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Research Note

A Study on Regional Economic Ripple Effect by Analysing Woody Biomass Energy Facilities†

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Abstract: The purpose of this study is to examine two different types of woody biomass energy facilities operating in Japan to determine whether the economic ripple effects on the local economy differ depending on how the facilities are managed and operated. Japan has been promoting the use of renewable energy through the Feed-in Tariff (FIT) system, and woody biomass has a high purchase price because of its ability to provide a stable energy supply and promote the forestry industry. However, the transfer of woody biomass energy, which is produced using imported wood, has been rapidly expanding nationwide; there are concerns that it will make little contributions to the development of the local economy and the measures mitigating global warming. Based on the result of the analysis of two biomass energy facilities that were fuelled by woody biomass, we confirmed that power generation facilities operated by the local community are effective from the viewpoints of local economic circulation and the environment.

Keywords: biomass energy, renewable energy, regional economy, money circulation

JEL Classification Numbers: P18, Q16, Q56, Q23

1. Introduction

Since the nuclear power plant accident caused by the Great East Japan Earthquake, Japan's energy self-sufficiency rate has been only 6 %. However, because of an abundant amount of unutilized renewable energy in Japan, the feed-in tariff (FIT) system has been introduced to promote the use of renewable energy from the perspective of energy security and regional revitalisation. The utilisation of renewable energy is also the key to revitalising regional economy. Therefore, the purpose of introducing FIT is to not only boost energy security but also enhance environmental measures and regional economic promotion. According to the IEA (International Energy Agency), the share of renewable energy in power generation is expected to reach 27 % in 2020 and 33 % by 2025. Renewable energy is expected to supply more electricity than coal-fired power generation, which is currently the most commonly used method.

In Europe, small-scale decentralised power generation systems are becoming more popular because of their effectiveness in improving sustainability performance in terms of their economic spillover effects on the region and reduction of environmental impact (Yan, 2020). Small-scale distributed power is used as the norm in many countries, including Japan, but technological innovation has made large-scale power generation and long-distance transmission possible, which has led to the global spread of centralised power systems. However, in the 1980s, cost reduction, electricity liberalisation, and the shift to a low-carbon society led to a global re-evaluation of distributed energy (Inazawa, 2017). Distributed energy, which is being introduced mainly in Europe and includes home power generation, storage batteries, demand response, and the use of renewable energy, reduces the environmental impact and has a high ripple effect on the local economy.

Japan has also introduced the FIT system and is promoting the use of renewable energy. In particular, the system focusses on the fact that woody biomass can provide a stable power supply compared to solar and wind power. In addition, woody biomass power generation is set to a high purchase price because it can expect the economic ripple effect to a wide industrial field, such as forestry, transportation and manufacturing. The introduction of FIT has led to a rapid increase in the number of construction plans for woody biomass power generation facilities in Japan; for example, the certified capacity of woody biomass energy facilities in 2015 was approximately 3.4 GW, but in 2016 it was about 12 GW, as per data obtained from the Japan Woody Bioenergy Association (JWBA, 2018). However, more than half of the woody biomass power generation facilities planned for construction in Japan use palm kernel shell (PKS) and wood chips (imported from overseas) as fuel. Therefore, there is concern that the expected economic effects on domestic industries will be limited (BIN: Biomass Industrial Society Network, 2020). What kind of utilisation of woody biomass energy can contribute to the independence of local economies?

In this study, we estimate the economic ripple effect in the same area by operating a woody biomass energy facility. By using an index that represents the degree of the economic cycle in the region called Local Multiplier 3 (LM3), we tried to estimate how much money is circulating in the local economy. LM3 is an indicator of the degree of economic circulation in the region, which indicates how much energy sales circulate within a specific area. We estimated the size of the regional economic cycle through the use of renewable energy using the index LM3, which indicates the degree of money circulation in the region.

We compared two woody biomass energy facilities having different characteristics. One was a large-scale wood biomass power generation facility (Facility A), where half of the fuel used in he facility is imported PKS. The other was a small-scale wood biomass heat supply facility (Facility B), which used wood derived from the region as fuel. In both the cases, the fuel was woody biomass, but the size, type of investment, and procurement method of the raw materials were different. The introduction of FIT has led to a rapid and nationwide increase in the number of woody biomass facilities using imported wood chips and PKS; 60 % of the facilities in operation were using imported wood as fuel in 2019. Since it is expected that the number of facilities using imported wood will continue to increase in view of the wood-chip supply capacity in Japan, we compares the facilities that used imported wood as fuel with those that used only domestic woody biomass.

2. Renewable energy and regional economy

2.1 Preliminary study

The following studies have been conducted on the impact of renewable energy on regional economy. Nakamura et al. (2012a, 2012b) estimated CO2 reductions and regional economic effects using regional input-output tables. Crawford (2008) estimated the economic ripple and environmental impact of the hybrid method (accumulation method + input-output table). Regarding the economic ripple effect on the local economy, many studies have used the input-output table. However, the data of the input-output table has the disadvantage of being difficult to observe the economic ripple effect on the regional economy because the table uses the unit of the average value of the national or prefecture.

Raupach (2014) also estimated the economic effect of the use of renewable energy through a value chain analysis. The value chain analysis method is estimated as regional value added, which is the sum of profit after tax, disposable income, and local tax revenue, but sit is also estimated using statistical data for the entire region; therefore, it can be not possible to see the different effects of the implemented management methods and types of renewable energy.

Therefore, in this study, we decided to quantitatively evaluate the economic ripple effect at the region level using an intra-regional multiplier (LM3) proposed by New Economic Foundation. LM3 is an index that tracks, up to the third round, the extent to which money paid into the region is reinvested into the region. Unlike conventional methods of measuring economic ripple effects, LM3 can track the flow of money for each project. Existing research methods have been able to measure the economic ripple effect of woody biomass energy facilities, but they were not able to evaluate the difference in the fuel used (domestic woody chips or imported woody chips). Therefore, we attempted to analyse the results using LM3, which allowed us to obtain and evaluate the results on a project-by-project basis.

2.2 Renewable energy situation in Japan

In Japan, renewable energy introduction plans are rapidly increasing after the introduction of the FIT (Table 1). The capacity of solar power generation is the largest, but recently, the number of biomass power plants has been increasing. As of March 2018, 295 biomass power generation facilities were operating under FIT, but the total number of certified facilities was 690; this number was expected to triple and the power generation capacity was expected to increase by 6.7 times.

Utilising renewable energy produced in Japan instead of imported fossil fuels can reduce the environmental impact and revitalise the local economy. However, more than half of the fuel used in future biomass power plants is planned to import palm kernel shells (PKS) from Indonesia and Malaysia and wood chips and pellets from overseas. Therefore, it is feared that the effects will be very limited from the viewpoints of employment, industrial revitalisation, and the environment of the local economy.

2.3 Japanese forests and consumer responsibilities

Japan has the third-highest forest rate in the world and has rich forest resources, but its timber self-sufficiency rate is less than 40 %, and most of them rely on imports. After World War II, in Japan, the demand for coniferous trees has increased greatly for construction and civil

Table 1. New certified capacity of renewable energy by Feed-in Tariff (Unit: MW)

		March, 2018	March, 2020	New certified capacity increase rate (2018-2020)
Solar	sum	70,172	74,314	6%
Wind	sum	6,532	9,071	39%
Hydrology	sum	1,168	1,293	11%
Geothermal	sum	82	55	-33%
Biomass	Methane gas	78	86	10%
	Unused wood(less than 2,000kW)	54	71	31%
	Unused wood(over 2,000kW)	438	456	4%
	General wood	7,412	7,396	0%
	Construction waste	87	86	-1%
	General waste and non-wood waste	332	435	31%

Source: Created by the author using the official website of the Ministry of Economy, Trade, and Industry.

engineering, but the timber price index has risen to more than double because it the forest resources were no sufficient. For this reason, ‘Afforestation policy’ was adapted, and the afforestation of domestic coniferous forests was recommended. In 1946, subsidies (for afforestation) were incorporated into public works projects, and afforestation was actively promoted throughout Japan with the aim of eliminating unforested land. In order to procure the timber needed domestically, timber imports have been liberalized, and the supply of domestic forest resources has decreased. In other words, in Japan, which has encouraged afforestation but not logging, forestry as an industry has not developed, and the number of forestry workers is decreasing (due to depopulation and the ageing of the population), resulting in the decline of forestry as an industry (Forestry Agency, 2018). Therefore, Japan began to use overseas timber as domestic forestry declined. However, there have been reports that Japan’s timber consumption behaviour is responsible for deforestation in other countries. For example, in Malaysia’s Sarawak province, rainforests are disappearing at the fastest rate in the world due to illegal deforestation; more than half of the illegal timber from these forests has been reported to be imported into Japan (Human Rights Now, 2016).

Such consumer responsibilities are important for solving global issues. Ensuring sustainable consumption and production patterns is one of the key points of the Sustainable Development Goals (SDGs) advocated by the United Nations, consumers are being asked to take responsibility for whether developed countries in particular are making responsible consumption choices that take into account environmental and social issues. In addition, if forests are not maintained, the water holding capacity and absorption rate of carbon dioxide are reduced. Another goal of the SDGs is ‘Life on land: Protect, restore, and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss'. Considering the effects of Japan's consumption behaviour on foreign countries and the situation of forestry in Japan, it is necessary to explore ways of utilising wood in Japan instead of consuming wood resources imported from foreign countries (UNDP: United Nations Development Programme).

2.4 Economies of scale of woody biomass facilities

The larger the scale of a wood biomass power generation facility, the lower the power generation unit price. In particular, when heat is not used, the cost of power generation for large-scale facilities is one-third to one-sixth of that of small-scale facilities. Therefore, considering only the profitability of the power plant, large-scale projects are more likely to be preferred (Table 2). However, as the facility becomes larger, a huge amount of initial investment, for taking care of the costs of constructing a stable supply system for wood chips and a power generation facility, is required. Therefore, in many areas, large-capitalized urban enterprises are planning to build facilities because it is difficult to cover project costs, including initial investment costs, in rural areas. The management of woody biomass facilities has an economic ripple effect. However, the profits of facilities operated by companies outside the region usually flow outside the region in which the investment was made, and the effect on the regional economy is limited.

Table 2. Comparison of costs by woody biomass power generation capacity

	Unit	1,000 kW	2,000 kW	5,000 kW	10,000 kW	20,000 kW
Generation cost (including heat profit)*	yen/ kWh	124 -46.7*	61.8 -25*	31.7	26.6	21.4
Construction cost unit price	thousand yen/ kW	52.2	46.1	38.1	32.1	25
Thermal efficiency	%	8	12	20.7	24.4	28.2

Source: Created by the author using reference work of Taki et al. (2015)

* The thermal efficiency when converting woody biomass energy into electricity is about 40 %, but in the case of cogeneration (that also uses heat), the thermal efficiency will improve to 80–90 %. However, since the FIT system does not provide incentives to promote heat use, heat is often not used.

There are few questions that are addressed in this study: What kind of woody biomass energy facilities will be effective in the regional economic cycle for rural areas with woody biomass resources? How will the differences in the operation and utilisation of wood biomass facilities affect the local economy and environment?

The purpose of this study is to visualise the impact of the differences in the operation of woody biomass energy on the local economy and to consider how to use local resources for the independence of the local economy.

3. Methodology

3.1 Target area and facility overview

In this study, we considered two biomass energy facilities having different scales and operating methods. The first facility was a large-scale woody biomass power plant A (Facility A) that was powered by PKS and used half of the total imported fuel, and the other facility was a small-scale distributed heat-supply facility (Facility B), which supplied heat using wood chips. Table 3 summarises the target facilities. Facility A was a facility that specialised in power generation, and heat was supplied only within the facility. The generated electricity was sold to all major electric power companies in the region. Additionally, Facility A was operated by an outside company by establishing a subsidiary in the area. Facility B was operated mainly by the town and supplied heat mainly to the public facilities. This facility did not generate electricity and sold only heat. For each region where each woody biomass energy facility was introduced, we tried to estimate the economic ripple effect and income effect in the region.

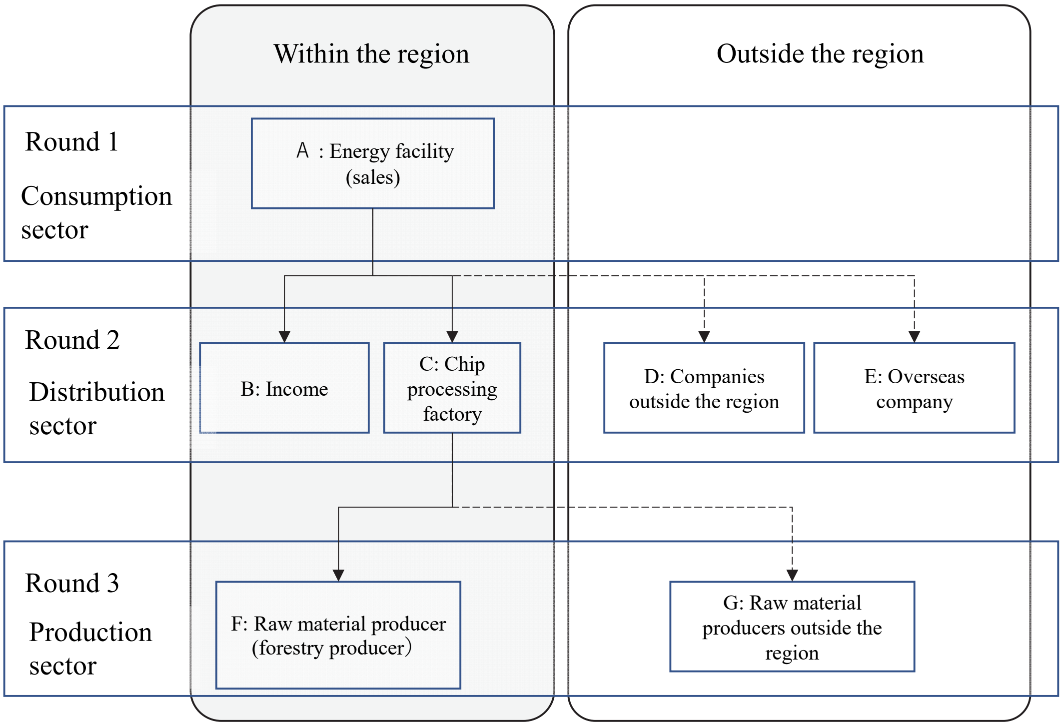
Table 3. Overview of research target facility

	Facility A: large-scale biomass power plant	Facility B: small-scale heat supply system
Installation location	Shimane prefecture	Hokkaido prefecture
Facility name	Shimane Forest Power Generation	Shimokawa Town Heat Supply System
Fuel	83,000 ton (woody chip made in the region), 32,000 ton (PKS from Indonesia)	3,000 ton (woody chip made in the region)
Generation/heat-supply capacity	Capacity: 12 MW Amount of generation: 87,000MWh (for 23,000 households)	4.6 MW（9 units, 11 public facilities） 31.5TJ = 8,750 MWh
Facility construction	Large urban companies/joint ventures in the region	Town public works
Annual sales of electricity/ heat	2.4 billion yen	45 million yen
Energy usage form	Mainly electricity only (heat supply in some facilities)	Heat only

Source: Created by the author using hearings and questionnaire surveys conducted between June and August 2017.

Facility A, which is the subject of this study, used imported wood and wood chips from domestic common wood. More than 60 % of the biomass power generation facilities in operation (by 2019) used imported wood as part of their fuel, and the number of woody biomass power generation facilities that use imported wood is expected to increase in the future. The scale of power generation is approximately the same as that of woody biomass power generation facilities scheduled to be constructed in the future, and the power generation capacity and raw material procurement method are approximately the same as those of woody biomass power generation facilities that are increasing nationwide. Facility B, on the other hand, used only heat. The introduction of woody biomass power generation facilities has been promoted by FIT, but the use of heat has not been promoted. However, it is more efficient to use woody biomass as thermal energy than electricity. Therefore, we compared the woody biomass power generation facilities that use imported wood (which are rapidly spreading throughout Japan) and heat supply systems that does not generate electricity.

Figure 1. Outline of concept of regional economic circulation



Source: Created by the author.

3.2 Methodology

This study clarifies the flow of money and the effect of income on related industries (forestry, wood-chip processing companies, energy companies), rather than understanding the economic ripple effect on the whole region. Our analysis method is based on the method of regional multiplier 3 (LM3) developed by the New Economic Foundation (Sacks, 2002). This method can measure the degree of economic circulation in the region by tracking how much money is re-invested into the region (see Figure 1). In other words, it is possible to measure how much of the sales (of woody biomass facilities) is circulating in the area.

In this research, we focussed on the flow of money to the industries related to energy facilities and measure the size of the economic cycle. Specifically, we estimated the economic ripple effects of energy sales in three industrial sectors: the consumption sector that sells energy (power generation and heat supply sector), distribution sector that delivers fuel to energy facilities (sector related to wood-chip supply), and the sector that produces raw wood, which is the raw material for fuel (forestry sector). We conducted a questionnaire and hearing survey on the flow of money to each facility and collected data. The LM3 portrays values between 1 and 3, with a value closer to 3 indicating a greater economic ripple effect within the region. Although there is no standard for determining what value is appropriate, it is possible to objectively compare the degree of contribution to the region.

4. Result

We collected data from the two facilities (Table 4 and Table 5). We observed that Facility A earned 2,480 million yen annually from electricity sales, of which 1.23 billion yen was paid to the region (consumption sector). The fuel for power generation was wood chips and PKS, and 1,270 million yen was paid for the processing and procurement of wood chips (distribution sector); with respect to the amount paid to this distribution sector, 590 million yen was paid to the region. In addition, 410 million yen was paid to the forestry sector (production sector) to procure wood chips, of which 150 million yen was paid to the region. From the above, facility A sells 2,480 million yen, of which the amount paid in the area was 1,230 million yen for the consumer sector, 590 million yen for the distribution sector, and 150 million yen for the production sector. The regional economic cycle (calculated by LM3) was found to be:

$$(2{,}480+1{,}230+590+150) / 2{,}480 = 1.79$$

On the other hand, in Facility B, the sales from heat energy amounted to 45 million yen, of which 35 million yen was paid to the region (consumption sector). 35 million was paid for the processing of wood chips as fuel, of which 27.5 million yen was paid in the region (distribution sector). And 8.3 million yen was paid for the purchase of raw wood, which is the raw material for wood chips, of which 4.3 million yen was paid within the region. From the above, the regional economic cycle of facility B was calculated to be:

$$(45+35+27.5+4.3)/45 = 2.48$$

The sales amount of facility A was as large as 2.4 billion yen, but it as operated by a company outside the region and used imported PKS as part of the fuel. Therefore, the degree of economic circulation in the

Table 4. Money flow between sectors for Facility A

(unit: million yen)

Sector	Items	Within the region	Outside the region
Consumption sector (Electricity sales) 2.4billion yen	Wood chip purchase cost	800	
	PKS purchase cost	430	40
	Plant operation and maintenance cost		330
	Initial investment return		880
Distribution sector (Woody chip production)	PKS transportation cost	20	20
	Wood chip manufacturing cost	210	200
	Wood chip purchase cost	330	
	Wood chip transportation cost	30	30
Production sector (Log production)	Personnel expenses (cutting)	150	100
	Logging costs (machine fuel, rental, etc.)		160

Source: Created by the author through hearings and questionnaire surveys conducted between June and August 2017.

Table 5. Money flow between sectors for Facility B

(unit: million yen)

Sector	Items	Within the region	Outside the region
Consumption sector (Heat sales) 45 million yen	Wood chip purchase cost	35.0	
	Plant operation and maintenance cost		2.0
	Initial investment return		8.0
Distribution sector (Woody chip production)	Log purchase cost	8.3	
	Labor cost (wood chip production)	11.5	0.8
	Transportation cost	5.0	
	others	2.7	6.7
Production sector (Log production)	Personnel expenses (cutting)	4.3	
	Logging costs (machine fuel, rental, etc.)		4.1

Source: Created by the author through hearings and questionnaire surveys conducted between June and August 2017.

area of Facility A was smaller than that in the area of Facility B, which is operated mainly by the town and used only locally found wood chips. Table 6 shows the regional income effect per energy sale at each facility. It can be seen that facility B has a higher income effect.

Table 6. Income effects in the region per energy sales (per 1,000-yen sales)

	Facility A	Facility B
Before the introduction of the facility	52 yen	177 yen
After the introduction of the facility	100 yen	396 yen

Source: Created by the author through hearings and questionnaire surveys conducted between June and August 2017.

5. Summary and discussion

In addition to contributing to a low-carbon society, the use of woody biomass energy is expected to face a new vitality in mountainous regions having forest resources. The amount of biomass power generation certified and operated in Japan has been increasing rapidly since the introduction of the FIT. In 2019, a total of 411 biomass power plants (producing a total of 2.21 million kW energy) were in operation nationwide and 662 plants (producing a total of 8.54 million kW energy) were certified. Among these, more than 60 % of the operating capacity and about 90 % of the certified capacity were power generation facilities fuelled mainly by imported biomass: 2.45 million tons of PKS and 1.61 million tons of wood pellets were imported annually, with an increase of 1.5 times compared to 2018.

Since the FIT price for woody biomass power generation facilities is set high, woody biomass power generation facilities have been constructed all over the country. While Japan has abundant forest resources, Japan's self-sufficiency rate for wood is only about 40 %. Japan's forestry industry has focused on afforestation for the past half century since the end of World War II, and has relied on foreign timber for domestic use. As a result, although there is an abundance of forest resources, forest roads have not been developed and there are only a few active forestry workers. Japan's forestry as an industry lags far behind that of Europe, and therefore, the supply of wood chips for biomass power generation facilities is insufficient and the price is high. If forest resources are not utilised, mountains will become degraded, and there are also concerns about the decline in water retention capacity and the increase in disaster risks. Therefore, the utilisation of domestic forest resources is in demand from both the environmental and economic perspectives.

Woody biomass energy is effective for the environment and economy. However, the economic and environmental impacts on the region vary greatly depending on the procurement and operation method of the funds and the form of energy use. In this study, it was confirmed that the facilities operated by the area that mainly used the local resources were effective for the economic cycle and the environment of the area.

While the construction of renewable energy facilities is being promoted nationwide through the FIT, there are many people who oppose the construction of renewable energy facilities in the rural areas. One reason for this is that it does not serve local interest. In order to spread renewable energy, FIT has set the purchase amount to ensure a certain level of profitability. As a result, major companies in urban areas have constructed power-generation facilities in rural areas, and most of the revenue from power sales has flowed outside the local area.

When aiming to return the economic effects of renewable energy to the local community, it is necessary to use local resources; the key is to manage and operate the energy facilities locally. The introduction of FIT has increased the number of large-scale concentrated biomass facilities nationwide in Japan; however, small-scale decentralised energy facilities that are managed and operated by local communities will be necessary from the perspective of rural economic independence.

Germany, which is an advanced region having small-scale decentralised energy facilities, has an energy co-operative that is organised and managed by the residents themselves. The energy used in the region is covered by local resources and the energy is sold to the outside region to make a profit. The renewable energy penetration rate in Germany is about 30 % (16 % in Japan), half of which is managed and operated by the residents. It is also seen that the residents can actively participate in the maintenance of the facility, which reduces the management cost. In Japan, while fiscal income is decreasing due to population decline, renewal costs are increasing due to ageing infrastructure facilities. Community-based facility management will become even more important in the future, especially as infrastructure maintenance in rural areas becomes an issue. Therefore, first of all, it is necessary for residents and local governments to understand the mechanism of making more profits by being involved in facility management.

In this study, the impact of two different woody biomass energy facilities on the local economy was analysed. Woody biomass facilities, especially FIT-based renewable energy facilities, can generate a certain amount of income and economic ripple effect in the area. However, because financing methods, fuel selection methods, management and operation methods, energy supply methods, and the scale of the facilities vary greatly from project to project, it is difficult to understand precisely what kind of differences affect the local economy. At a time when we are being called upon to take responsibility for our consumption behaviour, we should not only focus on the environmental aspects of renewable energy, but should also examine what kind of renewable energy choices contribute to sustainable local economic independence and environmental protection. In this study, we were only able to compare two facilities, but in the future, we would like to examine the factors that affect regional economic circulation for multiple facilities.

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