Cost and CO_2 balance analysis of biomass power generation in Vietnam

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Abstract

Biomass power generation in Vietnam is evaluated in terms of electricity generation cost, primary energy consumption and life cycle CO_2 emission, and each is compared with those of other fossil power generations. *Acacia hybrid*, the fastest growing tree in Vietnam (18 m^3/ha·y), was chosen as the biomass tree. The short rotation forest of *Acacia hybrid* has an exploitation cycle of 6 years, and the plantation area is divided into 6 radial areas. It is supposed that a power plant with biomass integrated gasification combined-cycle technology is constructed in the center of a circular plantation area. The parameter in the calculations is the capacity of the power plant (10 to 300 MW). The results show that the biomass generation cost is competitive with the fossil generation costs, and that the primary energy consumption and the life cycle CO_2 emissions are drastically lower than those in the fossil generations.

Keywords : Biomass generation, *Acacia hybrid*, Short rotation forest, Biomass integrated gasification combined cycle, Generation cost, Primary energy consumption, CO_2 emission, Vietnam

1. Introduction

Vietnam is a developing country that has achieved rapid economic growth for the last decade. Economic development involves a corresponding growth in energy consumption. Energy supply for sustainable economic development has been a big problem in Vietnam. Renewable energies have been recently attracting specific interest. Current studies in renewable energies in Vietnam have just come to the point in which biomass energy is seen as the most available renewable energy source. While biomass energy is estimated to account for 65-70% of total energy consumed[(1)], no option for development of biomass energy was brought forward in the Participatory Workshop in Hanoi on Options for Renewable Energy in Vietnam[(2)] (June 15-16, 1999) because of a lack of reliable data in this field.

Wood has thus far been commonly supplied for the paper industry. There are still over 8.3 million hectares of waste forest soil[(3)] (22.4% of country area). Therefore, wood fuel has a large potential as a biomass energy source.

Philippot[(4)] and Senelwa[(5)] developed simulation models and equations for short rotation forest (SRF) growth. Fuel characteristics of many tree species were analyzed[(6), (7)], except for *Acacia hybrid*. There are many guidelines on how to convert the biomass energy to electricity, and how to assess economic and environmental impacts [(8)-(15)].

The purpose of this paper is to examine and evaluate the cost and CO_2 balance of biomass power generation with the SRF of *Acacia hybrid* in Vietnam. Cost of electricity generation, primary energy reduction and life cycle CO_2 emission of biomass power generation are compared with those of other fossil power generation systems. The modeled power plant is assumed to be operated with biomass integrated gasification-atmospheric (BIG/CCa) and biomass integrated gasification-pressurised (BIG/CCp) technologies because they have high generation efficiencies compared with other combustion technologies[(10)]. Generation efficiencies, specific investment costs and maintenance and operation costs are obtained from the "trendlines"[(10)], and are adapted for conditions in Vietnam.

Life cycle CO_2 emission is calculated under the assumption that biomass fuels emit no CO_2, i.e., carbon neutral.

In case when the necessary data were not found for Vietnam, data from Japan, North-Western Europe and the United States were used.

In this study, it is the first time that a complete picture of biomass power generation accompanied with the biomass plantation is drawn by a very detail economic and environmental assessment. The previous studies are only on technology or economic or emission of biomass power generation[(10), (14), (15), (26)-(31)]. It is also the first time that this kind of study is made in Vietnam.

2. Acacia hybrid

There are some well-known fast growing tree species in tropical forests of Southeast Asia such as Acacia auriculiformis, Acacia mangium, Eucalyptus camaldulensis. Their growth speeds are only from 5.3 to 14.7 m^3/ha·y[(17)].

Acacia hybrid is a natural hybrid between *Acacia mangium* and *Acacia auriculiformis*, which were detected and initially studied at the Research Center of Forest Tree Improvement of the Forest Science Institute of Vietnam. Test results from many places in Vietnam[(4)] show that these hybrids are superior to their parental species in many aspects. The average growth speed of *Acacia hybrid* varies from 13.5 to 27.2 m^3/ha·y[(16), (19)]

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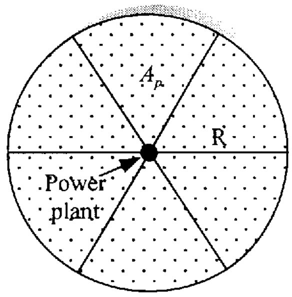
in all parts of the country, and can reach even 31 m^3/ha·y[19]. *Acacia mangium* and *Acacia auriculiformis* and their hybrids have demonstrated the ability to fix nitrogen and thereby enrich soil. Therefore, in this study, *Acacia hybrid* is adapted as the fuel stock for the power generation, and the growth speed is chosen to be 18 m^3/ha·y.

In this study, it is the first time that Acacia hybrid is applied as a fuel stock for power generation.

Figure 1 shows the overview of whole plantation area of the SRF. The shape of the SRF is a circle and the power plant is located in the center of the circle.



A_p [ha]: Plantation area required for power generation in 1 year
R [km]: Radius of the whole plantation area

Fig.1 Whole plantation area of the SRF

3. System description

The process flow of biomass power generation is shown in figure 1. There are 8 sub-processes. Fertilizer, pesticide and diesel fuel are required for production of wood chips. In this study, however, the production and using of pesticide is neglected because there is very little information on material and energy consumption in production of the pesticide, and the quantity used was also very few.

Production of wood chips consists of 5 sub-processes: (3) propagation of planting stock, (4) transportation of planting stock and fertilizer, (5) planting, cultivation, protection and harvest, (6) transportation of green whole tree, (7) conversion of green whole tree into wood chips. Planting stock of *Acacia hybrid* and fertilizers are transported from the power plant to the planting locations. After 6 years of cultivation and protection, entire trees are harvested by cutting. Then, trees are transported to the power plant, dried and chipped to become wood fuel for electricity generation.

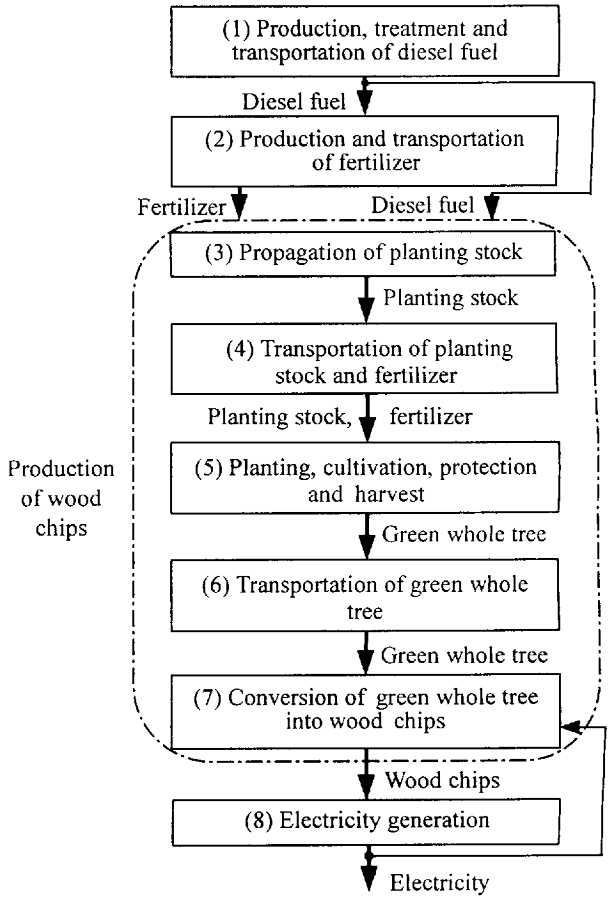


Fig.2 Process flow of biomass power generation

4. Calculation of total cost, primary energy reduction and CO_2 emission

Total cost is the sum of costs of making wood chips and cost of electricity generation. Various materials and operations are necessary for each sub-process for making wood chips. Their costs are calculated from the specific costs concerned. Cost of electricity generation is the sum of investment, operation and maintenance costs.

Primary energy consumption in each sub-process is calculated from its specific energy consumption. Primary energy consumed in constructing the system and manufacturing the equipment and the transport trucks are not taken into account, because they are also required in fossil power generation.

It is assumed that CO_2 is not emitted at the gasification stage of wood chips, because the biomass is considered to be carbon neutral fuel. CO_2 is emitted at the stages of manufacturing the equipment, constructing and operating the system.

Data necessary for calculating the costs, the primary energy consumption and the CO_2 emission of biomass power generation are presented in table 1.

4.1. Cost

Sub-process (1)

Commercial fuels such as diesel fuel and gasoline in Vietnam are mostly imported from Singapore. The import tax is 10%. Consequently, the price of diesel fuel at the gas station is about 0.3 $/liter.

Sub-process (2)

For one plant, 50 g of NPK fertilizer at the rate of (16:16:8) was used.

Cost of fertilizer (C_f) is:

$$C_f = CS_f \cdot M_f \qquad [\$/y] \qquad (1)$$

where, CS_f is the specific cost of fertilizer delivered at power plant and M_f [t/y] is the amount of fertilizer used in 1 year.

Sub-process (3)

There are 2 methods of vegetative propagation for *Acacia hybrid*, i.e., meristem tissure culture and cuttings[16]. Propagation by cuttings is the most widely used method in Vietnam. The required area for propagation by cuttings is about

Table 1 Data necessary for calculating costs, primary energy consumption and CO_2 emission of biomass power generation[14], [16], [19], [22], [24]

Parameter	Source	Abbreviation	Unit	Value
Short rotation forest (SRF) of Acacia Hybrid				
Plant density	VN	D_p	Plant/ha	2,220
Weight of 1 planting stock	VN	W_{ps}	g/plant	300
Weight of fertilizer (NPK 16:16:8) used for 1 planting stock	VN	W_f	g/plant	50
Average annual growth speed	VN	G_s	m^3/ha·y	18
Calorific value (LHV) of wood chips ($MC_{dry\ basic}$ = 16%)	VN	H	GJ/t	14
Exploitation cycle	VN	T	y	6
Moisture content of green whole tree	VN	MC_g	%	80
Density of green whole tree	VN	D_g	t/m^3	0.88
Specific costs				
Planting stock	VN	CS_{ps}	$/plant	0.035
Fertilizer	VN	CS_f	$/t	198
Field preparation	VN	CS_{fp}	$/ha	131.1
Planting	VN	CS_p	$/ha	78.6
Cultivation, protection and harvest	VN	CS_{cph}	$/ha	434.7
Transportation by 20-ton truck	VN	CS_t	$/20 tons·km	1.97
Chipping	VN	CS_c	$/t	1.8
Labor	VN	CS_p	$/y	900
Specific energy consumption				
Production of nitrogen fertilizer	N.A, U.S.A.	ES_{fn}	kWh/t	12,500
Production of phosphorus fertilizer	N.A, U.S.A.	ES_{fp}	kWh/t	4,833
Production of potassium fertilizer	N.A, U.S.A.	ES_{fk}	kWh/t	2,916
Transportation	VN	ES_t	kWh/km·t	0.117
Field preparation	VN	ES_f	kWh/ha	211.1
Cultivation	VN	ES_{cl}	kWh/ha	864.6
Harvest	VN	ES_h	kWh/ha	150
Chipping (electricity)	VN	ES_c	kWhe/t	22
CO_2 emission factor from operations				
Combustion of fossil fuel	JP	K_{fc}	g-C/kWh	79
Economic				
Operating hours	E.U.	L_f	h/y	7000
Lifetime	E.U.	n	y	25
Interest rate (overseas development aids (ODA) capital)	VN	r	%/y	3

VN: Vietnam   N.A, U.S.A.: North Africa, United State of America
JP: Japan   E.U.: Europe Union

1/1,000 – 1/1,500 of the plantation area in a year. Planting stock can be obtained 3 months after its establishment.

Cost of planting stock (C_{ps}) is:

$$C_{ps} = CS_{ps} \cdot D_p \cdot A_p \qquad [\$/y] \qquad (2)$$

where, CS_{ps} is the specific cost of planting stock and D_p is the plant density.

Sub-process (4)

Planting stock and fertilizer are transported from the power plant to planting locations by 20-ton truck.

The average distance of transportation (D_a)[10] is:

$$D_a = (2/3) \cdot R \qquad [km] \qquad (3)$$

Then, the cost of transporting planting stock and fertilizer (C_{tpf}) is:

$$C_{tpf} = CS_t \cdot D_a \cdot [(M_{ps} + M_f)/20)] \qquad [\$/y] \qquad (4)$$

where, CS_t is the specific cost of transportation, M_{ps} [t] is the amount of planting stock and used in 1 year.

Sub-process (5)

In the first year at each plantation area, field preparation, planting and cultivation are implemented. Field is plowed to a depth of 25-30 cm. After plowing, 20×20×20 cm holes are dug. In each hole, the first half of the dug soil is put back in the hole first, and the other half is mixed with fertilizer to fill the hole. After 5 to 15 days of filling the hole, planting stocks are planted. From the 7th to 9th month after planting, cultivation is followed. Cultivation includes plowing back between 2 rows of trees (twice a year, in the first 2 years) and cleaning weed (once a year, in the first 2 years). The tasks involved in protection and harvest are shown in table 2.

The cost of planting, cultivation and harvest (C_{pch}) is:

$$C_{pch} = CS_{pch} \cdot A_p \qquad [\$/y] \qquad (5)$$

where, CS_{pch} is the specific cost of cultivation, protection and harvest.

Table 2 Tasks and necessary machinery for plantation[(16), (19)]

Year	Task	Machinery	Tractor [kW]
1	Plowing Hole preparing Planting Cultivation	6-16" M.P. M.W. M.W. 6-16" M.P., M.W.	134 134
2	Cultivation Fire protection	6-16" M.P., M.W. M.W.	134
3	Cultivation Fire protection	M.W. M.W.	134
4	Fire protection	M.W.	
5	Fire protection	M.W.	
6	Harvest	F.B.H., M.W.	75

M.P.: Moldboard plow, F.B.H.: Feller buncher head,
M.W.: Manual work

Sub-process (6)

The cost of transporting green whole trees (C_{tt}) is:

$$C_{tt} = CS_t \cdot D_a \cdot (M_g/20) \qquad [\$/y] \qquad (6)$$

where, M_g [t/y] is the amount of green whole trees required for power generation for 1 year.

Sub-process (7)

The green whole trees, transported to the power plant, are dried in whole tree form[(18)]. The shed air drying method is applied for about 6 months when they reach an equilibrium moisture content (EMC) of about 14%. The trees then are chipped into wood chips by electric power.

Cost of building shed is assumed to be 0 because of its very small value. The cost of conversion of green whole trees into wood chips (C_c) is:

$$C_c = CS_c \cdot M_d \qquad [\$/y] \qquad (7)$$

where, CS_c is the specific cost of chipping and M_d [t/y] is the amount of wood chips required for power generation for 1 year.

Sub-process (8)

Cost of electricity generation includes amortization of investment, maintenance cost and operation cost. The specific investment costs of the biomass power plant shown in figure 3 was obtained from the "trendlines"[(10)] and were adapted for the conditions in Vietnam.

Amortization of investment cost for a year (A) is:

$$A = \frac{r \cdot (1+r)^n}{(1+r)^n - 1} \cdot CS_i \cdot P \cdot 10^3 \qquad [\$/y] \qquad (8)$$

where,

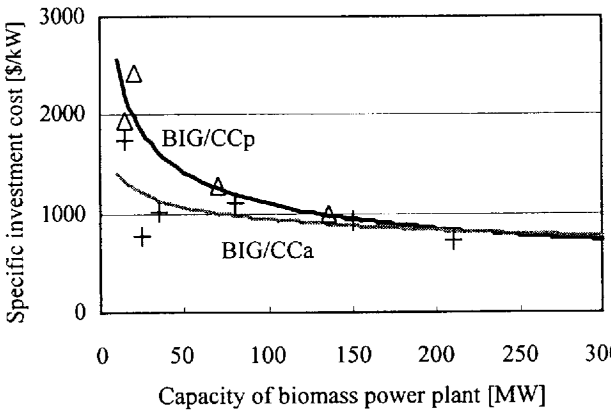
CS_i : Specific investment cost of biomass power plant [\$/kW]

P: Capacity of biomass power plant [MW]

Maintenance and operation costs include maintenance, personnel and insurance expenses. Based on the findings of Andre Faaij[(10)] and adjusting for the conditions in Vietnam, the costs of maintenance and operation for a year (MO) were chosen to be 3% of total investment cost.

Total cost

Total cost of biomass power generation (C_e) is:



+: Biomass integrated gasification-atmospheric (BIG/CCa)
Δ: Biomass integrated gasification-pressurised (BIG/CCp)

Fig.3 Specific investment cost of biomass power plant

$$C_e = \frac{(\Sigma C_i + A + MO) \cdot 10^{-3}}{P L_f} \qquad [\$/kWhe] \qquad (9)$$

where, C_i is cost of each sub-process from (2) to (7).

4.2. Reduction of primary energy

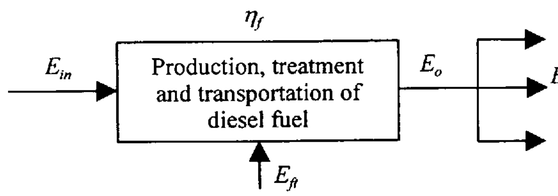
(1) Biomass power generation

Sub-process (1)

Energy flow of production, treatment and transportation of diesel fuel is presented in figure 4. According to "Database System of Crude Oil Characteristics from Oil Fields in Vietnam"[(25)], the energy ratio of input of crude oil to total output of productions (E_{in}/E_0) is about 1.087. Diesel fuel is produced with a factional distillation temperature from 230°C to 360°C. Thus, weight of diesel fuel is 25.81% of total input of crude oil. Heat value (LHV) of diesel fuel is 11.9 kWh/kg. Crude oil has a density of 0.82 kg/l. Thus, the energy ratio of diesel fuel to crude oil (E_D/E_0) is 0.236. Energy consumed at this sub-process (E_{ft}) is calculated as:

$$E_{ft} = \frac{E_D}{E_o} \cdot \left(\frac{E_0}{\eta_f} - E_{in}\right) \qquad [kWh/y] \qquad (10)$$

The values of η_f are shown in table 3.



E_{in}: Input energy of crude oil
E_0: Output energy of production
E_D: Diesel fuel consumed at all other sub-processes
E_{ft}: Energy consumed in this sub-process
η_f: Efficiency of this sub-process [%]

Fig.4 Energy flow of production, treatment and transportation of diesel fuel

Table 3 Efficiency of production, treatment and transportation of fossil fuel [13]

Fossil fuels	η_f[%]
Coal from coal fields	94 ± 3
Crude oil from oil fields	84 ± 6
Natural gas from gas fields	88 ± 1

Sub-process (2)

Energy consumed in the production of fertilizer (E_f) is calculated as:

$$E_f = \sum M_{fi} \cdot \mathrm{ES_{fi}} \qquad \text{[kWh/y]} \qquad (11)$$

where, M_{fi} are amounts of fertilizer of nitrogen, phosphorus and potassium, and $\mathrm{ES_{fi}}$ are their specific energy consumption. The values of $\mathrm{ES_{fi}}$ are shown in table 1.

Sub-process (3)

The energy consumed at this sub-process is almost 0.

Sub-process (4)

Energy consumed at this sub-process (E_{tpf}) is:

$$E_{tpf} = 2 \cdot (M_{ps} + M_f) \cdot D_a \cdot \mathrm{ES_t} \qquad \text{[kWh/y]} \qquad (12)$$

Sub-process (5)

Energy consumed by planting, cultivation and harvest (E_{pch}) is:

$$E_{pch} = (\mathrm{ES_f} + \mathrm{ES_{cl}} + \mathrm{ES_h}) \cdot A_p \qquad \text{[kWh/y]} \qquad (13)$$

where, $\mathrm{ES_f}$, $\mathrm{ES_{cl}}$ and $\mathrm{ES_h}$ are specific energy consumption of field preparation, cultivation and harvest, respectively.

Sub-process (6)

Energy consumed by transportation of green whole trees (E_{tt}) is:

$$E_{tt} = 2 \cdot M_g \cdot D_a \cdot \mathrm{ES_t} \qquad \text{[kWh/y]} \qquad (14)$$

sub-process (7):

Energy consumption of this sub-process are solar energy for drying green whole tree by shed air drying method in about 6 months and electricity consumed by chipper for making wood chips. There are no primary energy is consumed in this sub-process.

Electricity energy consumption of this sub-process (E_c) is:

$$E_c = \mathrm{ES_c} \cdot M_g \qquad \text{[kWhe/y]} \qquad (15)$$

where, M_g [t/y] is the amount of green whole trees required for power generation for 1 year.

The total diesel fuel energy consumption of the biomass power system (E_b) is:

$$E_b = \frac{\sum E_i}{P \cdot \mathrm{L_f} - E_c} \qquad \text{[kWh/kWhe]} \qquad (16)$$

where, E_i is energy consumed at each sub-process from (1) to (6).

(2) Fossil power generation

The energy flow of a fossil power generation system is shown in figure 5.

Efficiencies of a fossil power plant in Vietnam are summarized in table 4. The weight average efficiency of the fossil power system (η_{sf}) is calculated to be 30.4%.

Primary energy consumed by fossil power generation for generating 1 kWhe of electricity (E_f) is:

$$E_f = \frac{1}{\eta_f \cdot \eta_{sf}} \qquad \text{[kWh/kWhe]} \qquad (17)$$

Table 4 Current data of fossil power generation in Vietnam[24]

Power generation	Percentage of total electricity supply [%]	Efficiency η_{sf} [%]
Coal	11.3	≤ 20
Diesel fuel/Oil	15.1	18－20
Gas turbine	20.4	45－47

(3) Reduction of primary energy

The reduction of primary energy (E_r), i.e., the difference between energy consumption of the fossil power generation and the biomass power generation is:

$$E_r = E_f - E_b \qquad \text{[kWh/kWhe]} \qquad (18)$$

4.3. CO_2 emission

(1) CO_2 emission by operation

CO_2 emission by operation in each sub-process is calculated from its primary energy consumption and its emission factor of diesel fuel combustion.

For example, that in sub-process (1) is:

$$EO_{ft} = \mathrm{K_{fc}} \cdot E_{ft} \qquad \text{[g-C/y]} \qquad (19)$$

CO_2 emission by sub-process (7) (EO_c) is:

$$EO_c = \mathrm{K_{fc}} \cdot E_b \cdot E_c \qquad \text{[g-C/y]} \qquad (20)$$

where, E_b is the diesel fuel consumption of the biomass power generation for generating 1 kWhe and E_c is the electricity consumption of sub-process (7).

(2) CO_2 emission by manufacturing equipment and constructing system

Sub-process (1)

CO_2 emission factor is 0.077 g-C/kWhe[20].

Sub-process (2), (3)

CO_2 emissions in these sub-processes are neglected.

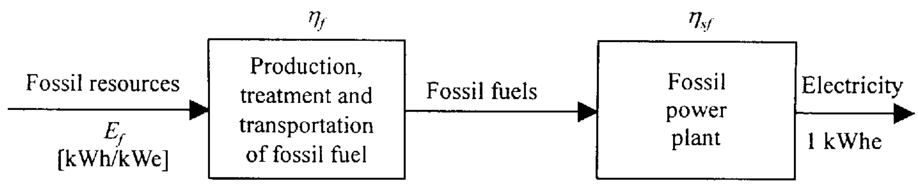


Fig.5 Energy flow of fossil power generation

Sub-process (4), (5), (6)

In this study, we assume that for every year, planting stock are planted at a new field in a period of 6 months of rainy season and green whole trees are harvested at an oldest field in a period of the following 6 months.

Using data in table 2, equipment and trucks required for production wood chips are calculated as follows:

a. Equipment required for plantation operations

The area that 1 tractor with a plow can plow in 6 months (A_0) is:

$$A_0 = S_o \cdot (N_{wd}/2) \cdot H_d \quad \text{[ha]} \tag{21}$$

where,

S_o: Working speed [ha/h]

N_{wd}: The number of working days in 1 year (234 d)

H_d: The number of working hours in 1 day (8 h)

The number of tractors required for plowing (N_p) is:

$$N_p = \frac{A_p}{A_0} \tag{22}$$

The number of tractors with a feller buncher head is calculated by the same way as above. Table 5 shows working speed and weight of steel and iron of the 6-16" moldboard plow and the feller buncher head[15]. The lifetime of a tractor is 25 years or 540,000 km (DynCorp, 1995; Delucchi, 1993).

b. Trucks required for transporting green whole trees

Amount of green whole trees are transported in 1 day (M_0) is:

$$M_0 = \frac{M_g}{N_{wd}/2} \tag{23}$$

Table 5 Working speed and material weight required for machinery[15]

Machinery	Working speed [ha/hours]	Weight of steel and iron [kg]
6-16" Moldboard plow	2	2,268
Feller buncher head	0.33	1,633
75 kW tractor	0.33	4,990
134 kW tractor	2	7,258

Assuming that 20-ton trucks can make 2 round trips per day (because with a power plant capacity of 300 MW, the maximum average distance of transportation is about 13 km). The number of trucks (N_t) is:

$$N_t = \frac{M_0}{2 \cdot 20} \tag{24}$$

Steel and iron are the main materials in the production of 20-ton trucks[23] and are shown in table 6.

Then, CO_2 emissions of trucks are calculated by using the emission factors shown in table 6.

Sub-process (7)

CO_2 emissions of manufacturing the chipper and constructing the shed for drying are neglected.

Sub-process (8)

Calculations of CO_2 emissions of manufacturing equipment and constructing the biomass power plant are based on primary materials shown in table 7 and their emission factors (table 6).

Table 6 Material composition of a 20-ton trucks and their CO_2 emission factors

Material	Amount [kg/truck]	Emission factor [g-C/kg][13]
Steel	4,914	570.0
Iron	1,243	570.0
Aluminum	1,372	2,754.5
Plastic	288	695.4
Copper	93	758.2
Glass	36	662.7
Rubber	863	3,360.8[12]

Table 7 Materials used for biomass power plant and their amounts [15]

Material	Amount required [kg/GWh electricity output][14]
Concrete	22,299
Steel	8,341
Iron	97
Aluminum	65

5. Results

5.1. Electricity generation cost

The plantation area required for biomass power generation is presented in figure 6. With a power plant capacity of 300 MW, the required plantation area is about 120 kha.

Figure 7 presents the electricity costs of biomass power generation. As the capacity increases from 10 to 300 MW with BIG/CCa technology, the cost decreases from 2.98 to 1.92 $cent/kWh, and from 3.8 to 1.84 with BIG/CCp technology. The items of electricity costs of BIG/CCa technology are shown in figure 8. Wood chips cost is over 50% and investment cost is about 30% of the total cost. Each decreases as the capacity increases. However, cost of transportation of green whole trees increases since the plantation area increases.

5.2. Reduction of primary energy

Figure 9 shows the items of energy consumption in biomass power generation with BIG/CCa technology. The primary energy consumption varies from 0.029 to 0.023 kWh/kWhe. The primary energy consumption for cultivation is the largest, followed by that for harvest. Primary energy consumption in fossil power generation is presented in table 8. Consequently, the reduction of primary energy by biomass power generation is 3.5 to 3.92 kWh/kWhe.

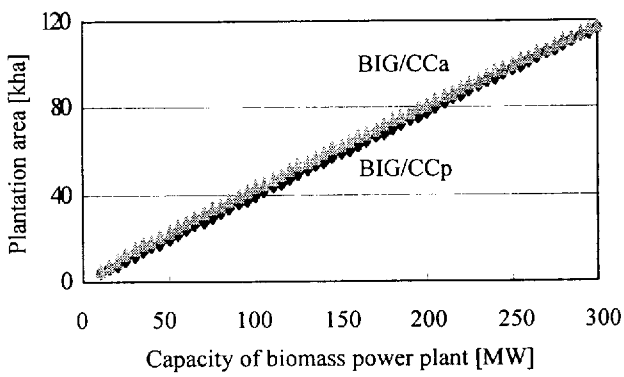


Fig.6 Plantation area required for biomass power generation

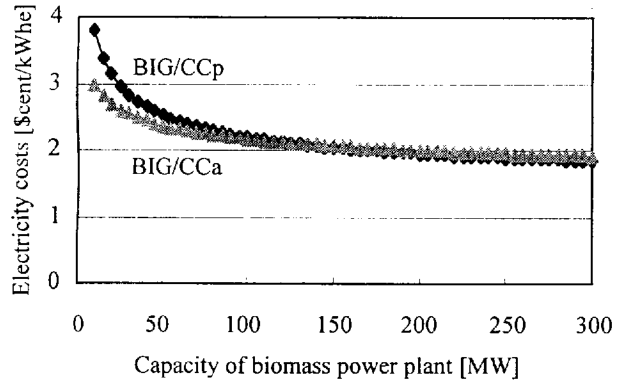


Fig.7 Electricity generation costs

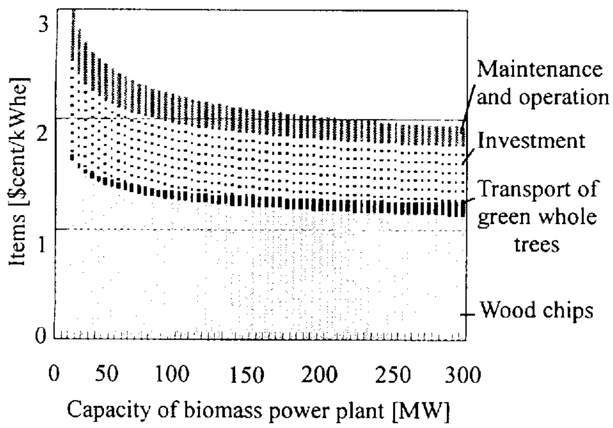


Fig.8 Items of electricity costs (Type of system: BIG/CCa)

Table 8 Primary energy consumption in fossil power generation

Fossil power generation	[kWh/kWhe]
Coal from coal field	3.50
Diesel fuel from oil field	3.92
Natural gas from gas field	3.74

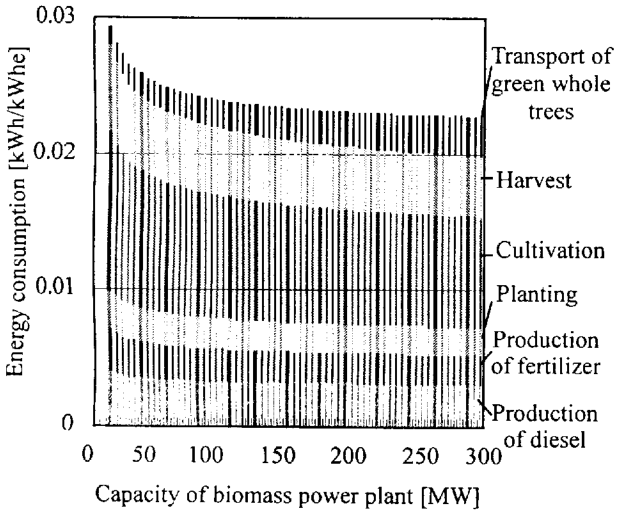


Fig.9 Items of primary energy consumption (Type of system: BIG/CCa)

5.3. Life cycle CO_2 emission

Figure 10 shows the items of life cycle CO_2 emission from biomass power generation. CO_2 emissions from construction of power plant, cultivation and harvest are 64%, 13%, and 7% of the total CO_2 emissions, respectively. CO_2 emissions from other items are less than 4%.

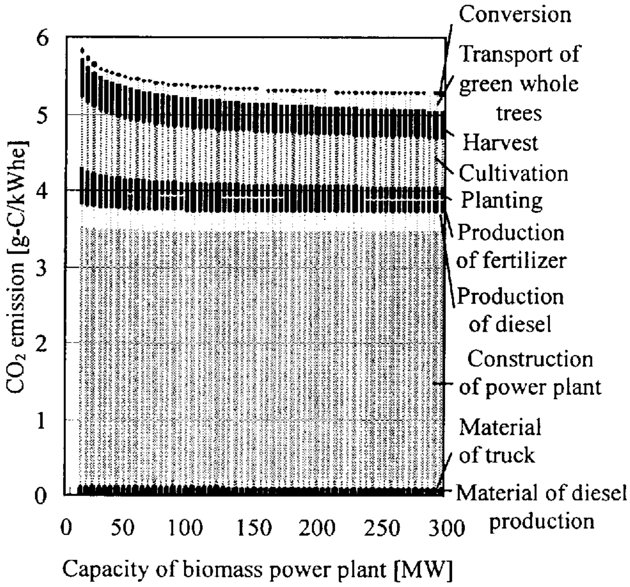


Fig. 10 Items of life cycle CO_2 emission from biomass power generation (Type of system: BIG/CCa)

6. Summary and conclusion

Cost and CO_2 balance analysis of biomass power generation in Vietnam was investigated. *Acacia hybrid*, the fastest growing tree in Vietnam, was chosen as the biomass tree. The growth speed was 18 m^3/ha·y. *Acacia hybrid* was planted, cultivated and harvested in a circular plantation area that was divided into 6 equal sub-areas. The exploitation cycle of *Acacia hybrid* was 6 years. This type of biomass plantation is called a short rotation forest. The electricity generation system was located in the center of the plantation area. The biomass integrated gasification combined-cycle technologies were adopted as the electricity generation system. The parameter in calculation was the capacity of the biomass power plant (10 to 300 MW). Calculation results show that:(1) As the capacity biomass power plant increases from 10 to 300 MW, the biomass power generating cost decreases from 3.08 to 1.84 $cent/kWhe, while the fossil power generating cost is 2.55 $cent/kWhe. The cost of wood chips has the largest effect on the electricity generation cost. (2) Energy consumption required for the biomass power generation is within the range of 0.023 to 0.029 kWh/kWhe, while the primary energy consumption of fossil power generation varies from 3.5 to 3.92 kWh/kWhe. This shows that biomass power generation can reduce primary energy consumption by 99.9%. (3) The life cycle CO_2 emission from the biomass power generation is 5.28 to 5.84 g-C/kWhe, while that of fossil power generation was 159 g-C/kWhe. Therefore, biomass power generation can reduce CO_2 emission by about 96%.

With the assumptions that *Acacia hybrid*, the fastest growing tree in Vietnam (18 m^3/ha·y), is chosen as the biomass tree. The short rotation forest of *Acacia hybrid* has an exploitation cycle of 6 years, and the plantation area is divided into 6 radial areas. Power plant with biomass integrated gasification combined-cycle technology (BIG/CC) is constructed in the center of a circular plantation area. Thus, the results of economic and environmental assessment do not change so much in different sites.

It is concluded that biomass power generation has great economic and environmental potential in Vietnam.

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