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A Local Enterprise to Construct 40 Small Hydropower Plants for Revitalizing Local Community

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Abstract

Japanese energy policy had heavily relied on nuclear energy until the Great East Japan Earthquake and the following Fukushima Daiichi Nuclear Power Plant accident (called 3.11). However, after 3.11, the Japanese government was forced to change its energy policy and now the government is putting an emphasis on utilizing renewable energy. Among types of renewable energy, small hydropower generation is winning attention because it provides many advantages: first, it is so-called *Chisan-Chisho* (produced locally and consumed locally) energy; Second, it does not produce any Greenhouse gas such as CO_2; Third, unlike other types of renewable energy such as solar energy and wind energy, small hydro power plants produce energy constantly; Fourth, there is a lot of potential sites for small hydro power plants in Japan; Fifth, small hydro power plants can be run for a long term. This study selected Kyushu Hatsuden, a new corporation in Kagoshima Prefecture established by local firms and influential people to promote small hydropower generation in the prefecture as a case study. This study conducted a socio-economic analysis using several analytical methods. The results of the series of analyses showed that the small hydropower business of Kyushu Hatsuden has a positive impact on the local community.

Keywords: socio-economic analysis, renewable energy, community development, social innovation

1 Introduction

The Japanese government had been following an energy policy that emphasizes nuclear energy. However, due to the Great East Japan Earthquake and the Fukushima Daiichi Nuclear Power Plant Accident also called 3.11, the Japanese government was required to drastically change its energy policy [1]. After 3.11, all of the nuclear plants in Japan were shut down, and the Japanese government had no choice but to utilize other energy sources, including renewable energy [2].

Today, the Japanese government set its target ratio of renewable energy among the total energy types at 22-24% by 2030.

Among the renewable energy sources, small hydropower plants have been winning attention because they emit no CO_2, generate so-called *chisan-chisho* (locally produced and locally consumed) energy, bring benefits to the local community, produce energy constantly, and there are many potential sites around Japan [3].

Small hydropower plants are different from large hydropower plants. Small hydropower plants do not require the construction of large dams, utilize water from nearby rivers, have

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small water mills and small power generators, and produce electricity [4]. This paper aims to analyze the impact of a small hydropower plant on the local economy using a small hydropower project of Kyushu Hatsuden as a case study. Kyushu Hatsuden, a local small hydropower plant constructor in Kagoshima Prefecture, was established in 2012 by leading firms, university professors and local politicians in Kagoshima Prefecture to construct renewable energy plants in the region [5]. Kyushu Hatsuden is planning to construct 40 small hydropower plants in Kagoshima Prefecture. When completed, their total output will be 24,000 kW, which will cover 50,000 households [6]. As of Jan. 2021, six small hydropower plants have been constructed and are in operation [6]. This study analyzed the socio-economic impact of Kyushu Hatsuden's small hydropower plants.

This article is consisting of nine chapters: Chapter 1 is an introduction, Chapter 2 is a previous studies analysis, Chapter 3 shows definitions of small hydropower plants, Chapter 4 explains background of small hydropower in Japan, Chapter 5 describes the Feed in Tariff in Japan, Chapter 6 discusses strengths and weaknesses of small hydropower plants, Chapter 7 is a background of Kyushu Hatsuden, and Chapter 8 conducts socio economic analysis of Kyushu Hatsuden, Chapter 9 is a conclusion.

2 Previous Studies Analysis

There are many articles which analyzed renewable energies and/or small hydropower plants. However, most of these papers analyzed technologies or economic impacts of renewable energies and/or small hydropower plants. There are a limited number of articles which analyzed social impacts.

A. Cost and Economic Analysis Papers

Y. Ishikawa et al., analyzed the regional economic recovery effects as well as the mitigation effect of CO_2 in monetary terms utilizing renewable energies (mega solar and wind power generation systems) in the Tohoku region, in particular, Iwate, Miyagi, and Fukushima prefectures, which were damaged substantially by the March 11, 2011 earthquake [7].

T. Ota analyzed the allocation of costs among stakeholders when a community introduces a small hydropower plant, using a small hydropower plant in Ida City, Nagano Prefecture as a case [8].

J. Raupach-Sumiya & T. Nakayama analyzed the economic impact of renewable energies on Japanese regions using the interregional IO table data by source of electricity [9].

B. SROI Analytical Method Papers

This study employed a social return on investment (SROI) analysis. The SROI method was developed by the Roberts Enterprise Development Fund (REDF), a Non Profit Organization (NPO) in San Francisco, in 1996. Later on, the SROI was introduced to the U.K. and has been used widely there. Some articles have analyzed the SROI method. Unlike return on investment (ROI), SROI not only considers economic impact, but also social impact.

K. J. Watson & T. Whitley argued that SROI analysis is an established analytical method for social impact and has been used widely in the U.S.A., the U.K., and EU countries. They analyzed the social values of three healthcare buildings in the U.K. using the SROI method. Then, they presented six recommendations for improving the SROI methods [10].

J. F. Williams & J. C. Parker analyzed the results of their waste-to-energy (WTE) project using both the conventional financial return on investment (FROI) analysis method and the SROI analysis method. They concluded that SROI is more suitable for social projects such as their WTE project since it measures social impact rather than economic impact [11].

C. Kousky et al. first pointed out that an SROI analysis has some limitations. For example, in some cases, it is impossible to find out all of the inputs and all of the returns. Based on their observation, Kousky et al. recommended, before launching the SROI analysis, that researchers should decide how much resources they could pour into the analysis [12].

C. Policy Analysis Papers

There are several theses which analyzed policies on renewable energy and small hydropower.

Y. Ito reported that many communities around Japan have launched small hydropower plant projects as part of their efforts to build sustainable communities. Based on his study on the current status of hydropower plants in Japan, Ito presented the institutional challenges of small hydropower plants in Japan [13].

K. Yamaguchi analyzed the current status and policy trend of renewable energy in other countries and recommended a policy to promote the introduction of renewable energy in Japan [14].

3 Definition of Small Hydropower Plants

There is no set definition of "small hydropower plants."

The U.S. Department of Energy (DOE) defines small hydropower plant as a plant that generates between 0.01 to 30 MW of power" [15]. On the other hand, Japanese Ministry of the Environment calls hydraulic power generation of 1,000 kW or less "small-scale hydropower plants" [16].

Kansai Electric Power Co., a major power company in Japan, refers to hydropower plants with an output of less than 1,000 kW as small hydropower plants [17]. The New Energy and Industrial Technology Development Organization (NEDO), a funding agency under the Ministry of Economy, Trade and Industry (METI), Japan, classifies hydropower plants into five categories based on output capacity. According to NEDO's definition, hydropower plants with an output capacity of 1,000 kW to less than 10,000 kW are considered small hydropower plants. Table 1 presents NEDO's hydropower plant classification [18].

Table 1: NEDO's Classification of Hydropower Plants

Classification	Output (kW)
Large Hydropower	100,000 or more
Medium Hydropower	10,000 to less than 100,000
Small Hydropower	1,000 to less than 10,000
Mini Hydropower	100 to less than 1,000
Micro Hydropower	less than 100

Source: NEDO, Micro Hydro Power Introduction Guidebook, 2013.

Moreover, the Japanese Association for Water Energy Recovery (J-WatER) defines power stations with an output of less than 1,000 kW as small-scale hydroelectric power stations [19].

4 Background of Small Hydropower in Japan

Hydropower plants have a long history in Japan. The first hydropower plant constructed in Japan was the Sankyozawa Power Plant built by Tohoku Electric Power Company in 1888 [20]. Hydropower was a major source of electricity in Japan until the 1960s, but soaring electricity demand accompanied by high economic growth after World War II and the increasing reliability and economy of thermal-generated power facilities led to its replacement by thermal power generation [21]. Subsequently, after the two oil crises of the 1970s, Japan pursued an energy policy with nuclear power as its pillar, but the above-mentioned 3.11 led to a new focus on renewable energy [22].

As explained in Ch. 3, there are several different definitions for small hydropower plants. The Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry, compiled the number of sites, the maximum output and annual power generation of hydropower plants in Japan. If we consider a hydropower plant with the output less than 1,000 kW as a small hydropower plant, there are 616 small hydropower plants in Japan and their total maximum output is 250,733 kW and their annual power generation is 1,527,710 MWh. Table 2 shows the current status of small hydropower plants in Japan.

Table 2: Current Status of Small Hydropower Plants in Japan

Classification (kW)	# of sites	Maximum output (kW)	Annual Power Generation (MWh)
Less than 1,000	616	250,733	1,527,710
1,000～3000	427	758,724	4,209,397
3,000～5000	167	624,535	3,276,591
5,000～10000	287	1,943,118	10,037,379
10,000～30000	369	6,192,560	28,166,150

Source: Agency for Natural Resources and Energy

5 Feed in Tariff in Japan

A. Introduction of FIT in Japan

The Japanese government introduced Feed in Tariff (FIT) system in 2012, just after 3.11(Tohoku Great Earthquake and the following Fukushima Daiichi Nuclear Plant Accident). The Japanese FIT system covers solar, wind, middle & small hydropower, geothermal and biomass energy [23].

B. FIT purchasing prices for small hyeropower plants

The Ministry of Economy, Trade and Industry (METI) reviews FIT prices every year. The latest FIT purchasing prices for renewable energy types including ones for small hydropower plants are shown in Table 3. Columns with grey shadow show prices for small hydropower plants [24].

Table 3: FIT Purchasing Prices

types	categories		prices (JPY/kWh)	period (yr)
Solar	less than 10 kW		21	10
	more than 10 kW less than 50 kW		13	20
	more than 50 kW less than 250 kW		12	
Wind	Onshore		18	20
	Onshore (replace)		16	
	Offshore (floating)		36	
Geothermal	Less than 15,000 kW		40	15
	15,000 kW or more		26	
	Total facility replace Less than 15,000 kW		30	
	Total facility replace 15,000 kW or more		20	
	Underground facility replace Less than 15,000 kW		19	
	Underground facility replace 15,000 kW or more		12	
Hydro	Fully new facilities	Less than 200 kW	34	20
		200-1,000 kW	29	
		1,000-5,000 kW	27	
		5,000-30,000 kW	20	
	Utilize existing headrace	Less than 200 kW	25	
		200-1,000 kW	21	
		1,000-5,000 kW	15	
		5,000-30,000 kW	12	
Biomass	Wood (general)	Less than 10,000 kW	24	20
	Forest residues	Less than 2,000 kW	40	
		2,000 kW or more	32	
	Wood waste from buildings		13	
	Muncipal waste		17	
	Biogas		39	

Source: Ministry of Economy, Trade and Industry (METI) website [24]

C. Achievements of FIT in Japan

Since 2012, the Ministry of Economy Trade and Industry (METI) has accepted applications for FIT certification systems, granted a certificate for the FIT approved facilities after careful examination. Table 4 shows the number of small hydropower plants started selling electricity based on FIT scheme to utility houses [25].

Table 4: FIT Achievements in Japan

Types of renewable energy	No. of certificated plants	No. of plants where purchasing has started	Total purchasing of electricity (10,000 kWh)	Total purchasing prices (100 mil yen)
Solar (less than 10kW)	7,290MW	7,032 MW	5,406,602	22,104
	1,548,009 plants	1,500,187 plants		
Solar (10kW or larger)	67,053 MW	44,889MW	24,283,529	93,890
	776,770 plants	634,441 plants		
Wind	9,049MW	1,820 MW	4,606,433	10,313
	7,932 plants	1,520 plants		
Middle & Small Hydropower	1,304 MW	589 MW	1,548,786	4,099
	728 plants	576 plants		
Geothermal	101 MW	78MW	103,080	389
	87 plants	69 plants		
Biomass	8,263MW	2,362 MW	6,225,106	15,404
	701 plant	432 plants		
Total	93,060 MW	56,770 MW	42,173,535	146,109
	23,334,227 plants	2,137,225 plants		

Source: FIT achievements as of Oct. 2020, FIT system, PR website: https://www.fit-portal.go.jp/PublicInfoSummary [24]

6 Strengths and Weaknesses of Small Hydropower Plants

A. Comparison of different types of renewable energy

There are several different kinds of renewable energies: solar, wind, hydropower, geothermal, biomass. Each type of renewable energy has different kinds of restriction. Table 5 shows technical restriction, economic restriction, social restriction and environmental restriction of each type of renewable energies.

Table 5: Variety of restrictions among renewable energy sources

types	technical restriction	economic restriction	social restriction	environmental restriction
solar	Power generation efficiency	Cost for introduction	Consensus building	Regional ecosystem
	Reliability of machines	Sales price	Land acquisition	Deterioration of the landscape
	Maintenance services		Securing right to sunshine	
	Poor construction			
	Secular change			
small-to-medium hydro	Reliability of machines	Cost for introduction	Consensus building	Impact on aquatic organism
	Maintenance services	Sales price	Water right・Fishery right	
	Distance of supply-demand		Outside use of Agri. waterway	
	Management of water intake		Daily check system	
wind	Power generation efficiency	Cost for introduction	System capacity	Noise pollution
	Reliability	Sales price	Consensus building	Radio disturbance
	Strong wind measures	Maintenance costs	Regulation	Deterioration of the landscape
	Lightning measures	Forest road maintenance		Bird Strike
geothermal	Power generation efficiency	cost for introduction	Consensus building	Impact on hot spring resources
	Reliability	Geothermal heat exploration co	Regulation	Deterioration of the landscape
	Reduction methods	Sales price		
biomass	Power generation efficiency	Cost for introduction	Consensus building	Noise pollution
	Maturity	Sales price	Regulation	Vibration
	Reliability	Maintenance costs		Exhaust gas
	Distance of supply-demand			

B. Strengths of Small Hydropower Plants

Among several types of renewable energies, small hydropower plants are winning attentions. A number of communities, districts and companies have constructed a small hydropower plant in their community as part of their efforts to revitalize community. It is because small hydropower plants have several strengths.

Japanese Association for Water Energy Recovery (J-Water) mentioned small hydropower brings many benefits to local community [26]: (a) Small hydropower plants are based on a local community, promote local economy; (b) Construction work promotes local economy; (c) Stable energy source (the most stable energy source among types of renewable energy); (d) Emit little CO_2 ; (e) Create jobs; and (f) Improve self-sufficiency of energy supply [25].

C. Weakness of Small Hydropower Plants

On the other hand, small hydropower plants have several weak points: (a) Water rights: all rivers have water right holders. How to eliminate red-tape holds a key for success; (b) Profitability: heavy initial costs. How to balance cost/benefits holds a key for success; and (c) Maintenance cost: to run a water mill for a long time, the operator needs to keep water clean [26].

7 Background of Kyushu Hatsuden

This study focuses on Kyushu Hatsuden and its small hydropower plants.

A. What is Kyushu Hatsuden？

In 2011, local government leaders, university professors, and business people in Kagoshima Prefecture founded the Kagoshima Prefectural Small Hydropower Use Promotion Council aimed to promote renewable energy use in the region. In February 2012, the council established Kyushu Hatsuden K.K. On May 28, 2012, the company announced its plan to construct 40 small hydropower plants in the Kagoshima Prefecture within five years [27].

Figure 1 shows the business model of Kyushu Hatsuden.

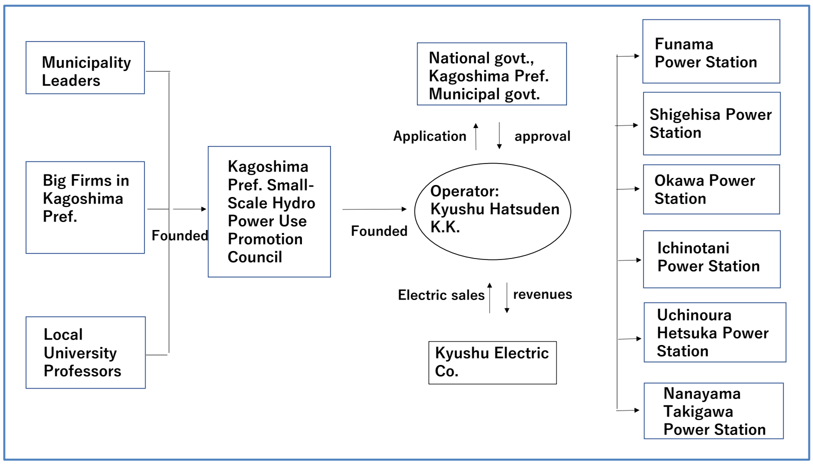

Fig. 1: Business Model of Kyushu Hatsuden

As mentioned above, first, local government leaders, university professors, and business people in Kagoshima Prefecture founded the Kagoshima Prefectural Small Hydropower Use Promotion Council, and the Council established Kyushu Hatsuden. Winning an approval from the National Government, Kagoshima Prefecture and municipal authorities, Kyushu Hatsuden has so far constructed six small hydropower plants in Kagoshima area and has been operating these small hydropower plants as the operator. Kyushu Hatsuden has been selling produced electricity to Kyushu Electric Co, a regional utility house.

B. Six Small Hydropower plants construdcted by Kyushu Hatsuden

As of Jan. 2021, Kyushu Hatsuden has constructed and launched six small hydropower plants in Kagoshima Prefecture. Table 6 shows the specifications of these six small hydropower plants [28].

Table 6: Specifications of Six Small Hydropower Plants by Kyushu Hatsuden.

	No.1	No.2	No.3	No.4	No.5	No.6
Location	Kimotsuki-cho, Kimotsuki-gun	Kirishima City	Nejimeheta, Osumi-Cho	Kishira, Kimotsuki-cho, Kimotsuki-gun	Kishira, Kimotsuki-cho, Kimotsuki-gun	Nanayama-Takigawa, Karatsu
Name of the Plant	Funama Power Station	Shigehisa Power Station	Okawa Power Station	Ichinotani Power Station	Uchinoura Hetsuka Power Station	Nanayama-Takigawa Power Station
River	Bakuchigawa	Tegogawa	Okawa	Ichinotanigawa	Ichinotanigawa	Takigawa
Power Output	995 kW	980 kW	1990 kW	990 kW	800 kW	990 kW
Effective Head	205 m	110 m	192 m	196 m	88 m	84 m
Water Use	0.59 m^3/s	1.2m^3/s	1.2m^3/s	0.62 m^3/s	1.1m^3/s	1.43 m^3/s
Start of Operation	Aug. 2014	Feb. 2015	Aug. 2016	Feb. 2017	Apr. 2017	Dec. 2019

As mentioned above, Kyushu Hatsuden is planning to construct 40 small hydropower plants in Kagoshima Prefecture in five years.

C. SWOT Analysis

This study conducted a SWOT analysis on the Kyushu Hatsuden business in order to clarify Strengths, Opportunities, Weakness and Threats of the program.

The following factors were found:

[Strengths]: Kyushu Hatsuden was established by local leaders – from the business, political, and academic sectors – and it has a strong management organization.

[Opportunities]: The FIT mechanism introduced by the government.

[Weaknesses]: This project has a weak financial structure. All construction costs depend on loans.

[Threats]: Uncertainty about whether Kyushu Electric, a local utility house, will purchase the power generated by small hydropower plants.

8 Socio Economic Analysis of Kyushu Hatsuden

A. Nanayama Takigawa Power Station

This study selected Nanayama Takigawa Power Station, for its socio economic analysis

Nanayama Takigawa Power Station is the sixth and the latest small hydropower plant constructed by Kyushu Hatsuden so far. Kyushu Hatsuden constructed Nanayama Takigawa

Power Station in Najimeheta, Osumi-cho, Kagoshima Prefecture. The plant, with an output of 990 kW, started operating in December 2019. The specifications of Nanayama Takigawa Power Station are shown in Table 7 [27].

Table 7: Specifications of Nakayama Takigawa Power Station

Location	Nanayama-Takigawa, Karatsu City	Start of Operation	Dec. 2019
Name	Nanayama-Takigawa Power Station	Type of Watermill	Horizontal Francis Turbine
River	Takigawa River	Construction Cost	1.7 bil. Yen
Power Output	990 kW	Annual Total Output	4720000kWh
Effective Head	84 m	CO_2 reduction	2500 ton/year
Water Use	1.43 m^3/s	FIT Puchase Price	29 yen/kWh

B. Cost-Benefit Analysis

The objective of this study is to clarify socio-economic impact of Kyushu Hatsuden small hydropower plant program. As a first step, this study carried out conventional economic impact analysis. This study conducted a cost-benefit analysis on Nanayama Takigawa Power Station. Kyushu Hatsuden secured a loan of 1.7 billion yen from Development Bank of Japan Inc. (DBJ). The interest rate for this project has not been disclosed. According to the DBJ website, the standard interest rate for small to medium enterprises for 20 years is 1.3%. Thus, this study decided to use the interest rate of 1.3% for this analysis.
First the costs were calculated as follows: The construction cost for Nanayama-Takigawa Plant was 1.7 billion yen. The total cost will be 2.20 billion yen, including interests. During the 20-year period (2019-2039), Kyushu Hatsuden will pay 2 million yen to the local community as a land usage fee. The total payment to the community will be 40 million yen.
Second, the benefits were calculated as follows: The annual electricity sales (based on FIT) is calculated as 137 million yen. For 20 years, the sales revenue will be 2.74 billion yen.
Based on the cost-benefit analysis based on these figures, this project was found to be efficient.

C. Balanced Score Analysis

This study utilized SROI method to analyze socio-economic impact of small hydropower plants run by Kyushu Hatsuden. In order to clarify factors to be used for SROI analysis, this study conducted a balanced score analysis [28].

The Balanced Score Analysis analyze the performance from four different perspectives: Financial Perspective, Customer Perspective, Internal Process, Organizational Capacity. The results of each of these four different perspectives are shown below:

[Financial Perspective]
Reduction of CO_2: Y27.2 mil
Sales revenues of electricity produced by the small hydropower plant: Y136.9 mil.
(Bank loan & interest payments): ▲Y110 mil
(Land usage fees): ▲2 mil
[Customer Perspective]
Deepening understanding about renewable energy: N/A
Improvement of image of Kagoshima Prefecture: N/A

Introduction of CO_2 reduction scheme: Y27.2 mil
[Internal Business Process]
Introduction of CO_2 reduction scheme: Y27.2 mil
[Organizational Capacity]
Community re-development programs: Y2 mil.

D. SROI SAnalysis

The study then conducted an SROI analysis using the results from the SWOT analysis and the balanced score analysis.

As mentioned above, the SROI analysis method was established in the 1990s by the Roberts Enterprise Development Fund (REDF), a venture philanthropy in San Francisco, U.S.A., as an approach to assess the impact versus the cost of these social-purpose enterprises. The implementation of SROI started around the 2000s in Europe, rather than in the U.S.A. In 2009, the Cabinet Office of the British government compiled SROI guidelines and started a process to standardize SROI [29]. SROI considers not only economic impact but also social impact. Social Return on Investment (SROI) is an outcomes-based measurement tool that helps organizations to understand and quantify the social, environmental and economic value they are creating [30].

The calculation formula for SROI is as follows:
SROI: realized social value (monetized value) / input cost [31].

Based on the cost-benefit analysis and the balanced score analysis, the input and output of Nakayama Takigawa Power Station were calculated as follows:
The Input cost of this project: 2,240 million yen
The Realized social values of this project: 3,284 million yen

When these figures were input in the formula, the SROI was calculated to be 1.47. Thus, this project is considered as a favorable project from an SROI perspective.

9 Conclusion

Kyushu Hatsuden was founded by leading companies, politicians, and professors in Kagoshima Prefecture in order to promote the usage of renewable energy in Kagoshima Prefecture. The firm successfully secured a loan from DBJ, and launched small hydropower plants construction. So far the company has constructed six small hydropower plants in the prefecture. The firm is aimed at constructing a total of 40 small hydropower plants in Kagoshima Prefecture in the next five years. When all of the 40 complete, the total output would be 24,000 kW, which covers 50,000 households.

This study analyzed the economic and social impact of Kyushu Hatsuden and its small hydropower plants using a SWOT analysis, a balanced score analysis, and an SROI analysis.

The SROI analysis on Nanayama Takigawa Power Station (the latest small hydropower plant constructed by Kyushu Hatsuden), showed that the power station is a valuable project.

This study conducted an SROI analysis on the Kyushu Hatsuden's Nanayama Takigawa Power Plant. The plant was completed and started operating in December 2019. It has been still running as a pilot stage; thus there are still unknown factors about the new small hydropower plant operation. Since there are still unknown factors, researchers need to follow this case carefully in the time being.

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References

[1] Japanese Energy Policy and Nuclear Energy Policy, Japan Atomic Energy Relations Organization website, https://www.jaero.or.jp/sogo/list/cat-01.html Accessed on Jan. 20, 2021

[2] Hironao Matubara, "Transition of renewable energy policies and vision of 100% renewable energy region," Sustainability Research Vol. 6, pp.37-56, March 2016. (in Japanese)

[3] Y. Miyata et al., "Renewable Energy," Asset Management Division, Mitsubishi Shintaku Bank 2012. (in Japanese) http://www.managenergy.net/actors/495

[4] "The Current Status and Future Prospects of Middle-to-Small Hydropower Plants in Japan," the Japanese Association for Water Energy Recovery (J-WatER) . (in Japanese)

[5] Y. Kawabata, "Small Hydropower Plants Construction Plan by Kyushu Hatsuden," 2015 (presentation materials). (in Japanese)

[6] "Kyushu Hatsuden's first small hydropower plant completed: the plant ran for the first month successfully, it is expected to grand big economic impact on the community," West Japan Newspaper, Sept. 7, 2014. (in Japanese)

[7] Y. Ishikawa, "Economic Effects of Installing Renewable Energy in the Tohoku Region: Analyses of mega solar and wind power generation using the interregional IO table" RIETI, Discussion Paper, 2012 (totally 29 pages). (in Japanese)

[8] T. Ota, "Burden of Costs for Introduction and Diffusion of Small Hydropower Generation in Rural Areas: From the Trends of the Approach on Small Hydropower Generation in Nagano Prefecture," Economic review, Shizuoka University, Vol. 17 No. 4, Feb. 2013, pp.221-245. (in Japanese)

[9] J. Raupach-Sumiya, and T. Nakayama, "Institutionalization of decentralized power system and socio-economic evaluation, concerning its contribution to regional regeneration," Discussion Paper Series No. 25, Research Center for Innovation Management, Ritsumeikan University, April 2015, totally 29 pages. (in Japanese)

[10] K.J. Watson & T. Whitley, "Applying Social Return on Investment (SROI) to the built environment," Building Research & Information by Routledge, Vol. 45, No. 8, Sept. 2016, pp.875-891.

[11] J. F. Williams & J. C. Parker, "Measuring the sustainable return on investment (SROI) of waste to energy," Proceedings of the 18th annual North American waste-to-energy conference (NAWTEC18), May 11–13, 2010, Orlando Florida, U.S.A. pp. 173-191.

[12] Kousky et al., "Social Return on Investment Analysis and Its Applicability to Community Preparedness Activities: Calculating Costs and Returns," Discussion Paper, Resources for the Future, 2017, totally 27 pages.

[13] Y. Ito, "The Current State and Significance of Small Hydropower and Institutional Issues Concerning its Popularization," Science & Technology Trends, Quarterly Review No. 45, Dec. 2012, p.14. (in Japanese)

[14] K. Yamaguchi, "Policy Trend of renewable energy and future prospects," Foreign Legislation, the Research and Legislative Reference Bureau, the National Diet Library, Vol. 225, Aug. 2005, total 21 pages. (in Japanese)

[15] "Small Hydropower Systems," Energy Efficiency and Renewable Energy, the U.S. Department of Energy, produced by the National Renewable Energy Laboratory (NREL). www.nrel.gov/docs/fy01osti/29065.pdf Accessed on Jan. 20, 2021.

[16] "What is a small hydropower plant?," The Environmental Ministry web site (in Japanese): https://www.env.go.jp/earth/ondanka/shg/page01.html. Accessed on Jan. 20, 2021.

[17] "What Is Small Hydro Power Plant?" Kansai Electric Power Co. Website. http://www.kepco.co.jp/energy_supply/energy/newenergy/about/learn/qa5.html, Accessed on Jan. 20, 2021.

[18] "Micro Hydro Power Introduction Guidebook," NEDO, 2013. (in Japanese)

[19] "What Is Small Hydro Power Plant?" the Japanese Association for Water Energy Recovery (J-WatER) website (in Japanese) http://j-water.org/about/index.html#about01 Accessed on Jan. 20, 2021.

[20] "Sankyozawa 100 Year Electric Historical Center," Tohoku Electric Co,'s website: https://www.tohoku-epco.co.jp/pr/miyagi/sankyozawa_pp.html Accessed Jan. 20, 2021

[21] Nuclear Energy Encyclopedia ATOMICA by Research Organization for Information Science and Technology (RIST). (in Japanese)

[22] "Energy White Paper 2020," the Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry, June 2020. (in Japanese)

[23] "Design of the Japanese feed-in-tariff scheme ~ for the achievement of low carbon society as well as new economic growth~," METI website: https://www.meti.go.jp/english/policy/energy_environment/renewablele/pdf/fit20100820a.pdf. Accessed on Jan. 20, 2021.

[24] "Purchasing Prices for Renewable Energy FY2021," METI Website (in Japanese): https://pps-net.org/column/72959

[25] "FIT achievements" (as of Sept. 2019), FIT system, PR website: https://www.fit-portal.go.jp/PublicInfoSummary Accessed on Jan. 20, 2021.

[26] "Features of Small Hydropower Plants," the *Japanese Association for Water Energy Recovery* (J-Water) website (in Japanese): https://j-water.org/about/index.html#about 03 Accessed on Jan. 20, 2021.

[27] "DBJ grants a loan to Kyushu Hatsuden," a news release by DBJ, Dec. 16, 2013. (in Japanese)

[28] Kyushu Hatsuden website (in Japanese): http://kyushu-hatsuden.jp/power_plant/ Accessed on Jan. 20, 2021.

[29] Yaeko Mitsumori, "Socio-economic Impact of Small Hydropower on community: A new local electricity biz in Kyushu to bring benefit to local community," IIAI-BMOT, via Zoom Sept. 1-15, 2020

[30] "SROI Implementation Guideline," Keio University SFC Research Institute, March 2014. (in Japanese)

[31] T. Yamaguchi et al., "Recommendation of utilization of SROI and SIB for accelerating social innovation," NRI Public Management Review. 103, 2012, pp.1-7. (in Japanese)

[32] "SROI Evaluation Report: FP Corporation – Cookchum-Kyujin Farm Joint Project for Creating New Jobs for Handicapped People," Public Management Social Strategy Institute Inc., Sept., 2015.