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Research Article

Economic and global warming impact assessment of biomass power generation in Thailand

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Abstract. To strengthen energy security, Thailand launched the Alternative Energy Development Plan (AEDP2018) in which the biomass energy production goal was set. The purpose of this study is to evaluate the economic and global warming impacts of power generation from biomass, including rice straw, rice husk, bagasse, and firewood, using input-output analysis. Five increasing biomass energy production scenarios are set corresponding to AEDP2018.The results show that biomass power promotion helps enhance Thailand's economic growth. The highest growth of all scenarios is found when 3,500 MW of installed fossil-fuel capacity is replaced by biomass-based capacity from rice straw. The replacement leads to 0.058 percent increase in Gross Domestic Product (GDP) and 0.050 percent increase in total employment as compared to business-as-usual (BAU). Besides, the total greenhouse gas (GHG) emission of the country is lower than that of the BAU in every scenario, showing that the development of biomass power generation can help reduce climate change impact. As it provides the highest economic benefits and still has large remaining resource potential, rice straw should be prioritized for expanding biomass power generation, while firewood, bagasse, and rice husk should play supporting roles based on their advantages. Not only can the results of this study support Thailand's transition toward a cleaner energy future, but also the method presented in this study can be a guideline for other developing countries aiming to expand renewable electricity from biomass.

Keywords: economic impact, greenhouse gas, input-output table, biomass energy

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1. Introduction

Exhausting natural resources, e.g. coal, lignite, crude oil, and natural gas, are commonly used in power generation over the world. Economic growth and technology improvement lead to increased energy requirement. It has been estimated that global petroleum reserves would approximately be available for another 50 years while natural gas reserves and coal reserves are for another 50 and 150 years, respectively (Kelkar, 2024). The depletion of these resources, together with rising greenhouse gas (GHG) emissions, has raised global concerns about energy security and climate change. As a result, many countries have committed to achieving net-zero emissions by 2050 under the Paris Agreement and are expanding the use of renewable and low-carbon energy sources (IEA, 2021; IPCC, 2022).

Being in line with the world energy directions that focus on promoting electricity from renewable resources and reducing GHG emissions, Thailand launched the Alternative Energy Development Plan (AEDP) to set the goals and framework for national renewable energy development. One goal of AEDP2018 is to achieve 34.23 percent contribution of electricity from renewable resources to the entire electricity demand of the country by 2037, which is greater than the goal of AEDP2015 that was 20.11 percent contribution of electricity from renewable resources to the entire electricity demand by 2036 (DEDE, 2018).

In 2021, Thailand's production of renewable energy was 3,970 MW in which biomass power has the highest contribution of around 29 percent, followed by solar power, hydro power, and wind power, respectively (DEDE, 2021). It was reported that, in 2022, there were 79 biomass power plants, consisting of 66 residue (rice straw, rice husk, and bagasse) power plants, 45 firewood power plants, and 7 bamboo and Napier grass power plants (DEDE, 2022). Most of the biomass that are used for power generation are agricultural residues. Apart from avoiding the consumption of fossil resources and their combustion in power generation, the utilization of biomass for power generation can add value to the residues.

Replacing fossil fuels with biomass in power generation has widespread effects to the economy and environment of the country, such as the change in Gross Domestic Product (GDP), employment, and the amount of GHG emissions. There were several previous works that focused on macroeconomic effects of biomass power development (Wianwiwat and Adjaye, 2011; Zhao and Yan, 2012; Bildirici and Ozaksoy, 2013; Jongdeepaisal and Nasu, 2020; Kumar *et al.*, 2022). Especially for the case of Thailand, Wianwiwat and Adjaye (2011) used computable general equilibrium (CGE) model to estimate the economic impacts of biomass power development Kumar *et al.* (2022) employed input-output (I/O) table analysis to assess the

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economic impacts of biomass power generation. Focusing on environment, Kumar *et al.* (2022) extended I/O table analysis to capture carbon dioxide (CO_2) emission, land use, and water use effects caused by biomass power generation. However, those previous works did not provide the comparison of both economic and environmental effects between various biomass types in macro-level which has implications for national resource allocation and renewable energy policy.

This study aims at assessing the macroeconomic and environmental effects of biomass power generation in Thailand corresponding to the target in AEDP2018. To provide the guidance on resource allocation, the scenarios are varied according to biomass types. Despite providing the uniform effect of policy, as I/O table analysis can avoid a great number of assumptions made in CGE model, it is used in this study. The analysis is extended to capture the effects of policies on GHG emissions. More explanation on the analysis can be found in Section 2. The results are shown and discussed in Section 3, followed by Section 4 where the conclusions are drawn. The results of this study are expected to be able to support the decision-making on sustainable biomass power development in Thailand.

2. Methods

I/O table analysis, the economic tool for estimating the quantitative changes in goods and services arising from the changes in final demand throughout the economy (Miller and Blair, 2009; United Nations, 2018), is employed to assess the macroeconomic impacts of biomass power generation, i.e., the change in GDP and employment, in this study. Five biomass power generating scenarios are set based on the target of AEDP2018, which aims to increase the installed capacity of biomass power by 3,500 MW by 2037 (Table 1).

To incorporate the additional 3,500 MW of biomass power generation into the analysis, the installed capacity is converted into annual electricity generation (MWh) by assuming 24 hours of operation per day and 330 operating days per year. Then, the annual electricity output is converted into monetary value using the electricity price of 3,800 THB/MWh (PEA, 2017) to estimate the change in final demand. Biomass-based electricity is assumed to replace electricity generated from fossil fuels. So, the final demand for biomass electricity is increased while the final demand for fossil-fuel electricity is reduced by the same amount, keeping total electricity demand constant. The adjusted final demand is then used as a shock to the electricity sector in the I/O model.

The first scenario represents an increase of 3,500 MW in biomass-based power generation, assuming the same proportion of biomass types as shown in the 2015 I/O table (42% bagasse, 30% rice husk, 17% firewood, and 11% rice straw). Each of the other four scenarios illustrates an increase of 3,500 MW in biomass-based power generation from a specific type of biomass. Due to the fact that in Thailand's 2015 I/O table there are the supplies from rice cultivation, rice milling, charcoal and firewood production, and sugar milling sectors to electricity production sector (NESDC, 2021), the biomass types, i.e., rice straw, rice husk, firewood, and bagasse are considered in this study. Following DEDE (2021)'s report, some biomass types currently do not have sufficient potential to support an additional 3,500 MW of installed power capacity. However, to compare the effects of each type of biomass power generation, this study only assumes equal amount of installed capacity of power among scenarios using the policy target.

2.1 Database

I/O table, the snapshot of economy at a point of time (Miller and Blair, 2009; United Nations, 2018), is used as the database. As it is the most updated version, Thailand's 2015 I/O table provided by the National Economic and Social Development Council (NESDC, 2021) is used in this study. The 2015 I/O table can be calibrated to the base year of 2018 where the energy plan begins or later than that but the economic transactions within the table will remain the same. Moreover, using 2015 I/O table can avoid the effects of Coronavirus disease 2019 (COVID-19) pandemic on the economic transactions during 2019-2021. Thus, the calibration of I/O table is not necessary in this case.

This study rearranges the I/O table of 180 sectors to obtain the I/O Table of 37 sectors (n=37) in which the electricity producing sector is separated into 5 sub-sectors as can be seen in Table 2. The separation is based on the proportion of each type of biomass electricity production to the whole electricity in 2015 derived from the Department of Alternative Energy Development and Efficiency (DEDE, 2015) and biomass prices from EFE (2015). The 37-sector I/O table represents the Thai economy in 2015 with the total value-added (GDP) of 13,920 billion THB and the total gross output of 41,618 billion THB. The electricity sector accounts for approximately 2.45 percent of total output. Agricultural sectors account for 5.97% of total output, non-electricity manufacturing sectors account for 64.58 percent, and service sectors account for 26.99 percent. The structure of I/O table is illustrated in Table 3, given that Zij denotes the value of commodity i that is used for the production of industry j (intermediate consumption), Fi represents the value of commodity i that is used for final consumption (final demand), Xj (identical to Xi) stands for the total output of industry j, and Vj indicates the total value-added of industry j. In this study, imports are not presented as a separate component in Table 3. They are included together with domestically produced goods in both intermediate transactions (Zij) and final demand (Fi).

Table 1
Biomass power generation scenarios

Scenario	Description
1	The installed capacity of power generation from various biomass sources is increased by 3,500 MW
2	The installed capacity of power generation from rice straw is increased by 3,500 MW
3	The installed capacity of power generation from rice husk is increased by 3,500 MW
4	The installed capacity of power generation from firewood is increased by 3,500 MW
5	The installed capacity of power generation from bagasse is increased by 3,500 MW

Table 2
Sector number and I/O mapping.

Number	Activities	I/O code
1	Paddy cultivation	001
2	Maize cultivation	002
3	Cassava cultivation	004
4	Sugarcane cultivation	009
5	Coconut plantation	010
6	Oil palm plantation	011
7	Rubber plantation	016
8	Other agriculture	003,005-008,012-15,17-29
9	Coal and lignite mining	030
10	Oil and natural gas extraction	031
11	Mining and quarrying	032-041
12	Coconut and palm oil plantation	047
13	Rice milling	049
14	Tapioca milling	050
15	Drying and grinding of maize	051
16	Flour and other grain milling	052
17	Sugar milling	055
18	Animal feed production	061
19	Food manufacturing	042-046,048,053-054,056-060,062-066
20	Textile and paper and printing industry	067-074,081-083
21	Fertilizer and pesticide production	085
22	Chemical industry	084,086-092
23	Petroleum refinery	093-094,136
24	Rubber and plastic production	095-098
25	Metal, metal products, machinery and non-metallic production	099-128
26	Other manufacturing	075-080,129-134
27	Electricity production from other energy sources	
28	Electricity production from rice straw	
29	Electricity production from rice husk	135
30	Electricity production from firewood	
31	Electricity production from bagasse	
32	Water supplying	137
33	Construction	138-144
34	Trade	145-146
35	Services	147-148,160-178
36	Transportation and communication	149-159
37	Unclassified	180

Table 3
Structure of I/O table

	To	Industry (j)			Final demand	Total output
From		1	2	n	(F_i)	(X_i)
Commodity (i)	1	Z_{11}	Z_{12}	Z_{1n}	F_1	X_1
	2	Z_{21}	Z_{22}	Z_{2n}	F_2	X_2
	n	Z_{n1}	Z_{n2}	Z_{nn}	F_n	X_n
Value added (V_j)		V_1	V_2	V_n	GDP	
Total input (X_j)		X_1	X_2	X_n		Gross Output

2.2 I/O Table analysis

The transaction of outputs between industries in this I/O table analysis is determined by Leontief production function as presented in Equation 1. Given that a_{ij} is the ratio of the value of commodity i that is used for the production of industry j to the total output of industry j, Equation 1 can be rewritten as Equation 2. The matrix form of Equation 2 is presented in Equation 3 where A represents the matrix of all a_{ij}, I is an identity matrix, X is the column vector of total outputs, and F denotes the column vector of final demand (Kunanuntakij *et al.*, 2017; Kumar *et al.*, 2022). $[I\text{-}A]^{-1}$ in Equation 3 provides the multipliers that can be used for estimating the effects of policy (the change in final demand) on outputs. The estimation of the impacts of policy on the sectoral value-added and employment are relied on Equations 4 and 5, provided that VA is the matrix of the total value-added of industry j, EM is the matrix of the value of employment in industry j, α denotes the ratio of the value-added of industry j (the combination of wage and capital return) to the value of the total outputs of industry j, and β stands for the ratio of the value of the employment in industry j to the value of the total outputs of industry j. It has to be noted that, in this study, wage rate is considered constant to reflect the change in employment.

$$\sum_{j=1}^{n} Z_{ij} + F_i = X_i \quad `(1)$$

given that

$$a_{ij} = \frac{z_{ij}}{x_j} \text{ or } Z_{ij} = a_{ij}X_j$$

$$\sum_{j=1}^{n} a_{ij}X_j + F_i = X_i \quad (2)$$

given that

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix}, F = \begin{bmatrix} F_1 \\ \vdots \\ F_n \end{bmatrix}, X = \begin{bmatrix} X_1 \\ \vdots \\ X_n \end{bmatrix}$$

$$X = AX + F$$
$$F = X - AX$$
$$F = X[I - A]$$
$$X = [I - A]^{-1}F \quad (3)$$

$$VA = \alpha[I - A]^{-1}F \quad (4)$$

$$EM = \beta[I - A]^{-1}F \quad (5)$$

2.3 Global warming impact assessment

The I/O table analysis is expanded to capture GHG emissions from fuel combustion and chemical fertilizer use based on Equations 6 and 7, where G refers to the matrix of total GHG of production sector j, X is equivalent to $[I\text{-}A]^{-1}F$ as can also be seen in Equation 3, and E denotes the matrix of direct GHG emissions coefficients that are basically derived from dividing the GHG emission factors [Column (a) in Table 4] by the price factors [Column (b) in Table 4].

The direct GHG emission coefficients for fossil fuel combustions are obtained from dividing the GHG emission factors of fossil fuel combustion (presented in 1,000 tonne CO_2 eq./ktoe) by fossil fuels' prices [presented in 1,000 million Thai baht (THB)/ktoe] which are either available from Haputta *et al.* (2022). The direct GHG emission coefficients for biomass combustions are obtained from dividing the GHG emission factors of biomass combustion (presented in 1,000 tonne CO_2 eq./KTOE) by biomass prices (presented in 1,000 million THB/ktoe). The GHG emission factors of biomass combustions are borrowed from Gómez *et al.* (2006) and TGO (2022) while the biomass prices are derived from dividing the price per tonne of each biomass type (EFE, 2015) by its heating value (DEDE, 2013) (see Appendix, Table A). Direct GHG emission coefficient for fertilizer use (Table 4) is computed from dividing the emission factor of chemical fertilizer application (presented in 1,000 tonne CO_2 eq./tonne fertilizer) by the chemical fertilizer's price. The emission factor of chemical fertilizer application is available from Thailand Greenhouse Gas Management Organization (TGO, 2016). The chemical fertilizer's price is provided by the Office of Agricultural Economics (OAE, 2015) (see Table 4).

$$G = XE \quad (6)$$

$$G = ([I - A]^{-1}F)E \quad (7)$$

It has to be noted that, the consumption of fossil fuels in petroleum refinery and chemical industry sectors are not multiplied by the direct GHG emission coefficients for fossil fuel combustions because fossil fuels are used as the raw materials of these sectors, not for combustion.

3. Results and discussion

The economic and global warming impacts caused by each type of biomass power generation are presented and discussed in this section. The economic impacts that are focused in this study are the changes in GDP and employment. Table 5 shows that, as compared to BAU, the GDP is increased in every scenario, aligning with the conclusion of Bildirici and Ozaksoy (2013) that biomass power consumption can help induce the economic growth and reduce poverty in developing countries. Raising up the installed capacity of biomass-based power generation by 3,500 MW using all types of biomasses (Scenario 1) causes 0.053 percent increment of GDP and 0.057 percent increment of employment. On the one hand, increasing the installed capacity of power generation from rice straw by 3,500 MW (Scenario 2) yields the highest GDP growth rate among all biomass-based power generation scenarios. This is because the value-added of rice straw electricity production sector is significantly increased according to the low cost of intermediate input, rice straw. Also, the higher demand for rice straw by rice straw electricity production sector helps enhance the value-added of paddy cultivation (see Appendix, Table B). On the other hand, the power generation from firewood provides the least GDP enhancement. The reason is that the feedstock sector of firewood electricity, i.e. charcoal and firewood production (a part of other agricultures) is the upstream sector that requires only little production inputs. Higher demand for charcoal and firewood does not much in turn increase the value-added of other sectors.

Considering employment effect, every scenario provides the positive change in employment as compared to BAU. The highest increase in employment is found in Scenario 5 where bagasse electricity is promoted, followed by rice husk, firewood, and rice straw, respectively. The reason for higher employment of bagasse and rice husk than rice straw and

Table 4.
Emission Factors

	Unit	Emission factor (1000 tonne CO_2/unit) (a)	Price factor (1000 Million THB/unit) (b)
Fossil fuel combustion			
Coal and Lignite	ktoe	4.105	0.004
Crude oil and natural gas	ktoe	1.039	0.016
Petroleum Product	ktoe	2.488	0.053
Biomass combustion			
Rice straw	ktoe	0.080	0.003
Rice husk	ktoe	0.080	0.005
Firewood	ktoe	0.081	0.003
Bagasse	ktoe	0.082	0.007
Chemical fertilizer use			
Chemical fertilizer	tonne	0.0007024	0.000012

Note: The GHG emission factors for biomass combustion are the aggregation of characterized methane (CH_4) and nitrous oxide (N_2O) emissions only as carbon dioxide (CO_2) from biomass is considered carbon neutral following the Intergovernmental Panel on Climate Change (IPCC, 2006); the emission factors for firewood and bagasse combustion are from TGO (2022); the emission factors for rice straw and rice husk are computed based on Gómez et al. (2006).

Table 5
Changes in GDP and employment (% Change from BAU)

Scenario	GDP	Employment
1 (Various types)	0.0525	0.0573
2 (Rice straw)	0.0584	0.0504
3 (Rice husk)	0.0520	0.0546
4 (Firewood)	0.0458	0.0523
5 (Bagasse)	0.0539	0.0629

Note: 2015 GDP is 13,743.5 billion THB (Bank of Thailand, 2015); 2015 employed persons in Thailand (BAU) was 38.1 million persons (National Statistical Office, 2015)

Table 6
Changes in GHG emissions (% Change from BAU)

Scenario	GHG emissions
1 (Various types)	-3.503
2 (Rice straw)	-3.412
3 (Rice husk)	-3.492
4 (Firewood)	-3.522
5 (Bagasse)	-3.527

Note: Thailand's GHG emission were 352 million tonnes CO_2 eq. in 2015 (baseline year) and 386 million tonnes CO_2 eq. in 2022 (for reference) (Department of Climate Change and Environment, 2024).

firewood is these materials are derived from the processing industries, i.e. sugar milling and rice milling. Not only can they help create the jobs at the mills, they can also in turn create jobs at farm. Unlike rice straw and firewood that are directly obtained from cultivation that create the jobs only in cultivation sectors. However, it is found that the employment of coal and lignite mining as well as oil and natural gas extraction sectors are reduced in every scenario. This is because the replacement of biomass for fossil fuels in electricity production brings about lower demand for fossil fuels and that affect the employment and value-added of these sectors (see Appendix, Table B).

GHG emissions brought by biomass power generation are illustrated in Table 6. It can be seen that GHG is decreased from the BAU in every scenario, implying that biomass power promotion helps reduce global warming impacts. The results show that GHG emission from coal and lignite mining and oil and natural gas extracting sectors are lower in all scenarios, aligning with the indication by Liu *et al.* (2014) that the replacement of biomass power generation for the power from coal can reduce the amount of GHG. The most decrease of GHG is found in Scenario 5 where bagasse is used as raw material. This is mainly because of the low emission coefficient of bagasse combustion. Conversely, the reduction of GHG in Scenarios 2 and 3 where rice straw and rice husk are used for power generation are even lesser than that of BAU. The reason is that, other than the emissions at rice straw and rice husk power plants, GHG in Scenarios 2 and 3 are also driven by the expansion of rice cultivation and chemical fertilizer production to serve the higher demand for rice straw and rice husk production. As GDP enhancement represents overall economic impacts relevant to policy decision-making, it is adopted as the main evaluation criterion for biomass power options in this study. Accordingly, rice straw may be considered a priority option, followed by bagasse, rice husk, and firewood.

Thailand generates an average of approximately 26.2 million tonnes of rice straw annually (Jusakulvijit *et al.*, 2021). However, a very little rice straw is currently utilized for power generation because it deteriorates easily, cannot be kept for long, and has high storage and shipping costs. As a result, a large amount of rice straw is still directly burned in the fields. Jusakulvijit *et al.* (2021) estimated that around 18–29 million tonnes of rice straw are burned annually as paddy stubble. Field burning has been reported to account for approximately 48% of rice straw disposal in Thailand (Pandey *et al.*, 2010; Singh and Patel, 2022). According to the Base Load Plant Research and Development Division (2023), a substantial amount of rice straw remains available to support an additional 3,000 MW of power generation capacity. This is consistent with the potential of rice straw for power generation in Thailand indicated by Cheewaphongphan *et al.* (2018). However, as GHG emissions under the rice straw–based scenario is relatively high, emissions from farming practices, such as flooded rice cultivation and the use of chemical fertilizers, should be carefully considered.

Bagasse is a very attractive resource because, apart from providing the second-highest GDP enhancement after rice straw, it also leads to the highest job creation and GHG reduction. However, as reported by DEDE (2013), bagasse has already been utilized to its full potential. So, it may be difficult to further increase power generation from bagasse. In addition, only a limited amount of rice husk remains available for power generation (Base Load Plant Research and Development Division, 2023). Moreover, due to the increasing number of rice husk power plants, the price of rice husk is relatively high compared to other types of biomass, which increases the cost of rice husk-based power generation.

Although power generation from firewood provides the lowest GDP enhancement, para rubberwood and cassava stems remain available to support an additional installed power capacity of around 1,000 MW. This is supported by the study of Waewsak *et al.* (2020), which confirmed a significant potential for power generation from para rubberwood in Southern Thailand. In addition, a small volume of eucalyptus firewood is also available (Base Load Plant Research and Development Division, 2023). Although I/O table analysis is useful for estimating economy-wide effects, it has some limitations. It assumes fixed relationships between inputs and outputs, no substitution between inputs, no price changes, and a constant production structure (Miller and Blair,2009; Henriques and Sousa, 2018). Hence, the results should rather be interpreted as scenarios-based estimates under I/O framework and may not reflect actual outcomes.

4. Policy recommendations

From the results, biomass power generation can help enhance the economy, generate more jobs, and decrease GHG emission. So, the government could support power generation from all biomass types, for instance, by setting the attractive biomass power purchase price. Especially, biomass power from rice straw appears to be a promising option for expansion, followed by bagasse, rice husk, and firewood, respectively.

As it provides the strong economic benefits and has substantial remaining resource potential, rice straw can be considered as an important resource for increasing biomass power generation. If the limitations of rice straw can be eliminated, for instance, by compressing rice straw into pellets instead of conventional baling to save transportation cost or by reducing its moisture content to improve energy efficiency, rice straw power generation may become more attractive. Other than that, the utilization of rice straw also helps reduce open-field burning, which is a major cause of GHG emissions and particulate matter formation.

Although firewood-based power generation provides less economic gain than other resources, it still has potential for further power generation. To increase the economic gain, adding value to the feedstock by processing raw firewood or charcoal into higher-value biomass fuels, such as wood chips or pellets, could be considered as an option. Besides, to increase its potential for power generation, planting fast-growing trees, such as rubber and eucalyptus trees, in wood lots should be promoted. This would allow their trunks to be utilized for energy production. As oil palm must be cut down in cycles, the utilization of oil palm trunks can also be an option.

Despite its limited potential for further expansion, bagasse may continue to play an important role as resource due to its environmental benefits and job creation. Furthermore, although rice husk provides lower economic and environmental gains, it still contributes to job creation and should therefore be maintained as a complementary biomass resource.

5. Conclusions

This study estimates the economic and global warming effects of biomass power generation using I/O table analysis. Five scenarios are set based on the biomass power generating target in AEDP2018, taking into account of the power generation from rice straw, rice husk, firewood, and bagasse. The results show that an increase in the installed capacity of biomass power by 3,500 MW leads to positive changes in GDP and employment, while also contributing to GHG reduction. Among all considered biomass types, rice straw provides relatively high economic benefits and still has a large remaining resource potential. So, rice straw may be considered a promising option for expanding biomass power generation. Bagasse is important for reducing GHG emissions and creating jobs, while rice husk and firewood should be maintained as supporting resources that help create employment and diversify biomass use. Overall, different biomass types may be promoted based on their respective strengths to support sustainable biomass power generation in Thailand. However, this analysis is based on a static I/O model and specific scenarios. Therefore, the results may not indicate that biomass power is the best option as other electricity sources can have different economic and environmental benefits. The method presented in this study can be used as a guideline for future impact assessment of energy policy. The future change of biomass prices may affect the results and that effect can be tested in future research. Also, this study considers only the main biomass types that have transaction with electricity production sector in Thailand's 2015 I/O table. Taking into account of other biomass types is still left for future research.

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Appendix

Table A.
Price and heating value of biomass

Type	Price (THB/tonne) (a)	Heating value (MJ/tonne) (b)
Rice straw	1,000	12,330
Rice husk	1,575	13,520
Bagasse	1,200	7,370
Firewood	950	15,790

Note: 1 MJ = 2.37E-08 ktoe; a is from the Energy for Environment Foundation (2015); b is from DEDE (2013).

Table B.
Change in sectoral value added

sector	Scenario (% Change from BAU)				
	1	2	3	4	5
1	0.96	3.82	1.74	0.03	0.00
2	0.03	0.02	0.01	0.15	0.01
3	0.01	0.00	0.00	0.01	0.02
4	2.05	0.00	0.00	0.00	4.84
5	0.13	0.01	0.01	0.03	0.28
6	0.00	0.00	0.00	0.01	0.00
7	0.01	0.00	0.01	0.00	0.01
8	0.07	0.04	0.02	0.32	0.02
9	-7.42	-7.45	-7.42	-7.42	-7.42
10	-0.84	-0.90	-0.84	-0.78	-0.85
11	0.01	0.02	0.01	0.01	0.01
12	0.00	0.00	0.00	0.01	0.00
13	0.56	0.00	1.88	0.02	0.00
14	0.01	0.00	0.00	0.01	0.02
15	0.07	0.04	0.02	0.32	0.02
16	0.02	0.00	0.00	0.01	0.04
17	2.06	0.00	0.00	0.00	4.86
18	0.08	0.04	0.02	0.39	0.02
19	0.00	0.00	0.00	0.01	0.00
20	0.00	0.00	0.00	0.00	0.00
21	0.43	0.99	0.45	0.14	0.38
22	0.02	0.01	0.01	0.02	0.02
23	0.13	0.07	0.13	0.18	0.12
24	0.01	0.00	0.01	0.01	0.01
25	0.01	0.00	0.01	0.01	0.01
26	0.00	0.00	0.00	0.00	0.00
27	-10.67	-10.69	-10.66	-10.66	-10.67
28	350.98	3079.91	0.06	0.05	0.05
29	277.47	0.02	933.76	0.06	0.05
30	207.17	0.02	0.06	1247.63	0.05
31	293.84	0.02	0.06	0.05	694.71

sector	Scenario (% Change from BAU)				
	1	2	3	4	5
32	0.01	0.02	0.01	0.01	0.01
33	0.00	0.00	0.00	0.00	0.00
34	0.00	0.00	0.00	0.00	0.00
35	0.00	0.00	0.00	0.00	0.00
36	0.00	-0.01	0.00	-0.01	0.00
37	0.01	0.01	0.01	0.02	0.01