.94 GJ \*74 kg CO<sub>2</sub> per GJ) = 291.6 kg CO<sub>2</sub>. CO<sub>2</sub> emissions from supply of power from central power plants, with an efficiency of 35 %, are estimated to (286 litre oil\*39.4 = 11,268.4 MJ = 11.37 GJ\*74 kg CO<sub>2</sub> per GJ) = 833.86 kg CO<sub>2</sub>. Thus, the total CO<sub>2</sub> emission from the energy system is 1,125.5 kg CO<sub>2</sub>. The total efficiency of the system is estimated to  $\eta = 40+90 / 100+286 = 0.34$ .

**Figure 7B: Biomass fuel Industrial Supply Side Project (Option A)**



**Source: Own figure**

In Option A above the manufacturing industry implement a modern biomass boiler, and make CO<sub>2</sub> displacements corresponding to the use of fossil fuel for heat coverage. Power consumption is transmitted from the national grid. CO<sub>2</sub> displacements therefore equal 291.6

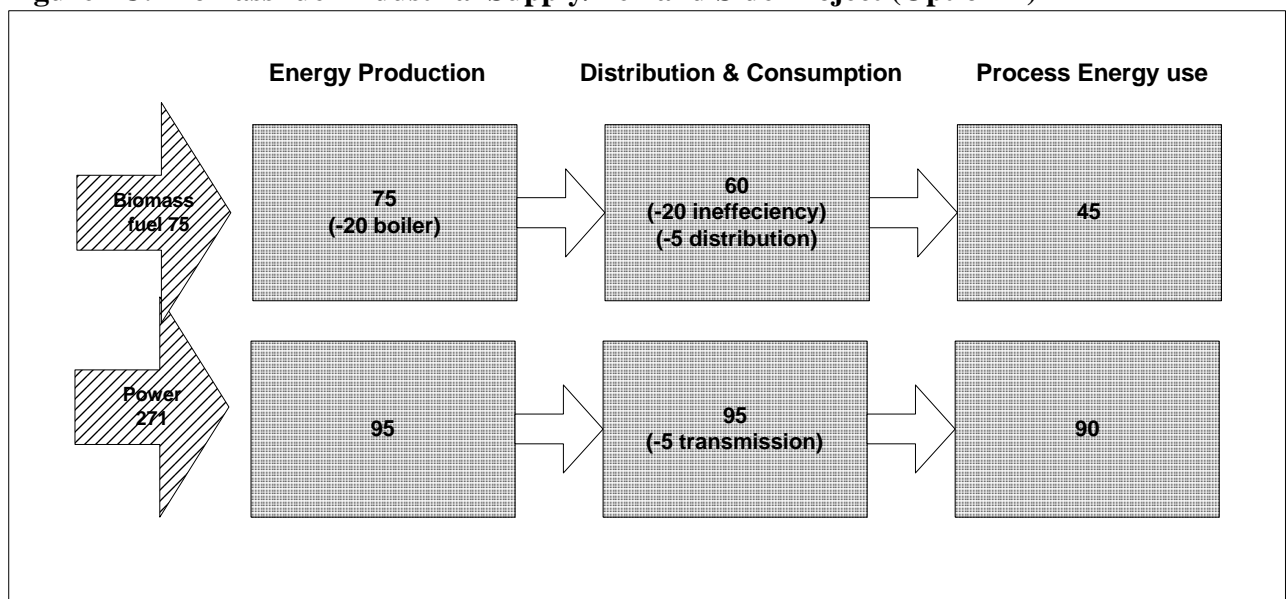
<sup>18</sup> Both power and heat production is calculated as being based on fuel oil for reasons of simplicity.

**kg CO<sub>2</sub>**, and the total emissions from the system (from power uses only) are therefore 833.68 kg CO<sub>2</sub>.

In Option B below, the manufacturing industry implements a biomass boiler, and hereafter establishes energy efficiency in processing activities etc., which leads to 50 % reductions in energy losses. The corresponding input of energy resources are thus similarly reduced, while performing the same energy service as in Option A.

CO<sub>2</sub> displacements from heat uses still equals 291,6 kg (even though energy efficiency have been applied), and the total CO<sub>2</sub> emissions from the power supply equals (286-271 litre oil = 15 litre oil\*39.4=591 MJ = 0.591 GJ\*74 kg CO<sub>2</sub> per GJ ) = 44 kg CO<sub>2</sub>. In total the CO<sub>2</sub> displacement are (291.6+44) = **335 kg CO<sub>2</sub>**. The total efficiency of the system is estimated to  $\eta = 45+90 / 75+271 = 0.4$ .

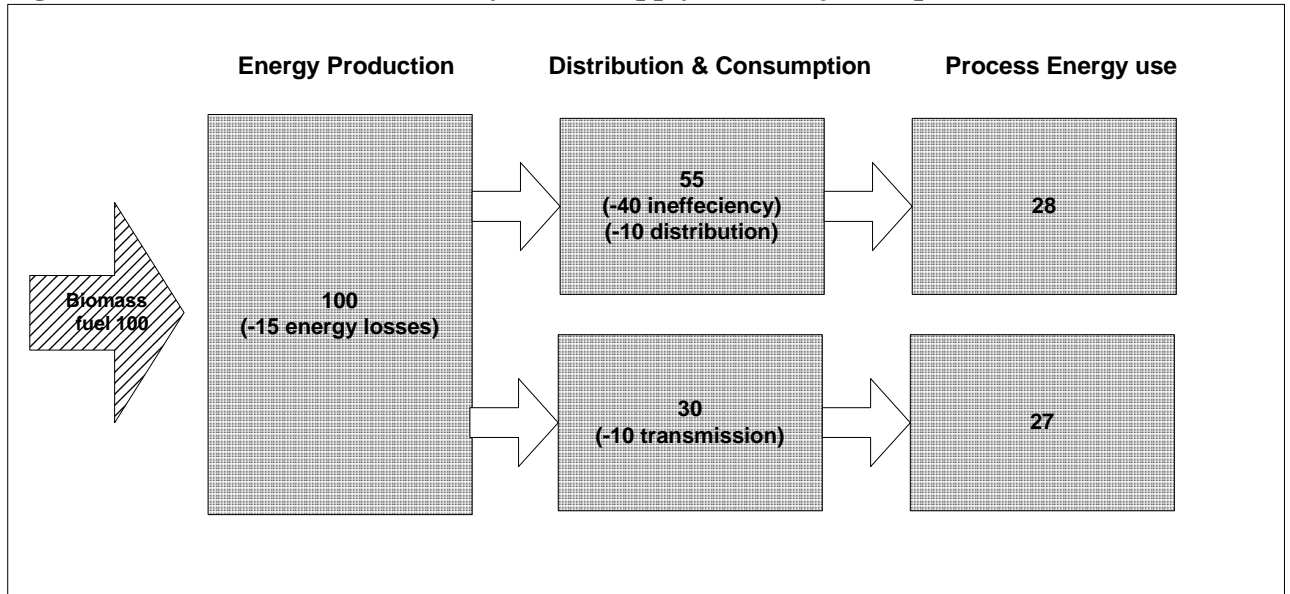
**Figure 7C: Biomass fuel Industrial Supply/Demand Side Project (Option B)**



Source: Own figure

In Option C1 below the manufacturing industry replaces the individual fossil fuel boiler, and the grid connected power supply, with energy supply from a CHP Plant. No means of energy efficiency are applied in this option.

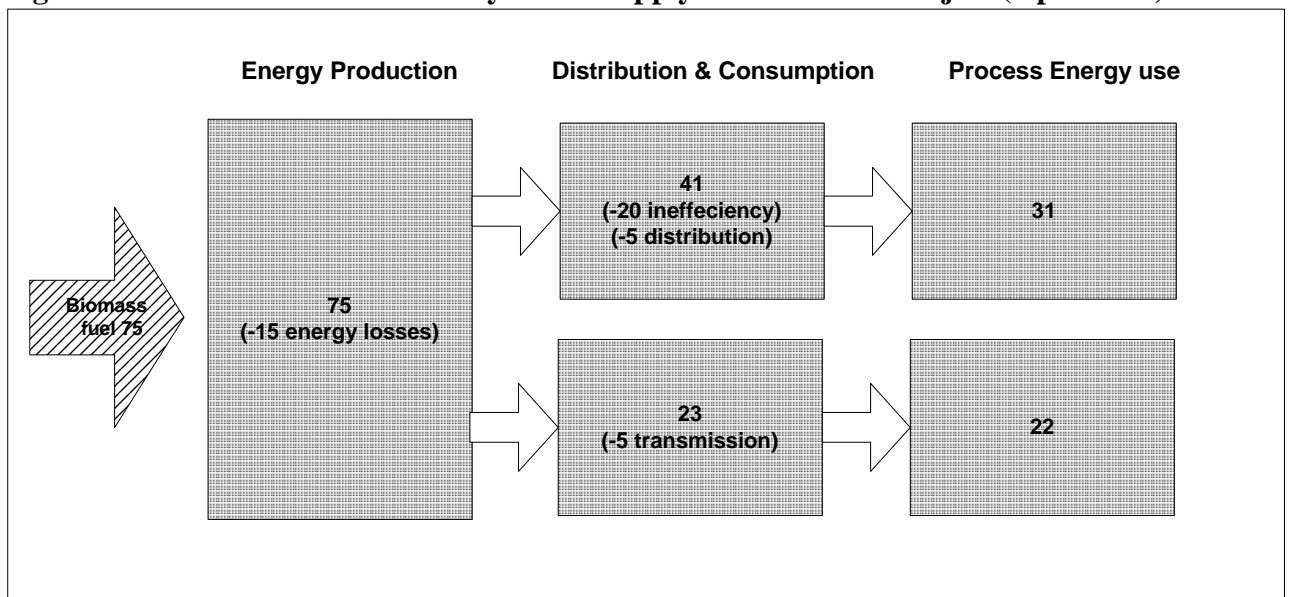
**Figure D: Biomass fuel Industrial Systemic Supply Side Project (Option C1)**



Source: Own figure

CO<sub>2</sub> displacements from heat uses once again equals 291.6 kg, and from power supply the total amount of 833.86 kg CO<sub>2</sub> is substituted, totalling **1,125.5 kg CO<sub>2</sub>**. The total efficiency of the system is estimated to  $\eta = 28+27 / 100 = 0.55$ .

**Figure E: Biomass fuel Industrial Systemic Supply/Demand Side Project (Option C2)**



Source: Own figure

In Option C2 above the CO<sub>2</sub> displacements are the same as in Option C1, but energy efficiency is applied on the system. The advantage of the system above is, however, the relatively low fuel supply, and thereby pressure on natural resources. Thus, CO<sub>2</sub> displacement equals **1,125.5 kg CO<sub>2</sub>**, and the total efficiency of the system is estimated to  $\eta = 22+31 / 75 = 0.7$ .

## 7.1.2 Comments

### *Generation of CER's*

As illustrated by the examples above, application of energy efficiency generates no CER's, when implemented *after* a conversion to biomass fuels. It is thus an activity which has no economical impacts for project developers, as it does not generate CER's. In the case of transformation of the industrial energy supply, as illustrated here, it is important that such activities are promoted, as it is a precondition for supply of - eventually later implemented - district heating to industries.

The promotion of energy efficiency in industries - which prepare for a later suggestive development of the system - could beneficially receive a certain amount of CER's, as to create incentives for project developers to implement energy efficiency. A type of graduation of CER's could be applied, in which energy efficiency - for instance implemented in industries as a preparation for a later connection to supply district heating - receive larger amounts of CER's, compared to ordinary CDM activities. The purpose of this is to promote energy efficiency *before* fuel switch initiatives.

It is quite clear from the examples above, that emission reduction by means of *various activities* (as for instance Option C2) along the materials and energy chain, lead to higher total CO<sub>2</sub> emission reductions compared to single standing initiatives in a limited part of the chain. It is thus appropriate to take an integrated approach to emission reduction, as the CO<sub>2</sub> displacement will be relatively higher when doing so.

The price of power has been quite steady recent years (THB 3.2 per kWh in 2008 data), whereas bunker oil prices has doubled from 2001 to 2008 (THB 18-20 per litre in 2008 data). When looking at the price structure, the focus of CDM projects in Thailand should therefore be to subsidise the 'heat-side' of energy production. In general, the pay-back period for heat production projects in Thailand is 1 year, whereas it is 3 years for CHP projects (Møller, 2008). So, even though CHP is more cost-full than heat-only technologies, it supports an integrated approach. The additional power produced on CHP Plants, not applied on heat-only plants, will in the long run leads to higher CO<sub>2</sub> abatement (and more CER's generated).

## 7.1.3 Options for transforming the energy supply system

### 7.1.3.1 'The transformation process'

As already pointed out in Chapter 6, it is evident that Option C2 is the most appropriate option when it comes to fulfilling the sustainable development concepts (Part I.), defined in Section 2.2.1.4, Chapter 2. For the project developer, however, Option C1 generates just as many CER's as Option C2, in which energy efficiency initiatives are included. Thus, from the point of view of generating CER's for emission trading, no incentives talks for selecting Option C2. Thus, energy efficiency must generate 'extra CER's', or be a part of a process in which energy efficiency (saved energy) can lead to expansion in the numbers of industries supplied by district heating.

It is, however, not likely that all industries find Option C1 and C2 attractive economically, and Option A or B might be the starting point for the transformation of the energy supply in some situation. According to the sustainable development concepts (Part I.), it is favourable to pursue the possibilities given by Option B, in which energy efficiency are included.

From a sustainability point of view it is not recommendable to let the starting point be energy efficiency, *if* it is a barrier for an actual fuel switch. The energy supply would in that case still rely on non-sustainable energy sources. Substituting the use of fossil fuels is thus a superior solution, but if energy efficiency *can* be implemented before an actual fuel switch it is quite beneficially and can generate income from CER's. If fossil fuel substitutions cannot be implemented for various reasons, energy efficiency could be pursued, not only due to the reduced amount of fossil fuels required, but most importantly for the continuing possibility of a suggestive transformation of the energy supply system later on.

By prioritising the option's in this order the industries will 'prepare' for a later connection to the district heating network, and at the same time establish a back-up supply of energy if temporary break-down in the supply of district heating occurs. Even though the individual biomass boilers will be over-dimensioned (too large capacity) when energy efficiency is implemented later on - reducing the overall energy requirements at the industry - this will be beneficial as a buffer for a higher industrial output and thus meet energy requirements that might occur later on.

The CHP technology can beneficially be implemented on a larger manufacturing industry using large quantities of high quality process heat, thus, where the 'heat market' is largest. In the case of Navanakorn, the CHP Plant could be placed at Imperial who has a relatively large energy requirement, as shown in Chapter 6. Later on, as energy efficiency are applied on the industry, the demand for energy decrease and 'waste heat' can be transmitted to other industries as cascading of steam and district heat. These industries will also have implemented energy efficiency, which prepared them for supply of district heating.

It will be more costly to go from Option A to B and then to Option C1 or C2, than directly to pursue Option C2. As mentioned, some stakeholders might think that this transformation is too cost full, and would prefer a more suggestive development even though it is more expensive in the long run. However, the slower pace of the suggestive development might also imply that more manufacturing industries would like to participate over time.

#### **7.1.4 The interests of case industries**

Apart from what is practically possible and feasible economically is the interest of industries in participating in different transformation processes. This issue is very context dependent, and must be examined in each case, which can lead to a different speed of implementing the biomass CHP technology with district heating. The section below is based on interviews with case industries in Thailand conducted in January/February 2007:

According to the empirical data, case industries do not necessarily pursue the option implying implementation of individual biomass boilers. Operating biomass boilers, compared to a joint system based on district heating, are not viewed as a more unproblematic or un-risky energy supply option. On the contrarily, if implementing biomass boilers, the industries will have to deal with operation of the boilers and the supply of biomass wastes. The latter also from

external sources, as the internal waste generation is too limited to cover the actual energy demand.

The industries' view when it comes to participating in a joint district heating network is simple: If the economic risk, and the practical issues related to operation and supply of biomass waste, is taken by someone else, they would like to participate. Their knowledge is limited to the manufacturing of goods and feeding the boilers with fuel oil. Thus, they have no ambitions of becoming experts in operating biomass based supply of district heating.

They find the option of a joint energy system more attractive than implementation of individual biomass boilers, as long as experts in this field will operate the plant etc. The reasons for this willingness to participate is off source increasing prices of fuel oil (from 9 to 15 THB/litre in 7 years), but also a growing concern for the environment, as they recognise the negative impacts of fuel oil on the local as well as global environment. The economically and practically concerns, are, however, still the main motivation for agreeing to participate in a joint energy system under the conditions of 'no responsibility'.

One industry stands out in the sense that they would like to invest or co-invest in a joint energy system, namely Imperial Industrial Chemicals. This industry consumes around 11,000 MWh of steam yearly, and the 'waste heat' from this consumption could cover the process heat demands in the remaining industries (when converted to water based demand). Even though the industry is categorised as a SME, it uses relatively large amount of energy to supply steam to reaction processes etc., taking place within the industry. So, in this case study, one of the industries was willing to invest or co-invest in an energy system increasing the energy efficiency and converting it to a non-fossil fuel supply.

The conclusion from the above discussion is that implementation of biomass boilers in SME's not are viewed as an attracting option, as it implies extra work and knowledge that exceeds the capacity of industries. It that sense continuous operation of the fuel oil boilers are preferred, as it is a simple task to operate and fuel them, even though the prices have increased quite dramatically recent years. The joint system is viewed upon positively and if implemented and operated by professionals - and with 'no responsibility' except from Imperial - this would be a good option to the presently applied energy supply.

## 7.2 Discussion

But how is it possible to combine the energy 'transformation process', with the priorities and wishes of the industries? Thus, how can the industrial sector be prepared or formed to participate in the transformation process? This will be emphasised in the following.

As already mentioned in Chapter 5, enhanced regulatory focus on 'heat' - here understood as CHP - could facilitate the transformation process proposed and lay the foundation for industrial participation. The Thai strategy on renewable energy and energy efficiency already focus on industries, biomass and 'heat'. In order to enhance the '*link between national and local levels*', I therefore suggests that the Thai Royal Government initiate a 3-year National Master Plan (on a mandatory or voluntary basis), in which the industrial sector in Thailand (industries located in Industrial Parks) undergo thorough actions in regards to energy efficiency and consumption of heat.



The overall purpose of the National Master Plan is to lower the total energy consumption in industries (quantitative) and to convert the industrial use of steam to a water based demand where possible (qualitative). The Master Plan should not only be limited to food-, wood and chemical industries, but cover all manufactures located in the sites mentioned.

I also suggest, that actions on energy efficiency should lead to higher amounts of CER's (a CER's 'ADDER'), as to create incentives to apply energy efficiency in industries *before* other types of actions (as for instance fuel switch).

Such actions will imply large saving in GHG emissions appropriate for trade through CDM. By bundling the projects and using the programmatic CDM approach (pCDM), the costs could be kept at a reasonable level. When the Master Plan is implemented an additional 3-year Master Plan can be commenced, in which the type of 'transformation process' is selected in each specific context. This transformation will, again, imply large GHG savings appropriate for trade. Whether being individual biomass boilers or a joint supply of district heating, it can once again be bundled and enjoy the pCDM approach.

If such Master Plan can be implemented it is very beneficially, as it shows *consensus on long-term vision* for the Thai society, and the chances for sustained environmental impacts increases. It is thus recommended that MoE, IEAT and MOI jointly set up such regulatory frameworks for this vision for targeted Thai industries (see more details on Thailand in Chapter 9).

## 7.3 Extraction of elements for the Manual

### Planning Guide elements

- Transformation 1: Place the biomass CHP Plant at the industry consuming the highest amount of energy, with previous energy efficiency applied;  
Seek local industries' connection to the district heating network, with previous energy efficiency applied for appropriate coverage of energy demands by district heating;
- Transformation 2: Place the biomass CHP Plant at the industry consuming the highest amount of energy;  
Replace the existing fossil fuel boilers at the other industries with more efficient biomass boilers;  
Improve the energy efficiency within the industries at a later stage (both the large industry with the CHP Plant, and those to be connected to the district heating network);  
And by then connect the CHP Plant to a district heating network for collective supply of energy to all industries;
- Clarify which interests industries have in participating in either of the two transformation processes. As this would be context dependent, one transformation process might not be the right process in a different context. The starting point of the transformation depends upon the interests of the industries, as well as on governmental actions etc. If energy efficiency, for instance, is applied in all industries, it is more likely that Transformation 1 will be selected;

## Policy Recommendations

- Set-up a National Master Plan consisting of two steps that will enable any of the above mentioned Transformation Strategies;
- Set-up a CER's 'ADDER' that will act as incentive for realising CER's from projects dealing with energy efficiency, based on National Master Plan actions in industries (before commencing fuel switching);

## 7.4 Revolving the development effect of CDM projects

Previously, I have emphasised on the use of Industrial Ecology etc. as a means of approaching industrial activities, energy production and consumption etc., thus a '*materials and energy chain-approach*'. In the following, I will introduce a quite similar approach to understanding industrial activities, but with emphasis on the economical side of these processes. The '*value chain-approach*' addresses economical consequences of production activities. It is therefore useful for pointing out areas of importance when enhancing the sustainable development contribution of future CDM projects. Below, I will look into different options for expanding the value chain connected to future CDM projects in Thailand.

### 7.4.1 Upgrading the energy supply

In this section, I will identify four potential means of upgrading the energy supply, which has positive impacts on the Thai value chain at many levels.

#### 7.4.1.1 Industrial energy supply

Option A in Section 7.1.1, '*Biomass fuel Industrial Supply Side Project*' implies a relatively simple value chain, which consists of: Biomass fuel input, Conversion technology (boiler), Thermal energy output and Energy use. The value chain is quite limited and possibilities for expanding it to a more advanced level are limited. Due to the relatively narrow value chain, it is likely that Option A carries great inefficiencies in the use of materials etc. (biomass fuel, energy production and consumption). Also, power supply must be transmitted from the outside, and therefore add negative to the value chain. An upgrading of this system - as proposed by Option B '*Biomass fuel Industrial Supply/Demand Side Project*' - implies a more efficient production and consumption of the energy, but the value chain largely remains the same.

#### 7.4.1.2 Upgrading

The *first upgrading* is to identify appropriate industries or waste generators, which can contribute with valuable biomass wastes, that otherwise, would have been discharged or inefficiently reused. This can be industrial waste, organic household waste or agricultural wastes from the local community. By using the discharges from various 'waste generators', the biomass waste will be included in a value chain and substitute the use of fossil fuels, which presently is an economic burden for industries (add negatively to the value chain). Moreover, the present waste handling costs, as for instance waste transportation to landfill areas, will be reduced, etc.

The *second upgrading* is to make sure that the positive impacts (environmentally and economically) from the potential use of biomass waste for energy production, is improved even further by applying energy efficiency. This can be obtained by implementing energy efficient equipment, by converting from high to low qualitative energy, by process integration and cascading of energy, the latter through district heating networks if implemented. This will add value as saved expenses on energy (quantitatively) and through lower temperature requirements of for instance process heat use leading to resource savings' (qualitatively). As illustrated earlier, energy efficiency can also add value through CER's generation if implemented *before* an actual fuel switch takes place.

The *third upgrading* is to apply production of both power *and* heat by for instance a CHP Plant, increasing the total efficiency of energy production and limiting materials consumption. The generation of both power and heat add another value chain to the supply of energy, as power will be generated internally and not transmitted from the grid, which presently pose an economic burden for industries. Power, not consumed within the industries, can be sold on the grid or to other industries nearby or to the national grid.

The *fourth upgrading* is to identify local manufactures of energy technologies, so as to expand the value chain to local manufacturing of renewable energy technology. If the technology cannot be manufactured by local suppliers, but require transfer from developed countries, another type of technology supply should be established, focusing on creating an expanded value chain through a domestic *distribution* system or chain. This upgrading will have a positive effect on local manufacturing industries, as they can engage in an expanded value chain with new business opportunities emerging.

## **7.4.2 Revolving development opportunities**

In this section, I will identify the opportunities for setting up manufacturing of energy technologies in Thailand; How it can be done and which technologies primarily to focus on in order to enhance the development effects.

### **7.4.2.1 Profile of the value chain in developing aid**

Development projects often struggle with a disproportion in project contribution. Not more than 20 % of the project contribution normally comes from the host country, whereas the remaining 80 % comes from developed countries. The 20 % contribution from the developing country is often - especially for energy projects - related to construction of the buildings etc., that are required for implementing and operating the energy facility. All other equipment (for CHP: pipers, boilers, turbines etc.) will be transferred from developed countries. Supply of spare parts etc. will most often also stem from developed countries. In most cases local jobs will be provided by maintenance and operation of the implemented energy plant, and the contributions to the 'hardware-side' of development projects, as mentioned, often be limited to building facilities. The spreading effect on other related branches and suppliers are thus limited or non existent (Kjær, 2006).

The above example illustrates that a very large part of the value chain stay's within the developed countries, and that the impacts on developing countries - from this 'global outsourcing' of activities - is quite limited (Gereffi & Sturgeon, 2004). The development effects would thus be more significant, if a larger project contribution from developing countries could be applied, and a similar lower contribution from developed countries could

be realised. This would not necessarily imply that more inefficient local technologies should be applied, but merely that another sort of distribution system could be promoted. Off course, if technologies with great potentials already exist in the developing country, resources from the North should be channelled as know-how to develop them even further. The 'technology transfer' must thus focus more on the know-how side, as opposed to the hard-ware side of transfer.

It would also not necessary imply that jobs are lost in countries in the North, or that the developing countries in the South will 'take-over' innovation of the specific technology and by-pass further technology development in the North - and thereby take over the market for renewable energy technologies.

As far as the first issue, literature suggests that as long as the distribution system is market-seeking, a 'global outsourcing' of activities will have either a beneficial or a neutral impact on the employment in developed countries. Most often, however, the new markets in developing countries will have a spin-off effect on the economy of countries in the North, when it comes to provide management and product innovation and development jobs, and to generate cash that might be used for domestic development etc. (Gereffi & Sturgeon, 2004). According to the Federation of Danish Industries (DI) this viewpoint seems highly accepted, and do not lead to concerns about the employment impacts on Danish companies, as the innovation and know-how connected to the technologies are expected to continue to be performed in the North (Hauch, 2008).

As far as the second issue, experience from South East Asia show that countries in the South are perfectly capable of manufacturing the technologies from the North, if adequate training and transfer of know-how is applied, but further innovation of the technologies is not likely to happen due to lack of capacities (Holm, 2008).

Several stakeholders also point to the inefficiency in transfer of hardware from the North to the other side of the planet in the South - being boilers from Vølund or wind turbines from Vestas. It makes little sense to transport the hardware over such distances, instead of setting up the construction of these technologies in the South, and create new business opportunities in developing countries (Møller, 2008 & Holm, 2008 & Prapasawad, 2008 & Greasen, 2008 & Prakitsri, 2008).

#### **7.4.2.2 Suggestions for a new distribution chain**

The distribution chain to be developed in host countries - here emphasising biomass CHP with district heating - is based on one or more *mega-suppliers*, contributing with for instance biomass boilers, district heating pipes and heat exchangers etc., manufactured in the host country or near by (not merely shipped from European countries). The mega-suppliers use equipment, materials and resources etc. from a *local supply-park* that develops and evolves around the mega-suppliers. Thus, the new distribution chain evolves around a local value chain, in which a higher part of the economic values generated in the distribution chain, *stays* within the developing countries in the South.

In the case of Thailand several companies already manufacture boilers, but the efficiency is not as high as boilers produced in for instance Denmark. The knowledge of designing furnaces for optimal conversion of biomass waste is thus limited in Thailand. In Malaysia boiler manufactures have enjoyed partnerships with a Danish boiler manufacturer named

Vølund, which have resulted in a more efficient technology with enhanced capacity to convert the waste from palm oil mills.

I suggest that such partnership is established in Thailand, between for instance Vølund and Bangkok Industrial Boilers or/and Hansa Boiler International, which are Thai companies with many years of experience in producing different kinds of boilers (Møller, 2008a). Such partnerships could also be established between Danish manufactures of district heating pipes (for instance Logstor or/and StarPipes), and relevant stakeholders in Thailand with knowledge of pipes for heat transmission, as for instance Tor Nam Thai (Sutiratana, 2008). Manufactures of insulated district heating pipes from Finland have previously been in Thailand, but do to lack of markets they pulled out of the country (Møller, 2007b). With the proposed market expansion discussed in the section below, it would, however, be possible to sustain a production of districts heating pipes in Thailand.

Also potential manufactures of heat exchangers in Thailand (as for instance Genesis) could be include in the effort to set up a local manufacturing scheme of biomass CHP with district heating. The steam turbine technology can for instance be provided by AG Kuhule, Kopp & Kausch, which origin from Germany. In Singapore, however, an authorised dealer of this technology 'Jepsen & Jessen Technology' is situated, and could provide the turbines required (Møller, 2007a). The company already has a local/regional experience in manufacturing efficient turbines, so an actual production in Thailand would not be reasonably. Also, Thailand has no previous experience in steam turbine manufacturing, and as it is a highly complicated technology to produce I recommend imports from the nearby Singapore or from China.

With or without a specific turbine manufacturing in Thailand, a local supply park will have to be established for spare parts and maintenance etc., so parts of the value chain will stay in Thailand. The above manufactures can act as the Mega-supplier, and a local or regional supply-park evolves around this manufacturing.

### **7.4.2.3 Market expansion**

The new distribution system requires that a large market (technology demand) for biomass CHP with district heating can be established, as the investments in setting up mega-supplier's, as well as the supporting supply-parks, are high. A potential market in Thailand for biomass CHP are, as earlier stated, the Industrial Parks in Thailand. Within these parks many industries are located with a demand for power and heat. Relevant biomass wastes are generated by industries placed in these areas, as shown in Chapter 6. Also, agricultural waste and organic waste from households and commerce in the community etc. can be supplied as fuel (Lybæk, 2004). In Thailand around 70-80 Industrial Parks exists, and in Asia a large part of the worlds 12,600 industrial parks are placed (GTZ, 2000). There is thus a great potential for spreading the technology, not only to Thailand.

As mentioned above, the market expansion can be commenced by a National Master Plan, in which actions within the Thai Industrial Parks are initiated by a two step plan. The first step would be to establish quantitative and qualitative energy savings in all industries located in Industrial Parks in Thailand, and then secondly, to implement biomass based CHP with district heating. In this way the biomass based CHP is connected to the existing national policies on 'DSM & EE'. On top of that it is, off course, important to evaluate whether the renewable energy resources identified are appropriate for the potential market identified. In

Thailand, the renewable energy resources available are mainly 'biomass resources', which are the case in many developing countries in SEA.

#### **7.4.2.4 Employment opportunities and biomass technologies**

Another issue which is important to include when increasing the sustainable development contribution of CDM projects, is the type of projects (technologies) to implement. Several studies point to a very different output in job creation for different kinds of technologies implemented. As effort is made to enhance the CDM in developing countries, this inequity is important to emphasise.

Research data indicates (Kjær, 2006), that biomass related technologies tend to be labour-intensive. The implementation of biomass technologies, as opposed to other types of technology implementation, could thus imply positive economic benefits for local communities in the developing world. This conclusion is also argued by IEA, the International Energy Agency, who state that:

*"...it is clear that bioenergy can significantly contribute to employment at local, regional and national level. [...] bioenergy is the most labour-intensive technology and has the highest employment-creation potentials"* (IEA Bioenergy, 2005:8).

And further:

*"Among other renewables, bioenergy is the most promising for the developing countries, as its mobilization can provide large employment generation scheme"* (IEA Bioenergy, 2005:7)

In my opinion, it is beneficial to implement biomass CDM projects in developing countries, as opposed to other projects, where possible. The long term impact when it comes to job creation and the related income generation is thus higher compared to other technologies.

Implementation of wind power and solar cells are for instance characterised by creating jobs in the 'construction phase', whereas the 'maintenance & operation' are relatively limited. For biomass technologies the majority of the jobs created are placed in 'maintenance & operation' and in the supply of fuel to the energy facility (IEA Bioenergy, 2005 & Kjær, 2006).

In the lifetime of such technologies the benefits for local communities are thus much higher, compared to technologies primarily providing job in a relatively short 'construction' period. Creating jobs in both short term (construction/manufacturing) and long term (M&O and fuel supply) has thus high priority. Such job creation could potentially be targeted marginal groups in Thailand, as to increase the level of income distribution and education for this group of people, who has been increasingly marginalised in post-agricultural Thailand (Laird, 2000 & Sukkomoed, 2008).

On top of the direct jobs created by implementation of biomass technologies indirect jobs will be created, as the direct employment creates income and demands, which again creates new jobs. Direct employment normally leads to indirect employment at a level 2 to 4 times the direct employment (Kjær, 2006). If Thailand manages to establish itself as a *mega-supplier* of biomass CHP with supply of district heating, including a large *supply-park* as discussed earlier, it will benefit employment even further, both directly and indirectly.

### 7.4.2.5 Costs of technologies

To make the transformation of the energy supply system as less cost full for the Thai society as possible, I also suggest the implementation of reliable and proven technologies with reasonable cost levels per unit of generated energy output. This will assist Thailand in lowering the economic burden on transforming the energy supply system, and secure a reliable and stable energy supply. Thus, Thailand will not be exposed to technology experiments, but solely to stable and reliable energy schemes.

## 7.5 Discussion

A stronger '*people centred*' approach to the implementation of CDM projects in Thailand could be applied in the future. 'Poverty reduction' is very much an issue of concern in Thailand these years, as a group of people has not obtained access to the increasing wealth in Thailand over the last 20 years. These groups of people have thus not benefited from the previous increase in income distribution in Thailand; thus the value chain has not penetrated down to this population (Sukkomoed, 2008). This could be resolved by making this group of people 'targets' for a new income distribution scheme in Thailand, enabled through enhanced CDM projects.

By looking at potential technologies that benefits 'short and long term employment', this group of people can be integrated in the value chain by various means: '*Long term employment*' for this group of people would be supply of biomass (agricultural waste or the growing of energy crops), and maintenance of the technology (or parts of it). '*Short term employment*' for this group of people is connected to the manufacturing of the technology (or parts of it). Thus, the value chain-approach has assisted in identifying future potential beneficiaries of enhanced CDM project activities.

Energy technology manufacturing in Thailand is, with a few exceptions, of a relatively low standard compared to the technology manufactured in the North. Imports of equipment from the North are therefore often applied, and almost any technology or project idea with a connection to the North is regarded as a quality proof (Salam, 2007). On the other hand, analysis above indicates, that Thailand actually have a large resource base when it comes to manufacturing energy technologies, and it is identified *how* Thailand can set up a local technology manufacturing scheme. It can therefore be concluded, that the value chain connected to energy technology manufacturing has not yet fully benefited the Thai producers.

Thus, the value chain-approach exercised here has identified weaknesses (no production of efficient renewable energy technologies in Thailand, but mainly imports), *and* possibilities (potential manufactures of energy technologies in need of transfer of know-how to improve the technologies). Technology manufacturing in Thailand can therefore '*develop and build on existing capacities*', by relying on and enhance the local resource base in the country. This technology manufacturing must, as mentioned earlier, be based on the production of proven and reliable technologies that are cost effective, as to lower the economic burden of transforming the energy supply system in Thailand.

By connecting the development of a local manufacturing of ‘appropriate biomass technologies’ in Thailand with ‘poverty reduction’, enhanced CDM projects can assist in expanding the value chain in Thailand on several levels with multiple purposes and benefits, improving the ‘*comprehensiveness and integration*’ of the CDM activities in Thailand.

## **7.6 Extraction of elements for the Manual**

### **Planning Guide elements**

In order to create changes in the value chain, with the purpose of enhancing the opportunities for resources *not* being transferred to the North, the following initiatives can be applied:

- Preferably select CDM project activities with a potential of high value chain expansion, by establishing as many upgrading as possible and thus potential development effects;
- Look at the market potentials for ‘spreading the technology’ and the match of identified ‘renewable energy resources’;
- Identify if local manufacturer of appropriate technology exist (or parts of technology), as preferably to apply local/regional manufactured technology;
- Preferably select biomass technologies before other renewable energy technologies, as the employment effects is highest;
- Implement cost effective technologies to lower the economic burden for the Thai society in transforming the energy supply system;

### **Policy Recommendations**

In order to create changes in the value chain, with the purpose of enhancing the opportunities for resources *not* being transferred to the North, the following initiatives can be applied:

- Identify potential manufactures of energy technology locally/regionally, to commence a joint venture with foreign (for example Danish) manufactures of efficient energy technology;
- Set-up Mega-Supplier’s of appropriate technologies, based on skilled Thai craftsmen and local resources utilisation in general;
- Set-up a local Supply-Park of goods and materials to service the Mega-Suppliers, based on skilled Thai craftsmen and local resources utilisation in general;



## Chapter 8; Planning Guide, PDD elements and case example

This chapter is separated into two parts: One Part is dealing with the Planning Guide based on the 'Planning Guide elements' identified throughout this study (Part I.A.), as well as on extracting PDD elements for future CDM project activities (Part I.B.). Another part of the chapter exemplifies the Planning Guide and applies the PDD elements on a Thai case study (Part II.). At the end of the chapter, I sum-up on the sustainable development contribution posed by the project activity on the specific Thai context addressed.

All 'Policy Recommendations' identified throughout the project report, are, as stated earlier, integrated into strategies for strengthening the overall Institutional & framework conditions in Thailand, presented in Chapter 9.

### 8.1 Part I.A.: Planning Guide

In the following section, I present the 'Planning Guide elements', identified throughout the project report, in a planning process following a logical planning order. The planning process takes its departure in the implementation of a sustainable energy technology posing many development possibilities for Thailand; the 'biomass CHP with district heating' (Option C in Figure 2D, Chapter 2). This technology is discussed up against other renewable energy technologies, and especially the biomass boiler (Option B), as to emphasise the advantages of the first. From the planning process described above it will be possible to draw out PDD elements leading to enhanced CDM projects.

Figure 8A below, illustrates the planning process of implementing 'biomass CHP with district heating', and the extraction of PDD elements. In the section below, I will arrange the 'Planning Guide elements' extracted throughout this study in a logical order following the planning process shown in the figure. If necessary, I will add additional elements to the Planning Guide not extracted in the study. The section that follows, will elaborate on the extraction of PDD elements.

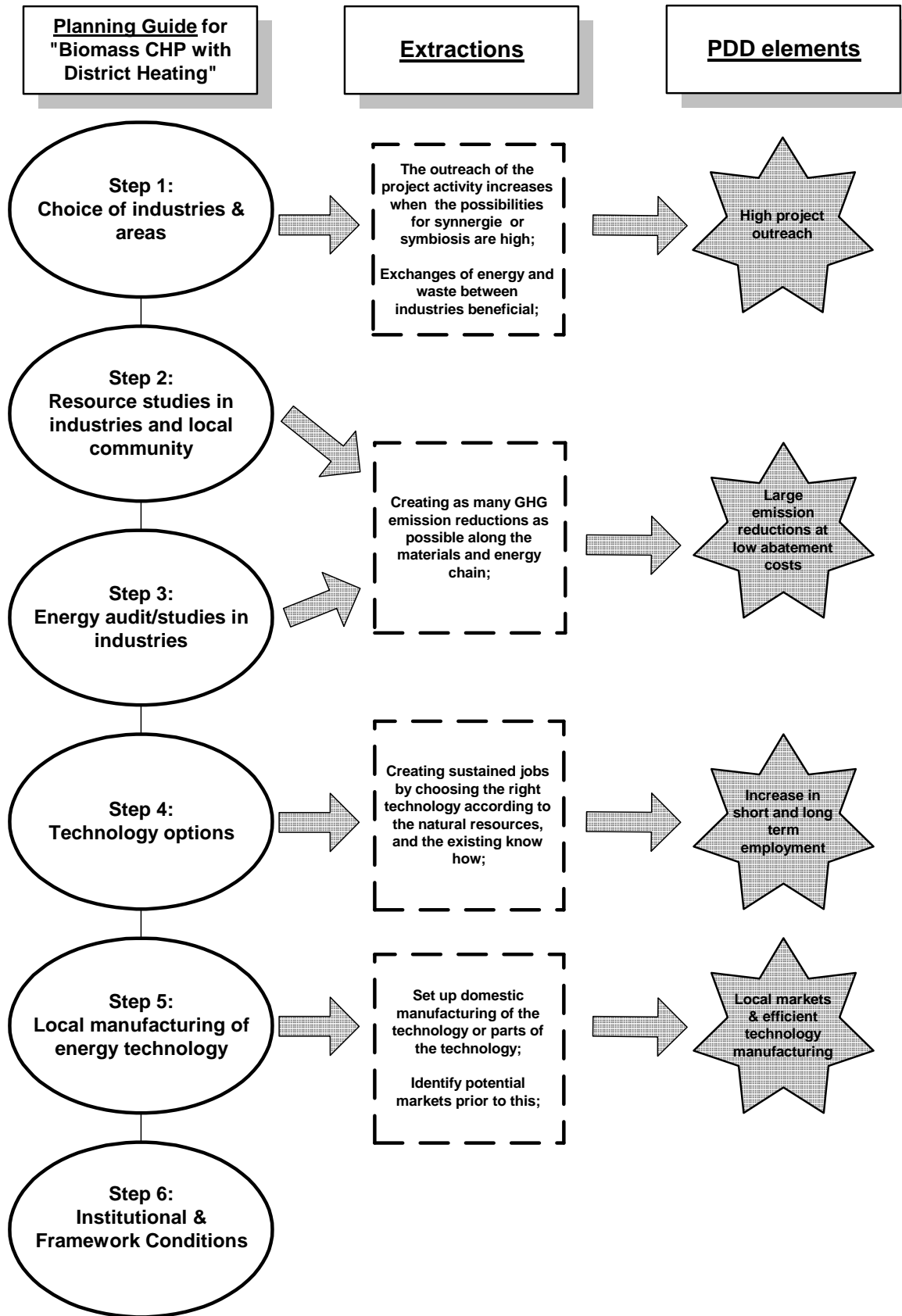
#### 8.1.1 Introduction

- Preferably select CDM project activities with a potential of high value chain expansion, by establishing as many upgrading as possible and thus potential development effects; (from Chapter 7)

##### ***Pave the way for future value chain upgrading***

The Planning Guide takes its departure in a *value chain expansion*, inspired by the upgrading of the energy system described in Section 7.4.1. Each step of the Planning Guide will enable, that later steps of the Planning Guide - and thereby even further value chain upgrading - are possible. The Planning Guide thus enables future activities not necessarily taken now, by identifying appropriate frameworks - or development path - for project activities. Thus, the Planning Guide is open for project activities implemented with different speed depending on local conditions, etc.

**Figure 8A: Planning Guide for biomass CHP with district heating and extractions of PDD elements**



Source: Own figure

## 8.1.2 Step 1: ‘Choice of industries and areas’

The first value chain expansion, outlined in Figure 8A above, is to *identify appropriate areas and target industries* for CDM project activities. By identifying resources previously treated as waste and converting these into valuable fuel for energy production consumed locally, a value chain upgrading at several levels are achieved. The purpose of the first value chain upgrading is thus to enable exchanges of materials and energy - applied now or later - and enhance the future outreach of CDM projects. This is described below:

- Identify Industrial Parks, or relevant industrial areas, in which industries are located close to one another; (from Chapter 3)

### *Identify appropriate sites*

To improve the possibilities for creating CDM project activities in Thailand with many development opportunities for the country, it is important to point out areas in which such projects can evolve, if necessary through a later suggestive development. In Industrial Parks the industries are located close to one another and relevant biomass residues are generated within and outside the site. This means that it is possible to establish symbiosis or apply Industrial Ecology principals between industries located in these sites, as options for exchanges of materials and energy are present. This means that many resources, which now are being wasted, can be re-used within such Parks.

Production and consumption of power *and* heat within the Industrial Parks is another possibility, as the market for heat is constituted by the industries located within the Parks. This means that energy wastes - such as the one that happens on for instance stand-alone palm oil or rice mills etc. - could be eliminated, as a market for excess heat exists. Likewise, industrial biomass residues, which previously were regarded as inappropriate for on-site energy production could be feasible as it will be collected from many sources, making it more appropriate for energy production. Such locations thus enable that materials and energy exchanges can be applied, as for instance through a collective distribution of power and heat by means of CHP. If biomass waste from the local community is re-used, instead of being discharged to landfills etc, it limits the pressure on locating dump sites and reduces the methane emissions from biomass decay, thus lowering the CO<sub>2</sub> emissions.

- Point out the food, - wood and chemical industries located relatively close to one another in the Industrial Parks, who is to become the main ‘CDM-industries’; (from Chapter 3)

### *Identify appropriate industries*

An identification of appropriate industries being especially relevant for conversion to biomass based supply of energy - either through implementation of biomass boilers or CHP - is pointed out. The focus is here on SME's and on those generating relatively large amount of primarily clean biomass waste (Lybæk, 2004). They are selected as appropriate target industries for distribution of process heat by means of biomass CHP with district heating. These industries are especially identified in the food, - wood and chemical line of business, but other types of industries like paper milling, tanning and brewery/soft-drinks businesses would also be appropriate (Ibid.).

It is beneficially to select industries acting as both biomass waste generators, as well as (power) and heat markets for the energy produced. The participating industries will in this way obtain 'ownership' to more than one part of the expanded value chain. The industries' commitment to participate will thus be higher, as they save expenses on both fossil fuel substitution, waste handling costs *and* on grid power substitution (when implementing biomass CHP).

- Preferably make improvements all along the materials and energy chain, as to increase the overall efficiency of the production process, and to avoid fossil fuel consumption; (from Chapter 3)

### ***Decentralise and decarbonise the energy supply***

The exchanges of materials and energy, which are possible within the identified sites and industries mentioned above, can also assist Thailand in decentralising its energy supply and thus help in limiting a huge economic burden put on the country (Laird, 2000).

The production of power on centralised power plants in Thailand is quite inefficient and primarily based on fossil fuels. There is no distribution of heat from the centralised plants, and this energy is therefore cooled down in cooling towers; thus wasted. By setting up renewable energy projects within Industrial Parks in Thailand, it gives the country a unique possibility of decentralising and decarbonising their energy supply. At the same time it improves the conditions for applying a more efficient use of energy in the Thai society; obtaining higher efficiency in the production, distribution and consumption of energy.

Through such decentralisation and decarbonisation of the presently much centralised energy supply, Thailand can achieve a higher energy self supply and rely less on fossil fuel imports, which they primarily do today as 60 % of the energy consumption is based on imports (Suksumek, 2008). The local community can be engaged in such decentralised biomass based energy supply at many different levels, creating jobs and new business opportunities, etc. Thus, waste from industries, households and agriculture etc. in the community can be re-used and thus benefit many potential local stakeholders.

### ***Establish high 'outreach' possibilities connected to future project activities***

As emphasised above, it is important to create good conditions for CDM project activities, by identifying viable frameworks or paths for a potential future suggestive development of the energy supply. Such 'viable frameworks' are obtained, if the CDM project proposed contains many different options for activities, connected to many different stages all along the materials and energy chain, and thereby contain potential *high project outreach*. This again leads to better possibilities for creating new business opportunities or/and avoided expenses (and thereby income) for stakeholders in the local community. Biomass CHP and Industrial Parks are therefore interpreted as 'Industrial Ecology Engines' or 'Symbiosis Motors', meaning that the many options for exchanges of materials and energy etc. within the Industrial Parks, can be materialised through the implementation of a biomass CHP Plant with supply of district heating.

- Include relevant local stakeholders in the project in order to enhance the benefits of the project activity in the local community. This can be relevant stakeholders at all levels of the materials and energy chain connected to the project activity, etc.; (from Chapter 4)

### ***Include relevant local stakeholders***

Relevant stakeholders are potential beneficiaries of setting up the energy system in the community. Firstly, it is waste generators from within the site: Industries, households, or owners/regulators of the industrial site, etc. Secondly, it is waste generators from outside the site: Farmers generating agricultural residues, and stakeholders responsible for waste generation and handling in the municipality or province, in which the industrial sites are located. These stakeholders must be included in the project activity to make it viably in the local community.

### **8.1.3 Step 2: ‘Resource studies in industries and local community’**

The previous upgrading focused on identifying areas with appropriate biomass waste for energy production, as well as on relevant industries creating potential options for later upgrading of the value chain for efficient production and consumption of energy. The present upgrading (Step 2), deals with options for achieving *large emission reductions in the production of energy*, by identifying available resources within the community and by selecting the most appropriate type of technology for the emission reductions. The following step (Step 3) deals with options for achieving emission reductions caused by energy savings within target industries.

- Preferably implement CDM projects leading to the highest CO<sub>2</sub> emission reductions, implying that attention should be given to the materials and energy chain as a whole, and not only to single standing initiatives; (from Chapter 7)

### ***Seek large emission reductions in production of energy - Materials chain***

CO<sub>2</sub> emission reductions can be obtained by using biomass residues previously treated as waste. It is therefore important to identify these resources as to enhance the possibilities for achieving high emission reductions by applying this waste in energy production, and thus phase out the discharge of valuable resources. In the following, some means of identifying biomass resources will be highlighted, but other resources than those mentioned below might be available in the given context:

#### Inside the Industrial Park:

*Industrial waste:* Biomass waste being either solid or liquid, which can be used for energy purposed (some of it must be pre-dried before incinerated). Large fractions of biomass waste highly appropriate for energy production (i.e. wood waste, sawdust), tend to be transported outs of the Industrial Parks, and re-used inefficiently for production of heat-only elsewhere.

*Household waste:* Relevant solid fractions from household waste appropriate for incineration.

*Waste from commerce/offices:* Relevant solid fractions from commerce/offices, like shopping malls, cinemas, hospitals, schools, etc.

*Sludge from WWTP's:* Waste water from the industries is often treated in central WWTP's at the industrial site. The sludge can be incinerated before going to landfills, or even digested in a biogas plant (together with liquid organic household waste), before being incinerated together with the industrial waste (Lybæk, 2004).

#### Outside the Industrial Park:

*Agricultural waste:* This type of waste can be any organic residues produced in the local community, like rice straw -and husk, as well as palm oil mill residues, etc.

*Waste from commerce/food markets:* Outside the industrial site there might be relevant solid biomass fractions available from commerce. Another possibility is the many fruit and vegetables markets in Thailand, generating various types of biomass waste that could be appropriate for energy production (shells, fibres, fruit and vegetable tops -or peel offs, etc.), of which some will have to be pre-dried before incinerated.

*Household waste from the Municipality and Province:* Also relevant solid fractions from the household waste generated outside the Industrial Park can be relevant resources for energy production. As the amounts of household waste in Thailand are increasing, the local authorities will be interested in finding other means of waste handling than landfill dumping (Lybæk, 2004).

In most cases, the majority of the waste mentioned above are being transported out of the Industrial Parks in Thailand, and dumped in landfills or directly on - in some cases unauthorised - dumpsites, leading to air pollution if burned uncontrolled or methane emissions if left to decay. As for the agricultural residues it is very common in Thailand to burn this waste on the fields, causing many environmental problems and traffic accidents due to the smoke developed (Sutiratani, 2008). Methane emissions are emitted when the waste decay on the fields, and when burned directly it causes particular emissions.

When using large amounts of the residues mentioned above in energy production, it will lead to CO<sub>2</sub> emission reductions all along the *materials chain*. Below, I will emphasise how to achieve many CO<sub>2</sub> emission reductions all along the *energy chain* connected to energy production.

### ***Seek large emission reductions in production of energy - Energy chain***

It is beneficially to create as many CO<sub>2</sub> emission reductions as possible along the energy chain connected to the project activity. Thus, single standing initiatives in a limited part of the chain have low emission reduction impacts, whereas various activities all along the energy chain have higher CO<sub>2</sub> emission reduction impacts.

Biomass CHP has a higher CO<sub>2</sub> emission reduction potential compared to for instance biomass boilers, as an actual conversion to biomass fuel are applied in *both* power and heat production. Thus, further emissions along the materials and energy chain, for instance related to extraction and transportation of fossil fuels from the outside (for both power and heat supply) are also avoided, leading to even further CO<sub>2</sub> emission reductions. It is clear that the implementation of biomass CHP reduce these emissions relatively more than biomass boilers do, as the technology phase out fossil fuels in *both* power and heat supply.

Another example is hydro power and solar PV which only phase out fossil fuels in a limited part of the energy chain; in power production. As these technologies has no impacts on the materials chain of energy production, they create no emission reductions in this part of the chain - for instance by making use of biomass residues etc. previously transported to landfills leading to high emissions of methane - and thereby no value chain upgrading.

Thus, biomass technologies therefore add value in the local community, as former waste products are converted into valuable resources upgrading the value chain. As mentioned above, the CHP technology here adds more value than the biomass boilers. Another advantage of biomass CHP compared to boilers is that the small amounts of waste, generated by some industries within the industrial sites, might only be feasible for energy purposes in a joint facility due to the large scale advantages, and not in smaller boilers for individual use.

A final advantage of biomass CHP compared to boilers is that the total amount of energy to be covered when applying this technology can be reduced significantly. Cascading of energy between industries and between industries and the district heating network, reduce the total amount of energy necessary to produce. This means that 'new energy' requirements are lowered, and that 'waste energy' can cover a large amount of the total energy consumption, leading to even further CO<sub>2</sub> emission reductions. Thus, biomass CHP with district heating are superior in limiting CO<sub>2</sub> emissions, as the expanded value chain interfaces with many CO<sub>2</sub> emission reduction opportunities.

- Implement cost effective technologies to lower the economic burden for the Thai society in transforming the energy supply system; (from Chapter 7)

### ***Seek low CO<sub>2</sub> abatement costs***

To achieve CO<sub>2</sub> reductions at a reasonable cost, it is also important to combine the above approach with economic considerations. Certain renewable energy technologies are relatively more expensive compared to other types of renewables. The financial generation costs of solar PV for power generation are for instance THB 15.42<sup>19</sup>/kWh, whereas this price is THB 2.52/kWh for mini hydro power. Also technologies capable of providing the same energy service, can vary greatly in cost depending on the renewable energy scheme selected. A '5 MW biomass condensing plant' has a financial generation cost of THB 3.33/kWh, compared to a '5 MW biomass backpressure plant' with supply of steam, which has a price of THB 0.23/kWh (DEDE & DANIDA, 2006). Thus, it is important to select a commercial and well-proven technology at a reasonable price, if the abatement costs should be kept at a low level.

Apart from the actual *costs* of the renewable energy technologies, its *character* also has an impact on the GHG abatement costs. As biomass CHP has a character enabling it to phase out the use of fossil fuels and generate both power and heat it impacts the total abatement cost, as more GHG emissions are avoided by relatively limited additional costs (Møller, 2008). Thus, the character of certain renewable energy technologies are therefore superior, as their GHG abatement costs are relatively lower compared to other technologies. From the example above it is evident that supply and thus consumption of steam from the 5 MW backpressure plant have a very high impact on the financial generation costs of the energy, compared to the 5 MW condensing plant with supply of power only.

Also large amounts of renewable resources have to be available if low abatement costs should be obtained. This is independent of whether the project activity is based on biomass, wind or solar energy. The higher amount of resources available the more viable the project activities. Large amounts of natural resources will benefit its potential usability, and the potential costs of using it will be lower compared to limited resource availability.

To sum up, the total abatement costs are lower when applying biomass CHP compared to biomass boilers, as the biomass waste is converted in a shared facility (and not many smaller units) generating both power and heat (not separate generation of heat and transmission of power from the grid). The biomass based CHP will, due to various activities along the materials and energy chain, contribute to large amounts of CO<sub>2</sub> emission reductions. This will again lead to GHG abatement costs that are relatively lower compared to the costs connected to few or single standing activities.

---

<sup>19</sup> In 2006-prices.

### **8.1.4 Step 3: ‘Energy audit/studies in industries’**

This upgrading of the value chain deals with options for achieving *emission reductions caused by energy savings* within the target industries. It must preferably be implemented before implementing the biomass technology to claim the CER’s, but can happen as suggested below where two ‘transformation process’ are proposed.

#### ***Seek large emission reduction in energy consumption***

In order to prepare the industries for CHP implementation it is beneficially to conduct the following analysis in target industries located in Thai Industrial Parks. These studies are required in order to implement energy efficiency, laying the foundation for a later fuel switch and supply of low quality process heat. The following analysis can beneficially be conducted in targeted industries in order to identify options for implementing energy efficiency.

- *Make materials and energy monitoring in selected industries, here access the:*
  - Amount of power and heat use;
  - Type of production process equipment; and
  - Amount of damaged goods and wastes;
  - Possibilities for applying internal or external re-use of the biomass waste, as either energy -or production potentials;
- *Make analysis of efficient processing equipment, here access the:*
  - Internal production processes in wood manufacturing industries, focusing on: Processing Wood, Compresses air, and Removals of sawdust;
  - Internal production processes in food manufacturing industries, focusing on: Cooling, Pumping and Ventilation activities;
  - Internal production processes in chemical manufacturing industries, focusing on: Process air (compression), Blowing machinery, Stirring and Cooling activities;
- *Make analysis of options for process integration, here access the:*
  - Process water: Identify options for operating the manufacturing process under Vacuum, for implementing Heat Exchangers, Recirculation of hot water, and for applying Cascading of steam;
  - Power use: Identify options for converting the use of process heat based on power to process heat based on hot water; (from Chapter 6)

#### ***Variable order and speed of CHP implementation***

After these analyses it must be decided in the specific context, which of the transformation process presented below should be pursued. This firstly includes an identification of the industries’ position:

- Clarify which interests the industries have in participating in either of the two transformation processes. As this would be context dependent, one transformation process might not be the right process in a different context. The starting point of the transformation depends upon the interests of the industries, as well as on governmental actions. If energy efficiency, for instance, is applied in all industries, it is more likely that Transformation 1 will be selected;
- Transformation 1: Place the biomass CHP Plant at the industry consuming the highest amount of energy, with previous energy efficiency applied;



- Seek local industries' connection to the district heating network, with previous energy efficiency applied for appropriate coverage of energy demands by district heating;
- Transformation 2: Place the biomass CHP Plant at the industry consuming the highest amount of energy;
  - Replace the existing fossil fuel boilers at the other industries with more efficient biomass boilers;
  - Improve the energy efficiency within the industries at a later stage (both the large industry with the CHP Plant, and those to be connected to the district heating network);
  - And by then connect the CHP Plant to a district heating network for collective supply of energy to all industries; (from Chapter 7).

### 8.1.5 Step 4: 'Technology options'

This value chain upgrading emphasise *selecting appropriate biomass technologies* that enables, the setting up of an industrial manufacturing scheme of the biomass CHP technology in Thailand later on. In the opposite end it also emphasises, that technologies must enable an upgrading of the local value chain by creating more jobs, with spin-off effects to marginalised groups in the Thai society.

- Identify if local manufacturer of appropriate technology exist (or parts of technology), as preferably to apply local/regional manufactured technology; (from Chapter 7)
- Select technologies that can establish a platform for local technology manufacturing; (from Chapter 4)

#### ***Technologies for short term employment (construction)***

Biomass technologies have been manufactured in Thailand for many years, and vary from traditional steam engines to different fossil fuels and biomass boilers. The latter are manufactured either by Thai producers or by producers operating on licence. There are, however, room for improving the technical level of the presently manufactured Thai technologies. This means that technology imports from the west (North) in many cases are applied, even though a resource base - with high potentials for further development - exists in Thailand. Thus, a knowledge base exists for biomass boilers, heat exchangers and pipes for heat distribution (Møller, 2008 & Sutiratana, 2008), but not for steam turbines. The latter technology can alternatively be imported from other countries in SEA, as no former experience in manufacturing this technology are present in Thailand (Møller, 2008a). In this way the value chain will remain in SEA instead of being transferred to the North.

Thus, implementation of biomass CHP with district heating in Thailand can rely on a mix of imported and locally manufactures technologies. Thailand can keep on pursuing imports and to a limited degree rely on domestic manufacturing of renewable energy technologies in the future. Or, alternatively, they can commence an industrial manufacturing of the technologies for large scales implementation of biomass CHP with district heating, as a knowledge base exists to build upon (See Step 5 below).

- Preferably select biomass technologies before other renewable energy technologies, as the employment effects is highest; (from Chapter 7)

### ***Technology for long term employment (maintenance & operation)***

To enhance the employment effects of future CDM projects technologies that are labour-intensive in their whole lifetime should be selected, before technologies mainly requiring labour when constructed. I will illustrate this by the following examples, identifying which of the technologies below are most favourable to implement in Thailand for both short and long term employment: 1) Wind power or biomass CHP? 2) Biogas technology or biomass CHP?

*Wind power:* The potentials for wind power in Thailand is limited do to lack of wind resources (EPPO, 2003), and only a few areas around the southern coast of Thailand is appropriate for implementation of wind power. The potentials for spreading the technology are thus low and Thailand has no history of manufacturing wind turbines, which imply that there is no knowledge base to build upon for this technology. On top of that, the jobs related to manufacturing wind turbines, are primarily placed in the construction part (IEA Bioenergy, 2005 & Kjær, 2006), typically in the countries they are imported from (the North). From a developing point of view implementation of CDM projects based on wind power in Thailand, has limited potential development effects (in India and China this example if different as they manufacture this technology or parts of it themselves).

*Biogas technology:* The potentials for biogas plants in Thailand are high due many pig farms and organic residues appropriate for digestion in biogas plants (EPPO, 2003). The technology are manufactures locally, and more than 20 producers of this technology exists on the Thai market today (Holm, 2008). The biogas plants were originally transferred from Germany many years ago, but the relatively simple technology has made a market for license manufacturing (Ibid.). As far as technology production (short term employment) the biogas technology is very beneficially for Thailand, as it can be manufactured locally.

In the local community, on the contrarily, this technology has a limited development impact on the employment opportunities (long term employment), as the biomass waste (pig slurry) is collected on the pig farms, and does not require assistance from the local community through supply of agricultural residues etc. to the plant. Thus, the value chain expansion does not benefit the local community. (Moreover, excess heat from the motor/generator can be difficult to use due to lack of heat markets, both within and outside the farm).

- Enhance the income distribution to marginal groups in the society (from Chapter 4).

### ***Benefit marginalised groups in the society***

As illustrated above, focusing on biomass CHP implies higher potential *development effects*, compared to imports of wind turbines and manufacturing of biogas plants. For biomass technologies in general it is a fact that they are labour-intensive, implying that many hands are involved in operating the technology, as well as in handling fuel supply. Thus, the example clearly indicates that implementation of biomass CHP lead to the highest value chain expansion opportunities in Thailand, and thus potential contribution to local beneficiaries. This is due to the possibilities of creating both short and long term employment.

Thus, technologies leading to both short and long term employment are to be preferred, as the economic and social benefits of the project activity can be expanded to the local community, including farmers and other marginalised groups in the society.

### **8.1.6 Step 5: ‘Local manufacturing of efficient energy technology’**

Due to the (appropriate) technology track selected in Step 4 above, it is now possible to make a final value chain upgrading, by seeking to *establish an industrial manufacturing scheme of biomass CHP in Thailand*.

This value chain upgrading is only realistic if a larger ‘market’ for the technology exists, and if appropriate resources are available in large scale, etc. Thus, if a large scale manufacturing of the renewable energy technologies should be pursued, the following issues must be highlighted.

- Examine the different sector’s emitting GHG; (from Chapter 5); *and*
- Make projections of the industrial sectors GHG emissions (will it grow in the future?); (from Chapter 5)

#### ***Identify market potentials through future emissions from the industrial sector (long term)***

Is the industrial sector in Thailand a large contributor of GHG emissions, and will they be so in the future? If the industrial sector is limited and the growth potentials low, a large scale manufacturing of CHP for distribution of power and heat to this sector will not be viable. Then, it might only be realistic to implement the technology in the few places where it is possible, and partly rely on imports of the technology required (thus apply Step 1 to 4 only). On the other hand, if the industrial sector is growing and the energy demands likewise, there is a great potential for supplying efficient energy technologies to this sector, by domestic manufactures CHP Plants. The latter is very much the situation in Thailand, where the industrial output keeps growing and the energy consumption therefore steadily rises in this sector, resulting in continuously growing CO<sub>2</sub> emissions (IGES, 2006).

Thus, the long term potentials for manufacturing efficient biomass CHP in Thailand is very much present, when looking at the future CO<sub>2</sub> emissions from the industrial sector. The CHP technology can thus help Thailand in reducing CO<sub>2</sub> emissions, by setting up efficient production and consumption of energy, which will enable economic growth without similar growth in energy consumption and thus CO<sub>2</sub> emissions.

- Identify the biomass waste potentials of the country (will it grow in the future?); (from Chapter 5)

#### ***Identify market potentials through future biomass waste generation (long term)***

The potentials for using biomass resources for energy purposes in Thailand are very high, as all sorts of agricultural biomass waste are available, as well as large amounts of industrial biomass waste not yet identified (like household waste and waste from commerce etc.). The biomass potential in Thailand is estimated to 7,000 MW (EPPO, 2003) from the extracting part of agricultural activities. Thus, when adding potential industrial biomass waste etc. not

yet identified quantitatively, there are large amounts of resources available in Thailand (Lybæk, 2004), for setting up a large scale industrial manufacturing of biomass CHP. 'Waste' and 'biomass' resources has also been identified in Thai country studies (ERM, 2000), as having the highest resource potentials for energy purposes in Thailand.

Thus, the long term potentials for manufacturing efficient biomass CHP with supply of biomass waste from the industrial and agricultural sector are quite high in Thailand, as the agro business is relatively large and the industrial sector continuously grows (Laird, 2000 & IGES, 2006).

- Look at the market potentials for 'spreading the technology' and the match of identified 'renewable energy resources'; (from Chapter 7)

### ***Identify market potentials through future industrial structure 'settlements' (long term)***

The industrial structure in Thailand is primarily based on the location of industries in Industrial Parks, which makes the spreading or penetration of the CHP technology a real opportunity in the Thai society, as argued earlier. This type of industrial 'settlement' keeps on evolving, as more and more industrial sites like this are developed in Thailand. The majority of the Industrial Parks are constituted by a mix of many different industries, which makes exchanges of materials and energy viable. Only few sites are solely based on industries manufacturing for instance electronics or petrochemicals, etc., and thus less appropriate for setting up biomass CHP, unless off source the biomass fuel solely are collected from outside the site.

Thus, the long term options for manufacturing efficient biomass CHP are quite high in Thailand, as the industrial structure keeps evolve around the development of new Industrial Parks, creating a very favourable 'settlement-pattern' for implementation of biomass CHP.

- Identify if national policies support actions related to use of biomass waste and efficient energy production and consumption, as important for supporting the CDM project implementation; (from Chapter 5)

Thailand has experience with promoting actions on energy efficiency, demand side management and implementation of renewable energy, etc. This is beneficial, as it can support a local manufacturing scheme of biomass CHP, due to the fact that the technology complies with some overall national energy policies and targets set forth by the Thai Government. The specific direction posed by this CDM project: 'biomass CHP with district heating', are therefore 'institutionalised' in the Thai society. CDM project going in a completely different direction of the national policies will hardly receive the same kind of support, and *could* become a barrier for setting up a manufacturing scheme.

## 8.2 Part I.B.: Extraction of PDD elements

### 8.2.2 Sum-up on PDD extractions

On the basis of the discussions above the following issues are identified as important PDD elements, gradually upgrading the Thai value chain:

- **High project outreach:** To increase the ‘outreach’ of the project activity, select appropriate industries and areas for its implementation, hereby supporting new income and business opportunities in the community, through exchanges of materials and energy, etc.;
- **Large emission reductions at low abatement costs:** Increase the level of CO<sub>2</sub> abatement by various activities all along the materials and energy chain, as to increase the CO<sub>2</sub> emission reduction potentials of the project activity, applying cost effective technologies. This will lead to CO<sub>2</sub> emission reductions at a relatively lower price, compared to single standing initiatives in a limited part of the chain, using inappropriate technologies;
- **Increase in short and long term employment:** To increase the employment effects of the project activity select technologies appropriate for this, which at the same time creates a platform for further job creations connected to a local manufacturing scheme.
- **Local markets and efficient technology manufacturing:** To make it viable to commence a local manufacturing of the technologies proposed by the project activity, an identification of the future ‘market’ for it must be outlined: The future industrial structure (the industrial ‘settlement-patterns’), the future needs for lowering CO<sub>2</sub> emissions in this sector, the amount of biomass waste generated within industry and agriculture in the future, and the future options for transfer of know-how and setting up partnerships.

## 8.3 Part II.: PDD case example; Navanakorn Industrial Promotion Zone

In the following section, I will exercise the PDD elements extracted above by going through the Planning Guide illustrated in Figure 8A on a Thai case. I will do this using an example similarly to Option C in Chapter 2 Figure 2D. The case will illustrate the elements to be included in the PDD for *enhancing the sustainable development contribution of future CDM projects*. How the PDD elements actually contribute to this will be argued after each step. Finally, I will sum up on the PDD elements applied on the case and the benefits caused by them, in Table 8I at the end of the chapter.

### 8.3.1 Applying the PDD elements on the case

The signs (# A, #E & #F) in the following section refer to the letters in the required content of a PDD preparation (UNEP, 2004:32), and are the ones included in this PDD case example. As seen below, the first three planning steps (1-3) are integrated into the required content of a normal PDD:

- General description of project activity (#A) = Step 1 & Step 3
- Calculation of GHG emissions by source (#E) = Step 2
- Environmental impacts (#F) = Step 2
- Opportunities connected to technology = Step 4-5

#### 8.3.1.1 General description of project activity (#A)

##### ► Step 1: Choice of industries & areas

###### *Introduction to Navanakorn Industrial Promotion Zone (hereafter 'Navanakorn')*

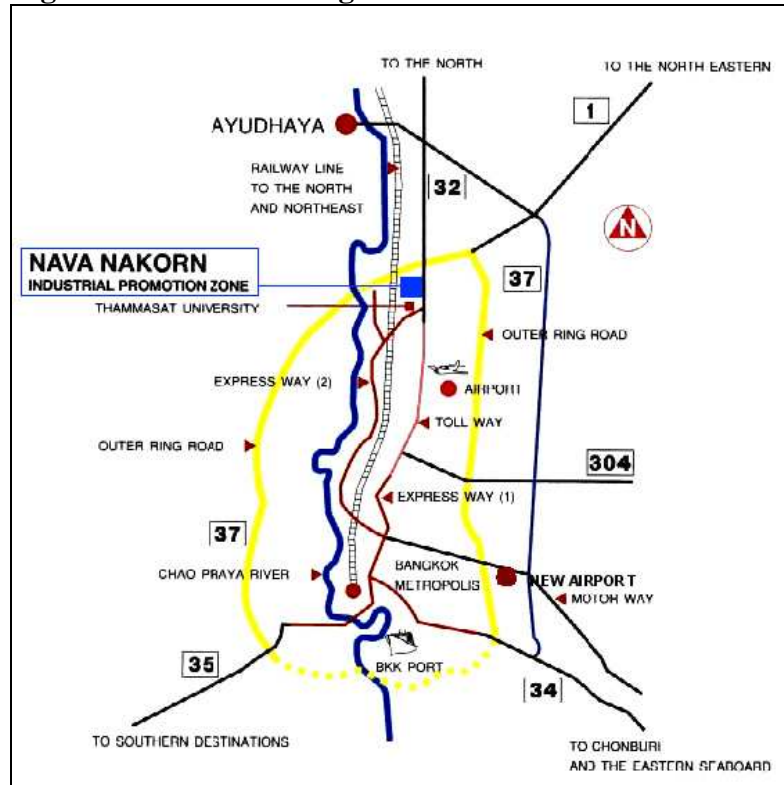
Navanakorn is a privately owned Industrial Park, located in Pathum Thani Province, approximately 45km north of Bangkok, as indicated in Figure 8B below. Navanakorn was the first industrial zone to be developed in Thailand, and was already established in 1971. The target has been to develop, and turn the 2,700 acre of land, into the first complete industrial town in Thailand. The good location of Navanakorn (see Figure 8B), including implemented facilities such as flood prevention, supply of power and water and waste water treatment etc., has made the area attractive for investors (Navanakorn, 2007).

There are approximately 250 industries located in Navanakorn, separated into four industrial phases, and the number is constantly increasing as new industries establish themselves in the Parks (Sasindran, 2007). Industries vary from food, medical and furniture industries, to electronically and assembly industries etc. A minority of the industries are large scale businesses, i.e. having more than 2,000 employees, but can in general be characterised as SME's with less than 500 employees (Lybæk, 2004).

Supply of power is transmitted to Navanakorn by a 115 KV transmission line, connected to a substation of the Provincial Electricity Authority (PEA), and a 22 KV line to each industrial site has a total power capacity of 285 MVA. Moreover, the Petroleum Authority of Thailand, PTT, distributes natural gas to the Park. Water supply is provided by 12 deep well pumps and 12 water storage tanks in the area, which has been provided by the Provincial Waterworks

Authority (PWA), who produces and distributes water to the industrial site (Navanakorn, 2007). The WWTP, which has a peak capacity of 26,000 m<sup>3</sup> per day, has been implemented in the Industrial Park in accordance with governmental regulations (Lybæk, 2004). The management of the industrial site also provides handling of solid and hazardous waste from industries located in the area, by sub-contracts to private companies, as well as maintenance of all infrastructure facilities mentioned above (Ibid.).

**Figure 8B: Greater Bangkok area and location of Navanakorn**

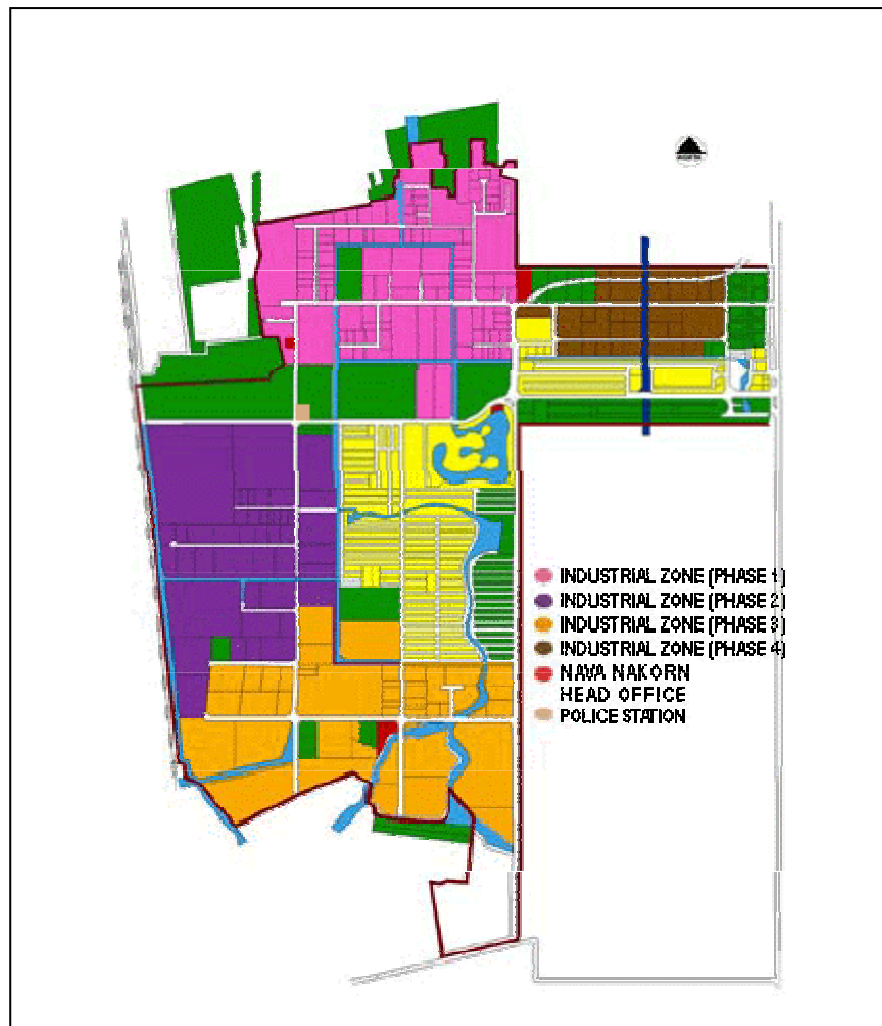


Source: Navanakorn, 2007

***Short description of the 'baseline'***

As illustrated by Figure 8D below, the *baseline* (existing energy system) rely on supply of fossil fuels, in the form of power from the Thai national grid as well as fuel oil (bunker oil) for individual process heat generation in boilers. The efficiency of the total energy production is low as based on separate production of power and heat (heat produced in individual boilers and power supplied from the national grid). The efficiency of power plants in Thailand is quite low, as combined cycle gas turbines, coal fired steam turbines and gas turbines only reaches efficiencies of 41 %, 30.4 % and 25.4 % respectively (Greasen & Footner, 2006).

**Figure 8C: Zoning in Navanakorn (case industries in Phase 1)**

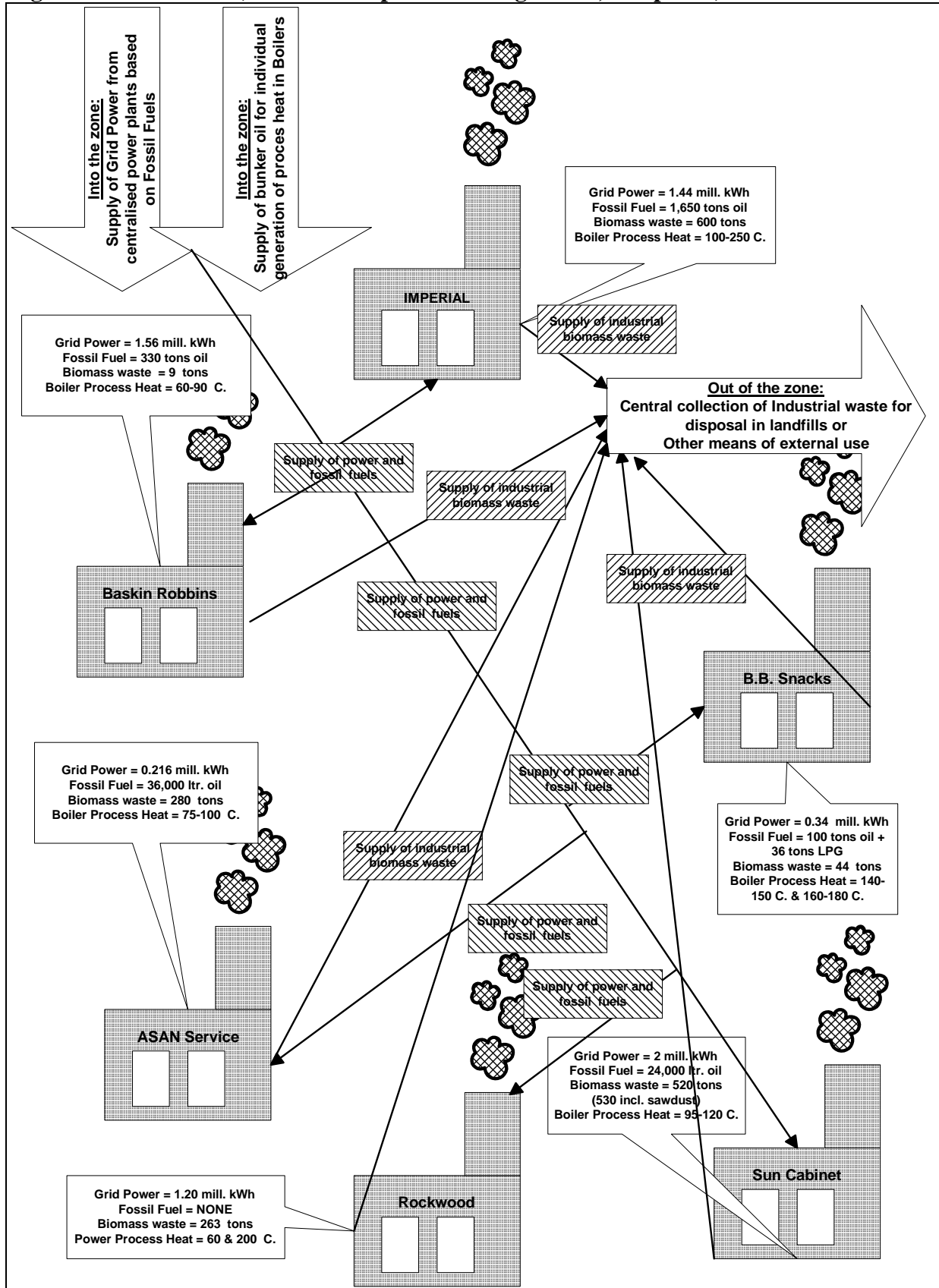


**Source: Navanakorn, 2001**

Valuable resources are moreover transported out of the Industrial Park, as the collected waste primarily goes to landfills or to other sectors for inefficient re-use, which in both cases leads to increased transportation and emissions of methane (CH<sub>4</sub>). Other provinces now receive this waste, as no more spatial areas for such disposal can be found in Pathum Thani Province (Lybæk, 2004). The zoning in Navanakorn is depicted in Figure 8C above, where the industrial zones, the recreational areas and the residential areas can be seen.



**Figure 8D: 'Baseline' (Similar to 'Option 0' in Figure 7A, Chapter 7)**



Source: Own figure, Background data from Chapter 6

## ■ Development effect caused by the PDD element

### “High project outreach”:

The project activity is located in Navanakorn, one of Thailand’s many Industrial Parks. This has made it possible to apply exchanges of materials and energy between the case industries, placed in the food, wood and chemical line of business generating large amounts of relatively clean biomass waste. Implementation of a biomass CHP Plant with district heating, *and* the location of industries within the Industrial Park, has created an ‘Industrial Ecology Engine’ or ‘Symbiosis Motor’ in the community. Here, materials exchanges and efficient supply and cascading of energy at different levels, can be applied. Due to the ‘high project outreach’ of the project activity, new business and income opportunities have evolved and many former expenses are now converted to income. The project activity enables the following savings and new business opportunities in the community.

Saved expenses: The transformation of the energy supply make the participating industries independent on fossil fuel supply, and thereby on energy expenses and price fluctuation on the world market. Except from limited quantities of domestic natural gas resources, fossil fuels are based on imports in Thailand. The dependency on fossil fuels is now converted to local biomass resources, which historically never has reached the price level of fossil fuels. Moreover, it is an indigenous resource. The economically burden, which purchase of energy services earlier posed on industries, will - when implementing the project activity - ‘work locally’, and lead to positive impacts in the community. Thus, power and fuel oil expenses will end, just as the former waste handling costs are terminated.

New business opportunities: Generated ash from incineration of biomass waste on the CHP Plant, can add value to the local community as soil fertiliser. Sale of power and heat can also be applied if surplus energy is produced. Also, supply of biomass waste to the CHP Plant can be a new business opportunity, either for local farmers or other stakeholders in the area. This can for instance be organic industrial/household waste, or waste from commerce etc. within Navanakorn. Or it can be organic household waste, or other organic fractions like vegetables or fruit residues etc. from markets outside Navanakorn, supplied by Takhlung Municipality and Pathum Thani.

### **8.3.1.2 Calculation of GHG emissions by source (#E) & Environmental impacts (#F)**

#### ► Step 2: Resource studies in industries and local community

In Table 8A below, potential resources for energy production have been identified in the community. In the table below potential biomass waste from vegetable and fruit markets, and relevant agricultural residues etc., are not included quantitatively. This PPD example thus deals with biomass wastes generated from within Navanakorn, supplied to the biomass CHP Plant, which equal 18,400 MWh/year for coverage of the industrial energy demands. But, as the table indicate, other relevant biomass waste from outside Navanakorn can be applied as well, especially rice husk and biomass residues from fruit and vegetable markets, etc. (Prapakornkiat, 2007).

**Table 8A: Biomass resources identified in the community (inside & outside Navanakorn)**

Waste (tons/year)	Navanakorn	Takhlong Municipality	Pathum Thani Province
Collected industrial/commercial waste	<b>6,300</b>		
-Estimated organic parts	<b>1,890</b>		
-For energy production	1,417.50		
Generated industrial/commercial waste	<b>7,200</b>		
-Estimated organic parts	<b>2,160</b>		
-For energy production	1,620		
Collected household waste	<b>14,400</b>	<b>21,600</b>	
-Estimated organic parts	<b>3,600</b>	<b>5,400</b>	
-For energy production	2,700	4,050	
Generated household waste		<b>57,600</b>	
-Estimated organic parts		<b>14,400</b>	
-For energy production		10,800	
Collected industrial/commercial/ household waste			<b>242,348</b>
-Estimated organic parts			<b>60,587</b>
-For energy production			(45,440)
Generated industrial/ Commercial/household waste			<b>301,763</b>
-Estimated organic parts			<b>75,441</b>
-For energy production			(56,581)
Sludge from WWTP	3,600		
Agricultural waste & residues from fruit markets etc.		NA	NA

Source: Lybæk, 2004 & Praphakornkiat, 2007

### *Baseline emissions*

In the following, detailed analysis of the CO<sub>2</sub> emission reduction potentials of the suggested project activity will be highlighted, and will prove the ‘biomass CHP with district heating’ capability to obtain large emission reductions through activities all along the materials and energy chain. I will look at important emission factors from the baseline situation, as well as from the project activity situation. For all emission sources holds that N<sub>2</sub>O emissions are not included, as they are expected to be very low.

### **(1) On-site emissions from fuel consumption:**

**Table 8B: Emissions from present fossil fuel use in case industries**

Component	Emission Factor [kg/GJ]		Yearly emission [kg/year]		⇒ Total [kg/year]
	(LPG)	(Oil)	(LPG)	(Oil)	
CO <sub>2</sub>	65	74	117,441	6,732,224	6,849,665
CO	0.013	0.012	23	1,092	1,115
NO <sub>x</sub>	0.100	0.100	181	9,097	9,278
UHC <sup>20</sup>	0.0021	0.0015	4	136	140
SO <sub>2</sub>	0.000	0.234	0.00	21,288	21,288

Source: Own calculation

<sup>20</sup> Unburned Hydro Carbons.

Total fossil fuel consumption (LPG + bunker oil): 92,782,793 MJ/year, divided as;

LPG: 1,806,793 MJ = 1,806.79 GJ/year.

Fuel oil: 90,976,000 MJ = 90,976 GJ/year.

CO<sub>2</sub> emissions LPG [kg/GJ] = 65

CO<sub>2</sub> emissions Oil [kg/GJ] = 74

Yearly emissions from LPG in kg: 1,806.79\*65 = 117,441.40

Yearly emissions from oil in kg: 90,976\*74 = 6,732,224.00

The avoided emissions of fuel oil uses are therefore:

117,441 + 6,732,224 = 6,849,665 ≈ **6,850 tons CO<sub>2</sub>/year.**

In order to get a picture of the total environmental impacts of the baseline energy consumption, the remaining emissions (i.e. SO<sub>2</sub>, NO<sub>x</sub>) are also calculated and depicted in Table 8B.

### **1b) Off-site emissions from fossil fuel extraction and transportation, etc.**

CO<sub>2</sub> emissions caused by extraction and transportation etc. of fossil fuel, normally come from the following activities: 1-4 % from extraction of crude oil, 8-10 % from refining and 1 % from distribution. The remaining 85 % of the CO<sub>2</sub> emissions stem from the actual combustion of the fuels (Jensen, 2007 & European Commission, 2007). CO<sub>2</sub> emissions from fossil fuel use are calculated to 6,850 tons CO<sub>2</sub>/year, which mean that additional emissions from extraction and transportation etc. lead to (0.15\*6.850) = 1,030 ≈ **1,000 tons CO<sub>2</sub>/year.** It is thus important to include such figures in the PDD calculations.

### **(2) Off-site emissions from power consumption:**

Total power consumption: 6,750 MWh/year.

CO<sub>2</sub> emissions from power production are calculated on the background of the fuel generation mix in Thailand (2007-data), and correspond to 0.519 tons CO<sub>2</sub>/MWh generated (EGAT, 2004 & Møller, 2008a). The emissions are thus: 6,750\*0.519 ≈ **3,500 tons CO<sub>2</sub>/year.**

**Table 8C: Emissions defined by the Thai fuel mix**

Component	Emission Factor [Tons/MWh]	Yearly Emission [Tons/year]
CO <sub>2</sub>	0.519	3,500

Source: Own calculation based on EGAT, 2004 & Møller, 2008a

**Table 8D: Emissions from use of natural gas in power production**

Component	Emission Factor [kg/GJ]	Yearly Emission [kg/year]
CO	0.01	593
NO <sub>x</sub>	0.05	2,963
UHC	0.03	1,778
SO <sub>2</sub>	0.0003	18

Source: Own calculation

In order to get a picture of the full environmental impacts of the baseline situation, the remaining emissions from power production are also calculated. Here, I have chosen a quite conservative approach, as the calculations are based on conversion of fuel in technologies, which will be more dominating in the future Thai energy supply; namely natural gas fired combined cycle technologies (EGAT, 2006) with an average energy efficiency set to 41% (Greasen & Footner, 2006). The emissions are thus:  $(6.750 \times 3,600) = 24,300,000$  MJ/year.  $(24,300,000 / 0.41) = 59,268,293$  MJ/year = 59,268 GJ/year. On the basis of these figures, the results are depicted above.

### **2b) Off-site emissions from fossil fuel extraction and transportation, etc.**

In order to produce the power required by case industries 59,268 GJ/year of natural gas are required feed into the power plants (using a Combined Cycle Gas Turbine, CCGT, with an efficiency of 41 % as example). Research conducted by the EU Commission (European Commission, 2007:86 (figure 4.8.2-3a)), indicates, that CO<sub>2</sub> emissions from power production - using natural gas in a CCGT and a 4,000 km long NG distribution pipeline - are 125g CO<sub>2e</sub>/MJ<sub>f</sub>. The CO<sub>2</sub> emissions from extracting and piping etc. natural gas, are thus  $(59,268 \times 1,000)$  (to MJ) =  $59,268,000 \times 125 / 1,000$  (to kg) = 7,408,500 kg ≈ 7,400 tons CO<sub>2</sub>/year.

For especially power supply based on natural gas, these off-site emissions are important to include. The emissions from supply of fuel oil as emphasised earlier are not as high, but never the less important to include.

### **(3) On-site emissions from biomass management (transportation)**

The present transportation of on-site biomass waste will undergo no changes with the project activity, as the biomass waste still need to be collected, this aspect is regarded as zero (balancing). If changes in transportation patters occur this must be calculated and added to the total baseline emissions.

### **(4) On-site emissions from industrial boilers**

If some of the industrial boilers convert biomass waste as well, emissions of methane will also occur. In this case example only Sun Cabinet converts limited amounts of sawdust to process heat in a Stoker boiler, whereas the remaining heat supply (the majority) is generated in a boiler feed by bunker oil. Emissions of CH<sub>4</sub> are therefore not included in this emission calculation, and in general regarded as being quite low (se for instance CH<sub>4</sub> emissions from CHP plant below: # 5).

### **(5) Off-site emissions from biomass decay in landfills**

In this case the industrial biomass waste is calculated as going to landfills in which degradation will take place leading to emissions. Previous studies have shown that the composition of waste in Thailand and Denmark are almost the same (Lybæk, 2004), which makes it possible to make a rough estimation of the CH<sub>4</sub> emissions from landfills using Danish data. A more thorough guidance of how to make such calculations can be found in the IPCC guidelines.

CH<sub>4</sub> emissions (2003-data) from 966 tons of mixed landfill waste leads to 63.2 tons of CH<sub>4</sub> emissions annually (DMU, 2005). The 379 tons of industrial waste lead to an average emission of 24.8 tons CH<sub>4</sub> annually (over a period of more than 15 years). This means that 1 tons of industrial waste equals emissions of  $(24.8/379) = 0.065$  tons CH<sub>4</sub>. If the biomass waste

from Imperial is excluded (600 tons) from this calculation, as going to the brick company, a total of  $(384+44+11+522+263) = 1,224$  tons of industrial waste are going to landfills. This leads to a yearly CH<sub>4</sub> emission of  $(1,224*0.065) = 80$  tons. CH<sub>4</sub> have a GHG equivalent of 21, which equal a yearly CO<sub>2</sub> emissions of  $(80*21) = 1,680$  tons  $\approx$  1,700 tons.

I here calculate the average total emissions from industrial wastes for a period of 10 year, as this equals a 10-year crediting period. The first year emissions are 1,700 tons, the second 3,400 tons and the third 5,100 tons, as the emissions from the previous two years still counts, etc. Over a 10 year period this equals an average yearly CO<sub>2</sub> emission of  $(1,700+3,400+5,100+6,800+8,500+10,200+11,900+13,600+15,300+17,000 / 10 \text{ years}) = \underline{9,350 \text{ tons CO}_2/\text{year}}$ . As the figure show, it is very important to include these emission sources in the PDD documents.

**Table 8E: Total ‘baseline’ emissions**

Component	Total emission per year [Tons]
CO <sub>2</sub>	$(1+2+3+5) (6,850+1,000)+3,500+7,400+9,350 = 28,100$
CO	1.7
NO <sub>x</sub>	12.2
UHC	1.9
SO <sub>2</sub>	21.3

Source: Own calculation

#### *Emissions from the proposed project activity*

##### **(6) On-site emissions from the biomass CHP Plant**

Emissions from the project activity are calculated on the basis of the biomass fuel feed into the technology. In this specific case study, the biomass fuel required is calculated to 18,400 MWh annually (net energy input equals 57,960 GJ/year), on the basis of a thermal match, applying a steam turbine plant below 1 MWe (Lybæk, 2004). The Danish report on renewable energy technologies (Energistyrelsen, 1996) are used in the calculations below:

SO<sub>2</sub> emissions:  $35 \text{ g} * 57,960 / 1,000$  (to kilo) = 2,028 kg  $\approx$  2 tons.

NO<sub>x</sub> emissions:  $75 \text{ g} * 57,960 / 1,000$  (to kilo) = 4,347 kg  $\approx$  4.3 tons.

Ash:  $0.75 \text{ kg} * 57,960 = 43,450 \text{ kg} \approx$  43.5 tons.

GHG emissions from ‘Other Biomass and Wastes’ are here selected as an average figure for all types of biomass fuel applied to the CHP Plant. According to IPCC, methane emissions from ‘...agriculture, municipal and industrial wastes’ combusted in energy industries, equals 30kg CH<sub>4</sub>/TJ biomass fuel (IPPC Guidelines, 1996:1.35), which - converted to CO<sub>2</sub> equivalent - amount to  $30*21$  (to CO<sub>2</sub>) = 630 CO<sub>2</sub>/TJ biomass fuel.

CO<sub>2</sub> emissions:  $630 * 57,960 / 1,000$  (to TJ) = 36,515kg CO<sub>2</sub>  $\approx$  40 tons CO<sub>2</sub>/year.

As illustrated, these emissions are relatively limited, and can preferably be excluded from the PDD document.

##### **(7) On-site consumption of fossil fuel for combustion support or start-up**

In this case (calculation example) no additional fossil fuels are used, as the liquid biomass waste from Imperial are intended to be used as combustion support in an over heater or as a start-up fuel etc. However, the use of fossil fuels for such purposes must be included in the total emission calculations, as it can reach relatively high figures for larger CHP Plants.

### **(8) Off-site emissions from ‘biomass leakages’**

Biomass waste from Imperial (liquid waste) is re-used externally by a producer of bricks outside the industrial area. As Imperial is the only case industry with a constant and guaranteed re-use of the biomass waste, I have not included eventual re-use from the remaining industries, as they often occur sporadic and with no certainty. As the project will use *all* the biomass waste generated at Imperial, it is conservatively estimated that the brick producer will convert to oil for the part of the fuel supply, previously covered by liquid biomass waste from Imperial. This is conservative, as the company might use another source of biomass waste instead of switching to fossil fuels. Thus, the calculations below will thus add to the CO<sub>2</sub> emissions from the project activity, and are included to illustrate the importance of such leakages in PDD documentation.

The calculation is based on the assumption that the producer of bricks would have used oil instead of the biomass waste from Imperial. The energy potential of biomass waste from Imperial is calculated to 6,300 MWh/year (Lybæk, 2004), and if the same amount of energy is to be covered by oil the emissions are as follows:

CO<sub>2</sub> emissions fossil fuel:  $6,300 \times 3,600 = 22,680,000 \text{ MJ/year} = 22,680 \text{ GJ/year}$ .

CO<sub>2</sub> emissions Oil [kg/GJ] = 74. This gives:

$74 \times 22,680 = 1,678,320 \text{ kg} \approx 1,680,000 \text{ kg CO}_2 \approx \underline{\underline{1,680 \text{ tons CO}_2/\text{year}}}$

### **(9) Off-site transportation of agricultural biomass waste**

In this case (calculation example) no supply of agricultural biomass waste is utilised on the CHP Plant. If so, additional emissions caused by transportation must be calculated and added to the total emissions. As the industrial biomass waste *not* are transported out of the site - ending up in landfills *after* the implementation of the project activity - it could be argued that the transportation of agricultural waste into the area would contribute to the same amount of CO<sub>2</sub> emissions that now are being avoided. This off source depends on the amount of biomass waste transported into the industrial site, and must be included in the emission calculations.

### **(10) Off-site avoided emissions from decay or open burning of agricultural biomass**

If agricultural residues are applied, it will avoid a certain amount of biomass waste being burned or left to decay on the fields. Such avoided emissions caused by the project activity, must be included in the PDD document.

**Table 8F: Total emissions from the ‘project activity’  
(transformed energy supply system)**

<b>Component</b>	<b>Total emission/impact per year [Tons]</b>
<b>Ash</b>	43.5 TS
<b>CO<sub>2</sub></b>	$(6+7+8+9+10) 40 + 1,680 = 1,720$
<b>NO<sub>x</sub></b>	4.3
<b>SO<sub>2</sub></b>	2

**Source: Own calculation**

Table 8G below illustrates which emission factors to include in the PDD calculations, as not all of the emissions have significant impacts illustrated above.

**Table 8G: Overview of inclusion vs. exclusion of emission sources in the PDD**

	Source		Gas	Included?	Comments
<b>Baseline</b>	Waste Handling	(5) Emissions avoided from Landfills.	CH <sub>4</sub>	Yes	An important emission source.
			N <sub>2</sub> O	No	Excluded for simplification.
	Fuel Supply*	(1) Emissions from Fossil Fuel uses. (2) Emissions from Power uses.	CO <sub>2</sub>	Yes	Emissions from fossil fuel extraction and transportation etc. must be included. + Emissions from 'non-CO <sub>2</sub> -emission sources' if any must also be included.
			CO <sub>2</sub>	Yes	
		(3) Emissions from Waste Management (transportation).	CO <sub>2</sub>	Yes	An important emission source.
			N <sub>2</sub> O	No	Excluded for simplification.
	Conversion Technology	(4) Emissions from Industrial Boilers.	CH <sub>4</sub>	No	Excluded for simplification.
			N <sub>2</sub> O	No	Excluded for simplification.
<b>Project activity</b>	Waste Handling	(10) Emissions avoided from present Agricultural Practices.	CO <sub>2</sub> / CH <sub>4</sub>	Yes	An important emission source.
			N <sub>2</sub> O	No	Excluded for simplification.
	Fuel Supply*	(8) Emissions from Leakages.  (9) Emissions from increased Supply of Agricultural Waste (transportation).	CO <sub>2</sub>	Yes	An important emission source.
			CO <sub>2</sub>	Yes	An important emission source.
			N <sub>2</sub> O	No	An important emission source.
	Conversion Technology	(6) Emissions from the CHP plant.  (7) Emission from use of Fossil Fuel as Combustion Support etc.	CH <sub>4</sub>	No	Excluded for simplification.
			CO <sub>2</sub>	Yes	An important emission source.
			N <sub>2</sub> O	No	Excluded for simplification.

**Source: Own table, Data from Chapter 8**

Below, I have summed up the Environmental impacts (#F) of the project activity. Additional environmental impacts caused by the project activity were highlighted in Section 8.3.1.1.



### *Total emission reduction*

**Table 8H: Sum of total ‘project activity’ emission reductions**

	[Tons CO <sub>2</sub> /year]
<b>Total Baseline emission savings</b>	28,100
<b>Total Project activity emissions</b>	- 1,720
<b>Net emission savings per year</b>	≈ 26,400

Source: Own calculation

### *Generation of CER’s*

**Table 8I: CER’s according to different crediting periods**

Type of crediting period	Total Net emission savings in the period [tons]
<b>10 years</b>	264,000
<b>1<sup>st</sup> 7 years (7 years)</b>	184,800
<b>2<sup>nd</sup> 7 years (14 years)</b>	369,600
<b>3<sup>rd</sup> 7 years (21 years)</b>	554,400

Source: Own calculation (based on the analysis in Chapter 8 above)

## **8.3.1.3 General description of project activity (#A)**

### **► Step 3: Energy audits/studies in industries**

#### *Transformation of the energy supply system in Navanakorn*

As already emphasised in this project, the case industries would like to participate in a joint energy facility, thus Transformation # 1. To sum up from the industries viewpoint, they do not find the implementation of individual biomass boilers an attracting option. It implies extra work and knowledge that exceeds the capacity of industries. In that sense continuous operation of the fuel oil boilers are preferred, as it is a simple task to operate and fuel them, and even though the prices have increased quite dramatically recent years. The joint system is viewed upon positively, and, if implemented and operated by professionals - and with ‘limited or no responsibility’ - this would be a good option for an energy supply system in Navanakorn.

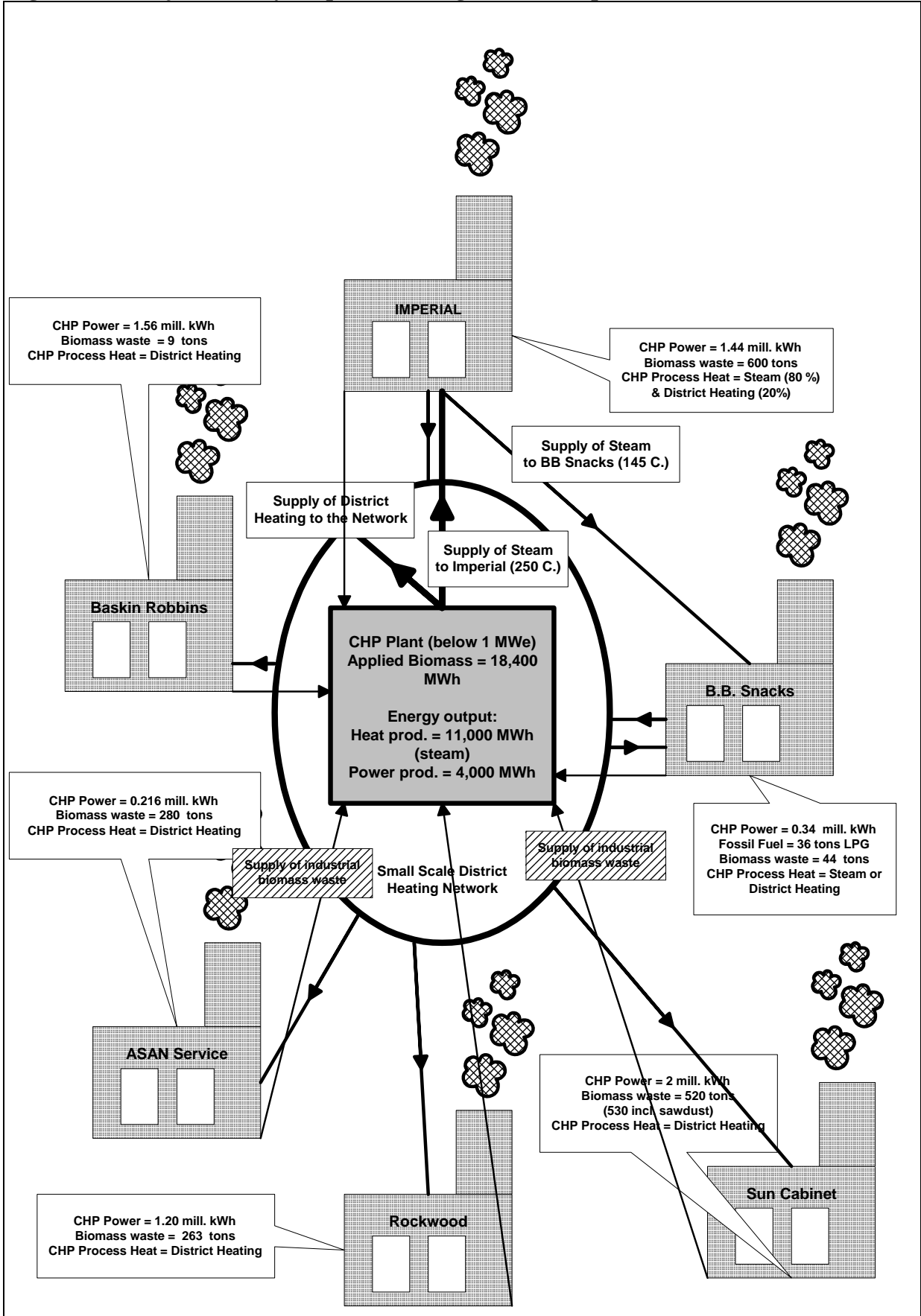
#### *Design of the project activity*

Apart from the above, in depth analysis of materials and energy throughputs, as well as technical analysis etc. in case industries in Navanakorn (see Chapter 6), has resulted in the following design of the energy system within Navanakorn.

The *project activity* (transformed energy supply system), depicted in Figure 8E below, thus seek to exploit local resources and minimise the flow of unsustainable materials (fossil fuel based energy) into the industrial area. Also, it prevents valuable resources from the area to be re-used inefficiently outside the Industrial Park. The energy supply is based on a local self-supply system, in which industrial biomass wastes are used as fuel in a CHP Plant, which distribute power and process heat to industries connected to the district heating network. Local agricultural biomass waste, or other sources of clean organic waste, can be supplied in order to increase the amount of biomass fuel.

As the consumption of steam only happens at Imperial (if B.B. Snacks can convert to district heating), it is possible to cover the process heat demands in the remaining industries solely by district heating. This means that energy savings are obtained both qualitatively (from ‘steam’ to ‘hot water’) and quantitatively (by the reduced amount of energy which is necessarily to produce, in order to cover energy demands).

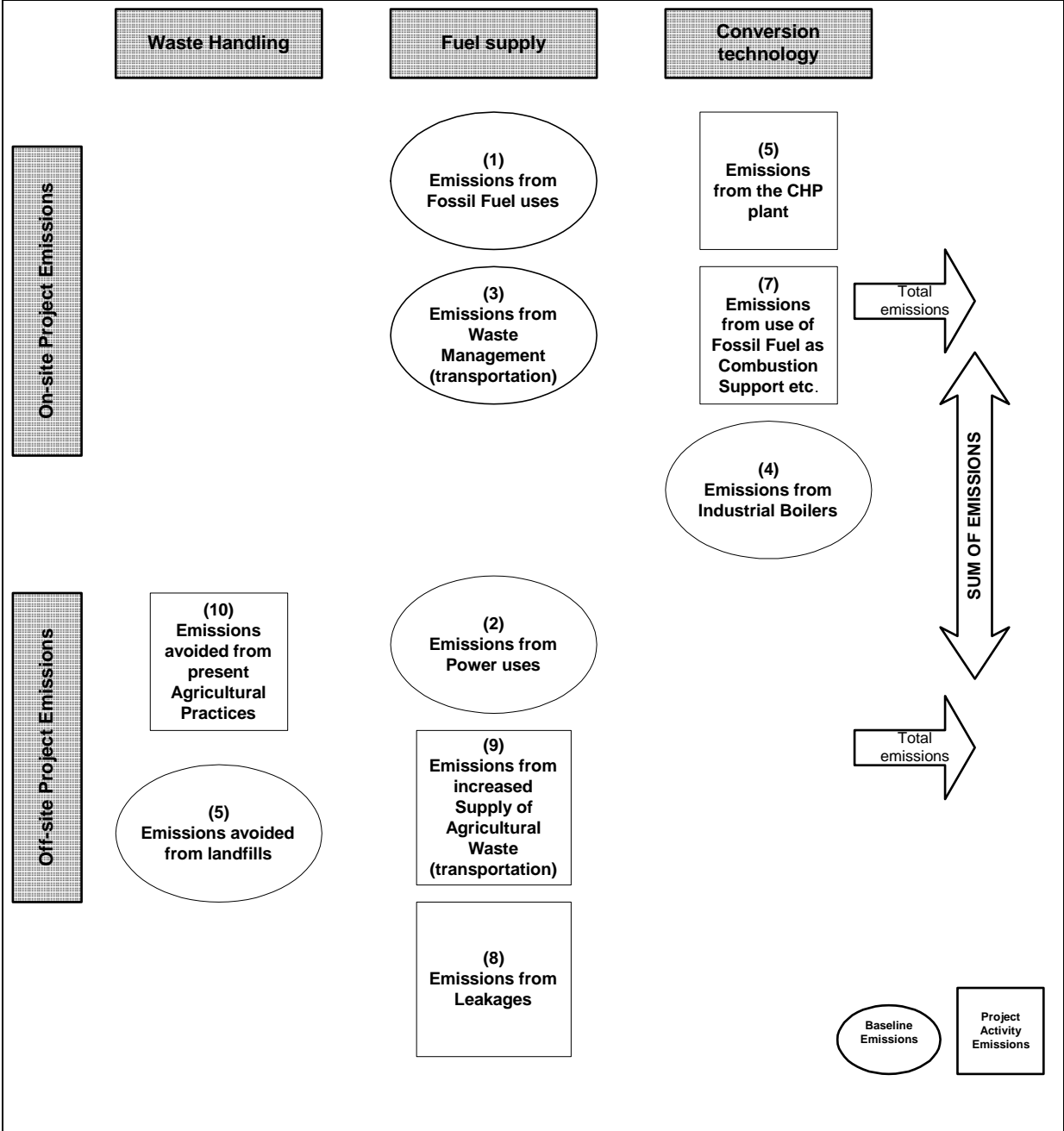
Figure 8E: 'Project activity' (Option C in Figure 2D, Chapter 2)



Source: Own figure, Background data from Chapter 6

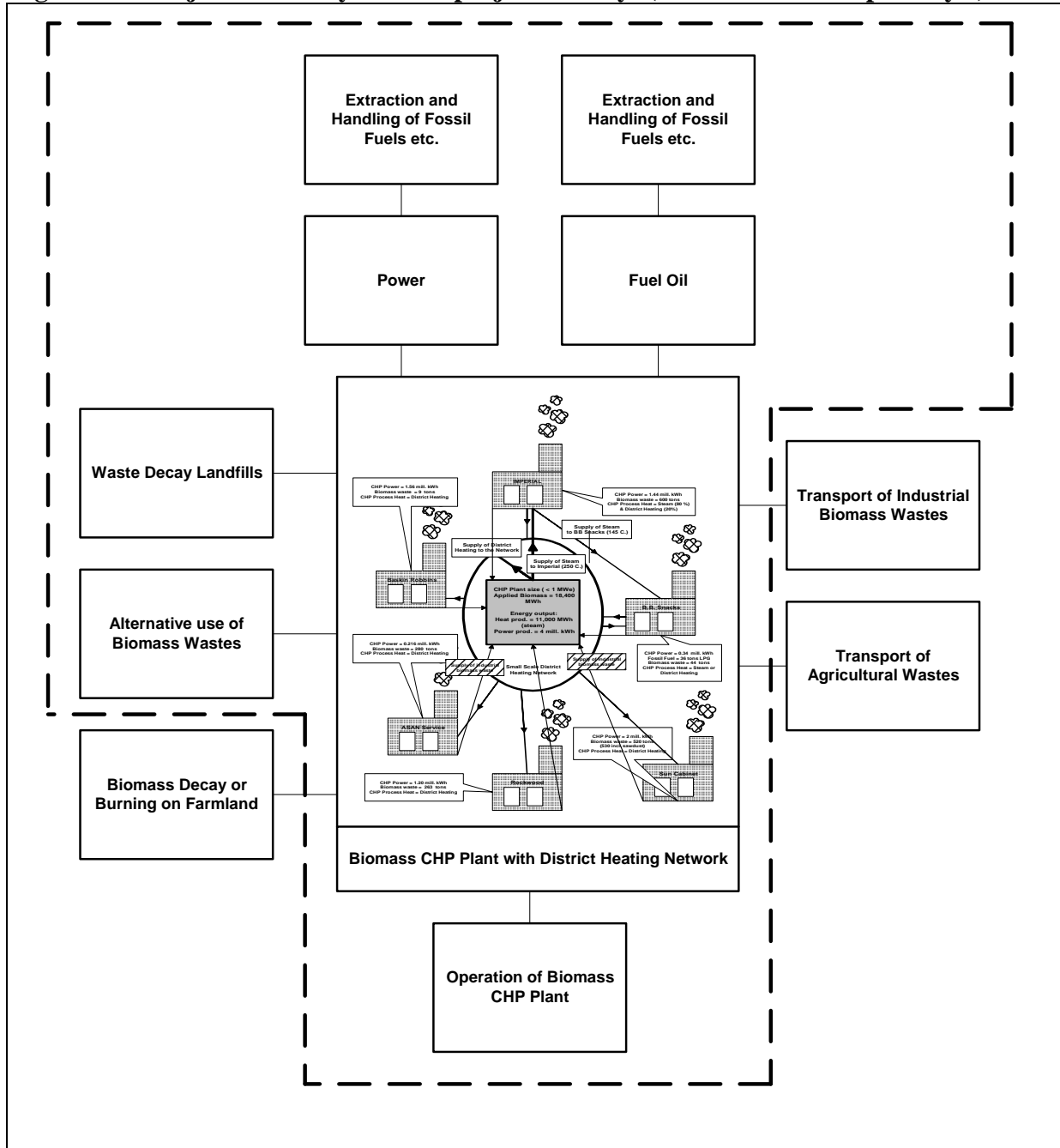
In Figure 8F just below, the process of calculating the CO<sub>2</sub> emissions are outlined for both 'baseline emissions' (ellipse), and for the 'project activity' (square). This also indicates the connection between the baseline calculations and Figure 8G showing the project boundary.

**Figure 8F: Outline of emission calculations (for both 'baseline' and 'project activity')**



Source: Own figure, Data from Chapter 8

Figure 8G: Project boundary for the ‘project activity’ (for this case example only)<sup>21</sup>



Source: Own figure, Data from Chapter 6 & 8

### ■ Development effect caused by the PDD element

#### “Large emission reductions at low abatement costs”:

CO<sub>2</sub> emissions from combustion of fuel oil will be phased out, by use of industrial and agricultural biomass waste etc. with neutral carbon content. Biomass disposals in landfills also lead to methane emissions, which pose a big pressure on local governments. CO<sub>2</sub> emissions

<sup>21</sup> In this example no industrial and agricultural biomass waste etc. from outside Navanakorn are applied, which means that emissions from transport, as well as terminated burning or decay of agricultural waste on the farmland, cannot be included in the present calculations. If included, the CO<sub>2</sub> emissions reduction caused by the CDM project activity would increase even further.

also come from transporting the waste out of Navanakorn (for dumping or in authorised landfills), and from the use (if any) of the biomass residues elsewhere. Burning of for instance rice straw on agricultural land also lead to CO<sub>2</sub> emissions and local air pollution etc., and if left to decay it will cause emissions of methane to the atmosphere. Biomass waste from within Navanakorn is supplied to the CHP Plant equalling 18,400 MWh/year.

Thus, GHG emissions emitted along the *materials chain*, as illustrated above, is terminated by implementation of the project activity. The pressure on natural resources (virgin wood fuel etc.) is also avoided by the project activity, as it is based on a biomass ‘waste product’. Thus, GHG emissions connected to extracting and transportation of virgin wood fuel for energy production is *not* applied in the project activity.

CO<sub>2</sub> emissions are avoided from the extraction, transportation and consumption of fossil fuels for both power (centralised power plants) and heat production (in individual boilers). The project activity is thus based on efficient production of both power *and* heat locally, and by improvements in the use of energy within industries by better manufacturing processes (process integration and energy efficient equipment) and supply of hot water instead of steam. Through the district heating network improvements are obtained by 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. Due to this, the required amount of energy necessary to produces has been reduced significantly; From 17,200 MWh/year to 11,000 MWh/year.

Thus, GHG emissions are avoided by the activities outlined above, which implied GHG abatement all along the *energy chain*. Apart from CO<sub>2</sub> reductions, the community will benefit from the project activity by better local air quality, as the emissions of SO<sub>2</sub> and NO<sub>x</sub> will decrease due to the fuel switch and smoke cleaning equipment (filter bags etc).

To obtain *low abatement costs*, a reliable and cost effective technology is suggested implemented in Navanakorn, with a relatively low production cost per kWh produced. The CHP Plant with district heating is a proven technology, which has been applied in especially northern Europe for many years.

As illustrated in the sections above, the project activity interferes all along the materials and energy chain, in which value adding activities are obtained. The project activity generates large emission reductions not only effectuated by one single standing initiative, but by many simultaneous initiatives leading to a ‘synergy-effect’ in emission reduction. Thus, abatement is pursued as *various activities* all along the chain of materials and energy consumption, which makes the quantitative emission reductions relatively higher, and thus the abatement costs lower.

#### **8.3.1.4 Opportunities connected to technology**

##### **► Step 4: Technology options**

The project activity focus on biomass technologies that has a high employment potential, as the jobs primarily are established in a part where it is persistent with the lifetime of the technology. Thus, if a manufacturing of the CHP technology - boilers, pipes and heat exchangers etc. - cannot be established in Thailand, the selected technology will as a minimum contribute to a relatively high job spin-off, compared to implementation of other

types of renewable energy technologies. Off-course, manufacturing of the whole system (by mega-supplier & supply-parks) are to be preferred.

## ■ **Development effect caused by the PDD element**

### **“Increase in short and long term employment”:**

With a thermal match (coverage of heat demands in industries), the size of the CHP Plant will be 2.63 MW<sub>total</sub>, separated as 0.4 MW<sub>e</sub> and 1.66 MJ/th. For biomass technologies the following new jobs are created per MW total installed capacity per year: Construction jobs = 3.71, Maintenance & Operation jobs = 2.28 (Heaver & Del Chiaro, 2003:22). With a case example of 2.63 MW<sub>total</sub> installed capacity the following direct jobs are created:

*Employment per installed MW:*

Construction jobs:  $3.71 * 2.63 = 9.76 \approx 10$ .

Maintenance & Operation jobs:  $2.28 * 2.63 = 6.99 \approx 7$  (in total 17 jobs).

The construction jobs will roughly be there the first year, whereas the M&O jobs will exist in the lifetime of the energy plant, for instance in 20 or 30 years.

Another estimate suggests that for ‘straw/wood CHP’ and ‘straw/wood District Heating’ the following average jobs are created per MW installed capacity per year respectively: 10.9 and 2.3 (Kjær, 2006:7). As the energy system proposed in Thailand is a mix of the two systems, the employment potential could be calculated as an average figure of the two approaches, and result in:

*Employment per installed MW:*

Average jobs:  $(10.9 + 2.3 / 2) = 6.6 * 2.63 \approx 17$  jobs

The latter result is not divided directly in ‘construction’ versus ‘maintenance & operation’, as the example above, but in ‘technology investment’, ‘maintenance & operation’ and ‘fuel’. Although the results from the two analyses above show identical figures for employment effects, the uncertainty of the calculations must off course be regarded as quite high (Kjær, 2006), but it gives an indication of the potential job effects of a relatively small (in MW installed) CHP scheme, as proposed by the project activity.

On top of the direct jobs created by implementation of the project activity indirect jobs will also be created, as the direct employment creates income and thus demands, which again create new jobs. Direct employment normally leads to indirect employment at a level 2 to 4 times the direct employment (Kjær, 2006).

## ► **Step 5: Local manufacturing of energy technology**

In order to examine whether a large scale manufacturing of the specific technology is viably, the following analysis must be conducted:

- Markets for implementing the technology nationally (spreading);
- ‘Market’ for adapting to efficient technologies nationally (needs);
- Adequate future supply of biomass fuel for energy production (supply);
- Options for setting up partnerships with countries in the North for transfer of know-how (co-operation);

## ■ **Development effect caused by the PDD element**

### **“Local markets and efficient technology manufacturing”:**

*(Spreading)* Thailand has numerous Industrial Parks in which industries are located close to one another with a demand for both power and heat. Many of these industries will also generate appropriate biomass waste, which could be used as proposed by the project activity. The Industrial Parks are usually surrounded by agricultural land, with large amounts of agricultural waste etc., which could be re-used effectively in CHP Plants. Many Industrial Parks are situated in Asia, which makes a large scale implementation of the project activity a realistic opportunities. Thus, the industrial ‘settlement’ is in place for a large scale manufacturing of biomass CHP with district heating in Thailand.

*(Need)* When it comes to identifying whether the industrial sector in Thailand will continue to emit large quantities of CO<sub>2</sub> - as thus be a potential market in the future for biomass CHP with district heating - it has been identified that implementation of this technology is very beneficial. This is due to the fact that emissions of from this sector will continue to grow in the future. *(Supply)* Relevant biomass waste from the industrial and waste/agricultural sector has also been identified. Like the industrial sector, waste generated by these sectors will continue to grow in Thailand in coming years. This means that relevant fuel will be available in the future, which makes a large scale manufacturing of biomass CHP with district heating viable.

*(Co-operation)* When it comes to manufacturing the technology, Thailand can supply the biomass boilers, heat exchangers and pipes etc. required for implementing the project activity; possible on license from relevant companies in the North, who produces efficient renewable energy technologies. The industrial development potential of the project activity is therefore high. The technology can be produced by Thai manufactures in the suggested *mega-supplier* and *supply-parks*.

## ► **Step 6: Institutional & Framework conditions (see chapter 9)**

**Table 8J: Enhanced sustainable development contribution of CDM projects applying the PDD elements; Sum up on the effects in Navanakorn - Thailand**

PDD elements	Development effect caused by the project activity
High project outreach	<p>The project activity is placed in Navanakorn and target 6 SME's in food, wood and chemical industries. The biomass CHP technology with district heating is implemented in an industrial area, where industries are located close to one another, creating an '<u>Industrial Ecology Engine</u>'. This implies that favourable conditions for exchanges of materials and energy within this area have been established, and that a more decentralised energy supply system can be developed. This can lead to the following benefits for the local community:</p> <p><u>Saved expenses on:</u></p> <ul style="list-style-type: none"> <li>• Power and fuel oil purchase;</li> <li>• Present waste handling costs;</li> </ul> <p><u>New business opportunities:</u></p> <ul style="list-style-type: none"> <li>• Sale of power and heat;</li> <li>• Sale of ash as farmland fertiliser;</li> <li>• Use of local biomass waste as fuel;</li> <li>• Local farmer's etc. supply of agricultural residues;</li> </ul>
Large emission reductions at low abatement costs	<p>By various activities along the materials and energy chain 28,100 tons of CO<sub>2</sub> emissions are avoided annually, from the following sources:</p> <p><u>Materials chain:</u></p> <ul style="list-style-type: none"> <li>• Transportation of waste;</li> <li>• Inefficiently (if any) re-use outside the site;</li> <li>• Biomass decay in landfills;</li> <li>• Biomass decay or burning on farmland;</li> </ul> <p><u>Energy chain:</u></p> <p>Grid power and individual fuel oil consumption (also lower SO<sub>2</sub> &amp; NO<sub>x</sub>);</p> <ul style="list-style-type: none"> <li>• Extraction and transportation etc. of the above;</li> </ul> <p>Instead the following has improved the energy chain in Navanakorn:</p> <ul style="list-style-type: none"> <li>• Production of biomass power <i>and</i> heat (applying 18,400 MWh/y fuel); in</li> <li>• A cost effective biomass CHP technology with district heating (0.4 MWe);</li> <li>• Process integration and cascading of energy;</li> <li>• Energy efficiency; hereunder</li> <li>• Supply of low qualitative energy instead of high qualitative energy (from steam to hot water; from electricity to hot water); leading to</li> <li>• 11,000 MWh/y of primary heat demand (down from 17,200);</li> </ul>
Increase in short and long term employment	<p>To increase the job opportunities from the project activity, emphasis is on biomass technologies with supply of biomass residues, as the employment effect is highest:</p> <p><u>Direct jobs:</u></p> <ul style="list-style-type: none"> <li>• 10 'Construction jobs' are here estimated (short term), and</li> <li>• 7 'Maintenance &amp; Operation jobs' estimated (long term);</li> </ul> <p><u>Indirect jobs:</u></p> <ul style="list-style-type: none"> <li>• It is argued that the direct employment can lead to 2-4 times indirect employment;</li> </ul>
Local markets and efficient technology manufacturing	<p>To increase the value chain, and thus potential development effects by the project activity even further, the following are highlighted:</p> <ul style="list-style-type: none"> <li>• Local market in Thailand (and other Asian countries) are large, due to the industrial structure, where industries mainly settled in Industrial Parks (spreading);</li> <li>• The market for applying efficient energy technology is high in the industrial sector in Thailand, as future CO<sub>2</sub> emissions are projected to grow here (need);</li> <li>• Large future generation of biomass from the 'industrial' and 'waste' sector, makes a future market for supply of fuel viable (supply);</li> <li>• Partnerships and transfer of know-how can start a manufacturing scheme of biomass CHP in Thailand (boilers &amp; district heating pipes etc.), to support a large scale implementation of the project activity (co-operation);</li> </ul>

Source: Own figure, Data from Chapter 8



## Chapter 9; Institutional & framework conditions for Thai CDM

This chapter builds and elaborates further on the extraction of ‘Policy Recommendations’, which I have exercised throughout the report. It seeks to identify the overall Institutional & framework conditions for CDM in Thailand, including already proposed and new Policy Recommendations. The Institutional & framework conditions will firstly be exposed, by identifying what generally impacts the conditions for CDM projects, and then secondly by pointing out how the extracted Policy Recommendations etc. can improve on these conditions. Thirdly, it identifies relevant Thai stakeholders, who potentially can influence on these conditions, or policies, for enhanced CDM projects. This chapter thus identifies influential stakeholders having potential impacts on enhancing future CDM project implementation in Thailand, and point to future CDM ‘project carriers’.

This will eventually lead to a “*systematic way of collecting information regarding the institutional conditions behind the different phases of a production process*”, as proposed by DANIDA. I have, however, not only established such systematic way, but also importantly come up with Policy Recommendations to *what* these institutions/stakeholders actually can do. This will be presented for Thailand at the end of this chapter.

In the following analysis, I distinguish between a **Market** and a **Non-Market** approach (*Governmental Organisation, GO & Non-Governmental Organisation, NGO*) to the Institutional & framework conditions having impact on the proposed CDM project activity, as well as on other potential CDM projects, at different levels. Behind the Market and Non-Market approach various stakeholders exist, each of them having either **influence** or **no influence** on improving the conditions for CDM in Thailand.

The Institutional & framework conditions for CDM will be analysed in this chapter, as exemplified below:

In Table 9A, I have - on a general level - identified **What impacts CDM projects** connected to planning, implementation and operation of CDM projects. Looking at the planning phase - the ‘*PDD phase*’ (9.1 & 9.2) - I have identified ‘Biomass fuel price’ and supply of ‘Appropriate technology’ as being important elements in this phase. Thus, relevant **Policy Recommendations** are pointed out with the purpose of strengthen the conditions for CDM in this phase. Hence, relevant ‘industrial and agricultural waste policies’ can thus strengthen these conditions (non-market), as well as more focus on and support to various ‘waste generators’ (market). **Influential stakeholders** are hereafter identified within the areas above, and project carriers pointed out. This systematic continues with an identification of what impacts CDM projects in the CDM ‘*implementation phase*’ (9.3 & 9.4), and in the CDM ‘*operation phase*’ (9.5 to 9.8), with Policy Recommendations and Influential Stakeholders likewise identified. All together these activities pose a strengthening of the Thai Institutional & framework conditions for CDM projects.

**Table 9A: Institutional & framework conditions**

	What impacts CDM projects?	Policy Recommendations		Influential stakeholders (or 'project carriers')
		Non- Market	The Market	
P D D	<b>Biomass fuel price (supply, quality and price of raw materials)</b>  (9.1*)	Industrial waste policy; Agricultural and energy policy;	Waste generators;	Relevant ministries etc. dealing with industry, energy, and agriculture etc. Provinces; Municipalities;  Industrial Parks; Municipalities Provinces; Farmers etc.;
	<b>Appropriate technology (supply)</b>  (9.2)	National policies; (Master Plan & CER's ADDER)	Local manufactures of energy technology and equipment;  Foreign manufactures of energy technology and equipment;	Relevant ministries dealing with energy;  Manufactures of biomass boilers, heat exchangers and pipers for distribution of heat etc.; (In joint venture with)  Relevant companies from the North with know-how to transfer;
P R O J E C T  I M P L E M E N T A T I O N	<b>Technology efficiency &amp; investment costs (development)</b>  (9.3)	National policies & initiatives (Efficient production and consumption of energy & conduction of PIN's);  National technology standards;  Public R&D in renewable energy technology;	Mega-suppliers of appropriate technology; Supply-park of materials and goods;  International technology standards;	Relevant embassies; business associations and chamber of commerce etc.  Relevant ministries dealing with energy; embassies and DNA's;  Relevant institutions dealing with standards;  Relevant international institutions dealing with standards;  Relevant national and quasi national institutions etc. dealing with research;
	<b>Financial conditions</b>  (9.4)	pCDM & bundling;	Commercial financial support;  Transaction costs;	Relevant banks or financial institutions;  Project developers; DNA's;
P R O J E C T  O P E R A T I O N	<b>Technology maintenance &amp; operation</b>  (9.5)	Training activities;	Supply-park of services;	Ministries dealing with energy and labour etc.. Universities dealing with technical knowledge and training activities;  Relevant embassies; business associations and chamber of commerce etc.;
	<b>Public subsidies</b> (9.6)	Financial support;		Relevant ministries dealing with energy; Investment institutions;
	<b>Power selling price</b> (9.7)	Regulation of power market;	National power companies;	Relevant ministries dealing with energy; Power companies;
	<b>Heat selling price</b> (9.8)	Regulation of heat market;	Demand / market for heat;	Relevant ministries dealing with energy; Relevant ministries dealing with industry;

Source: Own table (\* = the numbers refer to the sections below)

## 9.1 Biomass fuel price

As outlined in Table 9A above, **biomass fuel prices** impacts on the possibilities for implementing CDM projects in Thailand. Biomass fuel price is either the price of buying for instance agricultural waste, the price for collecting industrial wastes generated by industries located in Industrial Parks, or the price for buying appropriate waste from other relevant sources to support the energy production (or a combination of the three). 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 price' is without costs and lead to savings in industries, as expenditures on waste management will end with the transformation of the energy supply.

Waste from the residential and industrial sectors tend to be 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 more 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 placed, and the overall responsibility for pointing out appropriate areas for landfill areas are the Province, in which the industrial sites is situated (Ibid.).

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<sup>22</sup>. They authorise that industrial waste are moved from one place to another - with the purpose of for instance re-use - 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 supply of biomass wastes from Industrial Parks and to facilitate the project activity within these sites (Ibid. & Sutiratani, 2008).

In Thailand, a commercial biomass market as the one we know in Denmark are not yet established (Møller, 2007a). Some agricultural biomass residues are therefore openly dumped or burned on the fields etc. In Pathum Thani - the Province in which Navanakorn is situated - large quantities of rice straw are for example burned on the fields, and therefore pose a great potential as fuel supply to Industrial Parks in the Province (Praphakornkiat, 2007).

Unlike other kinds of biomass residues (rice husk & rice ash etc.), rice straw is not yet exposed to any kind of competition - meaning competitive use - which puts a price on it. Several cases in Thailand have recently pointed out how fragile energy producers can be, when they are depended on biomass supply from farmers. Even with written contracts in place farmers have chosen to sell the biomass to other sources for a price increasing from THB 300/tons to THB 1,200/tons, providing a favourable economic surplus even when the fine for breaking the contract are paid (Greacen, 2007a & Opatvachirakul, 2007).

---

<sup>22</sup> A distinguish is here made between private managed Industrial Zones and national managed Industrial Estates, of which the latter is far the majority.

Despite such cases, the future average price of biomass residues are not expected to increase extremely. Currently, the price is THB 188/MWh (DKK 30,-), which is expected to increase to THB 250/MWh in 2025 (DKK 47,-), reflecting the expected level of the crude oil price up to the year 2025 (Ministry of Energy, Thailand & DANIDA, 2006). However, recently prices for rice husk and palm oil shells have reached levels of THB 800 and 2,200 respectively (Sutiratana, 2008).

Thus, as the pressure on waste management in Thailand increases, relevant stakeholders will be interested in finding more local and sustainable solutions for the waste management. This can be stakeholders in the central administration, just as more local stakeholders responsible for waste disposals will be increasingly interested in finding new solutions.

### **9.1.1 Actions by influential stakeholders**

#### ***Industrial waste policy (Non-Market)***

At the Industrial Parks, DIW can especially 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 strengthening the regulation on industrial wastes, as to limit the amounts of biomass wastes that are discharged, and encourage that re-use takes place within the Industrial Parks. This should be done in collaboration with IEAT, who are in charge of the majority of Industrial Parks in Thailand.

At the municipal and provincial level Takhlong Municipality and Pathum Thani Province can both 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 site, as to prevent valuable biomass discharges. Presently, biomass waste are discharged with the normal wastes, and therefore ends up in landfills or dumped on land. Takhlong Municipality could set up a scheme, in which industries would have to pay a fine for discharging valuable biomass wastes. This will act as an incentive for separating the waste, and thus facilitate appropriate re-use of industrial biomass waste.

Another possibility is to examine the present re-use of biomass wastes, thus evaluate and suggest other means of re-use, preferably within the Industrial Parks. Some of the industrial biomass waste from Navanakorn are for example transported far away, and re-used quite inefficiently in other manufacturing business. In case industries (see Chapter 6 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 therefore very likely that large amounts of biomass waste undertake such inefficient re-use (if any) elsewhere. Such analysis could increase the amounts of biomass waste supply within Thai Industrial Parks, and could be undertaken by Pathum Thani Province, DIW and IEAT jointly. The outcome of the study could be strengthening of the industrial waste regulation by DIW, prohibiting outside re-use of biomass waste, if 'inside' more efficient options are available.

### ***Agricultural and energy policy (Non-Market)***

Moreover, Takhlong Municipality could 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 Ministry of Agriculture and Co-operatives, and the collected agricultural residues be distributed to the Industrial Parks within the Province. In order to increase the amount of agricultural biomass waste, Ministry of Agriculture and Co-operatives could prohibit burning of agricultural biomass waste on the fields, which would act as an incentive to participate in the collective system.

The Ministry of Agriculture and Co-operatives could also, in partnership with the Ministry of Energy, make analysis 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, as is referred to as 'waste-land'. 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 has been taken in this direction (Opatvachirakul, 2009).

→ Influential stakeholders for the two aspects above are DIW, Ministry of Agriculture and Co-operatives, MoE, Pathum Thani Province and Takhlong Municipality.

### ***Waste generators (The Market)***

'Waste generators' are here Industrial Parks as for instance Navanakorn in which industrial biomass wastes and household waste etc., are generated. It is also the municipal and provinces in which the Industrial Parks are located, contributing to biomass waste generation (household waste, residues from fruit and vegetable markets, waste from commerce, etc.). It is 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.

### **Sum-up**

'Waste generators' constitute the *Market* option and the Thai 'industrial waste policy' and 'agricultural and energy policy' the *Non-Marked* option, which can be *influenced* to support implementation of the project activity by improving the access to biomass waste for energy purposes, as discussed above.

## **9.2 Appropriate technology (supply)**

The next step in the production process upon a transformation of the Thai energy supply and consumption is the implementation of **appropriate technology**, as it impacts CDM. Thus, appropriate energy technologies should be manufactures 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.

## 9.2.1 Actions by influential stakeholders

### *National policies (Non-Market)*

Master Plan: To support a technology demand new national policies for supply and use of district heating could be introduced, and support the supply of appropriate technology for the project activity proposed. This could be initiated by a two step Master Plan for 'EE & District Heating' in the industrial 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, 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.

CER's ADDER: The above initiative could be supported by a CER's 'ADDER' for projects dealing with energy efficiency. Thus, more CER's generated per reduced emission unit coming from energy efficiency, acting as incentive for implementing the first phase of the two step Master Plan.

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

### *Local & foreign manufactures of energy technology and equipment (The 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, especially two manufactures are pulled forward, namely Bangkok Industrial Boilers and Hansa Boiler International, of which the latter previously has co-operated with Babco Borsig from Berlin, and have a great 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 manufactures of district heating pipes, as for instance Logstor, StarPipes and Isoplus could also establish such joint partnership with a relevant Thai stakeholders. This could for instance be a company named Tor Nam Thai, who produces un-insulated PVC pipes for energy supply (Sutiratana, 2008). As far as manufacturing heat exchangers for appropriate transmission of heat from the district heating network to the industries requiring process heat supply, local manufactures already exists in Thailand. A company named Genesis, produce efficient heat exchangers in their factory in Rayon, south east Thailand, at ¼ the price of imported heat exchangers from Finland (Salam, 2008).

Setting up manufacturing of steam turbines in Thailand is not likely to be feasible, as the resource base (knowledge connected to producing this kind of technology) in Thailand is limited. Import from the nearby Singapore is an option, as quite efficient German steam turbines are manufactured there under license (Møller, 2007). Alternatively, the steam

turbines can be supplied by Chinese manufactures. The efficiency of the technology might then be compromised, but the purchase prices are lower (Møller, 2008a).

→ Influential stakeholders regarding this aspect is thus Genesis, Bangkok Industrial Boilers, Hansa Boiler International, Tor Nam Thai, Vølund, StarPipes, Logstor and Isoplus.

### **Sum-up**

Foreign and domestic producers of energy technology constitute the *Market* option for supply of appropriate energy technology, whereas the overall national policies constitute the *influential Non-Market* option.

## **9.3 Technology efficiency and investment costs (development)**

The **technology efficiency & investment costs (development)** of energy technologies, also impact on future CDM projects. They largely depends on the maturity of technologies (technical reliability and energy efficiency), which tend to increase with increased market size (technology demand). A large 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.

### **9.3.1 Actions by influential stakeholders**

#### ***Mega-suppliers of appropriate technology & Supply-park of materials and goods (The Market)***

As suggested briefly in the section above, appropriate technology supply can be established by several suppliers in Thailand, based on joint ventures between Danish and Thai manufactures. Companies, as for instance Vølund and Løgstør Pipes, could join forces with Thai industries, as for example Bangkok Boilers, to produce efficient energy technology. They would become mega-suppliers of the technology not only in Thailand. A local or regional supply-park would evolve around the mega-suppliers, producing spare parts, materials and goods to support the production: Hereby, the majority of the value chain stays in Thailand instead of being transferred to developed countries in the North.

Thus, the technology efficiency is 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 non-developed country (cheaper labour, materials etc.). Observations point to the fact that technology produced in developing countries can lower the total investment costs by a factor four compared to the production cost 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 the collaboration between relevant technology manufactures' in Thailand and Denmark, with the purpose of creating 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 BKK, FTI and the Thai Chamber of Commerce.

### ***National policies/initiatives (Non-Market)***

Efficient energy production and consumption of energy: Energy efficiency can also be supported by national Governmental policies. 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 transfer of know how from the North through joint ventures with local companies, and the investment costs decreased by placing the production of the technology in developing countries. Governmental actions supporting the implementation of such technologies can be established by increasing the demands for efficient production and consumption of energy:

Thai regulation recently (December 2006) gave priority to heat generation by CHP production, by for instance re-allowing fossil fuel CHP Plants and by higher requirements on the quantitative output of heat from the technologies by adopting European standards; 10 % Primary Energy Savings (PES) for CHP production.

I suggest that a feed in tariff is developed for heat consumption, similarly 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.

This 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 also biomass CHP Plants in Thailand make use of generated heat, which presently only is required on fossil fuel CHP Plants. This will also act as incentives to locate the CHP Plants near a potential market or make optimisations in internal use of heat.

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

Conducting PIN's: In order to select the 'right' CDM projects, Thailand should not only wait for bilateral or multilateral projects to evolve, as the project developers connected to these projects not necessary looks at the future development options of their projects for Thailand in the long run; they would be more interested in quick projects leading to high CER's generation. Thailand should therefore initiate CDM project activities by themselves, thus establish unilateral project activities, and thereafter sell the CER's 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 Thai TGO should promote the biomass CHP as potential CDM projects in Thailand, which could be done by creating a one-stop PIN-shop (project identification notes), offering already identified biomass CHP projects to potential investors. Such project pipeline, identifying many 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 (ERI, 2007) (See more on this issue in 9.4.1).

Activities could also be taken by bilateral donors - like Denmark - wanting Thailand to benefit more from the CDM activities in the country. Denmark could set up a biomass CHP Plants as a sort of 'CDM demonstration plant', paving the way for more projects like this to evolve, with the Danish Embassy being active in this. 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 which identifies possibilities for implementing identical projects.

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

### ***National & International technology standards (Non-Market & The Market)***

Standard policies, 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 certain 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 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 is 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 ISO and TISI, dealing with international and domestic standards respectively.

### ***Public R&D in renewable energy technology (Non-Market)***

The development of technology also often depends on the level of public R&D invested in the specific technology. The development 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 MOST, thus NSTDA and TISTR.

### **Sum-up**

Setting up mega-suppliers and supply-parks in Thailand constitutes the *Market* option, whereas national policies requiring efficient production and consumption of energy, on the other hand, constitute the *Non-Market* option. Standards posed on energy technologies constitute both a *Market* and a *Non-Market* option. The latter is defined by international organisations, as for instance ISO, and the first by the Thai Government (TISI), when increasing the efficiency standards of technologies.

## **9.4 Financial conditions**

### **9.4.1 Actions by influential stakeholders**

#### ***Commercial financial support (The Market)***

Finally, the commercial financial conditions (possibilities for obtaining loan or other means of commercial financing) have 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 loan unless the pay back period is extremely short.

Thai Military Bank has a long tradition for supporting financing of renewable energy implementation. They also now 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 (The Market)***

Transaction costs for smaller CDM projects tend to be relatively higher than for larger CDM projects. This, off course, pose a barrier for the implementation of smaller projects with a relatively low generation of CER's, but often superior when it comes to sustainable development contribution in local communities (IGES, 2006). Several initiatives which can support the implementation of smaller CDM projects have however been developed:

'*Bundled CDM projects*' is an opportunity, in which CDM project clustering makes small identical projects economically viable. Hence, renewable energy implementation and energy efficiency initiatives, transferable from one industry to another, can be bundled to save transaction costs. Even sub-bundling can be applied, which can be an option when seeking improvements in the energy consumption within Thai manufactures. Along the many different production processes undertaken by these manufactures, similar actions will however take place, for instance substitution of boilers, implementation of more efficient processing equipment (motors, ventilation etc.). These activities can be sub-bundled and thus pose a reduced transaction costs, compared to isolated actions taking place in one single industry.

Smaller CDM project furthermore benefit from the following conditions:

- “A simplified project design document (PDD), including the additionally text;
- Simplified, predefined Baseline methodologies provided by category;
- Simplified monitoring plans;
- The possibility to hire the same operational entity for validation, verification and certification;
- Lower levies by the UNFCCC to cover administrative expenses and registration fees” (UNFCCC, 2002, p.220)

‘Programmatic CDM’ is also a possibility for lowering the transaction costs connected to CDM project implementation. Programmatic CDM is defined as:

“A programme of activities (PoA) is a voluntary coordinated action by a private or public entity which coordinates and implements any policy/measure or stated goal (i.e. incentive schemes and voluntary programmes), which leads to anthropogenic GHG emission reductions or net anthropogenic greenhouse gas removals by sinks that are additional to any that would occur in the absence of the PoA, via an unlimited number of CPA’s” (EB 32, Annex 38, paragraph 1).

A PoA is made up of CDM Programme Activities (CPA’s), where multiple CPA’s can be included under a PoA at the time of registration. Additional CPA’s can be added at any point in the life of the PoA. A CPA is defined as:

“A project activity under a programme of activities: A CPA is a single, or a set of interrelated measure(s), to reduce GHG emissions or result in net anthropogenic greenhouse gas removals by sinks, applied within a designated area defined in the baseline methodology” (EB 32, Annex 38, page 1).

A PoA can involve CPA’s being run in multiple countries, in which case a separate letter of approval would be required from each Party involved. Thus the physical boundary of a PoA may extend to more than one country provided that each participating non-annex I host Party provides confirmation that the PoA, and thereby all CPA’s, assists it in achieving sustainable development. The private or public entity that coordinates the PoA is referred to as a coordinating/managing entity. A PoA is different than a bundle of small-scale projects, because it is possible to add new CPA’s to a PoA without undertaking the validation process again.

The CDM project developers decide which type of projects to implement, and whether it/they will be a bundled or programmatic CDM project or not. The DNA’s can, however, promote and assist the project developers in using these types of project implementation tools, in order to promote these concepts in the future.

→ Influential stakeholder is here the Thai project developers, as well as the Thai TGO.

### Sum-up

*Financial conditions* are both a **non-market** and a **market** option, which partly can be **influenced** to support enhancements of CDM projects: The *Commercial financial support* is a market option, which depends on the will to support CDM projects on the financial markets. The *Transaction costs* connected to CDM projects is a **market** option, which depends on the project developers will to apply Programmatic CDM and Bundling of CDM projects. This can, however, be **influenced** by the DNA - the **non-market** - through their support of and promotion of programmatic CDM and project bundling, etc.

## 9.5 Technology maintenance & operation

Maintenance & operation of implemented technology must take place by skilled Thai craftsmen, trained to do the job. A supply-park of such services will have to be established, in order to service the technologies manufactured by the mega-suppliers.

### 9.5.1 Actions by influential stakeholders

#### *Training activities (Non-Market)*

The actual training of the craftsmen 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 (DEDE & EPPO) and academia (AIT).

→ Influential stakeholders are here Ministry of Labour, KMIT, AIT, EPPO and DEDE.

#### *Supply-park of services (The Market)*

The establishment of the supply-park of services 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, FTI and the Thai Chamber of Commerce.

#### **Sum-up**

The supply-park of services constitutes *The Market* option, whereas the training activities constitute the *Non-Market* option.

## 9.6 Public subsidies

**Public subsidies** can be used as financial support for biomass technologies, making them competitive against commercially energy technologies. Subsidies can also be granted to promote implementation of efficient manufacturing equipment in order to promote technological development in the manufacturing sector. Donation of grants can for instance take place as a governmental grant (construction/implementation grant), in which a certain percentage (for instance 30 %) of the investment costs is donated. Public subsidies can for example be an electricity or heat selling subsidy (operation subsidy), which the government put on the end-users, making them pay more for energy produced on biomass resources. In the following, relevant financial programs by the Thai Government will be highlighted, whereas conditions for power and heat sales will be emphasised in the next section.

### 9.6.1 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; thus the ENCON Fund and NSTDA Program.

### ***Financial support (Non-Market)***

#### **I: Energy Conservation Promotion Fund (ENCON)**

The ENCON Fund is financed by a gasoline tax put on all petroleum products sold in Thailand, and presently the financial revenue per litre petroleum is THB 0.04. The ENCON Fund provides funding for project preparation, project management and advisory services, investment and project evaluation, and financial assistance for investment in energy efficiency and renewable energy technologies (CEERD, 2008). Under the ENCON Fund the following two projects under the Voluntary Program are suitable under the CDM;

- Promotion of Renewable Energy Utilization Project;

The objective of the Program is “*to promote renewable energy, which has less impact on the environment, and to assist in energy conservation in rural industries, both in the agricultural and industrial sectors. Emphasis is placed on projects related to the introduction, dissemination, and transfer of renewable energy technologies; projects on energy-efficiency improvement using proven technologies; and projects utilizing agricultural processing residues (e.g., bagasse, rice husk and municipal waste) or agricultural wastes (e.g., animal manure) to produce energy*” (IGES, 2006, p. 106).

- Promotion of Small Power Producers using Renewable Energy Project;

The objective of the Program is “*to promote the use of renewable energy in power generation and enhance the existing policy on power purchase from SPP’s using renewable energy sources as fuel. Renewable energy here includes solar; wind; biomass; biogas; municipal wastes; agricultural residues; or industrial or agro-industrial residues*” (IGES, 2006, p. 108).

Further, due to the lack of actions resulting from the ‘Compulsory Program for Designated Factories and Buildings’ promoted in Thailand, the following fund were established in January 2003 with the aim of stimulating investment in energy efficiency and renewable energy by the Thai financial sector (IGES, 2006 & CEERD, 2008);

#### ***Energy Efficiency Revolving Fund (EERF);***

The objectives of the fund is to provide low-interest loans to private stakeholders (designated factory owners), to stimulate investments in energy efficiency. Such initiatives had proved to have very low priority in the industrial sector in Thailand, and the fund were thus seen as a way to improve the incentives for implementing energy efficiency measures at the industrial level:

*“Improvement in combustion efficiency of fuel;*

*Prevention of energy loss;*

*Recycling of energy waste;*

*Substitution of one type of energy with another type;*

*More efficient use of electricity through improvements in power factors, reduction of maximum power demand during the period of the electricity’s peak demand, use of appropriate equipment, and other approaches;*

*Energy use: efficient machinery or equipment as well as use of operation control systems and materials that contribute to energy conservation;*

*Other means of energy conservation as stipulated in ministerial regulations”* (IGES, 2006, p. 108).

Funding channelled to the EERF Fund comes from the ENCON Fund through 11 participating banks in Thailand, including Thai Military Bank, who provides credit lines of THB between 100 to 200 million (CEERD, 2008) for the types of projects mentioned above.

## **II. National Science and Technology Development Agency financial program (NSTDA Program)**

This program supports growth in Thailand through promotion of linkage and collaboration between the private and public sector, supporting and encouraging Research Development and Engineering (RD&E). To expand the technological capabilities and increase the private sector competitiveness of Thai companies, the NSTDA Investment Center (NIC) was created, with the purpose of supporting and encouraging RD&E (IGES, 2006 & CEERD, 2008). NIC offers two types of financial support:

- Soft loans (low interest loan from 7 participating financial institutions);
- Investment activities (management advisory, joint venture support, financing to high potential business projects);

Thus, the NSTDA Program offers soft loans and various investment to enhance development, research and engineering in technology development and implementation in Thailand for supporting the Thailand's competitiveness (IGES, 2006)

Below, I have outlined who is responsible for the programs above:

- 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 EPPO, DEDE, NSTDA and NIC.

### **Sum-up**

The possibilities for economic support illustrated above are *non-market* options, which can be *influenced* to support CDM enhancement in Thailand.

## **9.7 Power selling price**

The **power selling price** also impacts CDM projects if the project activity 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, 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 a CHP system (Lybæk, 2004).

## 9.7.1 Actions by influential stakeholders

### ***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 (See Chapter 5). Especially biomass waste 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.

### ***Power companies (The Market)***

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 activity. Alternatively, a local owned grid can be put in the soil to avoid such expenses (this is off course not without expenses).

→ Influential stakeholders are here primarily EGAT.

### **Sum-up**

Conditions for power sales, as illustrated above, can be described as a ***Non-market*** option, which can be ***influenced*** to support enhancements of CDM projects focusing on especially CHP production in Thailand. Decisions taken by EGAT regarding approval of ‘power purchase agreements’ and ‘wheeling fee’ are ***non-market***<sup>23</sup> option, which can be ***influenced*** to support enhancements of the condition for CDM projects.

---

<sup>23</sup> Due to public resistance in Thailand EGAT is not fully privatized. The people of Thailand have sued the government on this issue, claiming that the power sector is their rightful property, which the government has been trying to sell out. The Thai people won the court case and EGAT is still (or partly) a state company (Sutiratana, 2008).

## 9.8 Heat selling price

### 9.8.1 Actions by influential stakeholders

#### *Regulation of heat market & Demand / market for heat (Non-Market & The Market)*

The **heat selling price** also impacts CDM projects, and normally, at least in a European context, 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.

The options for selling heat very much depends on the possibilities of setting up district heating networks for 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 is thus formulated, and it is therefore likely that CDM projects addressing this issue will be met positively by various stakeholders including governmental organisations.

Another initiative can be applied by the IEAT in Thailand. They can - when planning the design of new industrial sites 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. And as mentioned, power supply can also be placed under the soil in the industrial sites, to avoid the use of EGAT transmission lines.

→ Influential stakeholders are here Ministry of Energy and IEAT.

#### **Sum-up**

The conditions for heat production and consumption, as highlighted above, is a *non-market* options, which can be *influenced* by MoE through their support in implementing the national policies (suggested in 9.3). The industrial demand for heat is a *market option*, but can *be influenced* by stakeholders responsible for operating and regulating Industrial Zones or Parks in Thailand, namely the IEAT.

## 9.9 Institutional & framework conditions

In the following, I have summed up on the previous analysis, which is outlined in Table 9B next page.



**Table 9B: Institutional & framework conditions - Thailand**

	What impacts CDM projects?	Policy Recommendations		Influential stakeholders (or 'project carriers')
		Non-Market	The Market	
P D D	<b>Biomass fuel price (supply, quality and price of raw materials)</b>  (9.1*)	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.;
	<b>Appropriate technology (supply)</b>  (9.2)	National policies; (Master Plan & CER's 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/Logstor/Isoplus;
P R O J E C T  I M P L E M E N T A T I O N	<b>Technology efficiency &amp; investment costs (development)</b>  (9.3)	National policies & initiatives (Efficient production and consumption of energy & conduction of PIN's);  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);
	<b>Financial conditions</b>  (9.4)	pCDM & Bundling;	Commercial financial support;  Transaction costs;	Thai Banks (Thai Military Bank or Siam Bank);  Project Developers; TGO;
P R O J E C T  O P E R A T I O N	<b>Technology maintenance &amp; operation</b>  (9.5)	Training activities;	Supply-park of services;	Ministry of Labour & KMIT; AIT; EPPO; DEDE;  Royal Danish Embassy in Bangkok; FTI; Thai Chamber of Commerce
	<b>Public subsidies</b> (9.6)	Financial support;		EPPO; DEDE; NSTDA Investment Center (NIC);
	<b>Power selling price</b> (9.7)	Regulation of power market;	Power companies;	MoE;  EGAT;
	<b>Heat selling price</b>  (9.8)	Regulation of heat market;	Demand / market for heat;	MoE;  IEAT;

Source: Own figure

# Chapter 10; Generic Manual

## 10.1 Answer to the research question

*How can the sustainable development contribution of future CDM projects be enhanced, using Thailand as a case study, and developed into a generic Manual with guidance on how to pursue this in Asian countries?*

By bringing in and developing a set of sustainable development concepts, a platform is established in this study from which extractions of elements for the Manual has been conducted throughout the report. These elements, being Planning Guide and Policy Recommendations, has hence been arranged and developed further to strengthen the sustainable development contribution of future CDM projects in Thailand, emphasised more below. In this chapter, the Manual addresses tropical Asian countries in general and not only Thailand.

Based on the Planning Guide extractions throughout the report, the Planning Guide has been developed (see Figure 10A next page). This has been done by arranging the extractions from each chapter of the report in a logical planning order. The Planning Guide focus on providing guidance to how to implement biomass CHP with district heating in tropical countries in Asia with a lack of heat markets. The CHP technology provides many development benefits and opportunities for countries in Asia. The Planning Guide thus focus on the implementation of *biomass CHP with district heating in Industrial Parks in Asia*, as the industries located here has a demand for process heat and are located close to one another.

Each step of the Planning Guide (Figure 10A) increase the benefits of implementing the CDM project activity in the host country, and in the latter steps, an actual manufacturing of the renewable energy technologies *could* be exercised in countries in the South if the conditions are favourable. Thus, a value chain expansion will occur connected to the implementation, operation, and eventually manufacturing of the renewable energy technology in Asian countries.

Figure 10B outline the sustainable development contribution of the proposed CDM project activity - the biomass CHP with district heating - if implemented in Asian countries. As the figure show, many benefits can be achieved if such projects were promoted. The biomass CHP technology supplying district heating to a community of SME's can thus be described as an *Industrial Ecology Engine* enabling a verity of environmental and GHG related actions to take place. This is due to the fact that the technology embraces and substitutes a lot of resources along the materials and energy chain connected to the use of energy and waste generation. Also when it comes to creating job opportunities many benefits can be achieved, as the biomass CHP technology is labour intensive in all its lifetime. This is opposed to many other CDM renewable technologies which lack the capacity to provide permanent jobs in host countries.

The last step of the Planning Guide in Figure 10A - the Institutional & framework conditions - is addressed in Table 10C. In order to support the usability of the Planning Guide, and thus enabling that more sustainable future CDM projects are implemented in Asia, the Institutional & framework conditions have been strengthened. The extraction of *Policy Recommendations* throughout the study has thus been integrated with an identification of *what impacts CDM*

*projects* and the relevant *Influential stakeholders*, in doing this. In each phase of CDM project implementation this strengthening has taken place: in the PDD-phase, in the Project implementation-phase and in the Project operation-phase.

The usability of the Planning Guide will be improved - and thus the options for implementing biomass CHP with district heating in Asia - if the suggested strengthening of the Institutional & framework conditions proposed is established. In general, however, the improved conditions outlined in Table 10C, will also improve the likeliness that other types of biomass projects are implemented in Asia; with or without CDM.

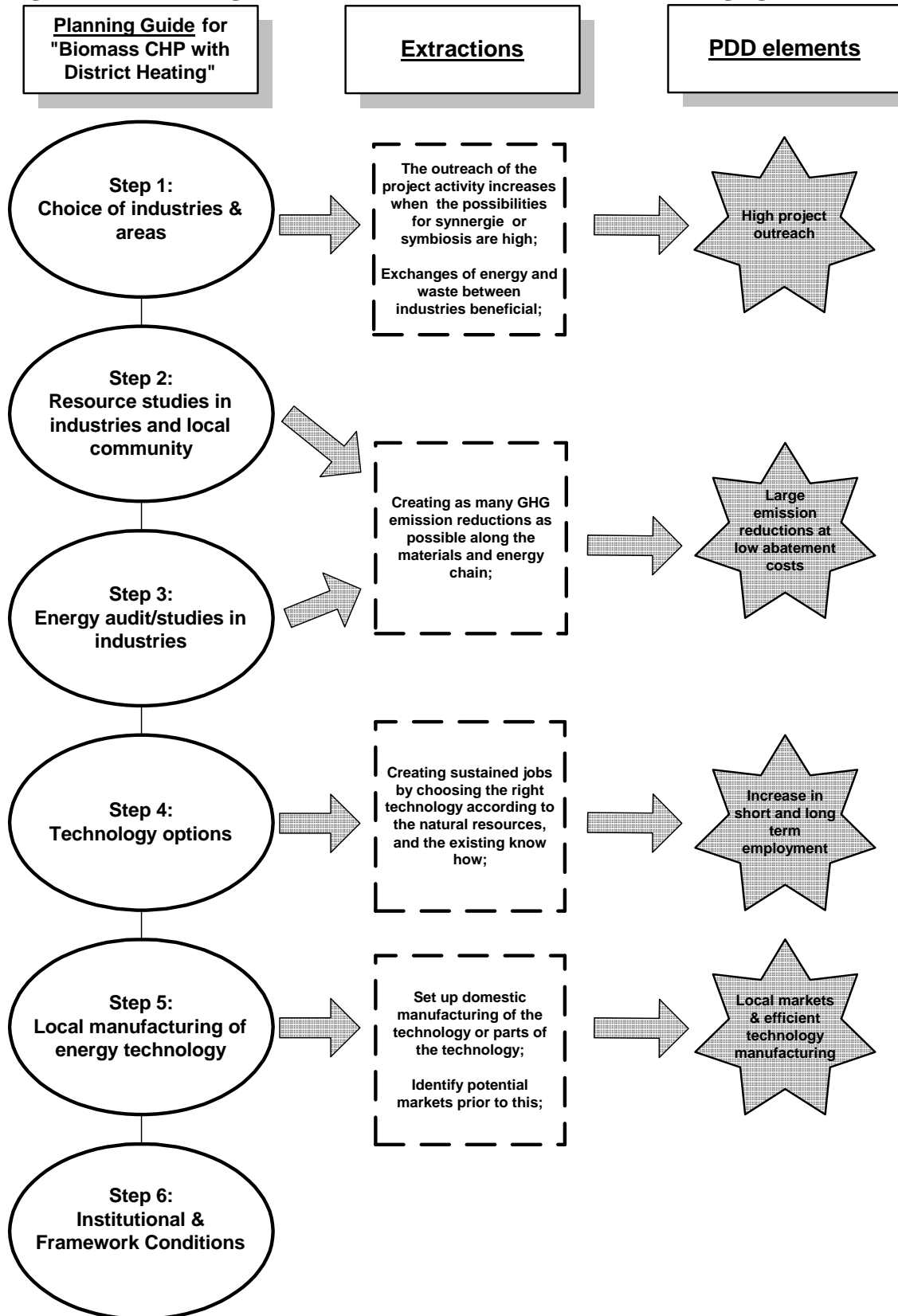
## **10.2 How to begin?**

In order to support the usability of the Planning Guide even further, I suggest that relevant stakeholders in Asia seek to kick-start the implementation of biomass CHP with district heating, within the many Industrial Parks established in this part of the world. Asian countries could thus set up a “CHP-team” who visits the Industrial Parks and promotes the implementation of biomass CHP with district heating. Workshops, seminars and promotion materials etc. need to be conducted and disseminated in each Industrial Parks to promote the idea. At the local level influential stakeholders related to the PDD-phase (see Table 10C) will have to be invited and included in the discussion and planning, as being very important local stakeholders; both as beneficiaries and contributors (municipalities, provinces, farmers and representatives for the local Industrial Parks etc.).

The lead stakeholders in this “CHP-Team” should thus be the most important influential stakeholders identified under the Institutional & framework conditions (in Table 10C), as for instance the Chamber of Commerce, relevant Ministries dealing with Energy, Industry and Agriculture, Ministries dealing with Industrial Parks, the national DNA’s, relevant local stakeholders as described above, and eventually also potential CDM project developers, etc.

The first assignment by the “CHP-Team” is to identify the CHP potentials within the Industrial Parks, and thus to initiate thorough analysis of the actual potentials. Another assignment which is very important is to eliminate barriers for implementation of such CDM projects, by bringing back comments and feed back on the current situation within the Industrial Parks to the central administration. In this way specific barriers can be eliminated, and a large scale implementation of biomass CHP with district heating can hopefully be initiated.

**Figure 10A: Planning Guide for biomass CHP with district heating - generic**



Source: Own figure

**Figure 10B: Enhanced sustainable development contribution of CDM projects - generic**

PDD elements	Development effect caused by the project activity
High project outreach	<p>The project activities will take place in Industrial Parks within SME's in the food, wood and chemical line of industries. The biomass CHP technology with district heating is thus implemented in industrial areas, where industries are located close to one another, creating an '<u>Industrial Ecology Engine</u>'. This implies that favourable conditions for exchanges of materials and energy within this area have been established, and that a more decentralised energy supply system can be developed. This can lead to the following benefits for the local community:</p> <p><u>Saved expenses on:</u></p> <ul style="list-style-type: none"> <li>• Power and fuel oil purchase;</li> <li>• Present waste handling costs;</li> </ul> <p><u>New business opportunities:</u></p> <ul style="list-style-type: none"> <li>• Sale of power and heat;</li> <li>• Sale of ash as farmland fertiliser;</li> <li>• Use of local biomass waste as fuel;</li> <li>• Local farmer's etc. supply of agricultural residues;</li> </ul>
Large emission reductions at low abatement costs	<p>By various activities along the materials and energy chain high amounts of CO<sub>2</sub> emissions are avoided annually, from the following sources:</p> <p><u>Materials chain:</u></p> <ul style="list-style-type: none"> <li>• Transportation of waste;</li> <li>• Inefficiently (if any) re-use outside the site;</li> <li>• Biomass decay in landfills;</li> <li>• Biomass decay or burning on farmland;</li> </ul> <p><u>Energy chain:</u></p> <p>Grid power and individual fuel oil consumption (also lower SO<sub>2</sub> &amp; NO<sub>x</sub>);</p> <ul style="list-style-type: none"> <li>• Extraction and transportation etc. of the above;</li> </ul> <p>Instead the following will improved the energy chain locally:</p> <ul style="list-style-type: none"> <li>• Production of biomass power <i>and</i> heat; in</li> <li>• A cost effective biomass CHP technology with district heating;</li> <li>• Process integration and cascading of energy;</li> <li>• Energy efficiency; hereunder</li> <li>• Supply of low qualitative energy instead of high qualitative energy; which</li> <li>• Lead to high energy savings;</li> </ul>
Increase in short and long term employment	<p>To increase the job opportunities from the project activity, emphasis is on biomass technologies with supply of biomass residues, as the employment effect is highest:</p> <p><u>Direct jobs:</u></p> <ul style="list-style-type: none"> <li>• 'Construction jobs' will be created (short term), and</li> <li>• 'Maintenance &amp; Operation jobs' also (long term);</li> </ul> <p><u>Indirect jobs:</u></p> <ul style="list-style-type: none"> <li>• It is argued that the direct employment can lead to 2-4 times indirect employment;</li> </ul>
Local markets and efficient technology manufacturing	<p>To increase the value chain, and thus potential development effects by the project activity even further, the following must be highlighted:</p> <ul style="list-style-type: none"> <li>• Are the local markets (or nearby markets) large, due to an appropriate industrial structure, where industries mainly settled in Industrial Parks (spreading);</li> <li>• Is the market for applying efficient energy technology high in the industrial sector, as the future CO<sub>2</sub> emissions are projected to grow (need);</li> <li>• Are there large future generation of biomass from the 'industrial' and 'waste' sector, making a future market for supply of fuel viable (supply);</li> <li>• Are there options for partnerships and transfer of know-how to start a manufacturing scheme of biomass CHP (boilers &amp; district heating pipes etc.), and to support a large scale implementation of the project activity (co-operation);</li> </ul>

Source: Own figure

**Table 10C: Institutional & framework conditions - generic**

	What impacts CDM projects?	Policy Recommendations		Influential stakeholders (or 'project carriers')
		Non-Market	The Market	
P D D	<b>Biomass fuel price (supply, quality and price of raw materials)</b>  (9.1*)	Industrial waste policy; Agricultural and energy policy;	Waste generators;	Relevant ministries etc. dealing with industry, energy, and agriculture etc. Provinces; Municipalities;  Industrial Parks; Municipalities Provinces; Farmers etc.;
	<b>Appropriate technology (supply)</b>  (9.2)	National policies; (Master Plan & CER's ADDER)	Local manufactures of energy technology and equipment;  Foreign manufactures of energy technology and equipment;	Relevant ministries dealing with energy;  Manufactures of biomass boilers, heat exchangers and pipers for distribution of heat etc.; (In joint venture with)  Relevant companies from the North with know-how to transfer;
P R O J E C T  I M P L E M E N T A T I O N	<b>Technology efficiency &amp; investment costs (development)</b>  (9.3)	National policies & initiatives (Efficient production and consumption of energy & conduction of PIN's);  National technology standards;  Public R&D in renewable energy technology;	Mega-suppliers of appropriate technology; Supply-park of materials and goods;  International technology standards;	Relevant embassies; business associations and chamber of commerce etc.  Relevant ministries dealing with energy; embassies and DNA's;  Relevant institutions dealing with standards;  Relevant international institutions dealing with standards;  Relevant national and quasi national institutions etc. dealing with research;
	<b>Financial conditions</b>  (9.4)	pCDM & Bundling;	Commercial financial support;  Transaction costs;	Relevant banks or financial institutions;  Project Developers; DNA's;
P R O J E C T  O P E R A T I O N	<b>Technology maintenance &amp; operation</b>  (9.5)	Training activities;	Supply-park of services;	Ministries dealing with energy and labour etc.. Universities dealing with technical knowledge and training activities;  Relevant embassies; business associations and chamber of commerce etc.;
	<b>Public subsidies</b> (9.6)	Financial support;		Relevant ministries dealing with energy; Investment institutions;
	<b>Power selling price</b> (9.7)	Regulation of power market;	National power companies;	Relevant ministries dealing with energy; Power companies;
	<b>Heat selling price</b> (9.8)	Regulation of heat market;	Demand / market for heat;	Relevant ministries dealing with energy; Relevant ministries dealing with industry;

Source: Own figure

# References

## Book & Reports

*Allenby, Braden R. (1999)*, Industrial Ecology: Policy Framework and Implementation, AT&T, Prentice-Hall, Inc.

*Asian Development Bank, ADB (1998)*, Asia Least-cost Greenhouse Gas Abatement Strategy: Thailand, ADB, Manila (ALGAS project).

*Bang, Christian & Gil, Gina (2005)*, Encouraging Greater Kyoto Participation with CDM Focused on Sustainable development, University of Roskilde, Department of Environment, Technology and Social Studies.

*Center for Energy Environment Resources and Development, CEERD (2008)*, SET Promotion at CDM Market - Thailand Report.

*Danish International Development Assistance, DANIDA (2004)*, Strategi for Danmarks miljøindsats i udviklingslandene 2004-2008

*DEDE & DANIDA (2006)*, Promotion of Renewable Energy Technologies (PRET Project), Thailand.

*Dansk Teknologisk Institut, DTI, Træteknik (1994)*, Reduktion af energiforbruget til udsugning i træindustrien.

*Danish Energy Authority (2004)*, CDM Projects: Opportunities for Danish Industry.

*Deutsche Gesellschaft für Technische Zusammenarbeit, GTZ (2000)*, Industrial Ecology in Asian countries.

*DMU / National Environmental Research Institute (2005)*, Denmark's National Environmental Inventory Report 2005, Research Notes from NERI no. 211.

*Environmental Resource Management, ERM (2002)*, National Clean Development Mechanism Strategy Study for the Kingdom of Thailand (National Strategies Study; NSS report).

*EC-ASEAN COGEN (1998)*, Evaluation of conditions for electricity based on biomass.

*Electricity Generating Authority of Thailand, EGAT (2007)*, National Power Development Plan 2007, PDP.

*Electricity Generating Authority of Thailand, EGAT (2004)*, Thailand power generation fuel mix in Power Development Plan (PDP), 2004.

*Energistyrelsen (1991)*, Biogashandlingsplanen, Baggrundsrapport # 12.

*Energistyrelsen (1995)*, Teknologikatalog - Energibesparelser i Erhvervslivet.

*Energistyrelsen (1996)*, Teknologidata for vedvarende energianlæg.

*Energistyrelsen (1999)*, Energi 21 - Opfølgningen.

*Energy Policy and Planning Office, EPPO (2003)*, Thai Ministry of Energy, Energy Strategy for Competitiveness.

*Energy Policy and Planning Office, EPPO (2008)*, Power Purchase from SPP and VSPP, Document hand-out EPPO, Bangkok, Thailand the 18-3-09.

*Energy Research Institute, ERI (2007) et. al.*, Study on the impact of the CDM Linking directive for Thailand - Project Synthesis Report, Chulalongkorn University.

*EU Commission (2003)*, The Kyoto-Protocol.

*EU Commission (2007)*, Well-to-Tank Report (WTT Report 010307, version 2C), European Commission Joint Research Center, at: [http://ies.jrc.cec.eu.int/media/scripts/getfile.php?file=fileadmin/H04/Well\\_to\\_Wheels/WTT/WTT\\_Report\\_010307.pdf](http://ies.jrc.cec.eu.int/media/scripts/getfile.php?file=fileadmin/H04/Well_to_Wheels/WTT/WTT_Report_010307.pdf).

*Gertler, Nicholas (1995)*, Industrial Ecosystems: Developing sustainable industrial structures, Massachusetts Institute of Technology.

*Garmichael, G. & Rowland, Sherwood F. (1998)*, Development of Asian Mega Cities: Environmental, economic, social and health implications, US Global Change Research Program.

*Greacen, Cris & Footner, Jim (2006)*, Decentralised Thai power: Towards a sustainable energy system, Greenpeace South East Asia.

*Hansen, Mogens Weel & Johansson, Mogens & Pedersen, Thomas (1988)*, Industrien som varmekunde, dk-Teknik Energi og Miljø.

*Heaver, Brad & Del Chiaro, Bernadette (2003)*, Renewable energy and jobs, Environment California, Research and Policy Center.

*International Energy Agency, IEA (2007)*, World Energy Outlook 2007 (China & India).

*International Energy Agency, IEA, Bioenergy (2005)*, TASK 29: Socio-economic drivers in implementing bioenergy projects, ExCo56, Dublin, Ireland.

*International Panel on Climate Change, IPCC (1996)*, Revised 1996 IPCC Guidelines for National Greenhouse gas Inventories - Reference Manual (Volume 3).

*Kjær, Tyge (1998)*, Green Power and Promotion of Power from Biomass, University of Roskilde.

*Laird, John (2000)*, Money politics, globalisation, and crisis, Graham Brash Pte Ltd., Singapore.



*Lowe, E. A. & Warren, J. L. & Moran, S. R. (1997), Discovering Industrial Ecology - An Executive Briefing and Sourcebook, Battelle Memorial Institute, Columbus, Ohio.*

*Lybæk, Rikke & Møller, Poul (1999), Teknologisk innovative- og markedsunderstøttende strategier for fremme af gårdbiogasanlæg, Speciale, TekSam, RUC.*

*Lybæk, Rikke (2004), Guideline for implementing co-generation based on biomass waste from Thai industries, Ph.D thesis, RUC, 2004.*

*National Energy Policy Office, NEPO (undated) - now EPPO - Implementation Achievement of the Voluntary Program, during the Period 1995-1999 under the Energy Conservation Program.*

*National Energy Policy Office, NEPO (undated) - now EPPO - Energy Conservation Program and Guidelines, Criteria, Conditions and Expenditure priorities of the Energy Conservation Fund, during the fiscal period 2000-2004.*

*Office of Environmental Policy and Planning, OEPP (2000) - now ONEP ? - Thailand's Initial National Communication (under the United Nations Framework Convention on Climate Change).*

*Organisation for Economic Cooperation and Development, OECD (2001), Strategies for sustainable development - The DAC guidelines.*

*Pedersen, Thomas (1991), Elbesparelser ved Elsyn, Dk-Teknik Energi og Miljø.*

*Thailand Greenhouse Gas Management Organisation, TGO (2008), CDM implementation in Thailand, TGO.*

*Thailand Greenhouse Gas Management Organisation, TGO (2008a), CDM project Assessment on Sustainable Development Criteria, Document hand-out ONEP.*

*Thailand Greenhouse Gas Management Organisation, TGO (2009), CDM implementation in Thailand, TGO.*

*Thai-Danish Co-operation on Sustainable Energy (1999), Sustainable Energy, Sustainable Society - A Non-Governmental Energy Sector Analysis.*

*United Nation Environmental Program, UNEP (2004), CDM Information and Guidebook, UNEP RISØ*

*United Nation Environmental Program, UNEP (2006), Sustainable development Benefits of Clean Development Projects - A new methodology for sustainability assessment based on the text analysis of the project design document submitted for validation, UNEP RISØ*

*United States Environmental Protection Agency, US EPA (1997), Profile of the pharmaceutical manufacturing industry.*

*United States Department of Energy, US DoE (2006), Energy Footprints.*

*Institute for Global Environmental Strategies, IGES (2006), CDM Country Guide for Thailand, IGES and others, Japan.*

*Parasnis, Mandar (1999), Environmental management in Thailand - Achievements, Barriers and future Trends, Ch. 12 in Growing Pains, Thailand Environmental Institute (TEI).*

*World Wildlife Foundation, WWF (2004), The Gold Standard, WWF.*

*World Commission on Environment and Development, WCED (1987), Our Common Future, Oxford University Press.*

*Yin, Robert (1999), Case study Analysis - Design and Method, Sage.*

### **Articles & Papers:**

*Bijoor, Sheila & Greacen, Chris (2007), Decentralized energy in Thailand: An Emerging light, World Rivers Review (June 2007, p. 4-5).*

*Energistyrelsen (2008), Statens JI og CDM projekter, at: <http://www.ens.dk/sw66649.asp?usepf=true>, per 25-3-08.*

*Frosch, R. A. & Gallopoulos, N. (1989), Strategies for manufacturing, in Scientific American, Special Edition, Vol. 261, number 3.*

*Greacen, Chris (2007b), An emerging light - Thailand gives the go-ahead to distributed energy, in Cogeneration and On-site Power Production (Marts-April 2007, p. 65-73).*

*Gereffi, Gary & Sturgeon, Timothy J. (2004), Globalisation, Employment and Economic Development: A Briefing Paper, Contribution to the Sloan Workshop Series in Industry Studies Rockport, Massachusetts, June 14-16, 2004.*

*Jelenski, L. W. et. al. (1991), Industrial Ecology: Concepts and Approaches, in Proceedings to the National Academy of Sciences, Vol. 89, number 3.*

*Kjær, Tyge (2006), Socio-economic and regional Benefits - Employment Assessment, REGENERGY, University of Roskilde, Denmark.*

*Point Carbon News (2009), CDM & JI Monitor, Vol. 6, Issue 4. (page 6), February, 2009.*

*Schlup, Michael (2005), One goal is not enough, Carbon Finance, September, 2005*

*Todoc, Jessie L. (2004), CDM in Thailand: Status and Policy Issues, <http://www.cdmasean.pelangi.or.id/countrypapers/cp-thailand.pdf>, (2005), per 15-9-06.*

*Wantawin, Sittichod (2003), Climate Change and CDM Activities in Thailand, ASEAN Energy Bulletin, 2. Quarter.*

*Wernick, Iddo K. et. al. (1996), Materialisation and Dematerialization: Measures and Trends, in Journal of the American Academy of Art and Sciences, Vol. 125, number 3.*

### **Homepage info:**

*Bangkok Post* (2007), Cabinet gives green light to seven 'clean' power plants (published online the 31-1-07).

*CDM rulebook* (undated), What is a programme of Activities?, at: <http://www.cdmrulebook.org/Page/home> (data from 2008), per 15-6-09.

*Energy Planning and Policy Office, EPPO* (2007), Average tariffs paid to firm and non-firm SPP generators 1995-2006 & SPP generators supplying power to the grid & VSPP electricity by fuel type, at: <http://www.eppo.go.th/power/data/data-website.xls>, per 3-1-07.

*Energy Planning and Policy Office, EPPO* (2009), Resolution on Energy Tariffs (ADDER), Document hand-out, EPPO, Bangkok, Thailand the 18-3-09.

*Embassy of Denmark, Bangkok* (2006), Capacity Development, at: <http://www.ambbangkok.um.dk/en/menu/DevelopmentCooperation/ProgrammeComponents/CleanDevelopmentMechanism/Capacitydevelopment>, per 6-12-06.

*Energistyrelsen* (2005), at: <http://www.ens.dk>, per 12-9-05.

*Navanakorn Industrial Promotion Zone* (2001), at: [www.navanakorn.co.th/intro-p7.asp](http://www.navanakorn.co.th/intro-p7.asp), per 15-3-01

*Navanakorn Industrial Promotion Zone* (2001), at: [www.navanakorn.com/index\\_r1.html](http://www.navanakorn.com/index_r1.html), per 10-12-07

*NetMeter.org* (2007), Thai Net Metering Project, at <http://www.netmeter.org/en/home>, per 27-2-07.

*National Science and Technology Development Agency, NSTDA* (2008), About Us, at: [http://www.nstda.or.th/en/index.php?option=com\\_content&task=blogsection&id=1&Itemid=74](http://www.nstda.or.th/en/index.php?option=com_content&task=blogsection&id=1&Itemid=74), per 26-3-08.

*Office of Natural Resources & Environment Policy and Planning, ONEP* (2006), Thailand's Policy, at: [http://www.onep.go.th/cdm/en/cdm\\_thaipolicy.html](http://www.onep.go.th/cdm/en/cdm_thaipolicy.html), per 26-10-01.

*National Science and Technology Development Agency, TISI* (2008), About TISI, at: <http://www.tisi.go.th>, per 19-2-08.

*Træets Arbejdsgiverforening* (2001), Sparet er tjent, at: <http://www.sparetertjent.dk/front.cmf>, per 27-6-01.

*Thailand Institute of Scientific and Technological Research, TISTR* (2008), About TISTR, at: [http://www.tistr.or.th/tistr2006\\_eng/index.php?pages=home](http://www.tistr.or.th/tistr2006_eng/index.php?pages=home), per 26-3-08.

*United Nations Environmental Program Risoe, UNEP Risoe* (2009), CDM Pipeline, at: <http://www.cdmpipeline.org/publications/CDMpipeline.xls>, per 7-5-09.

### **Power Point Presentations:**

*Bratasida, Liana (2006)*, Regional CDM update: Selected Asian Countries, at: [http://www.oecd.org/data\\_oecd/42/24/36349488.pdf](http://www.oecd.org/data_oecd/42/24/36349488.pdf), per 12-10-06.

*Department of Alternative Energy Development and Efficiency, DEDE (2006)*, Ministry of Energy (MOI), Energy Strategy and CDM in Thailand, [http://www.iges.or.jp/en/cdm/pdf/activity01/15\\_yoohoon.pdf](http://www.iges.or.jp/en/cdm/pdf/activity01/15_yoohoon.pdf), per 26-9-06.

*Lohsomboon, Pongvipa (2006)*, Outline of National Sustainable development Strategy for Thailand, Thailand Environmental Institute (TEI), [http://www.tei.or.th/Event/bep/060712\\_05\\_persentation\\_Pongvipa.pdf](http://www.tei.or.th/Event/bep/060712_05_persentation_Pongvipa.pdf), per 8-11-06

*Puvacharoen, Pongtip (2005)*, CDM Development in Thailand, ONEP, <http://www.cd4cdm.org/countries%20and%20regions/Asia/Fifth%20Regional%20Workshop/CDM-Thailand.ppt>, per 31-10-06.

*Suksumek, Samerjai (2008)*, Thailand: Developments in the Energy Sector & Responses to Climate Change Issues, Director of Bureau of Power Policies, EPPO, MOI, Document hand-out by Lars Møller on the 17-3-09.

### **Interviews/Communication in Denmark:**

*Fenhann, Jørgen (2006)*, UNEP Risø, Interview the 21-11-06

*Hauch, Anders (2008)*, Regional Manager, Federation of Danish Industries, Personal communication, the 10-3-08.

*Kjær, Tyge (2006)*, Personal communication, the 19-12-06.

*Kjær, Tyge (2003)*, Personal communication, the 18-1-03.

*Nielsen, Jan Sandvig (2001)*, Interview, dk-Teknik Energi og Miljø, Gladsaxe the 27-11-01.

*Nielsen, Jan Sandvig (2002)*, Interview, Dk-Teknik Energi og Miljø, Gladsaxe the 18-1-02.

*Stehr, Hans Jürgen (2006)*, Energistyrelsen, Interview the 20-4-06.

*Jensen, Michael Mucke (2007)*, Technical and Environmental Chef of The Oil Branch in Denmark, E-mail communication the 15-11-07.

### **Interviews/Communication in/with Thailand:**

#### **2006:**

*Holm, Karsten (2006)*, Long Term Consultant (DEMT), E-mail communication from Denmark the 6-11-06.

#### **2007:**

*Yamtgesorn, Mr. Somyos & Sumathi, Mr. Phayong*, Sun Cabinet, Interview, Navanakorn, Thailand the 1-2-07.

*Benraheem, Mr. Rastam & Pinyoying, Mr. Narong*, Baskin Robbins, Interview, Navanakorn, Thailand the 31-1-07.

*Gomi, Mr. Hitoshi & Kotiwet, Mr. Chao*, ASAN Service, Interview, Navanakorn, Thailand the 31-1-07.

*Greacen, Mr. Chris (2007a)*, Palang Thai, Interview, Bangkok, Thailand the 14-2-07.

*Opatvachirakul, Mr. Sittichai*, Energy Policy and Planning Office, EPPO, Interview, Bangkok, Thailand the 13-2-07.

*Møller, Lars (2007a)*, Long Term Consultant (ECN), Interview, Bangkok, Thailand the 7-2-07.

*Møller, Lars (2007b)*, Long Term Consultant (ECN), E-mail communication from Denmark the 21-2-07.

*Nuntavorakarn, Mr. Suphakit (2007)*, Healthy Public Policy Foundation, Interview, Bangkok, Thailand the 2-2-07.

*Salam, Abdul (2007)*, Energy expert, Professor at Asian Institute of Technology, Interview Bangkok, Thailand the 1-2-07.

*Sasindran, Mr. A. (2007)*, Imperial Industrial Chemicals, Interview, Navanakorn, Thailand the 5-2-07.

*Sutiratana, Mr. Somkiat (2007)*, Department of Alternative Energy Development and Efficiency, DEDE, Interview, Bangkok, Thailand the 30-1-07.

*Sombutsiri, Mr. Rintawat (2007)*, Ministry of Industry, Department of Industrial Works (DIW), Interview, Bangkok, Thailand the 13-2-07.

*Praphakornkiat, Mr. Winai (2007)*, Energy for Environment Foundation (EfE), Interview, Bangkok, Thailand the 6-2-07.

**2008:**

*Greacen, Mr. Chris (2008)*, Palang Thai, Interview, Bangkok, Thailand the 13-2-08.

*Holm, Karsten (2008)*, Long Term Consultant (DEMT), Interview, Bangkok, Thailand the 30-1-08.

*Møller, Lars (2008a)*, Long Term Consultant (ECN), E-mail communication from Denmark the 9-1-08.

*Møller, Lars (2008)*, Long Term Consultant (ECN), Interview, Bangkok, Thailand the 31-1-08.

*Mukdasathien, Nippon (2008)*, Danish Embassy Thailand, Interview, Bangkok, Thailand the 1-2-08.

*Nuntavorakarn, Mr. Suphakit (2008)*, Healthy Public Policy Foundation, Interview, Bangkok, Thailand the 14-2-08.

*Opatvachirakul, Mr. Sittichai (2008)*, Energy Policy and Planning Office, EPPO, Interview, Bangkok, Thailand the 7-2-08.

*Phonthiwisutwathee, Wichet (2008)*, Consultant in Environmental Resource Management, Interview, Bangkok, Thailand the 14-2-08.

*Prakitsri, Pravit (2008)*, Member of FTI Executive Committee of Industrial Environment Institute (IEE), Interview, Bangkok, Thailand the 6-2-08.

*Prapasawad, Anat (2008)*, Advanced Energy Plus Co. Ltd., Interview, Bangkok, Thailand the 30-1-08.

*Salam, Abdul (2008)*, Director of GENESIS, Interview, Bangkok the 4-2-08.

*Sukkomoed, Dechurat (2008)*, Ph.D. at Kasertsat University, Faculty of Economics, Interview, Bangkok, Thailand the 5-2-08.

*Sutiratana, Mr. Somkiat (2008)*, Department of Alternative Energy Development and Efficiency, DEDE, Interview, Bangkok, Thailand the 29-1-08.

*Visukamol, Aroonchai (2008)*, General Manager of TUC Thailand, Project Developer, Pers. Com., Carbon Expo, Cologne, Germany the 7-9 May 2008.

### **2009:**

*Cooper, Natarika (2009)*, Thai DNA, Thailand Greenhouse Gas Management Organisation (TGO), Interview, Bangkok the 17-3-09.

*Holm, Karsten (2009)*, Long Term Consultant (DEMT), Interview, Bangkok, Thailand the 26-3-09.

*Møller, Lars (2009)*, Long Term Consultant (ECN), Interview, Bangkok, Thailand the 17-3-09.

*Opatvachirakul, Mr. Sitticha (2009)*, Energy Policy and Planning Office, EPPO, Interview, Bangkok, Thailand the 18-3-09.

*Ward, Natalie (2009)*, Thai DNA, Thailand Greenhouse Gas Management Organisation (TGO), Interview, Bangkok the 17-3-09.

*Watanatada, Thawat (2009)*, Owner and founder of TRI, A.T. TRI Co., Ltd., Project Developer, Interview, Bangkok the 17-3-09.

### **CDM project site visits and interview with plant managers/owners:**

“Sima 2”, Biogas from Starch Plant, Chachoengsao, the 25-3-09.

“Nongbua pig farm Biogas”, Ratchaburi, the 23-3-09.

“A.T. Biopower Rice Husk Plant”, Pichit, 19-3-09.

“Siam Cement”, Kaeng Khoi, the 20-3-09.

“Jaroensompong Landfill Gas”, Rachathewa, the 24-3-09.

“CYY Biopower”, Korat, the 21-3-09.

### **Workshop/Seminars/Conferences referred to:**

*Chamornmarn, Mrs. Prasertsuk (2008)*, Deputy Executive Director of Thailand green house gas organisation (TGO) & Director of National Environmental Board, ONEP, Presentation on the Conference “Technology and Finance for CDM projects in Thailand”, arranged by the British Embassy in Thailand, Nai Lert Park Hotel, Bangkok the 28. January 2008.

*Dishon, Mrs. Adi (2008)*, Chief Executive Officer, EcoTraders, Statement posed at the ‘Cologne Carbon Expo 2008’, at the side-event on the 7<sup>th</sup> May: “Sustainable development and CDM - its path forward”, Cologne, May 7-9, 2008.

*Nielsen, Jan Sandvig & Hansen, Mogens Weel (2006)*, Energy Experts, Presentation on the Workshop “Viden og fremtidsværksted for industriproces”, arranged by Brændsels- og Energiteknisk Selskab, IDA, Copenhagen 13. June 2006;

### **Laws, regulations, conventions etc.:**

*Directive 2004/101/EC*, of the ‘European Parliament and the Council’ on the 27 October 2004, on the Linking Directive, at [http://europa.eu.int/eur-lex/lex/LexUriServ/site/en/oj/2004/l\\_338/l\\_33820041113en00180023.pdf](http://europa.eu.int/eur-lex/lex/LexUriServ/site/en/oj/2004/l_338/l_33820041113en00180023.pdf), per 6-6-08.

*Directive 2004/8/EC*, of the ‘European Parliament and the Council’ on the 11 February 2004, on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC, Annex III.

*National Energy Policy Council (2007)*, NEPC Resolutions #5 & #8/2550 (document hand-out).

*United Nation Framework Convention on Climate Change, UNFCCC (2005)*, The Kyoto Protocol, Articles 3 (Para2), at <http://unfccc.int/resource/docs/convkp/kpeng.pdf>, per 12-4-05.

*United Nation Framework Convention on Climate Change, UNFCCC (2002)*, p.220: quoted in IGES (2006) p. 29.