Macro Economic Impacts of Installing Rice Husk Electricity Power Plants in Thailand

Yoji Kunimitsu and Tatsuki Ueda

(National Institute for Rural Engineering)

2-1-6, Kannondai, Tsukuba City, Ibaragi Pref., 305-8609, Japan

E-mail: **ykuni@nkk.affrc.go.jp**

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Abstract

Macro economic impacts of rice-husk power plants (RHPP) in Thailand were analyzed by an Input/Output method. Results show that RHPP decreased sensitivity coefficients especially in the petroleum-sector, economic merits were realized in the agricultural-sector but total induced production effects were lowered, and induced imports by consumption were reduced with RHPP.

Key words: I/O analysis, Sensitivity coefficient, Oil price, Biomass resource use,

JEL code: C67, O13, Q20, Q42, Q43

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Introduction

A development of biomass resource usage increasingly attracts the interest of scientists and economists as a way to ease global climatic changes and to reserve the limited fossil resources. Biomass resources derived from agricultural production, now abandoned as industrial wastes, can be used for electric power plants, gas generation plants and bio diesel oil generation plants. These biomass resources have environmental friendly features, called carbon neutral, that produce emissions of carbon dioxide equal to the amount captured by plants (Bhattacharya et al., 1999). If photosynthetic efficiency of plants is considered, more biomass resources exist in the tropical areas such as Thailand and other Southeast Asian countries than the temperate and frigid zones. Therefore, an analysis of biomass resource use in Southeast Asia can provide a model for future development in this field.

In previous studies, the merits of biomass resource use have been evaluated for independent power facilities by comparison of management revenues and expenditures. From the environmental point of view, the life cycle assessment (LCA) method has been adopted to compare the total emissions of environmentally harmful gases and the total costs including disposal expenses of the facility (Kobayashi, 2004). This evaluation method focused on the environment affects of CO2 emissions instead of economic effects. As far as we know, there were few macro economic evaluations of biomass resource usage in previous studies. For better policymaking, the macro economic impacts must be evaluated with consideration of ripple effects through the inter-industrial structure.

This study aims to analyze the macro economic impacts of rice husk power plants (RHPP) that are representative of biomass resource uses in Thailand, where economic relations with Japan are indispensable and the amount of biomass resources is huge. An Input/Output (I/O) table revised by the onsite survey was used to estimate macro economic impacts, assuming a RHPP was installed and accounts for 10% of the entire electricity consumption in Thailand. Simulation results of RHPP installation by this table are compared with only conventional electricity generation plants such as thermal power plants.

Section 2 explains the method of the I/O analysis, features of RHPP in Thailand and how to create a RHPP sector in the I/O table published by the official statistics bureau. Section 3 provides results of the simulation on the effects of RHPP. The summary, conclusions and proposals for more comprehensive analysis are in Section 4.

Methods

Structure of Industries in Thailand

Table 1 shows the production share of each industry in Thailand. This table was calculated from an I/O table estimated by the JICA project, entitled “Agricultural Statistics and Economic Analysis Development Project (ASEAD Project)”. The light industry sector, such as food, textile and furniture, accounts for the biggest portion of gross production with manufacturing as the second largest sector. The rates of added value are lower in the manufacturing industrial sectors than average, showing 34% and 27% of these rates. This indicates that these sectors have long detour production processes and indicates high inducing coefficients.

The agricultural, mining, petroleum-and-nonmetal production and electricity sectors, which are supposed to be highly related to RHPP, account for 14% of the total added values, showing a remarkable share in gross production.

<Table 1.　Overall structure of industries in Thailand>

Outlook of RHPP

Thailand is known as a main exporter of rice in the world with most of the arable land used for rice paddies. Since the climate is hot and humid in tropical areas, farmers can produce a rice crop two or three times a year if the irrigation conditions are suitable. In addition, energy consumption of the post harvest process is relatively lower than regions in the temperate zone like Japan. Therefore, the total amount of rice husks produced in one year and available for RHPP is much larger in Thailand than regions in the temperate and frigid zones.

Rice husks are now used for the fuel of rice mills and raw material of composts, but almost half of the rice husks produced in the rice mills are piled and left for corruption in the field. The amount of rice husk usage for compost is decreasing due to increasing use of chemical fertilizers. Therefore, investments for RHPP can bring about efficient usage of rice husks.

Table 2 shows the outline of RHPP in the Roi-et province, a pioneer in this field in Thailand. According to an interview survey of RHPP staff, more than 10 RHPPs are in operation and more RHPPs will be constructed in the near future. The amount of power generation in one RHPP is small, but most RHPPs have a slight operation surplus between expenditures including depreciation and revenues from sales of electricity to electric power companies. The generation efficiency of these RHPPs is approximately 20% as good as a thermal power station.

<Table 2. Outline of the rice husk power plant in Roi-et>

Input/Output analysis

The I/O analysis was used to measure the macro economic impact of RHPP with consideration to industrial linkage in Thailand. The equivalence of supply and demand in the I/O table can be defined as $\{\mathbf{I}-(\mathbf{I}-\hat{\mathbf{M}})\mathbf{A}\}\mathbf{X}=\mathbf{F}$. **A** is the matrix of input coefficients that shows inputs from i-th industry for the unit output of j-th industry, **I** is the identity matrix, **F** is the final demand, and $\hat{\mathbf{M}}$ is the import coefficient generated in accordance with domestic demand. Here and after, the gothic character indicates the vector or matrix. The final demand can be defined as $\mathbf{F}=(\mathbf{I}-\hat{\mathbf{M}})\mathbf{Y}+\mathbf{E}$, and each diagonal element of $\hat{\mathbf{M}}$ can be defined as $m_i = M_i \Big/ \left(\sum_j a_{ij} X_i + Y_i \right)$.

The production **X** induced by **F** is,

$$\mathbf{X}=\{\mathbf{I}-(\mathbf{I}-\hat{\mathbf{M}})\mathbf{A}\}^{-1}\mathbf{F}=\mathbf{BF} \qquad (1).$$

Here, **B** is the inverse matrix showing the induced production coefficients of **F**. From coefficients of **B**, influence power coefficient (IPC) and sensitivity degree coefficient (SDC) can be calculated by,

$$IPC_j = \text{(the row sum of } \mathbf{B}) \,/\, \text{(mean of row sums of } \mathbf{B}) = \frac{\sum_{i=1}^{n} b_{ij}}{\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} b_{ij}},$$

$$SDC_\mathrm{i} = \text{(the line sum of } \mathbf{B}) \,/\, \text{(mean of line sums of } \mathbf{B}) = \frac{\sum_{j=1}^{n} b_{ij}}{\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} b_{ij}}.$$

The *IPC* is an index to compare the ripple effect for the whole industry of a certain section with another industry when the final demand values increase in the i-th sector. The *SDC* is an index to determine the strength of the degree of response received from the other sectors.

In addition to these coefficients, an induced production value is calculated by $\Delta\mathbf{X} = \mathbf{B}\Delta\mathbf{F}$ in the case of an increase in consumption by 10%. The converter, which divides total increase in each industry, is assumed to be the share rate of consumption in the original I/O table.

The I/O table also shows the balance of production and inputs, that is, $\mathbf{PX} = \mathbf{PAX} + \mathbf{P_V V}$.

Here, **P** is a price vector of each industrial product, $\mathbf{P_V}$ is a price vector of the added value components and **V** is the vector of added value. The following equation can be obtained by dividing the above equation by X_1 of a certain sector and taking $\mathbf{P_V}$ as a numeraire.

$$\mathbf{P} = (\mathbf{I} - \mathbf{A}')^{-1}\mathbf{v} \qquad (3)$$

Here, **A'** indicates the transposed matrix. From Eq. (3), the ripple effect of price on each industrial sector can be calculated when the price in the special sector rises. For instance, the price ripple effect in the 2nd and 3rd sectors ($\triangle P_2$, $\triangle P_3$) can be calculated as follows when a rise in the oil price $\triangle P_1$ occurs (Miyazawa, 1989).

$$\begin{pmatrix} \Delta P_2 \\ \Delta P_3 \end{pmatrix} = \begin{pmatrix} 1 - a_{22} & -a_{32} \\ -a_{23} & 1 - a_{33} \end{pmatrix}^{-1} \begin{pmatrix} a_{12} \\ a_{13} \end{pmatrix} \Delta P_1 = \begin{pmatrix} b_{12} / b_{11} \\ b_{13} / b_{11} \end{pmatrix} \Delta P_1 \qquad (4).$$

Changes in the I/O structure with install of a RHPP

This study used the I/O table estimated by the ASED Project in order to modify the I/O table for analysis. This table is expanded by several sub-sectors in the agricultural sector and includes 175 sectors, four added value sectors and six final demand sectors. The reason this study used this I/O table instead of the official one is because more detail input-output relations were required for rice production, which produces bi-products used for the RHPP.

In 1995, the RHPP accounted for less than 1% of the total electricity production, so the ordinal I/O table and even the 175-sector table are unable to analyze the effects of RHPP. To estimate these effects, it was assumed that the RHPP produces 10% of the total electricity in Thailand[i)]. The impact of RHPP installation was calculated by modifying the 1995 I/O table after taking the following assumptions into account[ii].

i) Divide the electricity generation sector into a conventional sector and a RHPP sector

The electricity sector in the current I/O table was divided into a conventional electricity sector producing 90% of the total electricity and a RHPP sector producing 10%. Because the amount of each RHPP input in a horizontal line indicates the supply of electricity, the line elements of the electricity sector in the original table was divided by a 9:1 ratio. Each horizontal element for RHPP was created by assuming that electricity as a product is the same as both sectors.

ii) Estimation of the inputs from the conventional electricity and RHPP sectors

The amount of input in the vertical direction indicates necessary input elements such as raw material and labor for the electricity sector. When the row of the I/O table was divided at 9:1, each element in the vertical direction of the conventional electricity sector was assumed to be 90% of the original sector and each vertical element of RHPP was 10%. Of course, an input element of the RHPP sector was different from the conventional electricity sector. Input elements in the RHPP sector from the coal mining sector and sectors related to petroleum were zero, but inputs from the rainy season rice and dry season rice sectors newly occurred. The input values of the rainy season and the dry season rice for RHPP, which correspond to 10% of inputs for coal and petroleum in the original table, were divided according to the ratio of total outputs in both sectors. Furthermore, inputs from the service sector and the value added sector in the RHPP sector were used at the same rate as total output in the original sector.

There were also inputs from both the conventional electricity and RHPP sectors to their own sector. The values of these inputs in each sector were calculated from the rate of the inputs of themselves in the original electricity sector. In other words, (the amount of input for each sector from own sector) = (the rate of their own inputs in the original table) * (total amount of electricity produced in the RHPP sector or the conventional sector). Moreover, it was assumed there was no exchange of inputs between both sectors and each input from another sector was set at 0.

iii) Revision of operation surpluses from the rice production sector

The commercial value of the rice husks that used to be abandoned have raised, so the operation surpluses may be increased the same amount. Then a balance between total outputs and total inputs was temporally achieved in the rice production sector.

iv) The first adjustment of the supply-demand balance

The total supply and demand of the I/O table becomes imbalanced because of a decrease in the sales of coal and petroleum products. In order to maintain the balance, input elements were assumed to change uniformly with the supply and demand imbalance for each sector in order to equal the total amount in the vertical elements and the total amount in the horizontal elements of the sector concerned. In other words, $c_{ij} = \sum_i (X_{ij} + V_{ij}) \;/\; \sum_k (X_{ik} + F_i)$ was computed from **X**, **V** and **F** calculated from i) to iii). After this, the amount of the first adjustment was calculated by multiplying this value to the amount of middle inputs and the added values.

v) The second adjustment of the supply-demand balance

Even with the above first adjustment of c_{ij}, the supply and demand were still imbalanced in sectors where the input elements multiplied by c_{ij}. Hence, the input value at the 2nd adjustment was manually calculated by changing the value of c_{ij} slightly until the supply and demand of all the sectors from j =1 to j =176 were within a range of ± 0.1%.

vi) The final adjustment of the supply-demand balance

The amount of imbalance in the i-th line [= $\sum_i (X_{ij} + F_i) - \sum_j (X_{ij} + V_j)$ for values from process i) to v)] within the range of ±0.1% was deducted from operation surplus of the j-th row, and the final I/O table (with 176 sectors including RHPP) was calculated.

vii) Integration of the simulation

Coefficients in the I/O table with 176 sectors were integrated with the classification of Table 3 to summarize the simulation results. This classification refers to abbreviation of the usual I/O table.

< Table 3. Classification for integration of the sectors>

Results

Changes in the influence power coefficient and the sensitivity degree coefficient by RHPP installation

Table 4 shows changes in the influence power coefficient, *IPC*, and the sensitivity degree coefficient, *SDC*, for conventional electricity generation and RHPP installation. First, *IPC* and *SDC* were greater than one for the petroleum, non-metal production and wholesale-retail trade sectors. Therefore, these sectors greatly affect the other sectors. On the other hand, these coefficients in the agricultural sector were lower than 1, indicating ripple effects of this sector are smaller than the other sectors.

Second, *IPC* increased slightly in the electricity sector after installation of RHPP. The affects of RHPP installation on the other sectors were not very high, though *IPC* changed in all sectors. Whereas, the *SDC* was originally high, so the affects of the other sectors on the electricity sector were very high. With installation of RHPP, *SDC* decreased in the electricity sector, but remained high, showing a high contribution of this sector to the other sectors.

Third, *SDC* remarkably increased in the agricultural sector, indicating that the industrial linkage became more deepened. This is because of a rise in the coefficients of the rainy and dry season rice. On the other hand, *SDC* decreased in the mining, petroleum and nonmetal production sectors, indicating contribution of these sectors to other sectors remarkably failed.

< Table 4. Changes in the influence power and sensitivity degree coefficients>

Influence of an increase in fossil oil price

Table 5 shows changes in prices of all sectors with an increase in fossil oil prices by 200%, when comparing the RHPP installation to the conventional electricity. The assumption rate of oil price was higher than the real situation, but in Thailand the oil price rose about 50% in 2005. If this soar in oil price was taken into consideration and the simulation was simplified, a 200% rise was acceptable for the simulation.

The prices in petroleum-and-nonmetal production, electricity and traffic-and- communication sectors largely increased with a rise in oil prices, especially for conventional electricity generation. Next, each price in the forestry-and-fishery sector and the manufacturing sector rose. The prices in the agricultural sector also increased although this increase was lower than the other sectors. In total, a rise in oil price affects all sectors.

All bad influences of a rise in oil prices shrank in all sectors with RHPP installation. Therefore, installation of RHPP makes the Thai economic structure robust against rises in oil prices and less dependent on fossil oil. In particular, a reduction of the effects of a price hike by installation of RHPP appeared most greatly in the electricity sector. Next to the electricity sector, the effects were great in wholesale-and-retail trade, food-textile-and-furniture and the manufacturing sectors.

< Table 5. Changes in the prices with an increase in fossil oil prices>

Changes in induced production and induced imports with an increase in private consumption

Table 6 shows the changes in induced production and induced import when the private consumption increased by 10% from values in 1995. This table compares conventional electricity generation and installation of RHPP in terms of an increase in induced production and induced imports. From this table, the following points are clear.

First, a change in the amount of induced production resulted in a positive increase in consumption for the agricultural sector by supplying raw materials to RHPP. This shows that installation of RHPP can greatly benefit the agricultural sector.

Second, induced production in conventional electricity generation and RHPP installation were increased by a rise in private consumption. The effect of RHPP installation was smaller than that of conventional electricity generation when the total values of increase were compared. The reason total increase in induced production went down with RHPP installation was because the I/O structure shifted to the agricultural sector with lower input coefficients from the petroleum-and-nonmetal production sectors with higher input coefficients. In general, the agricultural sector comparatively had a low detour production and lower contribution to induced production.

Third, the mining sector and petroleum-and-non-metal production sector dominantly decreased in induced production with installation of RHPP. In these sectors, the input values directly decreased with input reduction in demand for coal and petroleum production. A similar tendency was observed in the construction sector and other service sectors. A change in the construction sector became large because an increase in the amount of induced production shrank with RHPP installation in the pipeline construction sector related to the oil refining sector. The reason a change in the other-service sectors became large is because this sector was strongly related to all other sectors, although this sector was weakly related to the agricultural sector. Hence, the influence of a change in other sectors becoming small was accumulated in the other-service sectors.

Third, an increase in private consumption induced an increase in imports in both conventional electricity generation and RHPP installation. However, degree of increase in induced imports shrank in many sectors with installation of RHPP as compared to conventional electricity generation. The influence of a decrease in coal and oil by RHPP installation was serious in the mining and petroleum-and-nonmetal production sectors, an increase in induced imports was restrained in particular. A similar trend was seen in the manufacturing sector. This is because imports of electricity-related-machines were restrained in the manufacturing industries by installation of RHPP.

<Table 6. Changes in induced production and induced import with an increase in private consumption>

Summary and Conclusion

This study aimed to analyze the macro economic impacts in Thailand of RHPP installation, which is carbon neutral and is promising for the future of Southeast Asia. Results show that, first, installation of RHPP decreases the sensitivity degree coefficient in the mining sector, petroleum sector and manufacturing sector, and makes the economic structure less dependent on imports of oil. Second, economic merits of RHPP were mainly realized in the agricultural sector. Third, the RHPP makes the induced production effect lower in Thailand, because the process of detour production becomes a shorter with a shift to the agricultural sector from the coal and petroleum production industry.

Above influences are consistent to the economic theory, although they have not measured in economies. In this sense, the I/O analysis can be applied to this field. The influence of RHPP installation in Thailand should also spread to other Southeastern Asian Countries as well as Japan through the global oil market and import-export. In other words the following changes are expected to spread.

Installation of RHPP in Thailand ⇒ Change in Thai economic structure ⇒ Decrease in the demand for oil ⇒ Change in oil price and oil import ⇒ Change in production level in every country

An economic analysis of the above ripple effect is highly needed for making policies on biomass resource use.

Of course, there are several subjects untouched in this study. It is important to take Vietnam a rice growing country similar to Thailand into consideration, to consider electricity generation by biomasses other than RHPP, to modify the I/O table more elegantly and furthermore, to update the I/O table.

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References

Aumonier, S., (1998) “Life cycle assessment, electricity generation and sustainability,” Nuclear Energy Journal of the British Nuclear Energy Society, 37(5), 295-302

Bhattacharya, S.C., Joe, M.A., Kandhekar, Z., Salam, P.A. and Shrestha, R.M. (1999) “Greenhouse-gas emission mitigation from the use of agricultural residues: the case of rice husk," Energy, 24, pp.43-59

EPPO (Energy Policy and Planning Office), (2005) "Energy strategy: energy for Thailand's competitiveness, Ministry of Energy, Bangkok

Kobayashi, H. and Sago, R., (2001) "Calculation of an energy consumption for a life cycle of nitrogen and phosphorus manure and a CO2 discharge," (in Japanese) Nousagyo Kenkyu, 36(3), 141-151

Miyazawa, K. (1989) "Basic model and its application," (in Japanese) *Introduction to I/O analysis*, Nihon Keizai Shinbun, 102-112

Macro Econometric Study Group, (1998) "A commentary of Input Output analysis" User Manual of Economate I-O, Toyokeizai Shiposhya, 64-81

Srisovanna, P., (2004) "Thailand's biomass energy," *Electricity Supply Industry in Transportation: Issues and Prospect for Asia*, EU-ASEAN COGEN 3 Programme

Ueda, T., Kunimitsu, Y. and Shinogi, Y., "Agricultural Reuse of Rice Husk in Thailand," Paddy and Water Environment, 2005, Submitting

Table 1.　Overall structure of industries in Thailand

(million Bht)

Sectors	Gross Production		Added Value	
	Values	%	Values	%
01 Agriculture	501,800	5.6	354,374	8.3
02 Forestry / Fishery	170,731	1.9	126,877	3.0
03 Mining	83,740	0.9	59,490	1.4
04 Food / Textile & Furniture	1,914,958	21.5	656,507	15.3
05 Petro. & Non-material prod.	520,303	5.9	191,039	4.5
06 Manufacturing	1,570,839	17.7	424,719	9.9
07 Electricity	152,024	1.7	88,510	2.1
08 Construction	887,352	10.0	364,837	8.5
09 Wholesale & Retail trade	1,368,229	15.4	882,752	20.6
10 Transportation & Communication	503,828	5.7	243,612	5.7
11 Others service	1,219,884	13.7	895,633	20.9
total	8,893,688	100.0	4,288,350	100.0

(Data)　I/O table of JICA “Agricultural Statistics and Economic Analysis Development Project”

Table 2. Outline of the Rice Husk Power Plant in Roi-et

Name	Roi-et Green Power Plant
Location	Roi-et (North-east of Thailand)
Start of operation	May 1st in 2003
Source of construction fund	Electricity Generating Public Co.Ltd. (Main)
	Jpanese Power Development Co.ltd.
	Thai industrial finance public corporation
Quantity of generation	Gross: 9.95 MW,　Net: 8.8 MW
Quantity of annual true generation	56,120 Mw・hour/year
Input quantity of rice husk	300 ton/day (80,000 ton/year)
Purchase price of rice husk	600～700 Bht/ton
Sale price of electricity	2.0～2.4 Bht/kWh
No. of employees	30～35 person

(Data) Interview survey of staff at Roi-et Green Power Plant by authors.

Table 3. Classification in the integration of sectors

	Sector integrated	Original 176 sectors
1	Agriculture	47 sectors including Rainy season rice, Dry season rice, and
2	Forestry / Fishery	9 sectors including Forestry, Ocean fishery and Inland fishery
3	Mining	9 sectors including Coal mining and Oil production
4	Food / Textile & Furniture	48 sectors including Food processing, textile industry, and furniture manufacture etc.
5	Petro. & Non-material prod.	12 sectors including Oil refining, Non-metal products etc.
6	Manufacturing	18 sectors including Manufacture of machine, Electric appliance, and Car etc.
7	Electricity	2 sectors including Thermal electricity and Rice Husk
8	Construction	7 sectors including Building and engineering works etc.
9	Wholesale & Retail trade	4 sectors including Wholesale and Retail trade etc.
10	Transportation & Communication	11 sectors including Railroad, Aviation, Marine transportation, Tele-communication etc.
11	Others service	12 sectors including Bank, Insurance, Real estate, Education and Research etc.

Table 4. Changes in the Influence Power and Sensitivity Degree Coefficients

Sectors	Influence Power Coeff.			Sensitivity Degree Coeff.		
	Conventioal power plant	Intro. of RHPP	Difference (%)	Conventioal power plant	Intro. of RHPP	Difference (%)
Agriculture	0.8658	0.8660	0.03	0.8759	0.8823	0.73
Forestry / Fishery	0.8886	0.8889	0.03	0.7640	0.7646	0.09
Mining	0.7957	0.7958	0.01	0.9607	0.9502	−1.09
Food / Textile & Furniture	1.1708	1.1711	0.03	0.9273	0.9280	0.07
Petro. & Non−material prod.	1.1114	1.1109	−0.05	1.1385	1.1362	−0.20
Manufacturing	1.0191	1.0198	0.06	0.9926	0.9939	0.13
Electricity	0.9604	0.9665	0.63	3.0787	1.8812	−38.89
Construction	1.0380	1.0370	−0.10	0.8291	0.8262	−0.34
Wholesale & Retail trade	1.0186	1.0192	0.05	2.4735	2.4776	0.17
Transportation & Communication	0.9645	0.9643	−0.03	0.9316	0.9331	0.16
Others service	0.8952	0.8954	0.02	1.3441	1.3467	0.19

Table 5. Changes in prices by an increase in fossil oil price

Sectors	Conventioal power plant	Introduction of RHPP	Difference
Agriculture	5.98	5.95	−0.03
Forestry / Fishery	11.78	11.74	−0.04
Mining	8.80	8.76	−0.04
Food / Textile & Furniture	8.47	8.33	−0.13
Petro. & Non−material prod.	28.78	28.63	−0.14
Manufacturing	11.15	10.96	−0.19
Electricity	29.71	26.86	−2.85
Construction	9.62	9.50	−0.12
Wholesale & Retail trade	5.70	5.56	−0.14
Transportation & Communication	25.18	25.10	−0.08
Others service	4.61	4.55	−0.07

Note: Each value in second and third rows= (value of RHPP installation) - (value of conventional electricity)

Table 6. Changes in induced production and induced imports with an increase in private consumption.

(Billion Bhat)

Sectors	Increase in induced production			Increase in induced Imports		
	Conventioal power plant	Intro. of RHPP	Difference (%)	Conventioal power plant	Intro. of RHPP	Difference (%)
Agriculture	29,105	29,317	0.73	2,034	2,035	0.04
Forestry / Fishery	4,889	4,889	−0.00	1,138	1,137	−0.04
Mining	1,921	1,780	−7.31	3,411	3,395	−16.20
Food / Textile & Furniture	97,048	97,026	−0.02	23,919	23,919	−0.34
Petro. & Non−material prod.	12,496	12,380	−0.94	5,450	5,448	−2.15
Manufacturing	32,582	32,574	−0.03	21,998	21,992	−5.80
Electricity	7,752	7,747	−0.06	34	34	0.00
Construction	3,735	3,646	−2.39	11	11	−0.10
Wholesale & Retail trade	73,939	73,933	−0.01	2,610	2,610	0.13
Transportation & Communication	26,428	26,425	−0.01	32,173	32,173	0.12
Others service	49,101	49,056	−0.09	4,110	4,113	2.13

Note: Increased values in both cases were calculated from (value in simulation - present value), and difference values were calculated from (Installation of RHPP - Conventional power plant)

[i] Even if all rice husks produced by all paddy fields in Thailand were used in RHPPs, electricity could supply only approximately 4% of all electric energy (Ueda et. al., 2005). Supposing the rice husks are used as fuel for drying rice in rice milling and compost, the ability of RHPP to supply electricity is lower than 4%. The goal to cover 10% of all electric energy by only RHPP of this study is slightly unrealistic. However, biomass resources other than RHPP must also be taken into account. The Thai government announced that 8% of total electricity will be produced by biomass related power plants in 2010 (EPPO, 2005). Furthermore, a change in the 10% goal is necessary for simulations. In consideration of the above, generation by RHPP of 10% was assumed as a test calculation in this study.

[ii] The I/O table in 2000 with precise agricultural sectors had not been published at this time, so the 1995 table was used in this study. There may besome differences in the coefficient values between the RHPP installation and ordinal (What do you mean by ordinal?), even in the 1995 table.