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Biomass Supply Chain for Renewable Heat Incentive in Thailand

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Abstract

Thailand has the Renewable and Alternative Energy Development Plan for 25 percent in 10 years to identify the framework and direction of Thailand renewable energy development. That consist of 3 main sectors as follows, i.e. (i) renewable for power generation, (ii) renewable heat, and (iii) biofuel. This paper choose to study heat sector. Because the actual renewable heat used did not reach the target. To consider the RHI should be analyzed the whole supply chain because each step of the chain has an impact to cost to calculate the appropriate financial support. The study case of 50 kW power plant using biomass gasification technology is carried out. This research has been done by using Chiang Mai University – Sri Bua Ban located in Lumphun province as a sample model. In this case, the selected biomass is eucalyptus which is enormously planted around the province. The result found that the LCC of the supply chain is 0.46 Baht/MJ or 5 Baht/kg of pellet includes harvesting of 39%, transportation 54%, pretreatment 7%. Because energy conversion process requires just a few costs to change the system, this cost does not include in LCC. Therefore, by the economic calculation, the RHI is about 0.02 baht/MJ or 0.22 baht/kg of wood pellet.

Keywords: Biomass, Supply Chain, Renewable Heat, Incentive, Subsidy

1 INTRODUCTION

Thailand is an energy import country. Around 60 percent of primary commercial energy demand derived from import in 2011. Oil import took a high proportion at 80 percent of a total domestic oil consumption with increasing trend since not capable to increase domestic petroleum production to meet the demand. Substance development on energy will reduce dependency and import of oil and other energy resources, additionally help sharing the risk in providing fuel for power generation which previously depended on natural gas at over 70 percent. Renewable energy would be counted as target fuel expected to significantly substitute natural gas for power generation.

The Alternative Energy Development Plan (AEDP) consists of three main sections as follows, i.e. (i) renewable for power generation, (ii) renewable heat, and (iii) biofuel. While the subsidy program in biofuel production and power generation have been started for years, but the renewable heat incentives are still in limit and focus in only small solar water heater programs Hence, the renewable heat figures compared to AEDP are still far behind the plan, as presented in Table 1.

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According to this situation, the promoting of renewable heat schemes is necessary and the start of Renewable Heat Incentive (RHI) in Thailand to promote the renewable energy use such as waste, biomass, biogas and solar to replace the fossil fuel such as LPG, LNG, oil and coal in thermal utilization is strongly required. This leads to the study of the RHI program in Thailand.

Table 1 Performance of renewable heat compared to AEDP Target (as 2013)

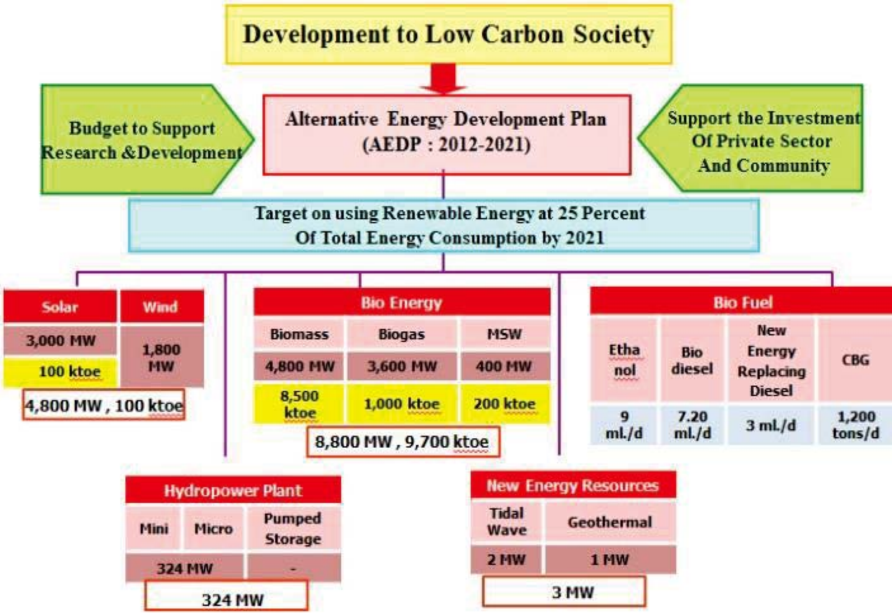
Types of energy	Unit*	Target in 2021	2013	2014 (Q1-Q3)**	Success Rate in 2013(%)
Heat	ktoe	9,800	5,279	4,368	53.87
Solar	ktoe	100	4.54	4.9	4.54
Biomass	ktoe	8,500	4,694	3,929	55.22
Biogas	ktoe	1,000	495	361	49.5
MSW	ktoe	200	85	73.5	42.50

*ktoe = kilo tonne of oil equivalent
**Q1-Q3 = quater1 to quater3

2 METHODS

2.1 Biomass for Heat Supply Chain Modeling

In this study, a biomass heat supply chain is comprised of four main components of harvesting and collection,



Source: Department of Alternative Energy Development and Efficiency

Fig. 1 Alternative Energy Development Plan: AEDP 2012-2021

Fig. 2 Biomass for Heat Supply Chain Management

pre-treatment, transport and heat conversion as shown in Fig. 2

2.1.1 Fast-growing wood plantation

Fast-growing wood can grow in many soil types such as watercourses, flood plains, dry forest types, semi-arid areas and long term arid. Furthermore, it can survive in acidic or sandy alluvial soils with precipitation less than 650 mm/yr. Only limestone soil condition cannot be tolerated to the fast growing wood. The mature tree height can be up to 24-26 m tall with 1-2 m diameter at 40% relative humidity the heating value of dry wood is *10.9 MJ/kg* (eucalyptus wood chip) [(2)]

2.1.2 Transportation

The transportation of biomass from Lamphun was mainly done by truck-based transportation. An average fuel cost for fully-loaded transportation consumption was *0.0180 litres/tkm* while an average fuel consumption for non-loaded transportation was *0.2133 litres/tkm*. The maximize capacity of fast-growing transportation was 8 kg per transportation vehicle

2.1.3 Conversion

To maximize the efficiency of the total combustion, the fuel wood conversion was carried out to reduce the size of biomass which was not less than 5 cm in diameter and not more than 10 cm in length.

2.1.4 Heat to Power Generation

The electricity power was generated by a steam turbine power plant. Mechanical power is produced by a heat engine that transforms thermal energy which flow from a high temperature sources to low temperature sources. All thermal power plants produce heat provided by biomass as a by product of the useful electrical energy produced. Steam turbine power plants operate on a Rankine cycle show in Fig. 3.

The main components of a steam turbine power plant are 1) Boiler 2) Steam Turbine 3) Generator 4) Condenser and 5) Boiler Feed Pump. The steam is created by a boiler, where pure water passes through a series of tubes to capture heat normally provided by burning fossil fuel or in this case, the biomass. The superheated steam leaving the boiler then enters the steam turbine throttle, where it powers the turbine and connected generator to make electricity.

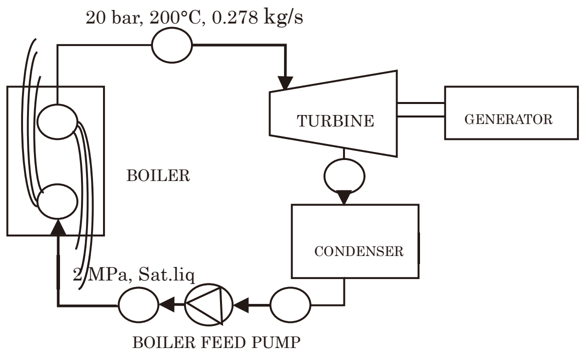


Fig. 3 Steam turbine power plants

2.2 Life Cycle Costing

Life cycle costing analysis involve the economic evaluation technique that determines the total cost of owning and operating a production facility over period of time by using Life Cycle Cost Analysis (LCCA).

$$LCC = C_C + C_{O\&M} + C_F - S$$

Where: C_C = The capital cost (Baht)

$C_{O\&M}$ = Operation and Maintenance Cost

C_F = Fuel Cost

S = Savage Value

This research was conducted to examined the following hypotheses of the Biomass Generation

- The electricity peak demand of the area is *50 kWe.*
- The generator operation period is *7,008 hour/yrs.*
- Fuel wood less than 5 cm in diameter and not more than 10 cm in length.
- Wood production *30.8 tons/Rai.*
- Relative humidity of the harvested fuel wood *60 %.*
- Relative humidity of the fuel wood before power generation *40 %.*
- At 40% relative humidity the heating value of dry wood is *10.9 MJ/kg* .
- Overall efficiency from fuel wood combustion to the boiler feed pump *80 %.*
- The annual power generation is *350,400 kWh.*

Details of the above production costs of the biomass generation system can be present as 4 separate factors.

1. The Capital Cost (C_C)

The capital cost includes the initial capital expense of a project. The costs are expressed as annual expenses incurred at the end of each year and determine by the formula:

$$C_C = P\left[\frac{i(1+i)^N}{(1+i)^N - 1}\right]$$

where: N = Number of years

P = Production cost (Baht)

i = Discount Rate % / year

2. Operation and Maintenance Cost ($C_{O\&M}$)

The sum of all yearly scheduled operation and maintenance costs (O&M). O&M usually assign as 20 percent of capital cost and determine by the formula:

$$PW = \sum_{t=1}^{n} \frac{F_t}{(1+i)^t} = \sum_{t=1}^{n} \frac{F_0(1+e)^t}{(1+i)^t}$$

where: PW = Present value of the project (Baht)

Ft = Production cost at the t year, t = 1,2,3,…n

Fo = Production cost at the present year

e = Escalation rate

n = Project period (year)

3. Fuel Cost (C_F)

The calculation is as same as O&M cost. The energy cost of a system is the sum of the yearly fuel cost.

4. The Salvage Value (S)

Salvage value is the net worth cost value at the end of the production system as the net worth in the final year of the life-cycle period. The salvage value rate is 10 % of the original cost by calculate the salvage value and subtract with the production cost in each year by the formula:

$$S = \frac{S_n}{(1+i)^n}\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$$

where: S= Salvage value in each year (Baht/year)

Sn= Salvage value at the n year

i = Discount Rate % / year

n = Project period (year)

2.3 Renewable Heat Incentive

The economic assumptions for RHI in this study are as follows.

- Debt to Equity Ratio (D/E) varies from 50:50, 60:40, 70:30 and 80:20,

- Minimum Loan Rate (MLR) consists of 4 major banks; i.e. Bangkok Bank, Krungthai Bank, Kasikorn Bank and The Siam commercial Bank, at *7%* per year,
- Repayment period of debt 8 years,
- The depreciation rate is linear,
- The internal rate of return (IRR) varies from *10% 12% and 15%,*
- Project duration is *10 years.*
- RHI can be calculated from the equation below.

$$RHI = \frac{FC + \sum_{n=0}^{N} \frac{VC}{(1+i)^n}}{\sum_{n=0}^{N} \frac{I}{(1+i)^n}}$$

FC = Project fix investment cost, Bath

VC = Annual variable cost, Bath/year (calculate by sum of operation and maintenance cost, fuel cost, depreciation cost and lending rate)

I = Annual income from the benefit, Bath/year (calculate by the expected IRR above)

i = Discount Rate

N = Project life time

3. Result and Discussion

3.1 Production Cost of the Biomass for Heat

Production costs in each year of the biomass for heat can be calculated using Life Cycle Cost Analysis (LCCA) to determine the cost per unit of heat production compare with the production cost of the transmission line. The production costs per unit along the life-span of the production system were converted to the present currency rate. The results were shown in Table 2.

Table 2. Life cycle costing along the total project period(Baht/MJ)

Processes	Costs	Percentage
Plantation	0.18	38.62%
Transportation	0.25	54.18%
Conversion	0.03	7.20%
Heat Production	0.00	0.00%
Total	0.46	100.00%

3.2 Renewable Heat Incentive (RHI)

From the result in table 2, extent the LCC percentage to project the whole country heat needs that is *19,392,122,458.66 MJ* and calculate the RHI by the economic calculation. We found that the government should support RHI about *0.02 baht/MJ* or *0.22 baht/kg of pellet*.

4 CONCLUTIONS

From the survey and calculation, LCC of the biomass to heat supply chain is *0.46 Baht/MJ* or *5 Baht/kg* of pellet includes harvesting of *39%,* transportation *54%,* pretreatment *7%.* Because energy conversion process requires just a few costs to change the system, this cost does not include in LCC. Therefore, the RHI is about 0.02 baht/MJ or 0.22 baht/kg of wood pellet.

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REFERENCES

(1) Information of Chiang Mai University Campus at Lamphun Province. [Online], Available:http://planning.oop.cmu.ac.th/web2004/Master Plan/inind.html

(2) Asia Institute of Technology, 1996, 2nd Regional Training on Wood Energy Planning, Volume 1, AIT, p.25

(3) International Organization for Standard, ISO14040, First edition, 1997

(4) Electricity Generating Authority of Thailand(EGAT), Annual Report, 2008

(5) Energy for Environment Foundation (efe), Information on http://www.efe.or.th/efe-book.php?task=25