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Hydro, Tidal and Wave Energy in Japan

Business, Research and Technological Opportunities for European Companies

by Guillaume Hennequin

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Guillaume Hennequin

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EXECUTIVE SUMMARY

In the long history of the Japanese electricity market, Japan has often reverted to concentrating on the use of one specific electricity power resource to fulfil its energy needs. After the going through periods of mainly hydropower, followed by a period of mainly fossil fuel generated power, Japan's regional monopolistic electricity market reverted to the use of nuclear energy for its main energy resource.

In 1995, the Japanese electricity market saw its first significant paradigm shift through the first step in the electricity market liberalisation process, until it was put on hold in 2008 for various reasons.

It was not until 2011, when the Great East Japan Earthquake shook Japan to its core that both the current electricity output supply structure and electricity market itself were shaken to its core, with a sudden change in the way the implementation of renewable energy in Japan was promoted: the introduction of the FIT system, and with the long-awaited implementation of the full retail-market liberalisation in 2016.

Now, with the explosive growth in solar power, causing a decrease in the generous Solar PV FIT rate, local communities are increasingly looking at stable energy supply such as small hydro to respond to their local energy demands. With an increasingly brighter future for renewables in general, and a big opportunity in the form of lagging domestic market supply, the Japanese hydropower market represents a big opportunity for European companies in small-scale hydropower looking to increase their business potential.

In the case of marine energy such as wave and tidal, the lack of publicly-funded research in this field has caused Japan to lag behind in terms of marine energy development, which present a big opportunity for European companies interested in entering this market and becoming some of the pioneering companies in the land of the rising sun.

All information and matters discussed in this report were gathered through interviews with Japanese market players, as well as official Japanese government reports and presentations, research papers, news articles and other relevant materials.

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List of Abbreviations

Abbreviation	Meaning
FIT	Feed-in-Tariff
FIP	Feed-in-Premium
RPS	Renewables Portfolio Standard
FEPCO	Federation of EPCO
TEPCO	Tokyo EPCO
KEPCO	Kansai EPCO
CHUDEN	Chuukoku EPCO
CEPCO	Chubu EPCO
KYUDEN	Kyushu EPCO
HEPCO	Hokkaido EPCO
RET	Renewable Energy Technology
RES	Renewable Energy Source
EPP	Electricity Power Producer
PPS	Power Producer & Supplier
JEPX	Japan Electricity Power Exchange
IRR	Internal Rate of Return
CAPEX	Capital Expenditure
NTB	Non-Tariff Barrier
NTM	Non-Tariff Measure
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
METI	Ministry of Economy, Trade and Industry
MOE	Ministry of the Environment
MOF	Ministry of Finance
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
MAFF	Ministry of Agriculture, Forestry and Fisheries
ROR	Run-of-River
PS	Pumped Storage
CC	Cost of Capital
GGE	Greenhouse Gas Emissions
EMSC	Electricity Market Surveillance Commission
OCCTO	Organization for Cross-regional Coordination of Transmission Operators
GDP	Global Domestic Product
WIPO	World Intellectual Property Organization
Solar PV	Solar Photovoltaic
COP21	21st session of the Conference of the Parties
SAEM	Special Account for Energy Measures
SME	Small and Medium-sized Enterprises
LNG	Liquefied Natural Gas
ENECHO	Agency for Natural Resources
EBL	Electricity Business Law

Chapter 1. Energy in Japan

1.1. Historic Overview of the Japanese Electricity Market

1.1.1. The Start of the Japanese Electricity Market

In order to look at the future, it is always important to always have a look at the past. By looking at the past, one can determine many factors that might help predetermine the future, and the Japanese electricity market is no different.

When looking back on the history of the Japanese electricity market, we have to first aim our gaze at the so-called '*Sakoku*' period that was started in the 17th century when Japan almost completely closed-off its borders to foreign influence: the Edo-period.

While often mistaken as a period of complete closure, certain countries still continued to influence Japan via the realization of trade between Japan and countries such as the Netherlands. Via these Dutch traders, who were allowed to trade certain goods via the port of Deshima, Japanese scientists were able to continue to discover foreign scientific discovery and re-invent them for Japan. One such scientist, and the father of electricity in Japan, Is the intellectual and 18th century samurai Hiraga Gennai, a so-called 'Rangakusha', a Japanese scholar that turned to studying Western science and technology via these few exchanges made with the Dutch traders[1].

Figure 1: Hiraga Gennai's 'Erekuteru'

Acquiring a primitive static electricity generating machine that was originally meant to be a present for the Shogun, Hiraga managed to repair and even rebuild the machine in 1774, which represented the birth of electricity in Japan, or as Hiraga called it: '*erekuteru'*. The machine was then reused and further developed by other rangakusha of the time such as Kanko Takamori and Yorinao Hosokawa in an attempt to apply it to other fields such as machinery etc. It would however take more than a century before electricity as we know it would be developed in Japan and create the beginning of the Japanese electricity market itself[2].

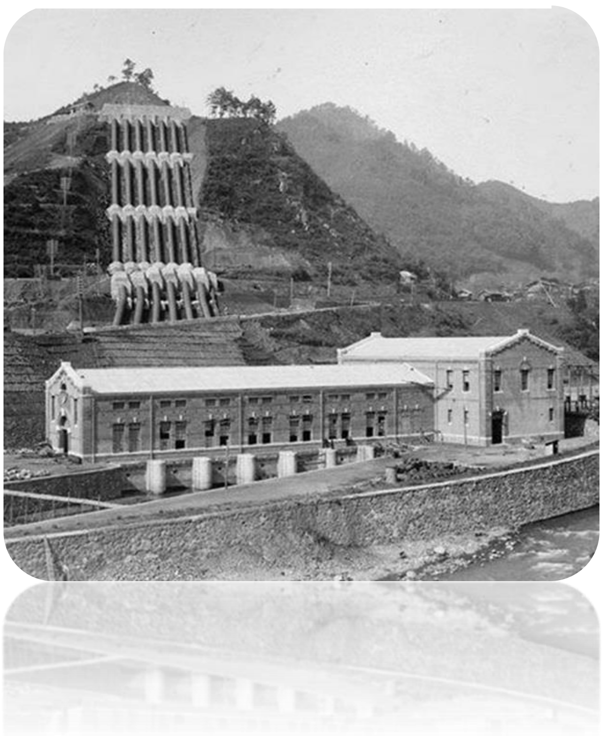
The Japanese electricity market itself was created in the second half of the nineteenth century. While electricity itself had already existed in Japan since Hiraga's '*erekuteru*', the invention had not permeated into the Japanese daily life yet. The first Japanese electricity company was established in 1883[3] followed by other privately owned electricity companies. By 1903, there were 76 electricity firms operational in Japan[4]. Demand for electricity, of which a major share was used for electric lighting, grew over the years with the supply following suit, thanks to the development of hydraulic power generators[5] and the development in light bulbs, and the hardware necessary for the electricity transmission network, decreasing costs and possible entry barriers for new users and suppliers[6], but with the increased use of this new technology mostly restricted to urban areas.

[1] Morris-Suzuki, T. (1994), p. 23-24
[2] Hennequin, G. (2015), p. 28-29
[3] Kikkawa, T. (Oct. 2012), p. 1
[4] Hennequin, G. (2015), p. p 30.
[5] Kikkawa, T. (Oct. 2012), p. 5
[6] Kikkawa, T. (Oct. 2012), p. 5

1.1.2. Hydraulic First, Thermal Second

While the roughly first two decades of the Japanese electricity market was based on small thermal power facilities, the technological improvement and decrease in cost of electricity transmission network lines, made it possible for Japanese electricity suppliers to shift their policy from coal-oriented electricity supply, to what would be called the '*Hydraulic First, Thermal Second*[7]' supply policy, a shift which can also be partially explained by a rise in coal prices due to the Russo-Japanese war in 1904-1905[8]. The low operational costs of this improved hydraulic power generation technology also made it possible to lower electricity rates and further decrease the electricity rates to attract more demand, growing demand from 10 000 consumers of electric lighting in 1894 to 210 000 in 1907[9].

Figure 2: Komabashi Hydroelectric Power Plant



By the 1930s, the Japanese market had undergone many changes in the electricity supply playing field, with the amount of players decreasing as the Electricity Business Law was reformed to create the predecessor of the post-WWII regional monopolistic system and with hydraulic power counting for 81% of the total generated electric output in 1938[10] continuing with the previously established business paradigm of "*Hydraulic First, Thermal Second*".

1.1.3. Moving Away from Hydropower

After WWII, the Japanese electricity market faced a new dilemma regarding the structure of the nation's market. Ever since a few years before WWII started, the Japanese government had slowly integrated all companies into one ruling state-run company. The end of WWII and the subsequent shift to a more democratic system for both the political and econo-industrial sector, put the current system in the spotlight as discussions on how to go on with the market got more and more heated. Eventually, it was decided to divide the country into a few vertically integrated, completely privatized regional electricity supply blocks[11] in 1951.[12]

With the following consumer heavy industry's growth and the consumer electronics boom, electricity demand grew[13], causing a rift in the long upheld traditional '*Hydraulic First, Thermal Second*' policy that couldn't keep up with the sudden rising demand for electricity, causing occasional outages due to insufficient supply. Firstly, old, small-scale hydraulic power generation facilities fell victim to the '*scrap-and-build'* system and were taken down to be replaced by newer, bigger facilities[14] to top up the existing

[7] 水主火従
[8] Kikkawa, (Oct. 2012), p 7
[9] Kikkawa, (Oct. 2012), p 9
[10] Hennequin, G. (2015), p 41
[11] Nine regional blocks with Okinawa added later on.
[12] Hennequin, G. (2015), p 59
[13] Hennequin, G. (2015), p 60-61
[14] Nakase (2005), p 177

potential hydraulic output, and entirely new facilities were also built[15]. However, while the annual hydraulic power output grew a few percentages per year in the 1950s, the shift towards thermal power generation caused that energy source to see its output grow at an annual rate of 23,6%[16], effectively shifting the energy paradigm to '*Thermal First*, *Hydraulic Second*'.

It wasn't until the two oil crises of the 1970s that Japan again shifted from thermal energy to a gradual change to nuclear energy. While Japan was aware of its fragile energy supply structure, as we can deduce from papers published in the years before the first oil crisis, it wasn't until the oil crisis happened that Japan strongly started to concentrate on further developing other energy sources such as nuclear power as well.[17]

Between 1974 and 1985, nuclear power grew at an accelerated rate, with an annual average growth rate of 30,2% nationwide, and with almost 1/3 of the entire electricity output between 1985 and 1994 coming from nuclear power[18].

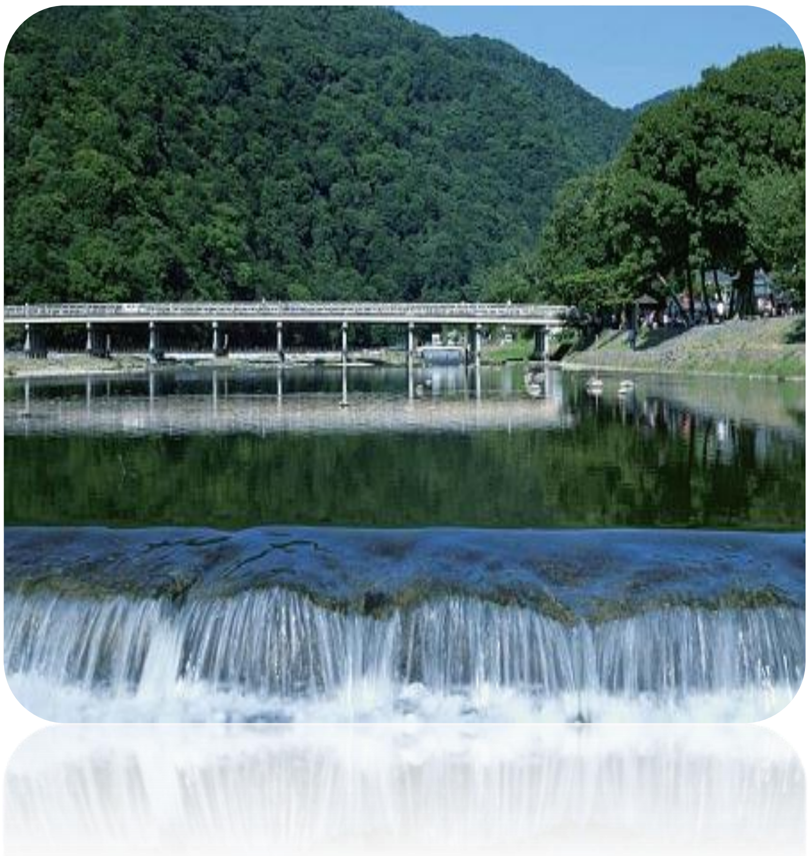
1.1.4. Electricity Market Liberalization Period

[19] Jumping ahead in time, in 1995 Japan introduced a revised version of its Electricity Business Law, which started the process that would forever change the Japanese electricity market landscape: the electricity market liberalization process. Originally divided into regional monopolies, this revision was the first step many countries all over the world were taking towards the creation of a liberalized electricity market.[20] The first of the liberalization process came in 1995 with the revision of the EBL to create the category of so-called IPPs (Independent Power Producers) who were allowed to sell wholesale power to the incumbent EPS allowing them to also obtain electricity in times of insufficient regional supply from both new PPS and the other incumbents[21]. Following changes to the relevant laws gradually opened up the retail market for parts of the Japanese electricity retail market, as well as the introduction of a basic wholesale market.[22]

[15] Osawa (1993), p 23
[16] Kikkawa (2011), p 236
[17] Cfr. Sinha, R. P. (1974), p. 335 and Morris-Suzuki (1994), p 178
[18] Kikkawa (2011), p 396-397
[19] First nuclear power plant japan: photo from http://www.japc.co.jp/haishi/tokai.html
[20] Hennequin (2015), p 70
[21] Kikkawa, Takeo. (S.a.), p 17 FEPC (2014), p 5
[22] Hennequin (2015), p 70-71

Ultimately, it wasn't until 2016 that Japan finally introduced the final step to the retail market liberalization, freeing up 1/3rd of the Japanese retail market. Similar to events in the past, Japan seems to have a history of changing the status quo of its electricity market only when it is absolutely necessary. For the Japanese electricity market, as was the case for both the switch to hydraulic power, to thermal power and to nuclear power, it was not until the perceived increase in electricity prices and the outside pressure from consumers and other parties, that these changes were really discussed as a possibility since its postponement[23].

Figure 4: First Class A River with Small-Scale Hydro

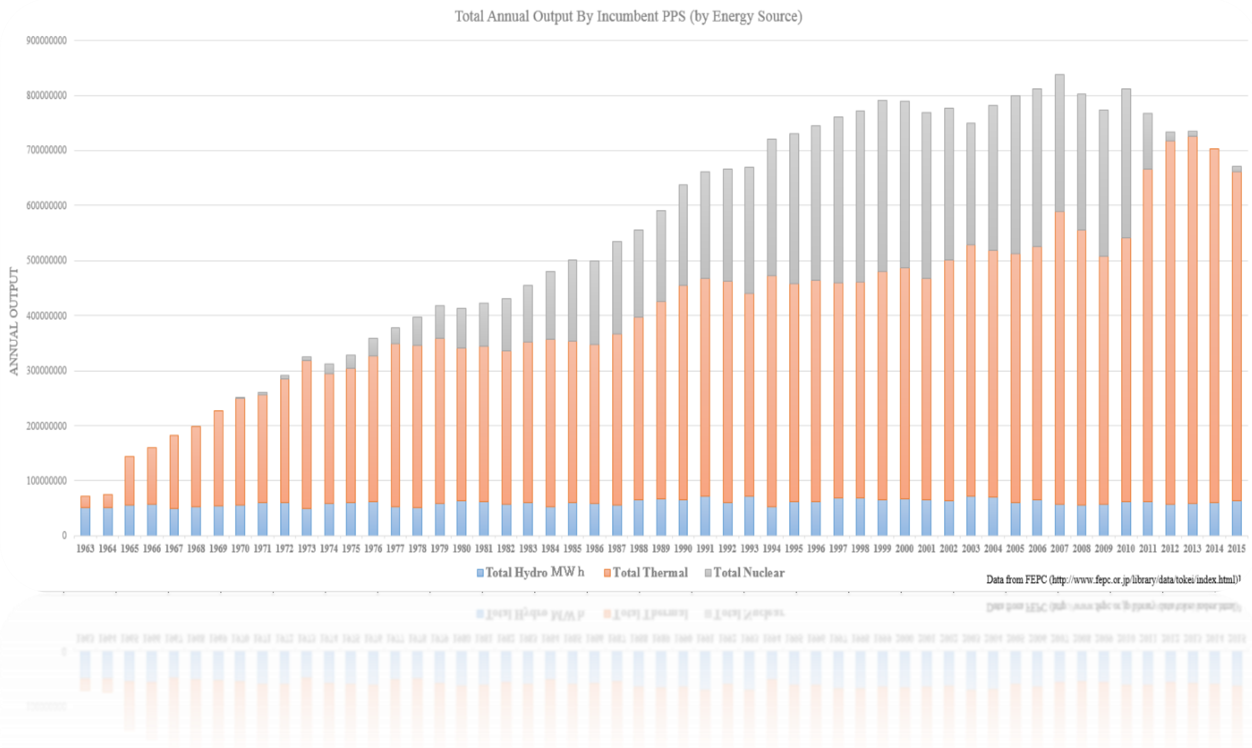


Due to Japan's low amount of resources, the switch towards more nuclear power had been an easy way towards achieving high amounts of energy with relatively low dependence on foreign countries for resources, thus achieving higher self-sufficiency rates. However, with the disaster in Fukushima in 2011 caused by the Great East Japan earthquake, nuclear power was gradually turned off, prices increasing as incumbent regional EPPs reluctantly had to switch to more expensive alternative fuel sources and other price schemes such as the FIT also added to the monthly electricity rates of consumers.

[23] Originally, the Japanese retail market was supposed to be fully liberalised in 2008.

1.2. The Electricity Market in Japan

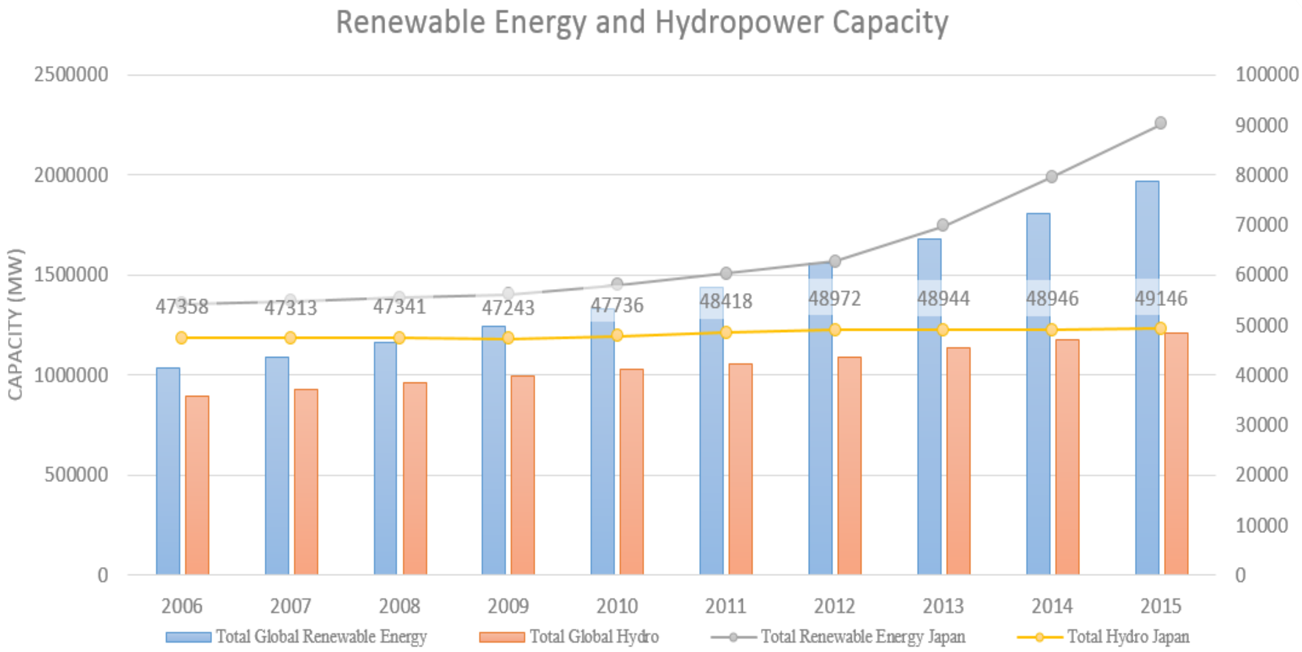
As mentioned in the previous chapter, Japan has known a multitude of positions towards its own energy mix. As you can see from the following graph[24], we can notice the three big points in time when the Japanese electricity market incumbents' energy mix drastically changed. In the middle of the 1960s the shift towards thermal power exploded until the second oil crisis at the end of the 1970s. After that we can observe the increase in nuclear power, followed by a sudden decrease of nuclear power and of the total annual electricity output in general starting from 2011.



In an attempt to decrease total end-user prices, diversify renewable energy rates and further motivate the participation in the energy market of RES, the Japanese electricity market that had stayed a regional monopoly for the past decades, fully opened up the doors of its retail market for new PPS officially from April 1, 2016. With this opening up of the electricity retail market, new electricity suppliers have entered the market en masse with a great number relying on renewable energy sources such as solar energy and/or retail bundles with other services such as gas, telecommunication and other services to attempt to supply energy packages to Japanese consumers at competitive rates even compared to the previous electricity supplying incumbents'. When looking at the increase in the total capacity of Japan's RES, we can also see an increase with a sudden rise after 2011 with a gradual slight increase in the total hydropower capacity for Japan as well.

[24] Non-hydro Renewable energy is not included in this graph.

Before analysing the two markets of interest to this report; the hydropower and marine energy market in Japan, it is important to look at the current situation of the electricity market. In the case of the hydropower market, this is of importance as the current situation gives an idea of the current expectations for foreign potential market entrants, while the current and future situation of the energy market will also help determine the potential and ease with which RET such as tidal energy will be imported into Japan which is planned to only implement its first foreign-made tidal energy turbine by 2018[25].



Data from IRENA RE 201‹

For the future of the marine energy market, as both fields have several points in common and the possibility exists that the tidal and wave energy market, depending on the type of technology, will also face similar problems in the beginning of its lifecycle, it is also interesting to look at the offshore wind market in Japan. We therefore also urge readers to have a look at the MINERVA report written by Ines Heger on the wind energy market in Japan.

[25] Open Hydro (2016)

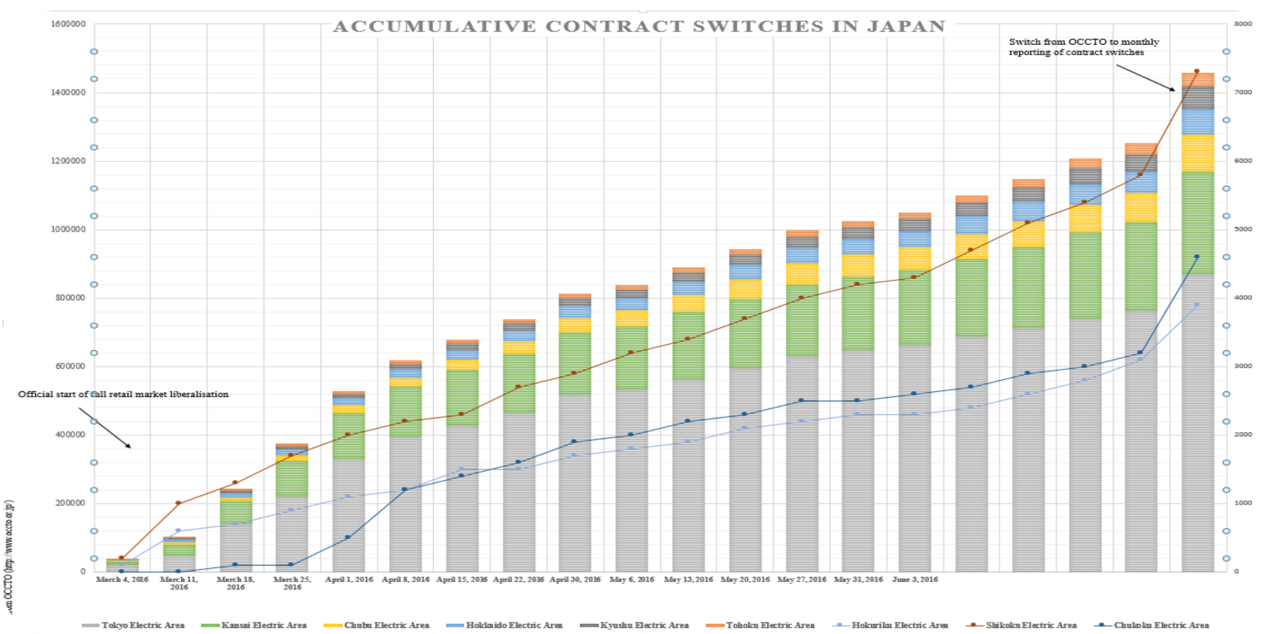
1.2.1. Current Market Environment

In order to better understand the future energy market, it is important to take a look at the current market structure, and to what problems are still causing the market to not be operating at what is deemed full capacity. To do that, we will be looking at the influence of the most recent change in the market: the retail market liberalisation, the FIT system used in Japan, and the on-going flaws and aspects that need to be adjusted in the future based on news articles and papers and reports from the Japanese METI itself.

1.2.1.1. Current Market Structure

On April 1, 2016, the Japanese electricity power market fully opened up to competition. The last step of this liberalisation process encompassed the small retail market, which includes households and small businesses, thus effectively freeing up the remaining 38% of the Japanese electricity market adding to the already liberalised parts of the market that represent the remaining 62% of the Japanese electricity demand side[26]. Previously, only 5% of the retail market for medium- and large-scale electricity consumers was being served by PPS that were not the regional incumbents.

As mentioned before, this restructuring of the Japanese electricity market is the result of the literal and figurative tremor caused by the Great East Japan Earthquake in 2011, and the nation's subsequent stop to using nuclear energy and the less stable and more expensive electricity supply that came from that. After the March 2011 earthquake, the numerous Tokyo electricity blackouts revealed the Japanese electricity system's vulnerabilities and the need to implement further mechanisms to ensure a more stable system via the bottom-up approach that is full market liberalisation.



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26 Stapczynski, S. & Emi Urabe (March 29, 2016)

As of 9 August, 2016, the retail market has a total of 334 PPS registered[27] with the Enecho[28] , offering many packaged deals to the freshly opened up 8,1 trillion yen electricity market and its 85 million newly freed up consumers[29]. As new competitors come into the market and offer new deals, often involving the use of RES for their supply, we should expect market prices to come more in line with the actual costs of energy generation as mark ups go down due to increased competition.

Furthermore, thanks to the generous FIT[30] system and the relatively smaller lead time, many of these new PPS that rely on RES, seem to rely extensively on solar power. However, with only limited spots for solar energy and measures taken to decrease lead time for RET such as hydropower, it is likely that as time progresses, we will see an increase in the variety of the total RES supply mix. New entrants such as *Marubeni*, have also been relying on newly built hydro-energy facilities for part of its energy mix, developed by its subsidiary *Mibugawa Hatsuden*.

The METI itself has also taken note of the big weight solar energy has taken up in the total output of renewable energy and has since already taken steps to change the related energy laws in order to "*Promote the implementation of a balanced energy resource mix*[31]" in the future. Also, due to the post-March 2011 public and legal climate towards nuclear energy, incumbents are still being restricted the use of nuclear energy in various ways, causing these companies to revert to the use of other fuel resources such as LNG etc. for their baseload electricity generation needs.

An example of measures taken by the incumbent electricity suppliers can be seen in the cooperation between *TEPCO* and *CEPCO*[32] who declared last year that they would be joining hands on a business level in order to reduce their operating costs. As Tomoaki Kobayakawa, a managing executive at *TEPCO* said:

> *This is a chance for us to transform into a comprehensive energy service company*[33].

Similarly, in 2016, *KEPCO* and *Tokyo Gas* also announced their mutual cooperation to share know-how and attempt to lower their LNG import costs to increase their competitiveness on their respective retail markets[34]. Other electricity incumbents such as *Kyuden* also reverted to setting up subsidiaries specifically aimed at the implementation of more renewable energy in the form of e.g.; *Kyuden Mirai Energy*[35].

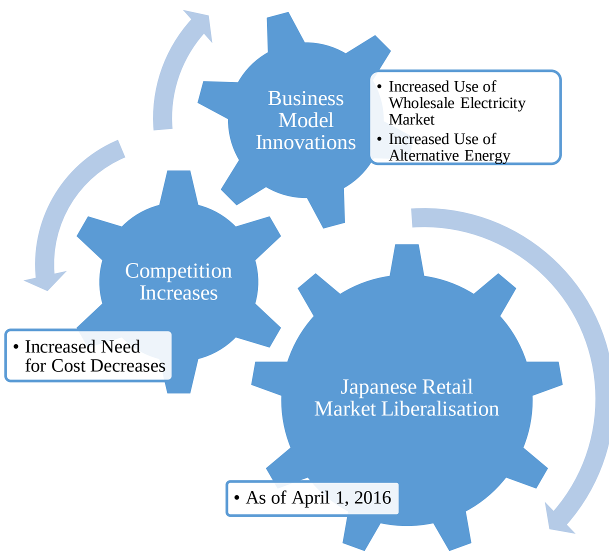
For small-scale companies, however, the increasing competition will make it hard for them to acquire a significant enough piece of the market, causing them to revert to exiting the market or merge with other companies. This is where the German 'Stadtwerke' phenomenon comes into place. While large companies will act for larger regions, the regional 'Stadtwerke' phenomenon distinguishes itself from its competitors by playing in on the aspect of true 'regional' value instead of individual value. Through the cooperation of the public services for energy, water and other infrastructures, and the local communities,

[27] Cfr. *Enecho*'s website for a full list of registered retail market users (http://www.enecho.meti.go.jp/category/electricity_and_gas/electric/summary/retailers_list/)
[28] Japanese Agency for Natural Resources and Energy
[29] Stapczynski, S. & Emi Urabe (March 29, 2016)
[30] Feed-in-Tariff
[31] Translated from (METI, February 9, 2016, p.1) APRIL BRIEF
[32] The Kanto and Chubu region electric power supplier incumbents.
[33] Stapczynski, S. & Emi Urabe (January 7, 2016)
[34] Yomiuri Newspaper (April 12, 2016)
[35] http://www.q-mirai.co.jp/company/index

Stadtwerke aims at strengthening regional independence after taking into account the characteristics of the region it is located on. In Germany, there exist around 900 *Stadtwerke* entities that combined hold about 20% of the retail electricity market share[36].

While we can assume that as time moves on incumbents will likely turn towards trying to reactivate certain nuclear power generators to decrease costs and tariffs, this increase in PPS in the Japanese electricity market is also bound to bring about direct and indirect influences to the Japanese demand for RET. Through the increase in PPS, increase in competition on the market and more varied electricity offers will bring about an increased need for innovation in the incumbents' business models. Furthermore, as new PPS will try to compete with the incumbents, they might revert to using (mature) RET with low (O&M and) LCoE costs.

Figure 5: Market Evolution



Smaller business entities might focus on staying in one region and aim to follow the example of the German *Stadtwerke* and go even further with the current business model used by many new entrants involving the bundling of different services. In order to satisfy this model, the regional production and regional consumption of energy would be of big importance, creating circular economy effects on a regional scale, which is also where certain RET would play a big role.

While the marine energy market in Japan is still in its early stages, as offshore wind has really only just started to kick off, and with tidal and wave energy technology still in its beginning stages, a number of European companies already offer marine energy technology that could be implemented in Japan. The mature hydropower market will also be influenced as Japanese incumbents will look towards refurbishing and/or updating older hydropower facilities, and as new players and entrants looking towards the creation of *Stadtwerke* on Japanese soil will examine the potential of medium to small-scale hydropower, which is where the relatively lower cost European hydropower technology comes in and other RET aimed at regional consumption[37].

[36] http://www.stadtwerke.jp/about/
[37] For more information on the Hydropower market, please refer to chapter 2 of this report. The marine energy market can be found in chapter 3.

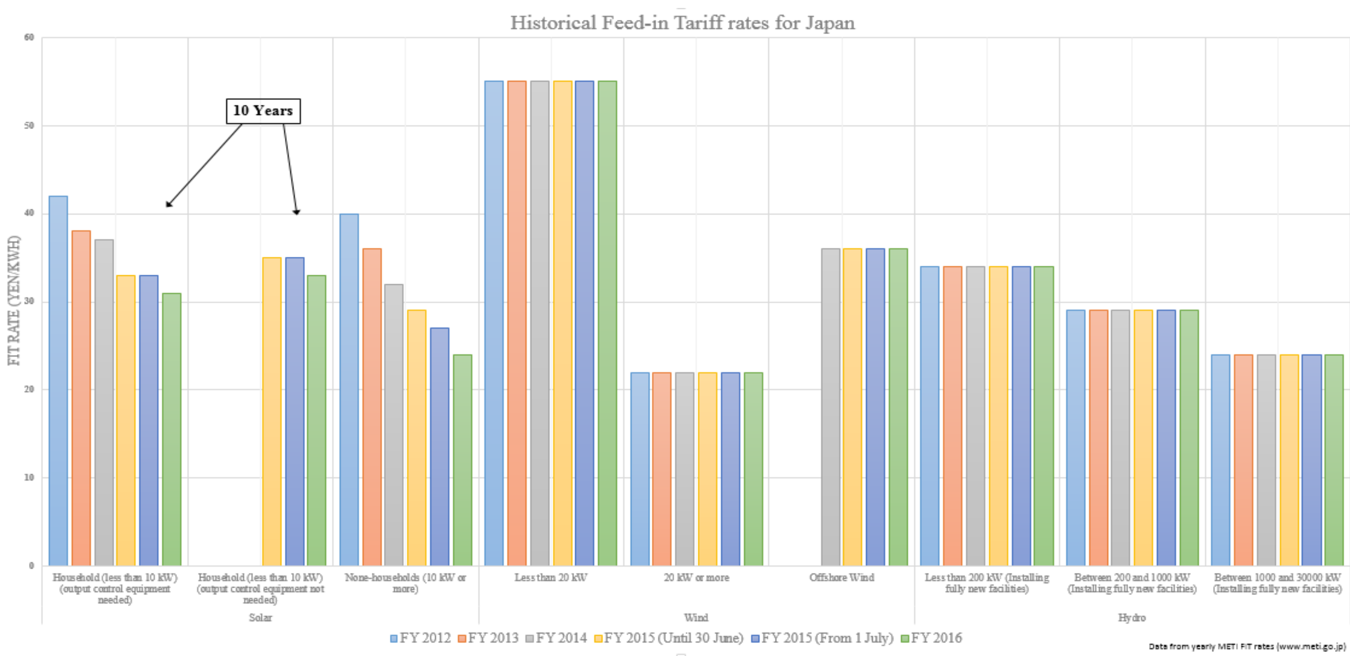
1.2.1.2. Japanese Feed-in-Tariff System

Similar to many other countries in the world, Japan has introduced the Feed-in Tariff system, after switching away from the RPS system in 2012. A main reason for the creation of these financial instruments aimed at promoting the development of a market with a higher share of RES, lies in the fact that RET hold positive external effects that usual market mechanisms do not take into account. While there are certain ways to calculate the LCOE of energy resources while internalizing the negative external effects created by the use of certain energy resources such as coal etc., general market mechanisms do not adjust for these effects. Unlike energy sources such as nuclear and fossil fuel-based energy systems, these RES are also often still in relative infant stages needing extra support to help them grow and mature into technologies with just as cost-effective LCOE as their more conventional counterparts.

The Renewable Portfolio Standards, or RPS, was a quantity-based scheme introduced in Japan in the beginning of the 2000s. The Feed-in-Tariff, or FIT, on the other hand, was the successor to the RPS, introduced in 2012 after the Great East Japan Earthquake. While the RPS was a quantity-based scheme, with prices determined by the market, but favouring low-cost technologies, the FIT functions as a scheme where prices are predetermined by the government and quantities supplied under that price per unit left to the market.

Under the RPS system, it comes as no surprise that as quantities are predetermined, the lowest cost technologies would be chosen first, leaving little space for the use of perhaps less cost-competitive technologies but even more promising technologies.

The FIT, however, gives the possibility for less mature RET to also enjoy the benefits of this extra funding, as the technology matures and FIT rates are adjusted after a predetermined time period.



In Europe, by 2012, 20 member states had implemented some sort of feed-in scheme as their RE promotional policy instrument, making it the most popular support scheme at the time[38]. The FIT scheme can also be complemented with other systems such as growth corridors, partial tender systems, quantity

[38] Ragwitz, M. et al. (2012) p16

caps, etc. This high level of adjustability and price insurance lowers the investment risks for RE suppliers and makes it possible to adjust to semi-volatile cost changes in the market.

In Japan, the FIT rates are re-calculated by a special committee on a yearly basis and sent to the Japanese METI, which then has final decision on the actual rates. Based on these rates, the surcharge on the consumers is also determined. These rates are calculated by the special committee by amongst other things taking into account:

- ✓ The tariff rate;
- ✓ The purchase period duration;
- ✓ The RET categories and subcategories;
- ✓ Capital costs and O&M costs reported by the electricity suppliers in the market.

The law that created the FIT system also gives preferential treatment to the supply of RES over traditional energy sources, and in times of excess demand, electricity suppliers first are expected to revert to lowering non-RES' supply mix, thus further ensuring the payment of the FIT to RE suppliers.

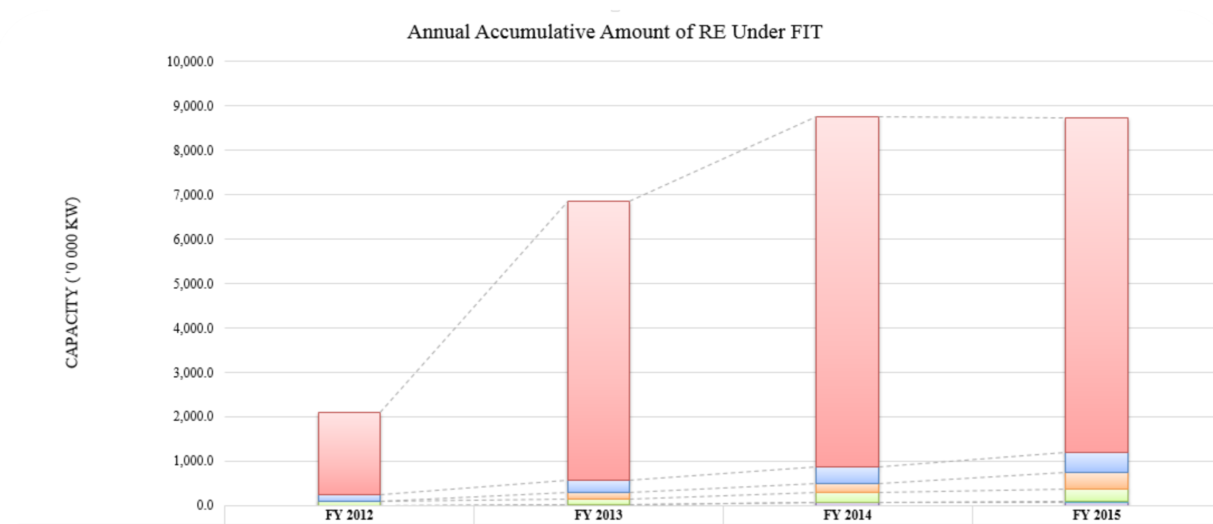
Since 2012, the FIT in Japan has also grown in amount of target RET. In 2012 the FIT covered fifteen types of RET, and this grew to 19 categories in 2014 and 20 categories by 2015, covering also electricity generated from biomass. [39]

Thanks to the FIT scheme, Japan has known an explosive short-term growth in the solar power supply market, aided by the ease of installing solar PV and its short lead time compared to other RET. The explosive growth in supply and rapid decrease in solar PV installation and O&M costs has also led to the extensive yearly revision of solar PV FIT rates as you can see from the above-mentioned graph[40]. In 2015, solar PV's O&M costs declined while the capacity factor improved leading to a recalculation of the Solar PV FIT rate a second time throughout the year. [41].

[39] METI (December 16, 2015), slide 19

[40] The graph only represents a part of all the FIT rates in Japan. Please refer to the annex for a full overview of all the FIT rates and subcategories.

[41] Watanabe (February 22, 2016)



	FY 2012	FY 2013	FY 2014	FY 2015
Solar PV (> 10 kW)	1,868.1	6,303.8	7,883.8	7,528.8
Solar PV (< 10 kW)	134.2	268.8	379.3	464.2
Bio Energy	19.4	156.5	202.7	370.0
Wind	79.8	104.0	229.1	283.9
Geothermal	0.4	1.4	7.1	7.6
Medium- and Small-Scale Hydro	7.1	29.8	65.6	77.6

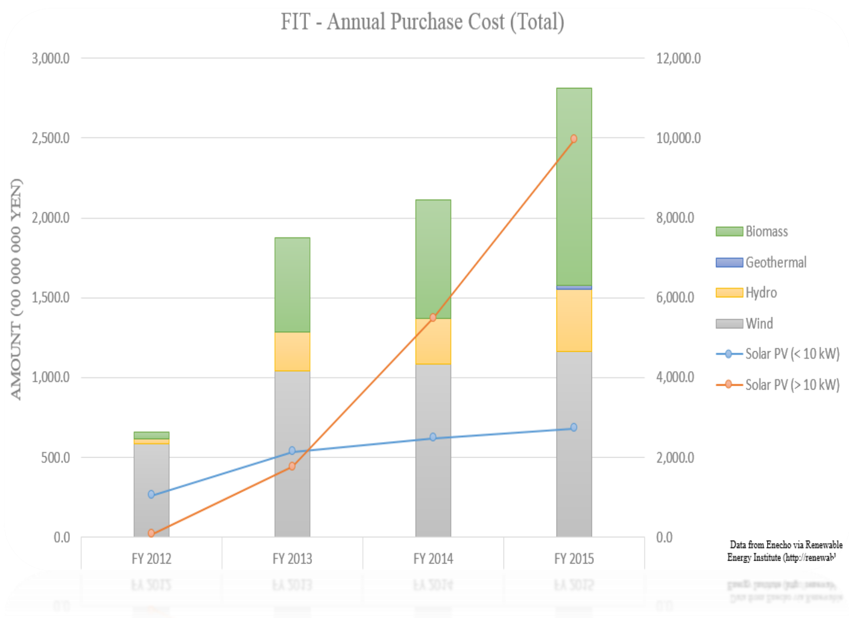
Data from Enecho via Renewable Energy Institute (http://renewable-ei.org/statistics/fit.p'

As can be seen from the sudden growth in solar energy on the graph, while the FIT system has proven its worth for RES such as solar energy in Japan, it is still an imperfect system that needs to be adjusted in order to improve its efficiency in promoting the integration of RES. The disproportionate amount of available slots for RES has also mostly been taken in by solar power, which has caused a very big increase in its relative share of the total annual purchasing cost falling onto the end-use consumer[42].

The *Enekyo* however, an organization aimed at increasing the use of renewable energy in Japan, also rightly points out in a brief note following the COP21 in Paris last December 2015, that the FIT law, which is going to implement a tender system starting FY 2017 for certain categories of solar PV, should increase its transparency by specifying the RES that will fall under said tender system. The *Enekyo* also utters the importance of the implementation and transparency of the merit-order system of RES in the FIT law, and the specification of reasons for the refusal for connection of RES. Lastly, the *Enekyo* also mentions the importance of assuring the adequacy of the calculation of the possible connectable volume of renewable energy, and the increase of the maximum tolerable output by the electricity grid[43].

In December 2015, a METI subcommittee addressed another impediment in the current FIT system. Due to FIT rates being recalculated each year, the possibility exists that certain RET with longer lead times will not be able to receive a satisfactory purchasing price if the rate is suddenly lowered or will perhaps not fall under a favourable system if the FIT system is changed in the future, before the new facility has been finalized and connected to the grid. In order to avoid this lack of transparency and to decrease this potential investment risk, the subcommittee proposed the adoption of a system in which the FIT rates are calculated for a few years in advance. The METI also announced that the obligation of purchasing RES from the suppliers would be moved from the producers to the transmission network company[44].

[42] http://www.meti.go.jp/press/2016/06/20160603009/20160603009.pdf
[43] 27 p 2
[44] http://www.meti.go.jp/press/2016/06/20160603009/20160603009.pdf



While the FIT rates for a number of RET in Japan have been mostly static, if a sudden increase in foreign, cheaper technology in a certain year would be taken into account in the calculations of the following fiscal year's FIT rate, it would translate itself into a sudden decrease of the currently very beneficial rates. Of course, this also means that foreign companies with cheaper and/or more effective RET, would benefit greatly from exporting their technology to Japan compared to their Japanese counterparts. Furthermore, the Japanese side seems to be aware of the problems left in the current system, both for the consumers and the (potential) suppliers, and has shown that they will be taking the necessary steps to improve the situation for both parties.

1.2.1.3. Financial Atmosphere

In order to accommodate for a society towards more renewable energy, Japan has seemingly also been increasing the financial instruments available to support the R&D and continued growth of the sectors leading the country into this new era of green energy.

ANNUAL INVESTMENT / NET CAPACITY ADDITIONS / PRODUCTION IN 2014

	1	2	3	4	5
Investment in renewable power and fuels (not including hydro > 50 MW)	**China**	United States	Japan	United Kingdom	Germany
Investment in renewable power and fuels per unit GDP[1]	**Burundi**	Kenya	Honduras	Jordan	Uruguay
Geothermal power capacity	**Kenya**	Turkey	Indonesia	Philippines	Italy
Hydropower capacity	**China**	Brazil	Canada	Turkey	India
Solar PV capacity	**China**	Japan	United States	United Kingdom	Germany
CSP capacity	**United States**	India	–	–	–
Wind power capacity	**China**	Germany	United States	Brazil	India
Solar water heating capacity[2]	**China**	Turkey	Brazil	India	Germany
Biodiesel production	**United States**	Brazil	Germany	Indonesia	Argentina
Fuel ethanol production	**United States**	Brazil	China	Canada	Thailand

Source: REN 21[45]

In 2014, Japan was the country with the third highest amount of investment in renewable energy and fuels on an annual basis, behind China and the United States[46]. This impressive investment amount in renewable energy can also be seen in the government budget allocations aimed towards this field, and when looking at the amount of funds available for the implementation, deployment and research of certain types of RET. In case of small hydropower, we should point out the increasing annual public funding aimed at helping alleviate the upgrade and refurbishment of existing hydropower generating facilities[47].

While funding from public sources seems to be available to some amount, depending on the type of funding and the government body responsible for this, the rules, limitations and prerequisites can be quite different and make the funding application process long and arduous. Furthermore, as was also mentioned in the past in a previous MINERVA research paper, Japan seems to lack in funding from private sources, reducing the amount of potential clean energy projects to be financed[48]. Furthermore, the Japanese market is heavy on SMEs that would have difficulty bearing the financial burden to do much research without any supporting external funding.

Bringing in funding in the form of non-recourse loans outside of Japan is not uncommon, however, up until 2013 it was extremely rare for Japanese banks to help finance renewable energy projects via the use of these non-recourse loans[49]. This lack of funding from non-public sources such as the various Japanese governments can hinder market entry for foreign companies in certain cases and potentially hinder the possibility for Japan to benefit from foreign technology as well depending on the entrant company' in-house financial capabilities

[45] http://www.ren21.net/wp-content/uploads/2015/07/GSR2015_KeyFindings_lowres.pdf p 10
[46] http://www.ren21.net/wp-content/uploads/2015/07/GSR2015_KeyFindings_lowres.pdf p10
[47] http://www.enecho.meti.go.jp/appli/public_offer/1602/160218b/pdf/1.pdf
[48] http://cdnsite.eu-japan.eu/sites/default/files/publications/docs/clean-energy-paper27feb-b-finale.pdf p 24
[49] http://www.iflr.com/Article/3196272/Non-recourse-loan-unlocks-Japans-renewables.html

Government Budget

Although not a perfect substitute for measuring willingness towards certain policies, looking at the budget allocated by the government to certain projects can give a certain indication of the determination and the importance given to the policies. In the case of the Japanese renewable energy, and the energy market in general, one way to estimate this is by taking a closer look to the METI's annual budget allocation. Due to economic reasons and other factors, this does not give us a perfect image of the bigger picture, but it should give the external public an idea.

In the case of the METI, we can look at the **Enecho** and its ***Long-term Energy Supply and Demand Outlook*** to see that the Japanese government has made a target for itself of achieving around 22-24% of renewable energy. In order to compare this political stance with the financial commitments, we need to take a look at the '*Special Accounts for Energy Measures'* (hereinafter: SAEM)[50].

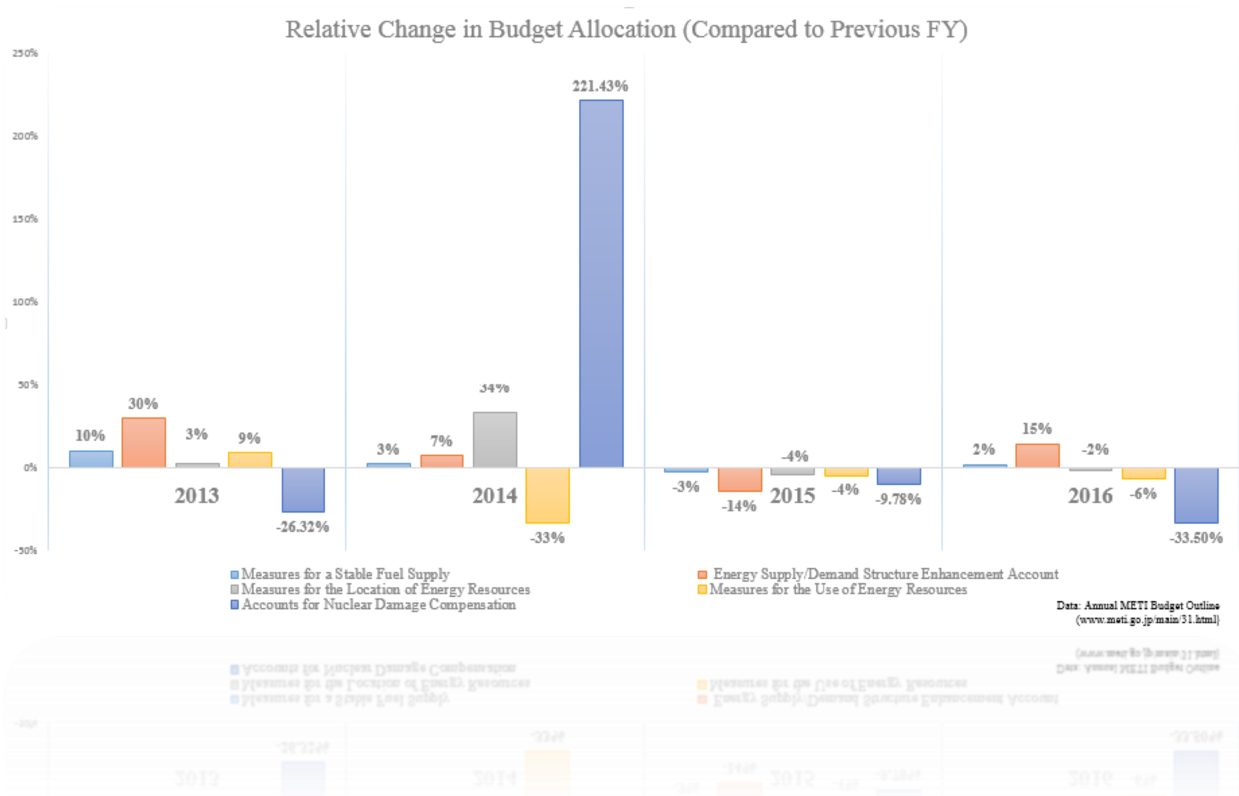
The SAEM was created in 2007 after the amalgamation of its predecessors; the *Special Accounts for Power Resource Development Measure* and the *Special Accounts for Oil and Energy Supply/Demand Structure Enhancement Account*, in an attempt to increase the transparency on the government's management of energy related matters.

Table 1: Special Accounts for Energy Measures Overview

Special Accounts for Energy Measures				
Accounts for Supply and Demand of Energy		**Accounts for power source development**		**Accounts for Nuclear Damage Compensation**
Measures for a Stable Fuel Supply	Energy Supply/Demand Structure Enhancement Account	Measures for the Location of Energy Resources	Measures for the Use of Energy Resources	Accounts for Nuclear Damage Compensation

[50] In Japanese : エネルギー対策特別会計

The first subdivision of the *SAEM* is the '*Accounts for Supply and Demand of Energy*' which is further divided into the '*Measures for a Stable Fuel Supply'* and the '*Energy Supply/Demand Structure Enhancement Account*', the second subdivision is the '*Accounts for power source development*' which is divided into the '*Measures for the Location of Energy Resources*' and the '*Measures for the Use of Energy Resources*' and the third and last subdivision of the *SAEM* is the '*Accounts for Nuclear Damage Compensation*'. As mentioned before, by looking at the budget for the *SAEM*, we can hope to somewhat gauge the interest of the METI in its energy policy related goals, even more so when looking at the



relative difference of the subdivision we are interested in.

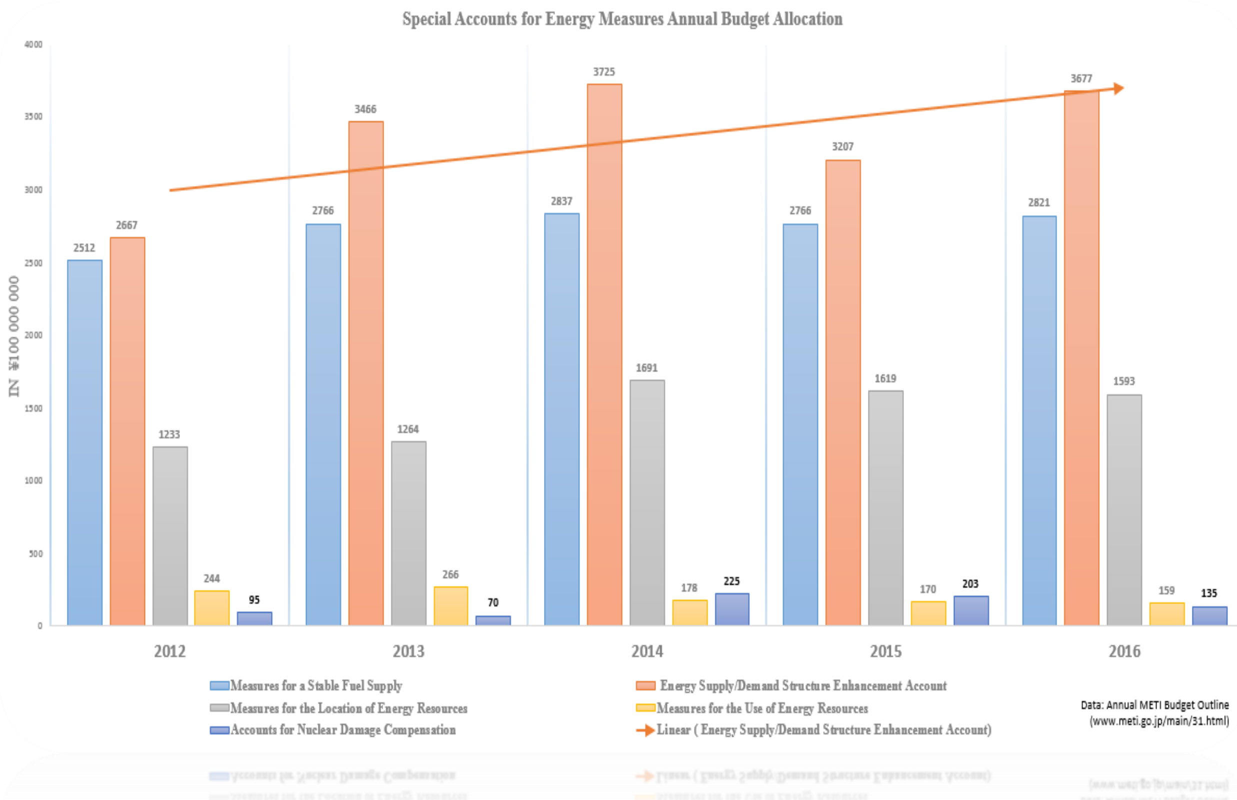
When looking at the governments' prospect on Hydro- and Marine Energy related projects, we must pay close attention to the *Accounts for Supply and Demand of Energy*'s *Energy Supply/Demand Structure Enhancement Account* subdivision, which is the subaccount responsible for:

> *"Taking measures towards the realisation of CO_2 emissions reductions from energy sources as well as for the preparation of energy efficiency and renewable energy strategies in order to build towards a stable and adequate energy demand and supply structure appropriate for both domestic and international economic and social environment.[51]"*

[51] Translated from Japanese from http://www.mof.go.jp/budget/topics/special_account/fy2015/tokkai2712_00.pdf, p. 82

As you can see from the graphs representing the SAEM, the overall trend in budget allocation towards this SAEM is slightly upwards-going, with the *Energy Supply/Demand Structure Enhancement Account* getting the biggest allocation of the five subaccounts. Furthermore, in recent years the *Energy Supply/Demand Structure Enhancement Account* seems to have gotten both the biggest ups and downs in relative percentage budget allocation, with a 15%[52] increase for the fiscal year of 2016 compared to FY 2015.

Taking a closer look at the individual projects in the budget outline released by the METI, we can see that this year's budget, which was released in March 2016, includes new projects related to the '*Funding for Project Expenses for the Advancement of the Hydro-Energy Generation Commercialisation*' and '*Funding for Project Expenses for the Advancement of the New Hydro-Energy Generation Technology Application*.'[53]



[52] Which translated into an increase of ¥47 000 000
[53] In Japanese:「水力発電事業化促進事業費補助金」and「水力発電新技術活用促進事業費補助金」respectively

For the 2016 budget, several projects related to the joint research and development of '*revolutionary energy technology*' between Japanese and foreign institutions, were allocated ¥420 000 000, which has tentatively been more than doubled to ¥900 000 000 in the current 2017 budget demand outline by the METI[54]. The description of this particular budget reiterates what was discussed between Japan and the other countries at the 2015 COP21 in Paris and is an example that illustrates the importance the Japanese government holds towards creating potential for international research cooperation.

[54] http://www.meti.go.jp/main/yosangaisan/fy2017/pr/e/e_sangi_taka_02.pdf

1.2.2. Future Market Environment

1.2.2.1. Future Market Structure

Based on the current situation of the Japanese electricity market, reports and presentations published by the METI and its many subcommittees and working groups, and the structural changes undergone by certain European member states to their own electricity market, we can make an educated guess at which way the market is headed towards and the role RET will play in it.

Due to the nature of both RES to be discussed in the following chapters[55], it is important to take a look at the future situation of the market. Not only will this give us an idea of the changes to come and how to interpret this for the renewable energy market sector, this should also give us an idea of RES' potential in general and the role it will play in the future Japanese electricity market.

Future Pillars

In order to achieve this future market structure to become the supporting foundation to a lower carbon society in Japan, the METI also formed a new subcommittee in September 2015; the '*Subcommittee for Reforming Systems Related to Introduction of Renewable Energy*', to help advise the government which measures to introduce and reforms to undertake in order for Japan to achieve the energy market of the future. The four pillars for the energy supply structure in Japan will be trying to mould over the following years are the **3E+S** principals[56]:

- ✓ Energy Security,;
- ✓ Economic Efficiency, ;
- ✓ Environment, ;
- ✓ Safety,;

In order to achieve this future energy market structure, the implementation of RES will be a necessary task, as RES achieve highly on many of the 3E+S principals to which the government holds much importance.

[55] And more specifically their tendency to take a long time before being readily available to reap the benefits from the Japanese FIT and electricity market system.
[56] http://www.meti.go.jp/press/2015/07/20150716004/20150716004_2.pdf p 1-4

Table 2: 3E+S Comparison of Different RET

Technology	Energy Security	Economic Efficiency	Environment	Safety
Transmission System Upgrade	High	High	High	High
Energy Efficiency	High	High	High	High
Distributed (roof top) Solar Power	High	Medium	High	High
Utility Scale Solar Power	High	High	Good	High
Onshore Wind Power	High	High	Good	High
Offshore Wind Power	Medium[28]	Medium	High	High
Small Scale Hydropower	High	Low	Good	High
Large Scale Hydropower	High	High	Medium[29]	Medium[30]
Small Scale Geothermal	High	Medium	High	High
Utility Scale Geothermal	High	High	Good	High
Coal (SCPC)	Poor[31]	Medium	Low[32]	Medium[33]
Coal (IGCC)	Poor	Medium	Low	Medium
Coal (CCS)	Poor	Low	Poor	Medium
Natural Gas (CCGT)	Poor	Low	Medium[34]	Good
Nuclear	Poor[35]	Low	Unknown	Unknown
Oil	Poor	Poor	Medium/Low	Medium
Existing Unit Efficiency Upgrade	Poor[36]	High	Medium[37]	Good[38]

Source: Buckheit B.[57]

[57] http://www.kikonet.org/wp/wp-content/uploads/2015/04/Japans-SEP-review-en_April-2015.pdf page 25

Reinvigoration of the (Local) Market

Firstly, as previously alluded to, the current structure of the Japanese electricity market is a traditional, centralised system in which the use of large-scale traditional energy sources is an important part of the electricity supply-chain. Recent trends and METI reports, however, show that Japan is also moving towards implemented a more regional block system in which regions locally consume what is locally produced in terms of energy[58].

The switch to this regional structure, similar to the Stadtwerke phenomenon, will evidently increase the demand from local communities to implement more RET. The METI has also taken note of this increasing tendency for local regions to be the lead in installation projects of certain RET such as Small- and Medium-scale hydro, and has expressed the need for a revision of certain instruments to help promote the development of this RET by locals[59].

Figure 6: Expected Effects of Stadtwerke system

Source: Stadtwerke.jp[60]

The MAFF also enacted in 2014 the *Act for the Promotion of Renewable Energy Harmonized with Sound Development of Forestry, Agriculture and Fisheries*[61] in order to continue the promotion of renewable energy in rural areas[62] and the increased independence from centralised systems, and cooperation of local communities as they increasingly implement RET projects themselves[63] through the potential human resource training via more exchange of information, training programs, helpdesks, the smoothening of the process of acquiring required funding etc. A successful example of this can be found in Nasunogahara, which has implemented a small-hydro facility, and solar PV that has successfully decreased the financial pressure felt by local farmers through the use of the profits from the FIT revenue[64].

[58] http://www.meti.go.jp/committee/sougouenergy/kihonseisaku/saisei_kanou/pdf/009_02_00.pdf slide 13
[59] http://www.meti.go.jp/committee/sougouenergy/kihonseisaku/saisei_kanou/pdf/009_02_00.pdf slide 31
[60] http://www.stadtwerke.jp/en/about/
[61]農林漁業の健全な発展と調和のとれた再生可能エネルギー電気の発電の促進に関する法律
[62] http://www.maff.go.jp/j/shokusan/renewable/energy/houritu.html
[63] http://www.maff.go.jp/j/press/shokusan/soumu/pdf/150310-01.pdf
[64] http://www.maff.go.jp/j/shokusan/renewable/energy/pdf/gaiyo_3.pdf p 3

As a result, we can expect data related to river discharge rates and other fundamental data needed for the installation of these types of RET with long lead times, to be publicly made available, lowering initial costs for the installation of certain renewable energy, as well making more capable human resources available locally through training programs, the exchange of information, and lastly the ease of finding funding needed for the implementation of RET for the purpose of local consumption[65].

Optimization of Financial Instruments

Secondly, as certain RET mature, decrease in cost, and increase in total output, the Japanese FIT system will also see changes in its provisions. While it is unsure whether the Japanese government will continue to adhere to a system based on the traditional FIT scheme with tenders for certain business-scale RES, or whether it will modify its scheme to the increasingly more popular Feed-in-Premium system, we can assume that pertaining the slowly increasing small- and medium-scale hydro market and marine energy market, the status quo will be kept until their individual shares in the energy mix significantly increases similarly to the Solar PV case.

The FIT tariff, however, will not be the only major defining factor in the use of RE. Changes in the structure of the Japanese energy supply such as the switch from obligating transmission companies to be in charge of purchasing RE from suppliers instead of the generators, as well as the unbundling from transmission companies and the generation incumbents, will hopefully improve the efficiency and potential implementation of RES as well as the improvement of the grid in general. As transmission is handed over to unbundled companies with their own agenda, neutrality of the grid should improve, and the grid reinforced over time to allow for more RE to be implemented through the grid[66].

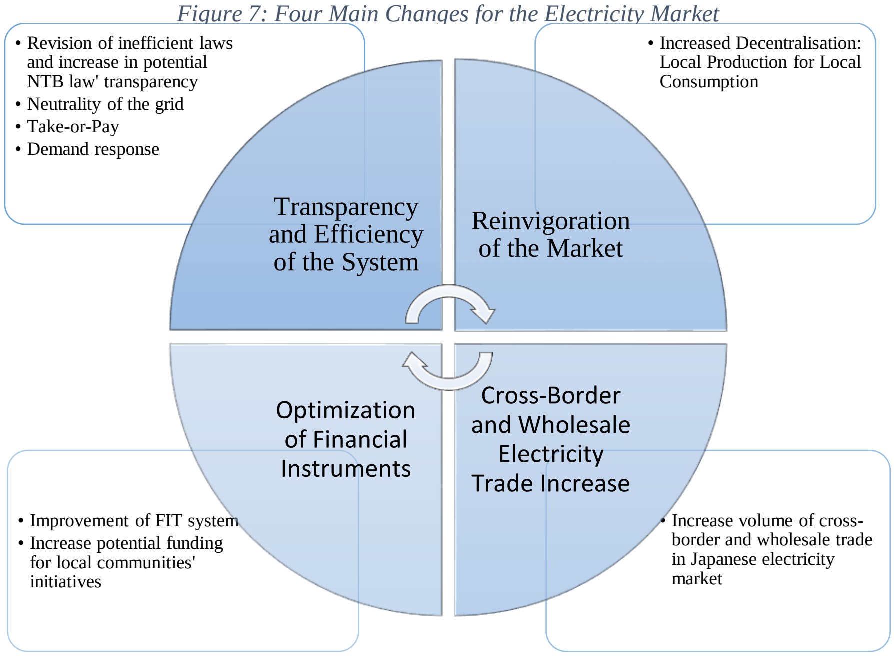
Currently, the Japanese grid still hasn't implemented a system similar to other countries' '*Take-or-Pay*' system. With the *Take-or-Pay* system, the Japanese utilities that have an obligation to buy energy from renewable energy suppliers, are forced to pay a certain fee even when they decide to curtail on the acquisition of the produced RE. Japanese FIT law gives the possibility for utilities to curtail the use, and ultimately the purchase, of electricity produced from these renewable energy suppliers, under certain conditions, conditions which are now based on the so-called "output control" system on which the Agency for Natural Resources and Energy has a say in. The output control is based on the technical grid access capacity, i.e. the grid's potential to take on the load of X amount of renewable energy on top of the predetermined traditional energy volume, and has been used as a way for incumbents to, at times, avoid using produced renewable energy[67].

[65] MAFF (s.a.), p 2
[66] As also evidenced by BNEF (2015), p 5
[67] Buckheit B.C. (April, 2015)

System Transparency and Efficiency Increase

As of 2015, the electricity market is scheduled to officially require the incumbents to legally unbundle their transmission and generation departments on 1 April, 2020[68], which should improve net neutrality and all the advantages with it, however, we have found no sign of the Japanese market headed towards implementing the previously mentioned *take-or-pay* measure to increase funding security and decrease investment risk[69]. The reworking of the current system of transmission grid capacity calculation will most likely also be needed in order to ensure enough flexible transmission resources for renewable to be used. Once potential has increased, and with long-term PPA and/or a *take-or-pay* system set in place, in case of potential conflict of interest amongst the TSO, the prioritized use of RES will be more advantageous due to the occurring cost differences between RES and traditional energy sources.

Figure 7: Four Main Changes for the Electricity Market



Even though the demand for RES and the potential for RES to be sent through the grid, i.e. the previously mentioned grid access capacity, can and should increase over the coming years via the implementation of net neutrality etc., installing RET also depends on many other laws related to the area and environment of the potential site on which the new RET facility will be installed.

Laws such as the *River Act*, and systems such as the *Environmental Impact Assessment*, which we will discuss more extensively in the second chapters, are laws that can potentially hinder the smooth implementation of RET such as hydro energy, and need to be addressed. Reports show that the government is aware of these problems[70], and past revisions to certain regulations that proved to be bottlenecks, such as the above-mentioned *River Law*, reaffirm the government's dedication towards revising old laws, and implementing new ones, such as the previously mentioned *Act for the Promotion of Renewable Energy Harmonized with Sound Development of Forestry, Agriculture and Fisheries.*

[68] http://www.occto.or.jp/koiki/koiki/index.html
[69] A measure which would especially be of importance to variable output RET such as solar energy.
[70] Cfr. METI (December 16, 2015), slide 25

Cross-Border and Wholesale Trade Increases

For years the Japan Electric Power Exchange, or JEPX, has been underutilized as incumbents avoided the use of wholesale markets. To illustrate: in March 2015 the JEPX only accounted for 1,5% of the total power market's output as high-voltage users preferred the use of bilateral agreements rather than wholesale exchange-based trade, in Norway's infamous Nord Pool, 80% of electricity exchanged hands via its wholesale market. The Tokyo Commodity Exchange is also planning to list forwards starting from the first quarter of 2017[71].

The role of wholesale trade in the electricity market is to facilitate market entry and exit to enable risk management by producers, suppliers and consumers through forward trading, and will ideally inform all investment and divestment decisions. All of this will then underpin the retail competition, which should guarantee customer choice, product innovation and variety and improve efficiency of the market, all through the accurate signal that is the market price[72]. As the wholesale market becomes more common use, wholesale market prices can become signals reflecting the "*true value of scarcity during times of system stress and high demand for power (…) give(s) signals for storage operators/investment if they are not caused by out of the market reasons.*[73]"

However, in tandem with the newly liberalised market, a more extensive range of wholesale market services have also been introduced in Japan as of April 2016. Currently, the JEPX has two types of spot-price contracts; the Day-Ahead and Hour-Ahead spot market, as well as five types of forward contracts[74]. The increase of the use of wholesale markets is also hoped to offer change is set create a 'virtuous cycle' as it should also help encourage utilities to sell more power on the exchange rather than to their own retail units[75]. However,

> *An exchange must have a significant share of the market to provide trust and transparency. An exchange will become relevant if the share is in the range of 10 to 20 percent or above.* [76]

Up until the liberalisation of the market last April, the basis of the use of the wholesale power market was that of 'voluntary effort' by the incumbents, but with the liberalisation, the wholesale power market will ideally be used in bigger volumes and provide beneficial effects to both market prices as well as the efficiency of the market and the use of RES. This exchange has, however, yet to take place, as EPCO's contribution to the JEPX has not greatly improved since the liberalisation. This standstill might potentially cause actors such as *J-POWER* to attempt to implement certain steps to activate this much-needed wholesale market.

Similar to the wholesale trade changes, the government has also planned to motivate the use of cross-border trade. During the incumbents' period of regional monopolies, interregional trade was low, but with the liberalisation of the electricity market, the amount of electricity to cross borders should increase. In April 2015, the Japanese government also created the so-called *Organization for Cross-regional*

[71] JEPX (2016)
[72] EFET (June, 2016), p 1
[73] Quote from EFET (June, 2016), p 2
[74] Stapczynski, S. & Emi Urabe (March 29, 2016)
[75] Stapczynski, S., Inajima, T. & Emi Urabe (March 31, 2016)
[76] Quote by Hans Gunnar Navik, (Stapczynski, S., Inajima, T. & Emi Urabe (March 31, 2016))

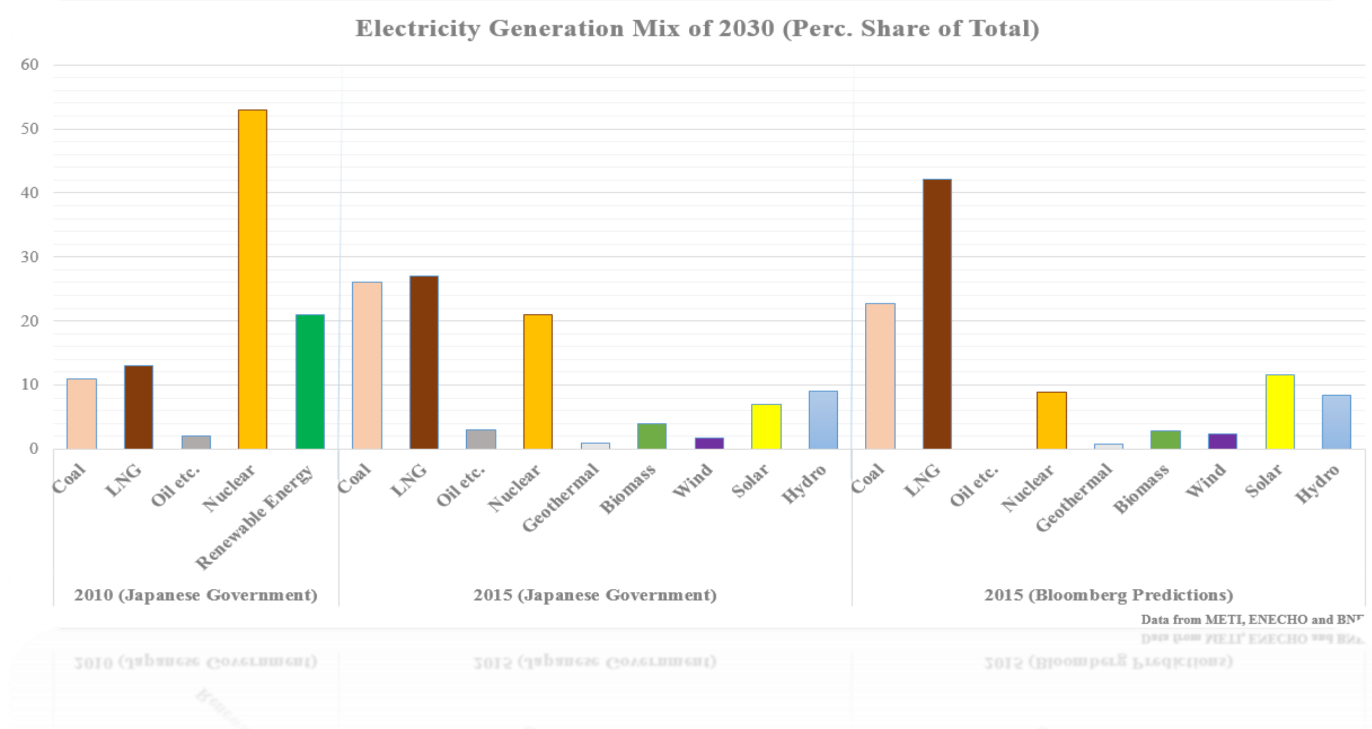
Coordination of Transmission Operators, or OCCTO, to help monitor and regulate this endeavour[77]. In September 2015, the government also created the *Electricity and Gas Market Surveillance Commission*, or EMSC, to strengthen the oversight of the electricity market and increase healthy competition[78]. In both cases, it is of absolute importance that these organizations are run independently and act as a neutral third-party actor in the market, with sufficient instruments to ensure the compliance to its oversight, to ensure that the market works as efficiently, transparently and fair as possible[79].

Similarly, as the development of cross-border trade increases, retailers, and ultimately the end-use consumers, should be able to profit out of the potential differences between regional characteristics in terms of weather. If one region in Japan profited from more generous renewable energy supply due to differences in the weather conditions decreasing wholesale prices for said energy, retailers from other regions might use this more favourably-priced energy to supply their customers, ultimately leading to the increased use of more efficient use of RES.

[77] http://www.occto.or.jp/en/occto/about_occto/index.html
[78] http://www.emsc.meti.go.jp/committee/
[79] Renewable Energy Institute (April 2016), p 24-25

1.2.2.2. Future Energy Demand and Supply

One way to assess the importance of certain types of energy sources in a country would be to look at market growth trends; another is to look at government predictions. For Japan, the government has released numerous projections in the past, related to the share of the various energy sources in its electricity generation structure over the past years. In the graph below, you can see two government projections done by the Japanese government for the electricity generation mix of 2030. Very noticeable is the difference in the attitude towards nuclear energy before and after the 2011 Great Earthquake of East Japan, in 2010 and 2015 projections.



With the increasingly more important global trend towards lower carbon emissions, the Japanese government has most recently released a prevision of the future output and energy mix of Japan by 2030; the previously mentioned *Long-term Energy Supply and Demand Outlook*. As the aim towards lower carbon-emission grows, and RET' LCoE decrease to competitive numbers to those of more traditional energy sources, RE output is also expected to increase.

The projections of the government are based on several assumptions on future micro- and macro components such as the future economic growth rate of Japan, the population growth, the existing project pipeline etc. Furthermore, as Bloomberg New Energy Finance also states, the government seems to assume the possibility of keeping a somewhat elevated share of nuclear energy in the total electricity supply, possibly through the extension of the existing plants' lifecycle to 60 years, or through the construction of new facilities to replace the ones that have reached a 40-year total lifespan.

While these projections are only that, projections, they do give a good idea of the current governments' goal and hopes in terms of energy. In terms of renewable energy, while this projection does not include any type of marine energy (besides most likely a share of offshore wind energy), the 2030 goal according to the government is at 22% to 24%[80], while Bloomberg New Energy Finance calculates the RES share in

[80] Depending on the share of hydro, biomass and geothermal.

the electricity output mix to be around 26,1%, mainly due to a higher estimated amount of potential solar energy and wind. The lower share of estimated future solar energy given by the Japanese government can be explained by the assumption that solar energy without any financial support in the future, would diminish the interest in the energy resource, even though other countries have proven that growth in solar supply can still be achieved without the initial financial incentive in the form of a FIT-type subsidy[81]. The 2030 energy outlook also makes assumptions related to the share of energy savings on the demand part due to various technological advancements and energy efficiency increasing measures[82].

Furthermore, if the government's proposed 'negawatt trading' program successfully launches and increases the demand response in the Japanese electricity grid, we believe it might also affect the total needed electricity and the importance of RES[83]. We are unsure, however, if the use of pumped storage hydropower will also qualify as a type of 'negawatt trading' due to its characteristic as a battery that can ease the electricity supply curve during peak times when a surge of electricity output is needed.

[81] BNEF (June 2, 2015), p 4
[82] METI (July, 2015)
[83] ENECHO (March 30, 2015)

1.2.2.3. Future Challenges Left to Be Addressed

As touched upon in the previous sections, Japan has yet to see many changes implemented before RET can be implemented as effectively as possible in amounts as big as possible. Many of these problems seem to be in the crosshairs of the government for future reforms, but others still remain to be addressed. The aforementioned transparency and neutrality of the electricity network not only will need to happen in order to avoid any potential conflicts of interests to happen, and for the grid to grow in output potential, but transparency of the generation supply will also need to happen. In Europe, retailers are obligated to divulgate the exact composition of their supply structure and the GGE. While not very elevated, a 2015 research performed by the Nomura Research Institute would suggest that the source of the electricity output accounts has a 10% weight on Japanese consumers' decision to change and/or stay with a certain electricity supplier[84] making this type of transparency also a potentially important factor to be introduced to the market.

Transparency and strengthening of the grid is planned to happen after the transmission networks in Japan have been legally unbundled from their incumbent's generation and other branches, but it might be necessary to take it one step further and continue the unbundling of these transmission companies to a full ownership unbundling and/or ensure the effectiveness of the Electricity and Gas Market Surveillance Commission to prevent biased transactions[85]. The reason for this is that the independence from generation sectors and interregional cooperation will become increasingly important as RES' energy mix increases.

The current system of 'Scheduled interchanges' which basically makes estimates on needed future energy output and the way the market will supply this, usually only allows for small percentages of so-called 'open capacity'[86] for renewable energy, potentially greatly limiting their amount of possible energy output. In order to tackle this issue, it is important for RET to be supported by systems that can accurately foresee the supply output of a certain RET in order to be able to be counted as a stable supply of energy, or to change the way the Japanese supply output is being planned in the future, in order to more easily accommodate for RES similarly to the European way[87] [88].

Lastly, while already addressed by the Japanese government for certain RET, in order for a smooth transition to more RES to happen, it is equally important to work on the education and training of the next generation of engineers and workers that will be needed for the installation, operation and maintenance of new RET.

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[84] NRI (October 8, 2015), p 1

[85] Renewable Energy Institute (April 2016), p 6-10

[86] In Japanese: 空容量

[87] While this is an important issue to tackle, as we will see in later chapters, the target energy resources of this report do not suffer from this problem as much as solar PV or to some extent even wind energy.

[88] Renewable Energy Institute (April 2016)

1.3. Technological, Business and Research Cooperation Potential

While separated geographically, Europe and Japan share many common societal and economic values. EU-Japan relations in the field of science and technology has therefore long been of strategic importance in order to increase their industries competitiveness. In a joint press statement for the 3rd Joint Committee on Scientific and Technological Cooperation between the EU and Japan, which is organised under the EU-Japan Science and Technology Cooperation Agreement[89],[90] both parties mentioned the importance to continue to seek potential avenues to promote

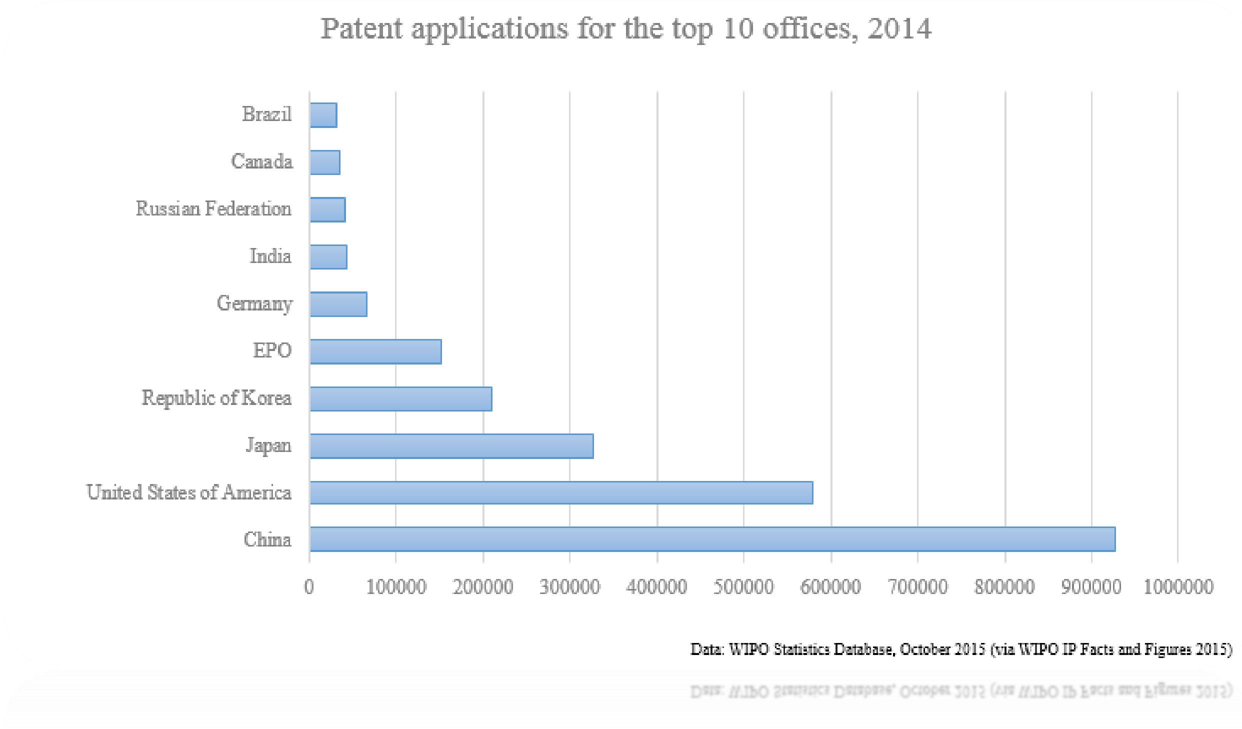
> *"opportunities for increasing mobility of researchers between Europe and Japan. We particularly welcome the Implementing Arrangement between the European Commission and the Japan Society for the Promotion for Science (JSPS), to be signed in May 2015. This arrangement provides opportunities for Japanese researchers to pursue research collaboration with European Research Council (ERC) grantees in Europe. The EU-funded Marie Sklodowska Curie Actions also provide opportunities for increasing the mobility of researchers between Europe and Japan.*
>
> *We recognise the high importance of establishing streamlined mechanisms for the joint funding of research and innovation projects, which are acceptable to both the EU and Japan, to fully exploit the potential of our cooperation. We therefore appreciate highly the scheme developed by the Japan Science and Technology Agency (JST) in close cooperation with the European Commission to establish a process for the joint funding of projects."*[91]

Furthermore, with the upcoming Europe-Japan EPA, it is also possible that business cooperation between Japanese and European companies will be facilitated even more as NTMs and NTBs to Trade might be lifted for the energy sector, market access increased, customs and trade will be facilitated and exports and imports to and from Japan and Europe will be made easier[92]. This should especially become a potential opportunity for foreign manufacturers of hydropower turbines interested in exporting their machinery, depending on the provisions in the upcoming EPA related to the export of these types of machines, to the Japanese market as we will make clear in the following chapter.

[89] Which entered into force on March 2011
[90] http://www.mofa.go.jp/dns/isc/page3e_000347.html
[91] MOFA (May 29, 2015), p 2
[92] European Commission (May 12, 2016), p 1-3

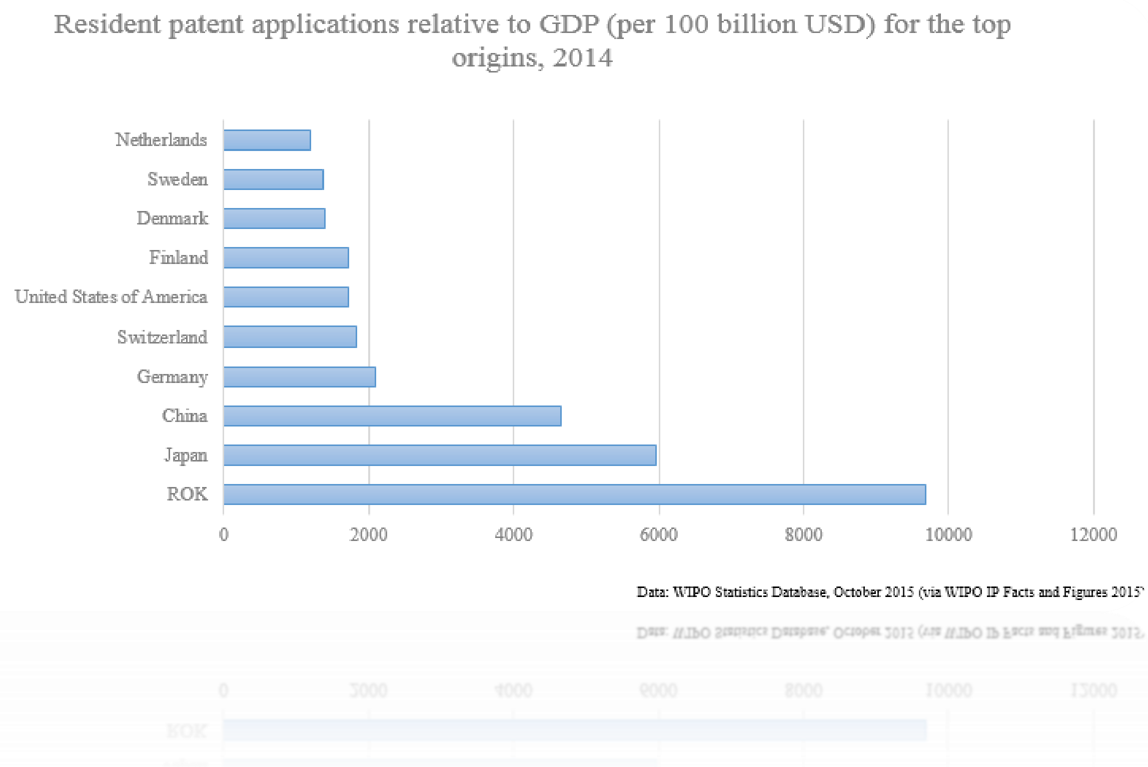
1.3.1. Technological and Research Cooperation

Japan has a range of potential to offer foreign companies looking for a Japanese partner. In 2015, Japan played, and still plays, a substantial role in the output of technologies and innovations with a global impact as mentioned by a previous MINERVA report[93]. The 2015 WIPO report shows that for the period of 2011 to 2013, Japan was ranked first, in the top five patent offices around the world, in amounts of patent applications published in the field of electrical machinery, apparatus and energy. In total amounts of patent applications, Japan globally ranked third, behind China and the U.S.A., and even placed second when adjusting the resident patent applications relative to GDP[94].



Thanks to the inherent incentivization programs set up in Japan by the METI such as the 'Promotion of Business Innovation', 'Promotion of Start-Ups', by the MEXT such as its START program, A-STEP program and by the Japan Patent Office via its numerous measures and initiatives to cultivate an environment for intellectual and innovative technological growth[95], Japan was able to grow from a country known for its heavy industry after World War II, to a country known for its grasp on the so-called immaterial "soft-power".

93 Escoffier (April, 2015), p 12
94 WIPO (2015), p 17-19
95 Escoffier (April, 2015), p 44-50



This support provided to both large-scale Japanese companies as well as SMEs to innovate paired with the previously-mentioned high amount of interest in energy technological development as seen from the Japanese METI's annual budget changes, would suggest that Japan is inherently a country brimming with opportunities for technological and research collaborations. Nevertheless, as we will see in a later chapter, even with the high amount of publicly funded projects, there are still potential projects and researchers that would be more than willing to work with foreign companies to see their energy technology related ideas come to fruition.

While not an easy task that can be done without using a high amount of time and effort, foreign companies interested in applying for any project opened up for private companies by the numerous Japanese government bodies, can do so with a Japanese branch, as those subsequently become Japanese companies by nature, and thus eligible to apply for projects. Most recently, this can be seen in the ocean energy market, which we will discuss in more detail in a later chapter.

1.3.2. Business Cooperation

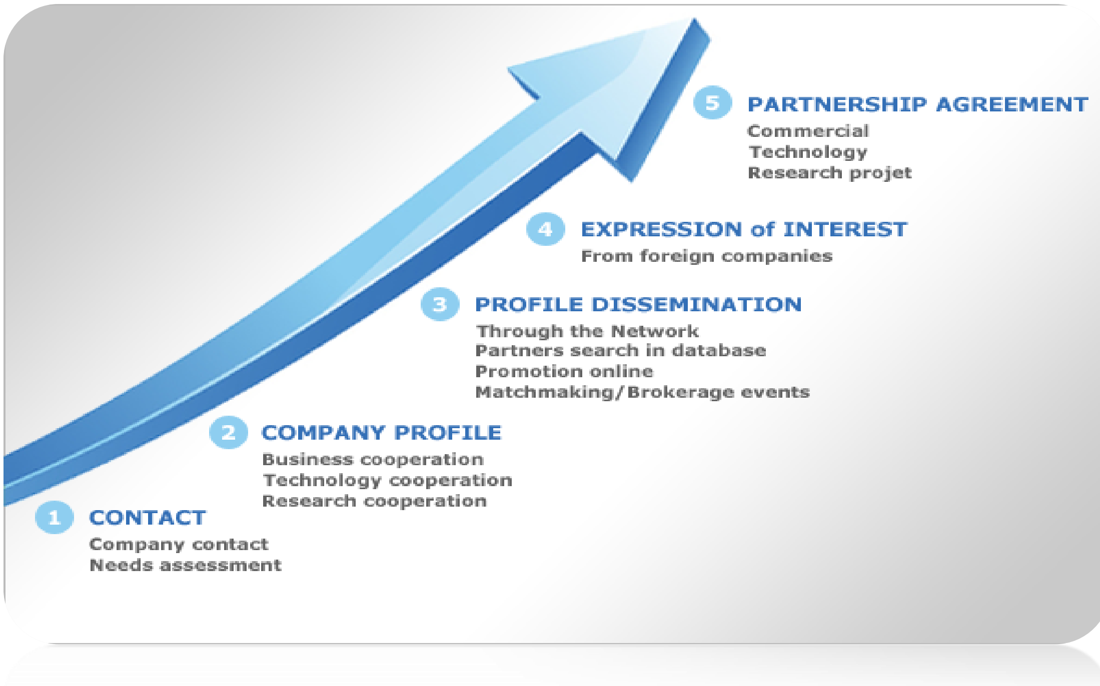
Companies looking to find business partners have many possibilities of tackling the issue. The most direct, but comparatively more expensive approach is through the direct contact of companies at workshops, exhibitions and other events such as these. In the case of the renewable energy market, foreign companies could participate in energy related exhibitions such as:

- The ENEX;
- The Smart Energy Japan;
- The Energy Supply & Service Showcase;
- Renewable Energy Industrial Fair; or even
- The Renewable Energy Exhibition.

In the case of foreign companies looking for business partners in Japan, there are many services available to help provide the necessary support to find relevant information, support and business match-making services. One example of this is the Enterprise Europe Network that can be used by companies outside of Japan.

The EEN in Japan has been under the coordination of the EU-Japan Centre for Industrial Cooperation, and helps "connect, innovate and grow" all companies and SMEs by supporting them in their search for partners on either side of the globe through amongst other the offering of tools and expertise to enable companies to develop a partnership with other businesses and researchers, the provision of the technology database to find a potential partner and support from contact to partnership agreement[96].

[96] http://www.een-japan.eu/content/think-technology-innovation



With its close ties to the European Commission and Japanese METI, the *EU-Japan Centre for Industrial Cooperation* also organizes:

- Seminars and webinars,
- managerial training programmes,
- Student internships,
- An information desk, and
- Matchmaking activities and more[97].

[97] http://www.een-japan.eu/content/about-your-network-partner-japan

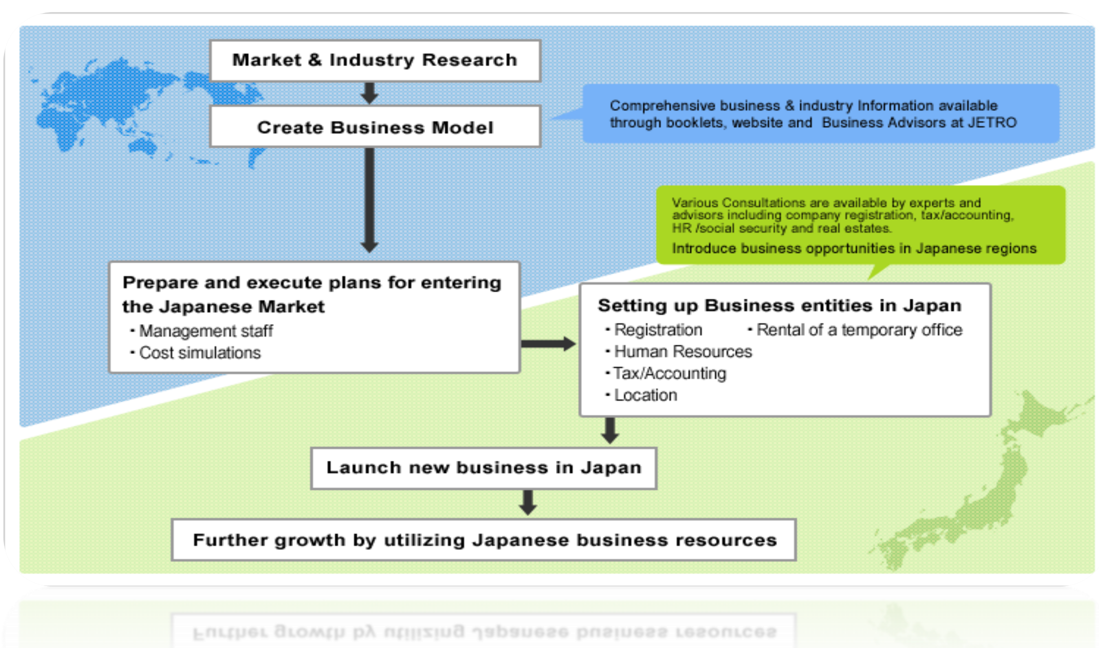
JETRO

Japan External Trade Organization

On the Japan side, JETRO also offers support to foreign investors looking to do business in Japan by organizing business matchmaking events and industrial tours and symposia as well as through their Invest in Japan Business Support Centres via the possibility of helping establish new bases in Japan by:

- Providing expert consultation,
- Providing target market overviews,
- Helping set up a business entity in Japan,
- Giving the possibility of free temporary office spaces

Examples of companies in the energy market that successfully made a foothold in Japan include the Japanese branch of French floating solar power producer Ciel & Terre[98], and the German company Juwi Holdings AG[99].



98 https://www.jetro.go.jp/ext_images/en/invest/success_stories/pdf/ciel_terre.pdf

99 https://www.jetro.go.jp/ext_images/en/invest/success_stories/pdf/juwishizen.pdf

Similar to European companies, **Japanese companies** that are looking for foreign companies to form business ties with can also revert to using the EEN, which can provide necessary support for this type of matchmaking via their database.

Furthermore, with the help of the Horizon 2020 National Contact Point in Japan and the JEUPISTE project, which can help Japanese companies with Horizon 2020 project management through the implementation of training seminars, the operation of a helpdesk for any inquiries related to EU-Japan Science, Technology and Innovation and more[100].

Lastly, it is also worth mentioning that companies from different European MS can also revert to their countries' embassies Science and Technology offices, Chambers of Commerce or other relevant departments for business type inquiries.

Horizon 2020

[100] http://www.jeupiste.eu/about

Chapter 2. Hydropower

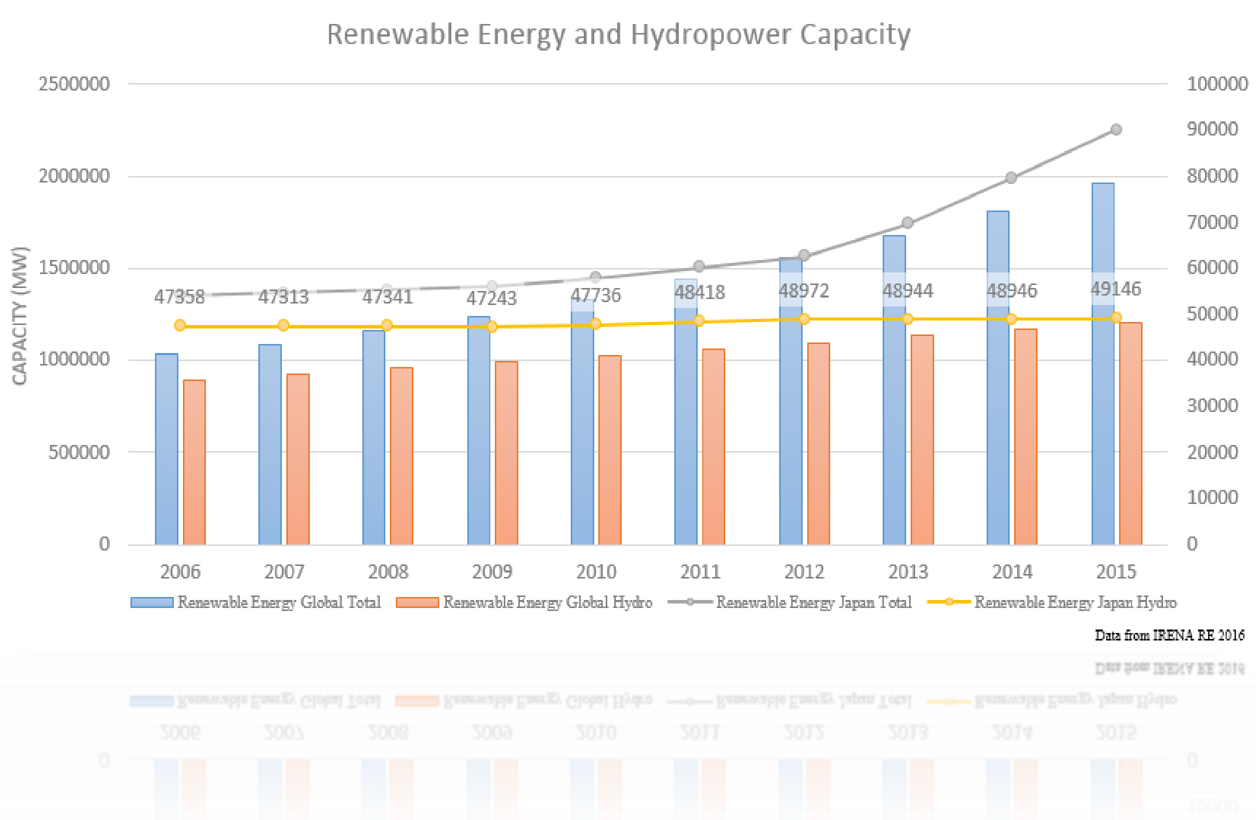
2.1. Introduction

As discussed in the previous chapter, over the course of its electricity market's history, Japan has often reverted to focusing on the use of one certain energy resource to fulfil the majority of its energy demand. Starting with primarily hydro energy, post-WWII Japan switched to a more thermal power-focused energy mix until the oil crises in the 1970s. In order to decrease its fuel dependency from oil exporting countries, Japan then made the jump to introducing more nuclear energy as its baseload energy supply until the 2011 Fukushima disaster.

Torn between the utility of nuclear energy and the importance of having a safe energy supply, Japan finally decreased its use of nuclear energy to almost 0% as of today. In order to refill the energy supply it had lost from switching off the majority of its nuclear power plants, the country reluctantly moved towards its other existing electricity generating plants and to start introducing more energy efficiency and a more diverse energy mix by increasingly looking at both new RES as well as expanding its use of already existing and the well-established RET that is hydro-power.

In many developed countries such as Japan, hydropower, the so-called 'blue battery', has in recent years mostly been used as nothing more than a complementary baseload energy resource. When used in combination with a type of storage system such reservoirs, this power resource not only helps stabilise the electrical system, but also allows for flexibility thanks to its ability to start-up in a short amount of time, and put less pressure on the electrical grid compared to other RET such as solar PV or wind-power[101].

Graph 1: The Global and Japanese Capacity for Renewable Energy



[101] IRENA (June 2012), p 4

Hydropower can be categorised into three main types:

- Run-of-River
- Reservoir Storage
- Pumped Storage

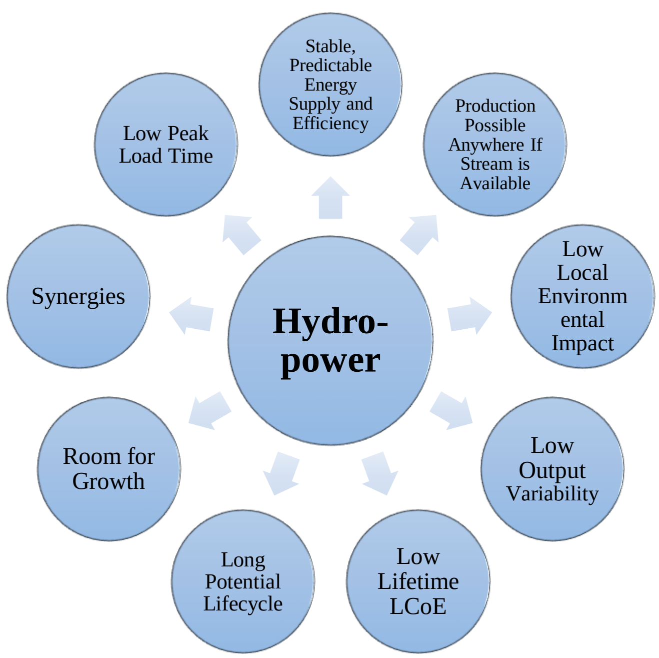
While **Run-of-River** has the benefit of often needing lower initial financial resources, due to its limited 'pondage' and thus lower need for civil works-related costs, this type often does not produce as much output as the other types.

Reservoir Storage, on the other hand, increases the potential of delivering energy when needed by storing large amounts of water.

Pumped storage goes one step further and makes it possible to pump water back to the reservoir when energy is in oversupply, in order to prepare the potential supply during peak demand. Hydropower's high energy conversion efficiency factor and low load peak time, combined with Pumped Storage, makes it a perfect way to top up a sudden excess demand without at a last moment's notice.

Hydropower can also be further subcategorised depending on the electricity output generated by the site. While large hydro facilities need a certain amount of civil engineering, especially in the case of reservoir storage type hydro using dams etc., compared to its fossil fuel and other resources, hydropower holds a relatively small carbon footprint that only becomes smaller as the scale of the hydropower facility decreases, further lowering the impact on the local environment.

Figure 2: Benefits of Hydropower



The lifecycle of hydropower facilities can also last 50 to even 100 years[102] as upgrades and/or refurbishments can help extend the lifetime of existing facilities of both large- and small-scale as the technology, while mature, keeps advancing and finding greater scopes for its applications[103]. Its low CO_2 output (11g CO_2/kWh for hydropower compared to 25 g CO_2/kWh for wind energy and 38 g CO_2/kWh for solar PV[104]) over the operational lifetime of a hydropower plant also makes it a very favourable energy resource in a world where achieving low carbon emissions is becoming increasingly more important. As you can see from Chart 1, the global renewable energy capacity has almost doubled between 2006 and 2015, with Japan's already well-matured hydropower capacity growing an additional 4% in the same timeframe.

Large hydropower facility can also potentially be combined with smaller hydro as well as other new RES such as solar energy when combined with floating solar panel system offered by companies such as the French company *Ciel et Terre*. By adding floating solar panels, it might be possible to use the same space for both hydropower and solar power generation, increasing the synergistic effects of large scale (reservoir and pumped storage type as well as regular non-power generating reservoir facilities) hydropower. The use of this type of technology could also potentially work as insulation to a certain degree, causing a decrease in water evaporation of the reservoir water[105].

Hydropower holds many benefits, which can explain why it has been so popular in history and still holds a very important role in the global energy mix.

[102] It is of course important to take into account the economic feasibility of these refurbishments or upgrades.
[103] IEA (2010)
[104] http://www.kepco.co.jp/energy_supply/energy/newenergy/water/shikumi/index.html
[105] Hartzell (2016), p 15

2.1.1. Costs

"Without access to reliable information on the relative costs and benefits of renewable energy technologies it is difficult, If not impossible, for governments to arrive at an accurate assessment of which renewable energy technologies are the most appropriate for their particular circumstances.[106] *"*

Contrary to other technologies, the investment costs for both large-scale as well as medium- and small-scale hydropower largely originate from the initial investment costs. Investment costs and return on investment also widely differ depending on the country in which the project is being installed, the size of the reservoir in case of the installation of a reservoir, and whether there already exists one or not, on the project scale and the power use of the project which will further determine the technology to be installed, and on other benefiting factors such as flood control mechanisms, fresh water supply, irrigation etc.[107]

Because of all these initial investments, as also reported by a report by the IEA, depending on the economic feasibility of certain sites, it might be more beneficial to revert to a refurbishment or upgrade of an existing older facility than installing a new one[108].

Table 3: Estimated Global Costs per Category and Type of Hydropower Facility

Category	Output/Unit	Storage	Power Use (Load)	Investment Costs (Million USD/MW)[109]
Small	<10 MW	ROR	Base	2-4
Medium	10-100 MW	ROR	Base	2-3
Medium	100-300 MW	Dam and Reservoir	Base and Peak	2-3
Large	> 300 MW	Dam and Reservoir	Base and Peak	< 2

Source: OECD/IEA, 2010

In discussing energy costs, several methods can be used to assess the costs of a specific RET[110]. These include:

- The equipment costs
- The total installed project cost including fixed financing costs
- The LCoE

[106] IRENA (June 2012), p 1
[107] IEA (2010), p2
[108] IEA (2010), p 2
[109] IEA (2010), p 2
[110] IRENA (June, 2012), p 1

Another way to try and objectively assess different RET is through the comparison of the capacity factor of said RET. However, while each method has its own purpose and thus its own advantage, it is always important to take into account the assumptions and indirectly related benefits that may not be included into the calculation method.

While LCoE is often a preferred way for the comparison of different RET and traditional energy technologies, LCoE does not (usually) include CO_2 prices nor does it usually include any other externalities[111]. Furthermore, comparing final LCoE for the same RET between different countries can also strongly differ due to factors such as civil works which often can not easily be further decreased due to differences in local salaries and local resources needed.

Table 4: Estimated Global Costs of Large-, Small-Scale Installations and Refurbishments/Upgrades

	Installed Costs (USD/kW)	**Operations and Maintenance Costs (% / Year of Installed Costs)**	**Capacity factor (%)**	**Levelised Cost of Electricity (2010 USD/kWh)**
Large	1050 – 7650	2 – 2,5	25 to 90	0,02 – 0,19
Small	1300 – 8000	1 – 4	20 to 95	0,02 – 0,27
Refurbishment/Upgrade	500 – 1000	1 – 6		0,01 – 0,05[112]

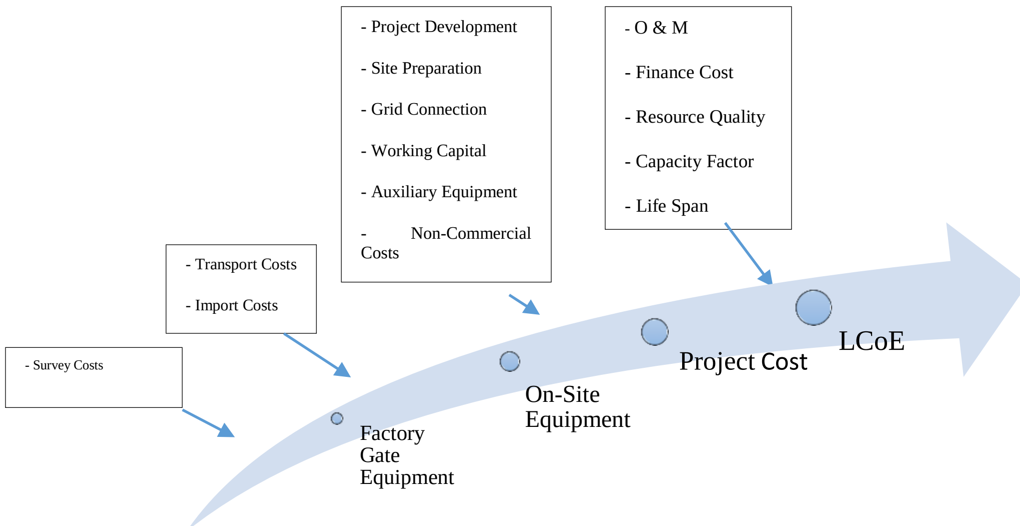
LCoE also usually does not include beneficial financial support systems set up by local governments aimed at promoting the deployment increase of a certain RET such as some of the many subsidies and incentives programs that exist in Japan (for local communities wanting) to install (small) hydro facilities.

A significant bottleneck in hydropower projects is the large scale of civil works costs associated to the installation, which represents a big burden on the initial fixed costs. This capital-intensive aspect, combined with relatively low O&M costs, no fuel costs and a long lifecycle make these projects especially sensitive to investment costs and to interest rates, even more so than other RET projects[113].

Unlike the hydro turbines, civil works are by nature difficult to make more efficient, making it difficult to diminish their percentage cost on a project. Due to the necessity of high amounts of civil works for most types of hydropower generating projects, and high initial costs related to these civil works, larger scale hydropower projects were more economically beneficial on this front as well, depending on the location.[114] In Japan this translates to 60% of installation costs consisting of the civil works for ROR hydropower projects[115].

[111] IRENA (June 2012), p 2
[112] Assuming a 10% CC
[113] IRENA (June 2012), p 31
[114] IRENA (June 2012), p
[115] Ishida (June 22, 2016)

Furthermore, as hydropower projects are subject to longer lead times, with high initial costs, while O&M costs and fuel costs are relatively cheaper than other fuel resources', hydropower projects are also very sensitive to investment costs and thus to interest rates. It is therefore of high interest to decrease the lead time by as much as possible in order to decrease this investment risk due to the volatility of the market.



[116]

$$\text{LCoE} = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

I_t = Investment Expenditures in Year t　　E_t = Electricity Generation in Year t

M_t = O & M Expenditures in Year t　　r = Discount Rate

F_t = Fuel Expenditures in Year t　　n = Economic Life Cycle of the System

Similar to other technologies, the total LCoE of hydropower in Japan on average is higher than in many other countries due to, amongst other things, the higher civil works costs, but also due to the O&M costs costs related to the grid connection, site surveys and most importantly due to the higher costs in domestic hydropower generating turbines. In the next chart table you can see an overview from the NEDO showing examples of power plants in the world and in Japan with certain outputs and their estimated costs.

[116] IRENA (June 2012), p 2

Table 5: Estimated Costs of Hydropower Plants in the World and Japan

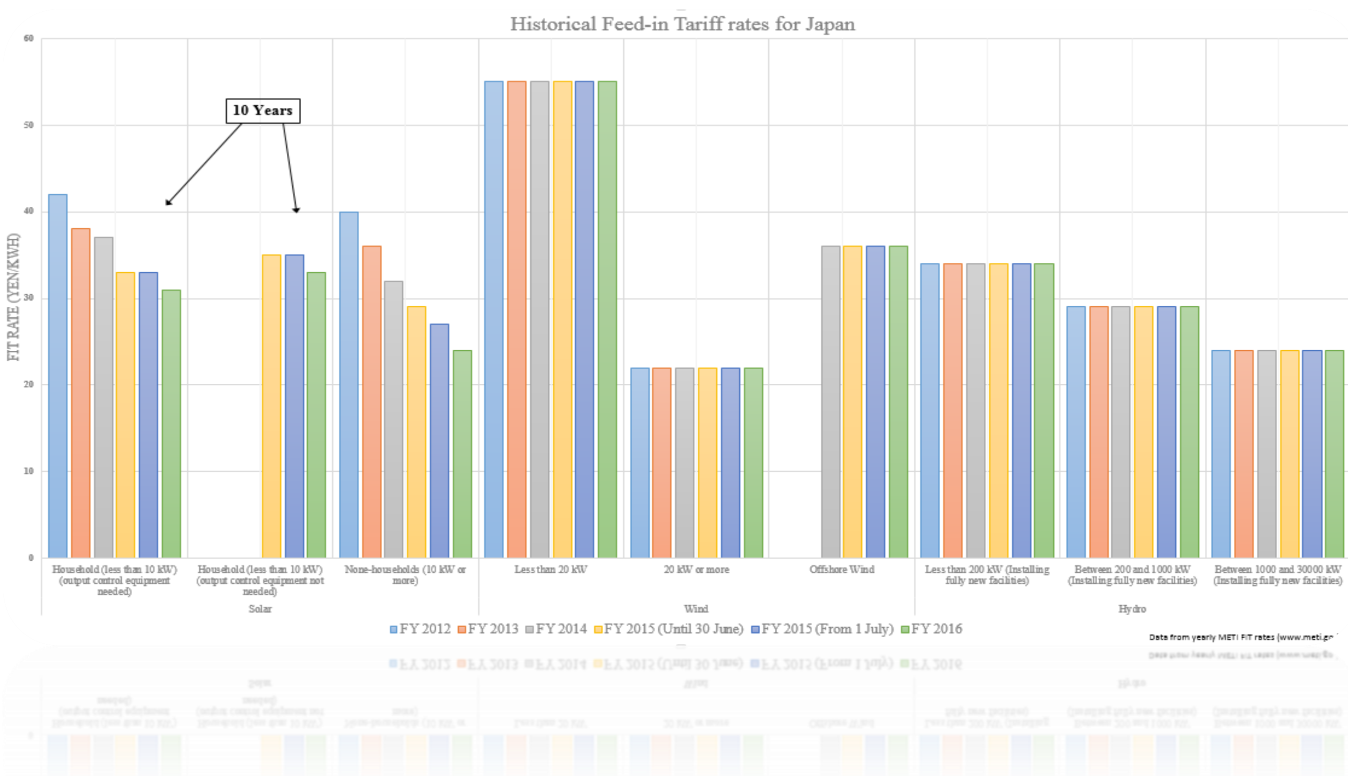
Hydro Energy Output of Sample Facility	Estimated Building Costs	Estimated Generation Costs	Sample Region
100 kW-300 MW (Small & Medium)	2000-4000 Dollar/kW	5-10 Cents/kWh	World
Over 300 MW (Large)	1000-2000 Dollar/kW	1,8-10 Cents/kWh	
200 kW	800000-1000000 Yen/kW	19,1-22 Yen/kWh	Japan
12 MW	850000 Yen/ kW	10,6 Yen/kWh	

Source: NEDO (2013)

2.1.2. Feed-in-Tariff

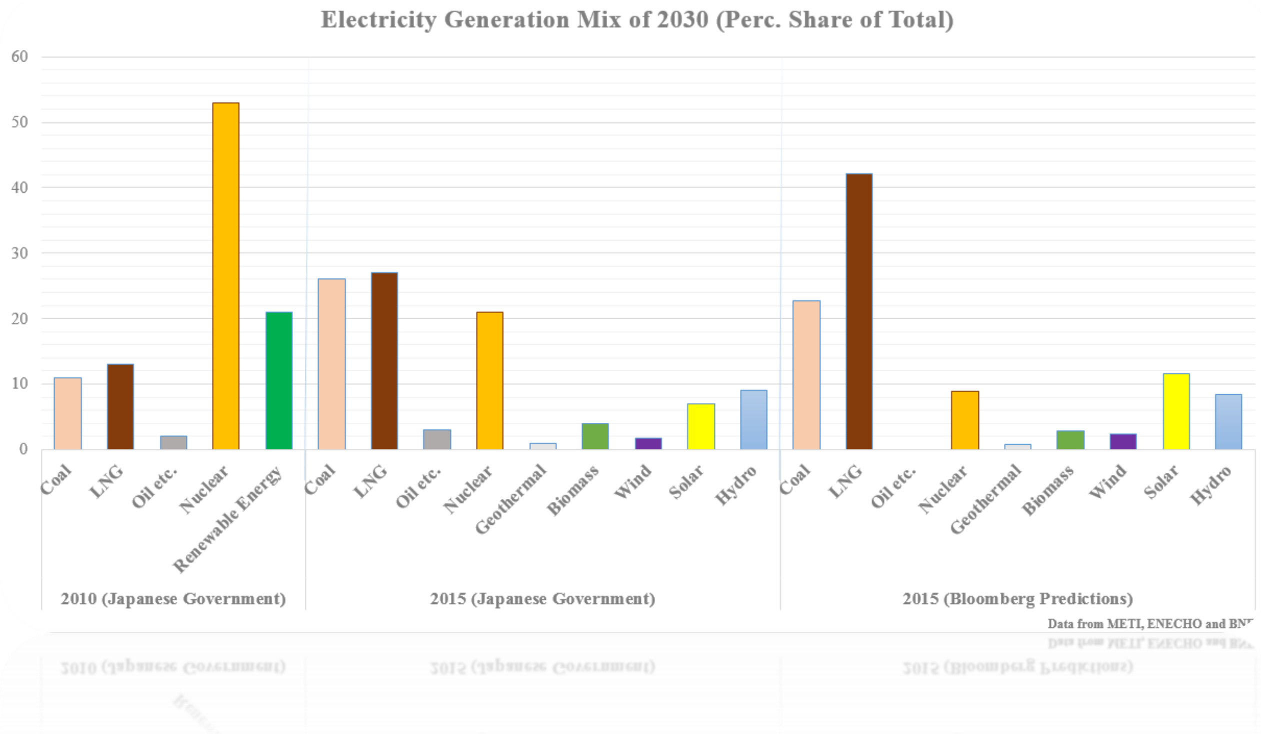
Before converting to the current FIT system, Japan had implemented the so-called RPS system in 2003. Starting from 2009, Japan also further introduced a ‘surplus electricity purchase system’, which effectively helped jumpstart the share of solar PV energy in the Japanese electricity grid[117].

In July 2012, the Japanese government switched from the RPS system to the globally frequently used FIT system. With this, the Japanese utilities were required to buy the generated renewable energy from any FIT-approved supplier at a fixed rate, for a fixed amount of time. This monetary-policy, contrary to the quota-based system that was the RPS, has shown enormous growth for certain RE and has resulted in a general increase in the amount of RES in the Japanese energy mix.



However, as is the case for many other countries that had adopted the FIT system, this system also comes with a plethora of imperfections. And as previous research has shown, the importance of the FIT tariff and related support schemes to the implementation of RES should not be overlooked, making it important to get the FIT system just right.

[117] ENECHO (July 2012), p 1



Furthermore, in order to achieve the goal set by the Japanese government in 2015 for their 2030 energy mix; 22-24% of total energy output produced by renewable energy, being an island country with low resources, its number one goal for many decades now has been to attain a higher self-sufficiency rate.

However, with the 2011 Fukushima disaster, this goal has also been joined with the goal of achieving a safe and stable power supply through the implementation of multiple layers[118] in the energy mix, while at the same time achieving a diversified, yet low cost energy supply mix which is based on economic efficiency and adjustability to the environment[119].

A paper released by the Japanese government in 2015, the Long-term Energy Supply and Demand Outlook, reveals the government's new goal of reaching 22 to 24% of renewable energy (To put in perspective: in 2015 the total of electric output generated from renewables was at 12.2%, or 3.2% without counting hydropower) by 2030, so fine-tuning the FIT system has been a big priority of the Japanese government.

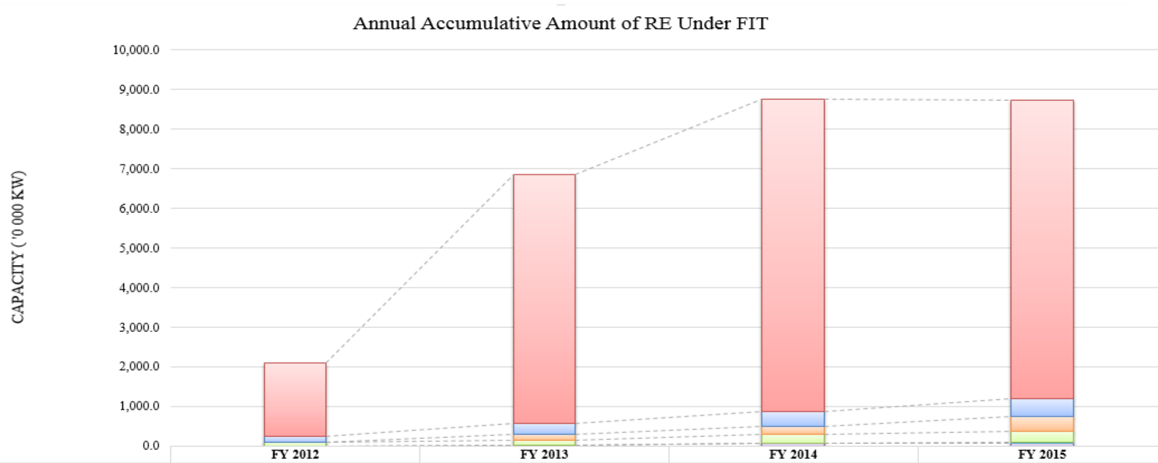
Previous research has shown the importance of support schemes such as the FIT system to increase the amount of renewable energy integrated into a country's electricity grid, but the sudden increase of renewable energy and misuse of the apparent flaws in early years, has made the subsequent total RE purchase cost increase greatly inflate the financial burden on the consumers' side as the major utilities have been passing on the FIT costs to the consumer side[120].

[118] METI (July 2015), p 1
[119] METI (July 2015), p 1
[120] Japan Times (September 27, 2015)

Depending on the region the additional cost coming from the FIT rate can vary significantly[121], and while the global decrease in the LNG and other's fossil fuel sources' purchase price showed a general decrease in electricity prices in April[122], May saw increases of 123 yen for the monthly bill of an average household getting their electricity from Kyuden, compared to 49 yen to TEPCO customers in the Tokyo area[123]. The Japanese government's ultimate goal is to increase the renewable energy share, but implemented in such a way that every resource is used in the most efficient way, and to use the freed up budget to invest in even more renewable energy implementation schemes.

Currently, the biggest source of financial burden in Japan in terms of renewable energy is solar PV. Due to the explosive growth this market has known, the costs related to solar energy have had a great impact on the financial cost increase from the FIT system. Furthermore, the early FIT rate for solar PV has increased the trend amongst certain suppliers to take advantage of the system by applying for some of the limited spots available for FIT producers, and waiting to install the promised RET until prices drop further (by September 2015, there were 700 000 solar PV producers registered for the FIT system without actually producing energy yet)[124].

In order to avoid hurting the consumers any further, Japan will be implementing changes to the FIT system next fiscal year, and will most likely continue to do so for the years to come.



	FY 2012	FY 2013	FY 2014	FY 2015
Solar PV (> 10 kW)	1,868.1	6,303.8	7,883.8	7,528.8
Solar PV (< 10 kW)	134.2	268.8	379.3	464.2
Bio Energy	19.4	156.5	202.7	370.0
Wind	79.8	104.0	229.1	283.9
Geothermal	0.4	1.4	7.1	7.6
Medium- and Small-Scale Hydro	7.1	29.8	65.6	77.6

Data from Enecho via Renewable Energy Institute (http://renewable-ei.org/statistics/fit.p

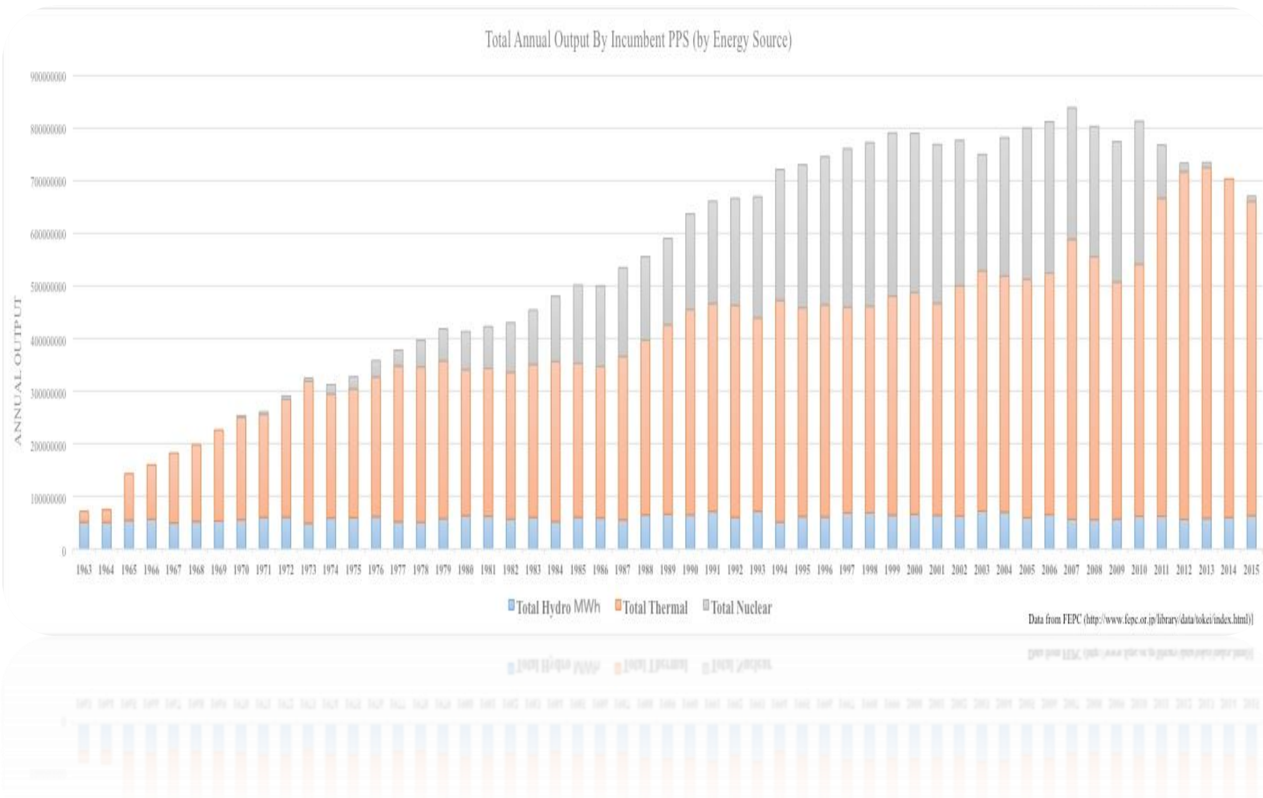
[121] This variation can be explained by the difference in the energy mix of each region in Japan.
[122] NHK Japan (April 1, 2016)
[123] NHK Japan (March 30, 2016)
[124] Japan Times (September 27, 2015)

2.2. Japan

Ever since the beginning of the Japanese electricity market, hydropower has been a very important energy resource to fuel its economy. Thanks to its characteristics as a stable source of energy, it is now being used as a complementary base load to its energy output. Up until the 1950s, however, hydropower (mainly large and medium-scale) was used as Japan's primary resource resulting in a well-developed large and medium hydro electricity market. After the 1950s, however, the focus shifted from hydro energy to thermal power, decreasing the relative rate of deployment over the years.

Contrary to Europe, which has a historically well-developed small hydro electricity market, due to its focus on mainly large hydro through history, Japan has only been active in the commercial small hydro market for roughly the past ten years.

With this in mind, it goes without saying that on the side of hydro energy deployment, the biggest potential lies in the small-(and to some extent medium-) scale hydro energy. In order to understand this market correctly, this section will be looking at the legislative aspects of this market, as well as the market demand, supply and potential.



2.2.1. Legislation

While Japan has been very reliant on large-scale hydro since its electricity market's inception in the 19th century, as we mentioned before, commercial small-scale hydro has comparatively lagged for quite a while. Therefore, unlike the large-scale hydro whose biggest hurdle lies in the financial initial investment, until recently, small hydro was also very much obstructed in its deployment on the legislation side.

2.2.1.1. Hydro Power Categorisation

Before going into the legislative details of small hydro electricity, it is important to take into account what the different categories of hydro electricity are in Japan. While hydropower is categorized in many countries as 'large', 'medium', 'small' etc., no one set of rules exists on the capacity range of these categories. This results in very different interpretations of the hydro-output categories.

In the case of Japan, when looking at the categorisation of small hydro under Japan's FIT rates, we can categorise it as any hydro-driven power source with an output smaller than 10 000kW. Meanwhile, medium-scale hydro lies between 10 000kW and 30 000 (100 000) kW. Mini Hydro is anything between 1000 kW and 100 kW and Micro is used for hydropower with an output under 100 kW[125].

2.2.1.2. Environmental Impact Assessment

While it is indeed important for a country to pursue a high self-sufficiency rate to achieve a stable and safe energy supply to become the backbone of a developed economy, negative impacts on the environment must be taken into account and any project must be justified before pursuing with its implementation.

In order to justify and assess the influence of projects such as hydropower, onshore wind power, etc. generating facility installations, these projects must be subjected to the so-called Environmental Impact Assessment (hereafter EIA) as to correctly take into account not only direct socio-economic effects, but also the environmental and indirect socio-economic impacts. The results of the EIA are then also publicly revealed to the public allowing not only professionals to objectively assess the potential problems, but for the public to also address their concerns. Ultimately, depending on the effectiveness of the EIA, this process might significantly increase the lead time of energy projects, but also help increase the public awareness as well as the public acceptance and get rid of any imperfections that might exist, for a more sustainable future.

In 1972, Japan introduced the EIA for public works, following in the U.S.A.'s footsteps after it became the first country in the world to introduce such a system in 1969. Over the following years, Japan introduced new bills and enacted new systems such as the failed 1981 "Environmental Impact Assessment Bill", the 1984 "Implementation of the Environmental Impact Assessment" and subsequent guidelines and ordinances by local governments, the 1993 Basic Environmental Law act legally recognizing the EIA to finally be enacted and implemented by 1999. Lastly, the EIA was revised in 2013 taking into account the results from the past 10 years to further improve the system.[126]

The Japanese EIA system can be summarised as follows: in order to achieve a sustainable society, EIA Law is tasked to formulate a procedure to follow on how to assess large projects' environmental impact, to reflect the results of said pre-determined assessment, in order to finally carry out the project, whilst

[125] http://www.pref.nagano.lg.jp/nochi/kurashi/ondanka/shizen/hatsuden/hatsuden.html
[126] EIA (2012), p 2

being assured of the environmental soundness of the project. Depending on the size and type of project, the applicability and extent of the EIA system and the subjected EIA method changes.

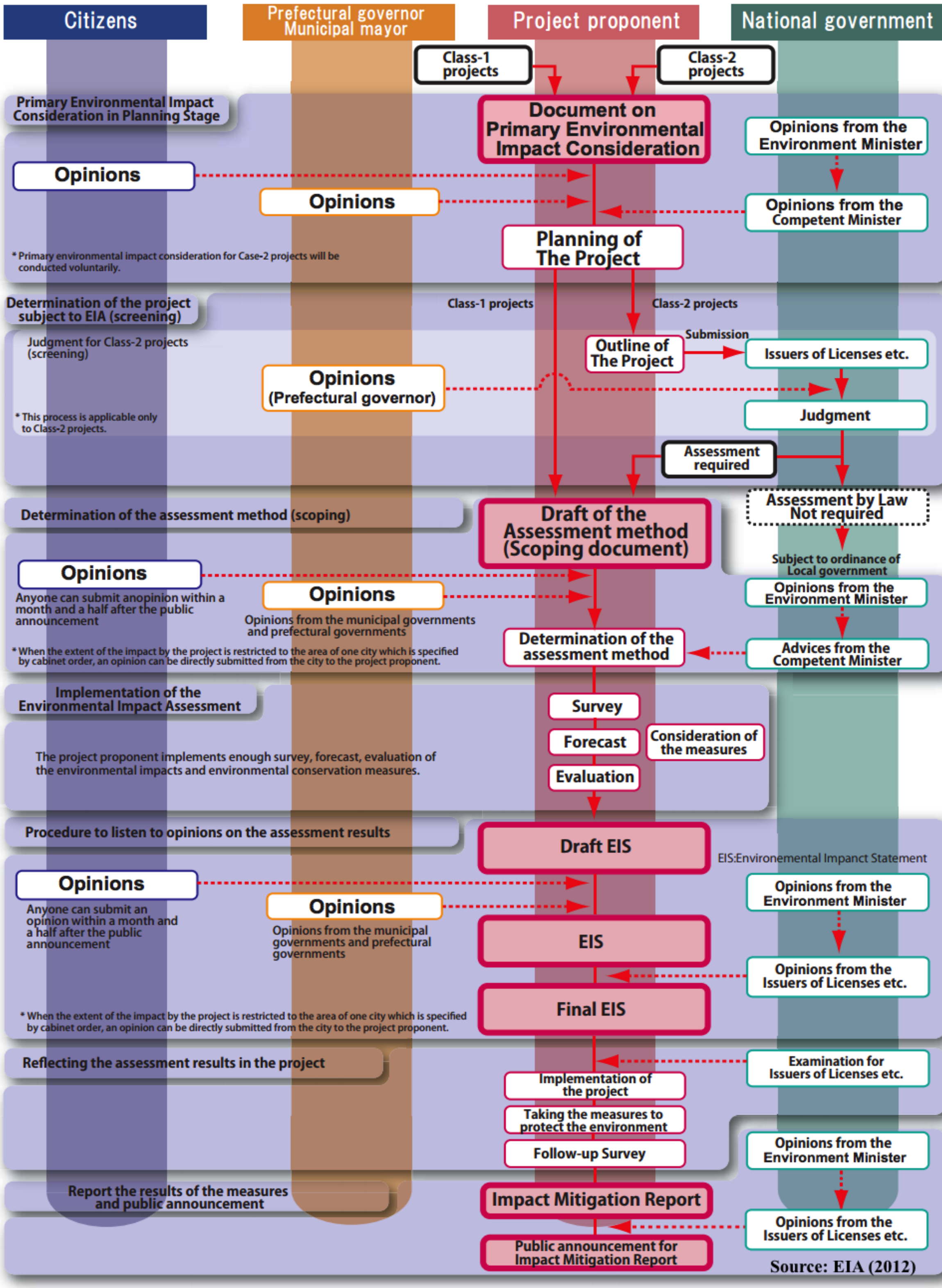
While the scale of a project primarily determines under which category a certain project falls, this is not the only considered factor. Further factors such as the level of involvement of the national government (via a subsidy or due to the need of its approval/authorisation) as well as the level of potential impact these so-called Class-2 projects might have, might make them targets of a screening process to determine whether or not to pursue an EIA. Aside from these types of projects that might involve the natural environment of certain rare animals etc., very small-scale hydro turbine installations should be exempt from such scrutiny. Medium to large-scale hydropower projects however will most likely fall under the category of either Class-1 or Class-2 projects.[127]

In the case a project falls under the EIA's range, the next step consists of drafting the assessment method. While there exist a range of assessment methods to be undertaken for certain types of projects, speeding up the process, different sites consist of different characteristics, which in turn allows for local players (citizens and local government) to include additional comments on the initial 'ready-made' assessment.[128] Once the scoping process has been passed, business projects, which have been deemed to need an EIA, will continue on with the subsequent environmental survey and data collecting to address the problems reported during the scoping process. Followed by the delivery of the Environmental Impact Statement and also follow-up surveys during and after the construction of the project.

During the entire EIA process, the opinions of local authorities, citizens as well as the relevant governmental bodies are reflected in the project. Furthermore, electricity-related projects such as the installation of power plants also need to include the opinions of the METI.

It goes without saying that considering the amount of comments to be taken into account as well as the amount of steps needed before authorization is given to start with a project can lead to longer lead times for projects such as hydro-power projects. Furthermore, while not on a national level, even small-scale projects can be subjected to local governments' additional local governments' scrutiny under the form of local EIO that can take into more consideration the projects' potential impact based on the local characteristics[129].

[127] EIA (2012), p 4-8
[128] EIA (2012), p 9
[129] EIA (2012)



Citizens
Prefectural governor
Municipal mayor
Project proponent
National government
Class-1 projects
Class-2 projects
Primary Environmental Impact Consideration in Planning Stage
Document on Primary Environmental Impact Consideration
Opinions from the Environment Minister
Opinions
Opinions
Opinions from the Competent Minister
Planning of The Project
* Primary environmental impact consideration for Case-2 projects will be conducted voluntarily.
Determination of the project subject to EIA (screening)
Class-1 projects
Class-2 projects
Judgment for Class-2 projects (screening)
Outline of The Project
Submission
Issuers of Licenses etc.
Opinions (Prefectural governor)
Judgment
* This process is applicable only to Class-2 projects.
Assessment required
Assessment by Law Not required
Determination of the assessment method (scoping)
Draft of the Assessment method (Scoping document)
Subject to ordinance of Local government
Opinions
Anyone can submit anopinion within a month and a half after the public announcement
Opinions
Opinions from the municipal governments and prefectural governments
Opinions from the Environment Minister
Determination of the assessment method
Advices from the Competent Minister
* When the extent of the impact by the project is restricted to the area of one city which is specified by cabinet order, an opinion can be directly submitted from the city to the project proponent.
Implementation of the Environmental Impact Assessment
Survey
Forecast
Consideration of the measures
Evaluation
The project proponent implements enough survey, forecast, evaluation of the environmental impacts and environmental conservation measures.
Procedure to listen to opinions on the assessment results
Draft EIS
EIS:Environemental Impanct Statement
Opinions
Anyone can submit an opinion within a month and a half after the public announcement
Opinions
Opinions from the municipal governments and prefectural governments
Opinions from the Environment Minister
EIS
Opinions from the Issuers of Licenses etc.
Final EIS
* When the extent of the impact by the project is restricted to the area of one city which is specified by cabinet order, an opinion can be directly submitted from the city to the project proponent.
Reflecting the assessment results in the project
Examination for Issuers of Licenses etc.
Implementation of the project
Taking the measures to protect the environment
Follow-up Survey
Opinions from the Environment Minister
Report the results of the measures and public announcement
Impact Mitigation Report
Opinions from the Issuers of Licenses etc.
Public announcement for Impact Mitigation Report
Source: EIA (2012)

2.2.1.3. Installation

Mountain streams, Agricultural waterways, waterworks, sewage lines, industrial water works, in-line waterways, … There are many places where hydro turbines can be installed to generate hydropower. But as with any country, the Japanese market is characterised by certain specific laws, rules and regulations to which business projects must adhere before a hydropower project can be initiated, continued and finished. Similar to any project, the first step would of course be to select a potential, and suitable, place to install the hydropower facility. In the case of Japan, the head and water flow amount differs greatly depending on the prefecture, and depending on the type of hydropower, the steps that follow will also somewhat change. Luckily, however, due to its mountainous area and heavy rainfall, Japan still holds many potential sites.

Even though the amount of rivers and economically feasible sites in Japan can range from small to high depending on the region, the possibilities, however, are plentiful. Dams, rivers, agricultural waterways, drainage systems, waterworks system… From large-scale to micro-scale hydropower, the untapped potential in Japan is still plentiful and with the constantly evolving regulations, installing new (small- to medium-scale) hydropower is becoming gradually easier and more streamlined. Nevertheless, in order to be aware of the Japanese hydropower market's peculiarities, this section will go over some of the laws and other main regulations to take into account during the installation of a small-scale hydropower plant in Japan.

As is the case for any electricity generating device, the first law to adhere to for hydro energy projects is the Electricity Business Law, including the need to submit necessary application forms to receive the approval to construct the device, the need to notify the lead engineer on a new project and the notification of the applicable safety regulations and other application forms[130][131].

With the growing high expectations towards RES such as small hydropower, the Japanese MLIT has put into motion many changes to the existing system regarding the installation of this technology. Application forms for permission of the use of water have been partially omitted depending on the type of hydropower, the MLIT has started a local consultation service for advice regarding advice for creating a small hydro project for local communities, has made the application procedure for using waterways easier and more efficient, and more.

Furthermore, as of recently, the procedure regarding the use of secondary waterways for hydropower projects has also been changed to diminish the amount of lead time spent with this kind of paperwork.

[130] http://www.meti.go.jp/committee/sankoushin/hoan/denryoku_anzen/pdf/008_02_01_02.pdf

[131] The Electricity Business Law has however been the subject of frequent changes in the past year and we thus recommend project managers to look into how any changes have translated themselves for the implementation of hydropower turbines in Japan.

River Law

The Japanese River Law ensures that Japan's abundant, but extremely valuable water resources are used comprehensively and in a manner that still allows for the maintenance of minimum downstream river flows. For years, the River Law was one of the biggest hurdle to overcome for especially small-scale hydropower project developers as the time and effort needed to comply to it was not insignificant, and similar to more economically efficient large scale hydropower projects.

In the case of the use of secondary waterways, recent changes to the River Law have made it easier to use these waterways. Together with the Water Use Application, small hydro using secondary waterways have been changed from a permissions-type to a registration-type system reducing the time needed to get approval to continue with the development of the project from 5 months to 1 month. Agricultural waterways, however, due to their importance to the local agricultural community in Japan, are still subjected to an approvals-system.

Furthermore, changes have also been made concerning the government body responsible for handing out the approvals for Class A rivers depending on the expected output, rendering also the previous need of organising an conference with concerned administrative bodies not necessary for certain case[132].

Lastly, it is also important to note that depending on the ownership of the waterway in question, the feasibility of a project can also change significantly, more specifically: even with the fiat of surrounding communities, publicly owned waterways have shown to be difficult targets to implement privately started hydropower installation projects in the past.

Others

Besides the Electricity Business Law and the River Law, other Laws, Acts and Regulations might also apply when installing a (small) hydropower turbine; below is a non-exhaustive list of some of the laws and acts that might apply depending on a certain hydropower project.

The aforementioned Water Use Application has changed very much in recent years and is very case-dependent on output, location. type of waterway etc. and we recommend any potential market entrant to look at the specifics for their turbines and target implementation sites.

- ✓ **Water Use Application[133]**
- ○ **Natural Parcs Law[134]**
- ○ **Forest Act[135]**
- ○ **Agricultural Land Act[136]**
- ○ **City Planning Act[137]**
- ○ **National Land Use Planning Act[138]**

[132] Ministry of Land, Infrastructure, Transport and Tourism - Water and Disaster Management Bureau (March 2016), p 2-4
[133] The Water Use Application which is related to the River Law.
[134] In Japanese: 自然公園法
[135] In Japanese: 森林法
[136] In Japanese: 農地法
[137] In Japanese: 都市計画法
[138] In Japanese: 国土利用計画法

2.2.2. Market

Based on the market structure and the entrants, the Japanese hydropower market can be clearly divided into two groups:

- The Large Scale Hydropower Market
- The Medium- and Small Scale Hydropower Market.

On a global scale, the hydro market only reached 19% of its full potential by 2010[139], showing a lot of room to grow, in the case of the large scale hydropower market, some sources argue that it seems to be slowly headed towards the limit of its (currently) economically feasible installation sites.

When addressing the topic of the Japanese market the general consensus from specialist and suppliers in the market on the Japanese side is that there is still a lot of room to grow on the medium and small scale hydro market, and, unlike the European market which has already reached a considerable size, this market still holds much potential for supply thanks to a trend in increasing demand in Japan in the last few years.

"What the economically feasible hydropower potential is for a given country is a moving target. The cost of alternative generation options, which sets the limit at which the LCoE of a hydropower project would be economically feasible as well as the costs of the developing hydropower projects will change over time.[140]*"*

Furthermore, with the development of new hydropower technologies and the increase in energy efficiency and decrease in technological costs, it might be possible for the market to grow even beyond those initial predictions of hydropower potential that you can see later in this chapter.

As mentioned above, the (high output medium and) large-scale hydro market has evolved to a point where the majority of its revenue would most likely come from upgrades and/or refurbishments depending on the age and state of said hydropower plant. Since the adoption of the FIT, ¾ of all FIT adopting hydro projects were done using existing facilities, with only 10% or so of projects consisting of entirely new facilities[141].

As Japan comes closer to the physical limit of potentially exploitable large scale hydropower areas[142], similar to other countries, its majority of large scale hydropower going onwards will lie in the improvement of the efficiency and capacity of already existing facilities, and to add generating capacity to non-powered dams and increasing the advanced pumped storage hydropower capacity[143]. In 2011, Japan owned a vast majority of pumped storage installations[144] with 18% of its total generation capacity being represented by it[145] [146].

[139] IEA (2010), p 2
[140] IRENA (June 2012), p 13
[141] Ishida (June 22, 2016)
[142] Akiyama (July 31, 2015), p 11
[143] IRENA (June 2012), p 15
[144] IRENA (June 2012), p 9
[145] IRENA (June 2012), p 9
[146] It is important to note that while pumped hydro storage for small-scale hydropower has been researched in the E.U., the presence of pumped hydro storage capacities in a site would make the site not a potential site to receive the profitable FIT rate.

"Refurbishments will become an increasingly important way of boosting hydropower output and adding new capacity[147]"

Nevertheless, the value of pumped hydro tends to increase as the variable RES of electricity output expands in the market[148]. Therefore, as Japan goes on to integrate more RES to its energy mix, the importance of energy storage technology, of which pumped storage for medium and large-scale hydro is a part of, will surely grow.

In the case of the medium and small-scale hydropower market, recent years have shown an increasing interest in the development of this local power resource for local communities, and with the increased steps by the government to facilitate and more the installation of this power source more efficient, it has become a potentially more viable possibility for local communities to look towards.

Compared to its European counterpart where there are a few hundred new (small) hydropower turbines being implemented per year, the Japanese medium- and small-scale hydropower market is relatively less mature and is only seeing about fifty[149] new small hydropower turbine installations per year. In 2005, the first small-scale hydropower plant in a Class A river was installed[150], and it was at the same time that the first real commercial, private small hydropower turbine manufacturing companies started to form.

With the advent of the RPS system in the mid 2000s, the spotlight was put on many comparatively new RET to attempt to increase the country's RE energy share such as Geothermal energy, Solar PV, Wind, Biomass and Small Hydro (under 1000kW)[151]. While small hydro was not entirely unknown to Japan; its long history with large (and to some smaller extent certain types of medium- and small-scale) hydro and favourable topography and weather conditions had after all given it an affinity to using hydropower, but small-hydro had until then not grown for business purposes. The introduction of the RPS was the catalyst to a slow return towards active hydropower implementation; but this time for smaller scale hydro

One of the first companies that would be implementing small hydro for business purposes are Japan Small Hydropower Co. Ltd.,"Mibugawa Denryoku", a company with a long history in hydro-electricity, bought over around the same time as the RPS was implemented in Japan, by industrial giant Marubeni Co. that effectively became a Marubeni subsidiary and is continuing to produce small scale hydropower plants for Marubeni to use[152], and current small hydro giant Tanaka Hydropower Co. Ltd.[153].

While Small Hydropower Co. was comparatively a young company, it was among the first Japanese companies[154] in the sector to form a partnership with a European company[155] to complement the lack in industrial and manufacturing expertise and increase their potential supply.

Nevertheless, according to interviews with existing Japanese small hydro companies, with the perceived recent increase in demand for small hydro machinery and limited scale of the majority of Japanese

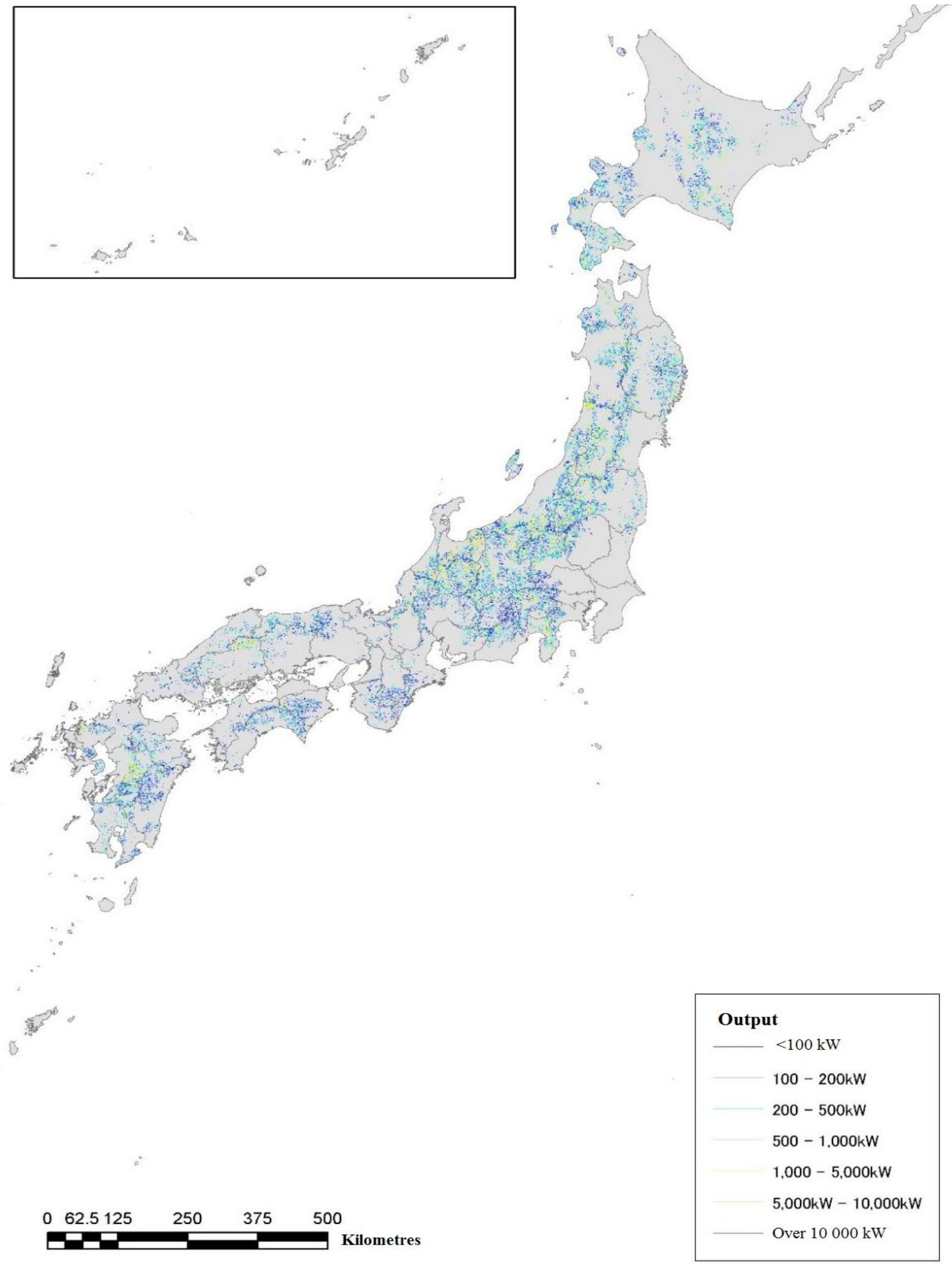
[147] IRENA (June 2012), p 21
[148] IRENA (June 2012), p 9
[149] No official numbers exist, this is an estimate given by someone from the Japanese small-scale hydropower market.
[150] Kurasaka (June 29, 2011)
[151] http://www.rps.go.jp/RPS/new-contents/top/toplink-1.html
[152] New Energy News (March 22, 2016)
[153] Similarly to Japan Small Hydropower and Mibugawa Hatsuden, around that time the aptly named "Alps Hatsuden" situated in the Toyama Prefecture was also founded.
[154] According to an interview with a representative from Mavel a.s.
[155] The European company in question is the Czech Republic company Mavel a.s. Small Hydropower

suppliers[156], increasingly more Japanese companies have been attempting to enter this market either through the manufacturing of their own machinery, as well as by partnering up with foreign companies in order to increase supply without the initial investment costs needed to perform the necessary R&D to build small hydro machinery.

Examples of the former include Kyowa Consulting and JAG Seabell and Sinfonia. These companies have already been involved in other industries, with both JAG Seabell and Kyowa Consulting having played a part in hydropower related consulting, and other electricity related markets. Meanwhile, examples of the latter can be found in the increasingly more frequent business partnerships between Japanese and European companies such as:

- Wasserkraft GmbH & Co. KG. and Okayama Densetsu Co., Ltd. (2015)[157]
  - ➢ Joint Venture WWS-JAPAN
- C-Tech and Ossberger GmbH & Co. (2015)[158]
  - ➢ Sales Agreement
- Shizen Denryoku and Gugler Water Turbines GmbH[159] (2016)
  - ➢ Non-Exclusive Sales Agreement
- Nidec a.s.
  - ➢ Increase of existing Japanese subsidiary business scope into small hydro
- Japan Small Hydropower Co. Ltd. and Cink Hydro-energy k.s. and Mavel
  - ➢ Sales Agreement

[156] While there are about one (to two) dozen (active) domestic manufacturers of hydropower turbines in Japan, the recent increase in demand and low supply potential of Japanese manufacturers has increased supply times to sometimes up to two years before supply.
[157] The result of Austrian company Wasserkraft acquiring a Japanese company to work as a subsidiary since 2015
[158] Only certain types of Ossberger's crossflow turbines on top of C-Tech's existing technology.
[159] Shizen Denryoku, originally a company focused on Solar PV energy generation, has recently also started a partnership with Austrian small hydro manufacturer Gugler to expand their business to include small hydro as well.



Geographical Distribution of Potentially Deployable Hydropower in Japan

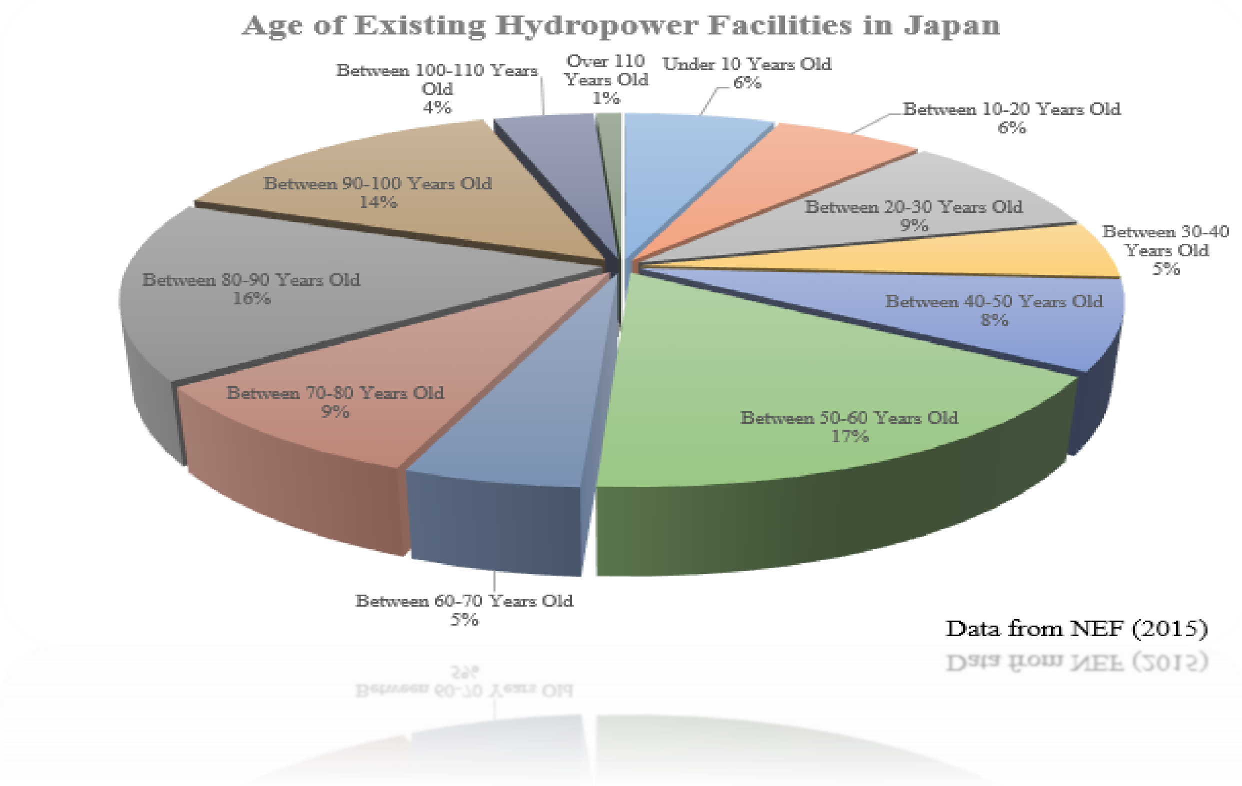
Source : MOE (2016)

2.2.2.1. Market Potential Large-Scale Hydro

As you can see from the previous figure from the MoE, Japan still holds much potential in hydroelectricity, all scales included. But with large hydropower turbines now closing in on the theoretical limit for electricity efficiency, going up to 96% for some cases when operated at best efficiency, the technical potential of efficiency growth for large hydro technology is small, however, older facilities, often have lower efficiency due to out-dated design, corrosion or cavitation damage[160] due to old age. Refurbishment of existing facilities can help extend the life of existing hydropower plants.

Of course, the costs for these refurbishments and upgrades need to be lower than the increased revenue to make this an economically viable endeavour. The exact costs are not known, and would change considerably depending on the site and degree of refurbishment or upgrade. An IRENA report mentions that refurbishments are estimated to cost at 60% of greenfield electro-mechanical costs and upgrades anywhere between that and 90%[161]. These costs are then of course also reliant on the actual costs of the turbines and ancillary equipment provided by, mostly, the domestic existing hydro manufacturer. In the case of Japan, the market for large-scale hydropower has historically been very closed off with major players including a handful of producers such as Hitachi, Fuji Electric, Mitsubishi Heavy Industries and Toshiba.

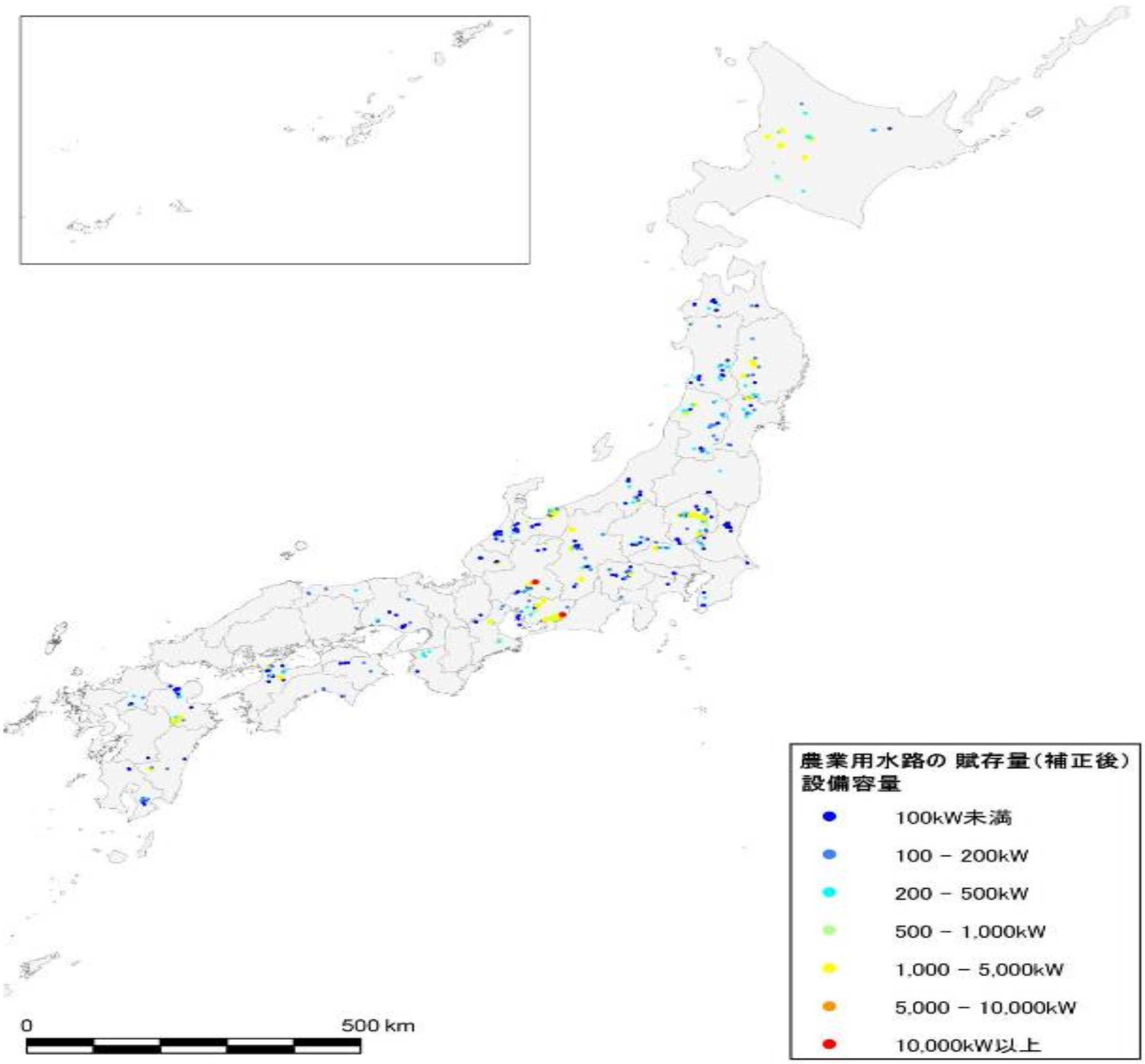
Furthermore, unlike the solar energy market and the boom in competition it has known in the past few years, new players in the large-scale market in Japan seem to be rare and for any European manufacturer interested in entering this part of the Japanese market, it will be necessary for them to work together with one of the existing Japanese market players.



[160] Kumar, A., T. Schei, et al. (2011), p 474
[161] IRENA (June 2012), p 21

Due to the large variety of industrial branches existing Japanese medium to large-scale hydropower companies are involved in[162], the possibility exists for specialised European companies to offer increased output efficiencies or comparably lower costs. Nevertheless, as one of the players in the Japanese hydro market explained, any new entrant will most likely need to show a record of previous large-scale upgrade and/or refurbishment related projects before being considered for any joint projects.

When looking at the age of existing hydropower facilities in Japan, we can indeed see that according to the NEF, more than half seem to consist of power plants aged over 50 years old, which, if economically feasible, could translate into many refurbishments and increases in capacities and efficiencies etc.



Geographical Distribution of Potential Agricultural Waterways Hydropower in Japan
Source: MOE (2011)

[162] The aforementioned Hitachi, Fuji Electric, Mitsubishi Heavy Industries and Toshiba

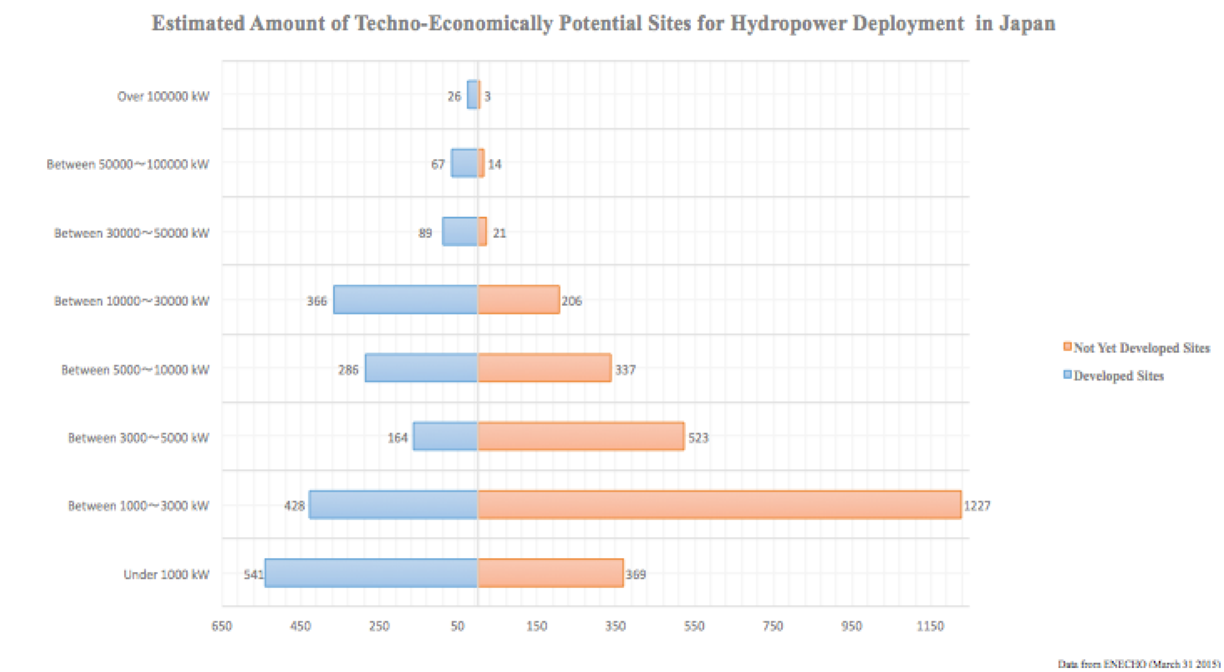
2.2.2.2. Market Potential Medium- & Small-scale Hydro

When discussing the potential of medium and scale hydro, one way to estimate this would be to look at the potential energy capacity or annual output still to be developed. Another way to determine the potential, with an eye on the business-side of the energy market would be to look at the amount of (economically feasible) sites with available streams to install any type of hydropower technology.[163]

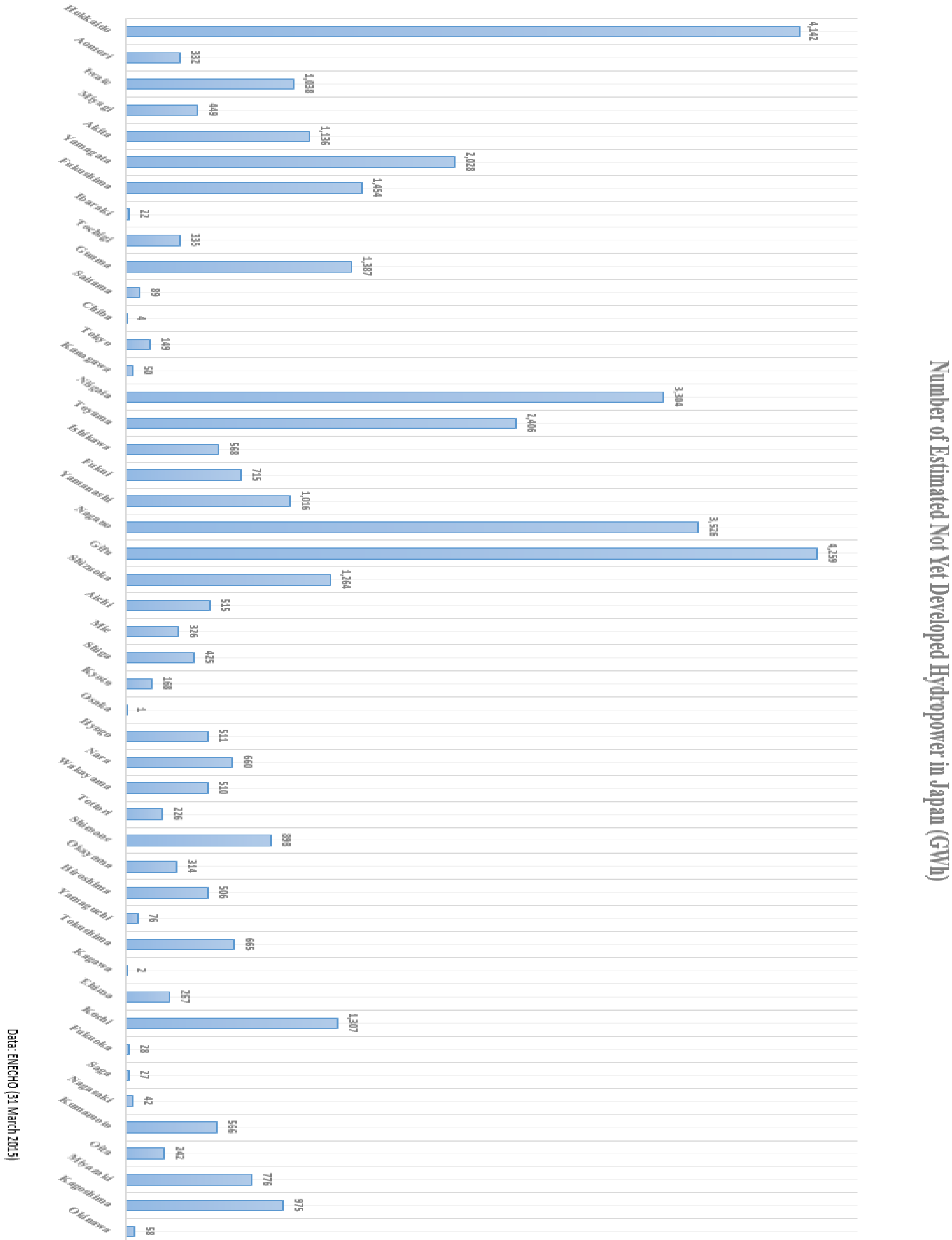
Both the Japanese MOE and METI have made their own estimations on the potentially deployable sites in Japan for hydro energy (both small, medium as well as large-scale), with very differing results. The Ministry of Environment, using GIS data, estimated that there were 24554 sites available in Japan for the installation of hydropower, incl. hydropower with a scale over 10 000 kW, for a total of 13 786 518 kW total potential output in 2014, but in 2016, using the same assumptions for economic feasibility as in 2014, resulted in finding 28 199 potential sites for a total of 9 013 664 kW[164].

In the next graph, using data from the ENECHO, you can see an overview of the estimated potential exploitable sites in Japan[165]. Based on this data, it is undeniable that Japan still holds many potential for the installation of small and medium scale hydro.

Furthermore, while Japan has mostly been actively pursuing small electricity production for business purposes since around the beginning of the RPS system in the mid-2000s, it is important to note that there are also a number medium-(and small) scale hydropower facilities that have been around in Japan for many decades already. Upgrading these facilities would not only increase their output and efficiency, but also give the possibility for them to fall under either the 'Utilizing Existing Facilities' FIT category for hydro, or the 'New Facilities' category depending on the extent of the refurbishment and/or update. This would make it possible for companies to benefit from the more beneficial FIT rates.



[163] It goes without saying that the amounts reported differ depending on the survey.
[164] MOE (March 2016), p 90
[165] Caveat: as always these are just estimates given by the Japanese Ministry of Economy, Trade and Industry and can be subjected to human error, thus either overestimating or underestimating the actual potential deployment sites. Furthermore, the way of estimating potential sites is reliant on certain assumptions (efficiency of small-scale hydropower turbines etc.) that are constantly changing, thus as the technology increases in efficiency, the amount of potential sites would also increase.



[166] Hatake (July 8, 2014)

making it possible for the town to recuperate their initial investment within a few years once the plant will be up and running again.

2.2.3. Type of Technology

Similar to Europe, Japanese hydro includes a multitude of different technology. Contrary to Europe however, active players are relatively smaller in amount and in scale and often only focused on supplying a specific type of technology and with a limited amount of total supply.

On the front of micro hydro-technology, certain Japanese companies have also been investing considerable amounts of R&D and money, sometimes at least partly funded by a public funding source, into developing hydro-powered systems fitting for closed water systems such a public waterways, buildings' ventilation cooling systems etc.[167]

Similar to their larger counterparts, the so-called 'in-line' hydropower generation systems often include high initial costs for the machines but make the potential exploitable areas higher by also including industrial sites, large buildings, public water systems and more. These systems also usually include a considerable smaller amount of civil works as long as the space surrounding the pipeline system is big enough. These kinds of micro-scale hydro systems can perfectly be integrated into the public water systems without disrupting the water flow, and installation can be timed with the refurbishment of the piping system itself to avoid any excess downtime.

An example of a publicly funded micro-hydro development project in recent years includes the system developed by Daikin. In Japan, not a lot has been happening in the development of hydropower systems under 100 kW and with low head, due to their perceived large initial fixed costs and their size. Daikin, however, has been developing a system with "half the surface"[168] of previous transverse systems.

The latest version of this Daikin Micro/Pico Hydro system is currently being tested in the city of Kobe's waterways, starting from May 2016. The goal of this project would be to install a hydro-generation system with a capacity of 10 kW or less and an annual output of 211 MWh, to be used in these types of public waterways or even industrial waterways. Daikin has previously also developed a micro-hydro system in Toyama Prefecture with an annual output of 135 MWh (22 kW), and a 75 kW model (460 MWh) in the Fukushima prefecture in 2015[169].

While these micro-hydro systems can be interesting sources of additional energy, supported by a generous FIT system and due to the high amount of potential exploitable sites in Japan alone; 1482 waterways in the country and 3160 industrial waterways[170], the costs of the system still remain high and further development and technological innovations could help decrease the initial system costs. This type of technology is also already on the market in the U.S.A.[171] and could most likely be used in European countries that are determined to achieve higher rates of renewable energy, as well as provide a stable supply of backup energy in a clean way. Other examples include the Hitachi Recovery system that also

[167] According to an anonymous source involved in the small hydro market, however, the decrease in public funding for these types of research has urged Japanese companies to look for other ways to enter this market.
[168] Daikin (2016)
[169] Daikin (2014)
[170] Daikin (2015)
[171] Vella, H. (April 10, 2013)

uses similar extremely small-scale inline hydropower system to generate energy from flowing water inside buildings[172].

2.2.4. Market Challenges

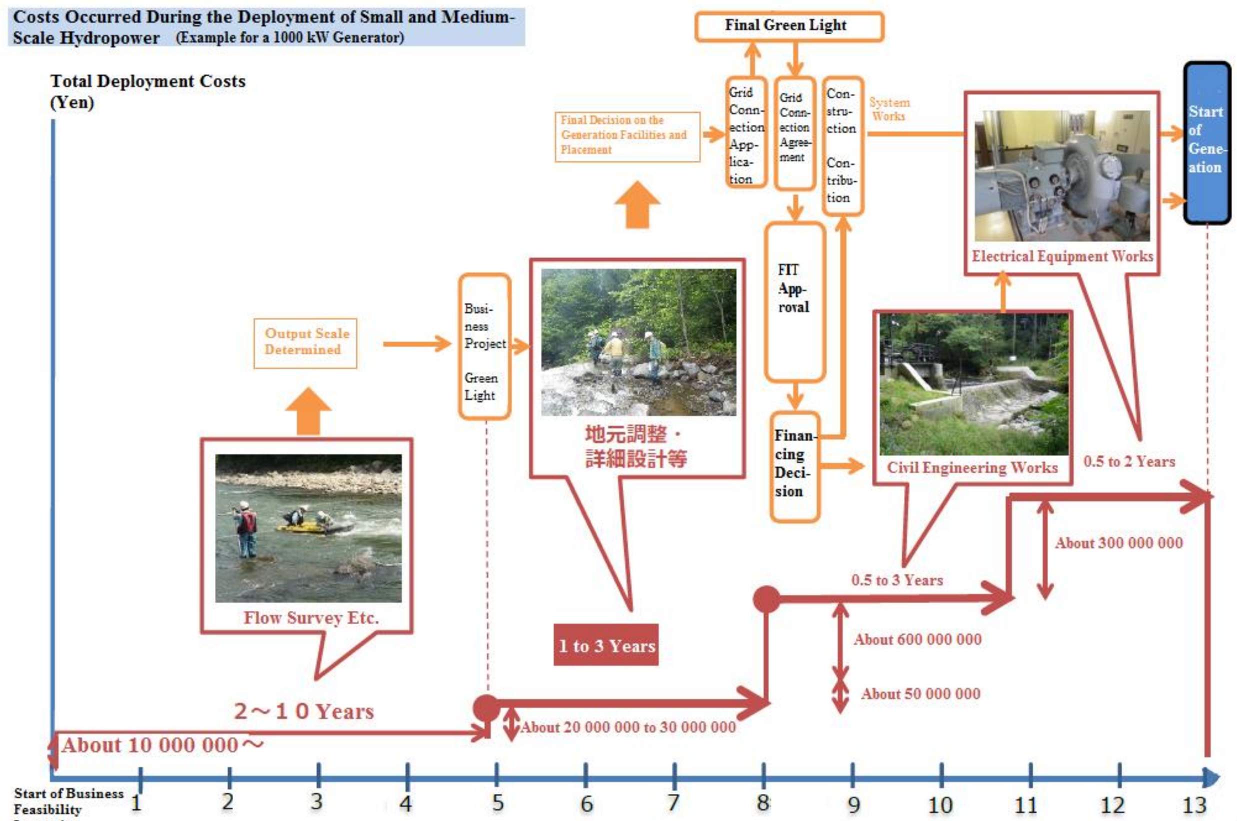
While the hydropower market in Japan has evolved since the implementation of the FIT and its generous rates for hydropower, just as with any market, the Japanese market also holds a number of challenges that need to be taken into account. As mentioned in other parts of this report, the legislative and investment climate are some of the NTBs new entrants could encounter when entering the market.

With a big majority of the **large hydro** market's potential sites already filled, and the difficulty of entering the market for new players, the biggest challenge for the large hydropower supply market would be related to overcoming the initial entry barriers and general NTBs found in many other traditionally mature markets such as this one.

Due to the somewhat closed-off nature of this market, these NTBs would be related to acquiring contacts with any of the few existing Japanese players in this market and to proving the cost-efficiency of the new entrant's technology compared to the existing technology in the Japanese market, and also to prove the reliability of the technology and the company itself.

Furthermore, while not only relevant to the large-scale hydro market but also the small- and medium-scale hydro market, a remaining problem for the hydro market is the long lead time between the start of a business project and the start of the plant's operation. A report by the Advisory Committee for Natural Resources and Energy's New Energy Subcommittee mentions that this market currently has an average lead time ranging from 4 to 18 years depending on several factors[173].

[172] http://www.hitachi.co.jp/environment/showcase/solution/industrial/micro.html
[173] ENECHO (October 20, 2015), p 9



Source: METI (translated from original Japanese)

The biggest time sinks in this process are the estimated 2-10 year long flow rate inspections undertaken to undertaken for the Water Use Application (River Law), the surveying for and calculation of feasibility of sites, as well as the local area inspection and other environmental measures undertaken due to local and national EIA, etc.[174].

Because these steps all precede the potential approval to the FIT system, this not only impacts the investment costs that can swell up over time, but might also generally increase the perceived investment risk of hydro projects in general due to the current system of FIT rate approval.

While new entrants such as Voith Fuji Hydro are aiming to become more involved in the large-scale Japanese electricity market by introducing technologically more efficient and more pumped-storage technology to existing Japanese facilities[175], the Japanese large-hydro electricity market might become more difficult to enter as times passes.

Similarly for large-scale hydro, the biggest potential issue medium and small-scale hydro market entrants could encounter is also the **investment** climate. Due to **the long lead time** of these types of projects partly due to the **Environmental Impact Assessment** and other time-consuming steps, similarly related laws, administrative grey areas, and high initial investments, small-scale hydro projects can reveal themselves to be very dependent on the generous FIT rates to become economically viable.

[174] METI (December 16, 2015)
[175] Voith Fuji Hydro K.K. (2011)

Currently, the **FIT** system enacted by the government is updated yearly giving an idea of the FIT rate for the coming fiscal year in Japan. Due to hydropower's comparatively much longer lead time, this can cause uncertainty on the actual price a company can expect to receive for its electrical output. While hydropower's FIT rates has not immensely changed in previous years, the possibility of a decrease happening currently still remains. This increases the investment risk and possibility for private sourced funding to cover the initial costs.

Due to small hydro's relative short history in Japan, **administrative NTBs** also represented a big issue that had to be surpassed by market entrants in previous years. According to an interview with a European small-hydro manufacturer who had worked together with a Japanese company to install small hydro turbines in a certain Japanese prefecture, this administrative grey zone a few years back and the then-active EIA, had caused quite some delay and problems to their project, which eventually had to be cancelled for administrative reasons. The Japanese company, a big player in other energy-related industries but a newcomer to the small hydro market, had performed all the necessary economic viability and river flow surveys needed when joining hands with said European company, but the local administration's insecurity on the matter as well as the necessary measures imposed on the two companies before being allowed to install the technology due to the nature of the rivers, had caused the project to be cancelled.

Lastly, in order to correctly assess the potential output, and most appropriate small hydro technology, data on the rivers in Japan is also needed. While it is possible for companies to perform surveys themselves or to cooperate with experienced companies to provide the needed data, this also increases the lead time of any small hydro project.

2.2.5. Market Opportunities

With the importance of renewable energy increasing as retail electricity prices are going up, the self-sufficiency rate of the Japanese energy mix staying down due to continued inactivity of nuclear power as well as the evident problems caused by imperfect renewable energy polices started in the past, the Japanese government seems more than ever adamant on continuing to improve current conditions related to all sorts of renewable energy technology. In the case of hydropower, a survey dating from 31 March, 2015, reveals that Japan still holds a vast amount of untapped sites for hydro-energy[176].

The December 2015 meeting held by the Advisory Committee for Natural Resources and Energy's New Energy Subcommittee[177] expressed their concerns towards numerous aspects related to the small hydro renewable energy market in general. The concerns uttered by the subcommittee included legislative, administrative and financial aspects that will be worked on towards the future to further facilitate the deployment of hydro-energy, a technology in which the committee is aiming for a 20% growth by 2030 to become a pillar of the future low-carbon society.[178]

With the increasing importance of RET such as hydropower to help smooth over peak energy demand and increase local production for local consumption via the use of small-scale hydropower, the Japanese government has also been continuing to allot a great amount of its budget to the promotion of hydropower development. An example of this is the MAFF's 2015 budget allotting ¥8.3 million for the financial support of small-scale hydropower deployment to alleviate the costs of the survey research, the costs incurred for the necessary training and/or payment of specialised people to help with the advisory services needed to implement a small-scale hydro project, and other costs related to the upgrade of the agricultural sewerage system of local communities[179].

Lastly, even as the Japanese hydropower market diminishes in the future, foreign hydropower turbine manufacturers in the hydropower market and the ocean energy market shared the opinion that the Japanese market is a good starting point for hydropower turbine manufacturers to be used as a hub for the purpose of business deployment to other neighbouring countries where the need and potential for hydropower is still very high. In the case of **Indonesia**, which has set the goal of adding up to 11000 MW of hydropower to its energy mix by 2028[180], Japanese hydropower turbine manufacturer Nippon Koei has started deploying part of its hydropower business to Indonesia where it will be installing 46.7 MWh of small-scale hydropower over the coming years.

[176] Cfr. The ENECHO website for more details
[177] In Japanese: 総合資源エネルギー調査会 省エネルギー・新エネルギー分科会 新エネルギー小委員会
[178] ENECHO (December 16, 2015)
[179] MAFF (2015)
[180] New Energy News (August 4, 2016)

2.2.5.1. Large-Scale Hydro

While not only restricted to large-scale hydropower facilities, but also to small- and medium-scale power plants, besides the targeted 20% growth in the hydro-market by 2030, the previously mentioned METI New Energy Subcommittee also mentions the increasingly occurring problem of hydropower facility aging. Due to the high ratio of Japan's hydropower-generating facilities having reached more than 40 years of operating time, both large, and smaller, scale water power facilities will need to be updated and/or refurbished[181]. Due to economics of scale and the sheer amount of large-scale water generating facilities in Japan, we can only assume that the most extra energy output potential, if economically feasible, would come from these large-scale hydropower plants.

電力会社名	発電所	出力（万kW）	種別	期間	定期検査の時期及び定期検査・補修等の延期が不可能な理由
北海道電力	瀬戸瀬	2.5	水力	6/27～11/24	摩耗が著しいため、発電機部品の修繕を行う必要があるため。
	下新冠	2	水力	6/1～11/30	摩耗が著しいため、発電機部品の修繕を行う必要があるため。
	新冠1号機	10	水力	3/1～12/29	運転寿命に達した発電機部品の取替を行う必要があるため。
	新冠2号機	10	水力	7/4～10/31	経年に伴い発電機の電力ケーブルの取替を行う必要があるため。
	高見1号機	10	水力	8/1～5	保安規程に基づき放水路の定期点検を実施する必要があるため。
関西電力	奥吉野1号機	20.1	揚水	3/19～7/5	同期遮断器の取替が必要であるため。
	奥多々良木1,2号機	60.6	揚水	1号機：2/27～H31.2 2号機：10/1～H29.12	深夜帯の周波数調整力対策として可変速化の工事が必要であるため。
	奥多々良木3号機	30.3	揚水	12/25～H28.11	12/25より事故復旧作業中であり、復旧資材調達や組立・試験により工期を要するため。
	黒部川第二1号機	2.4	水力	H26/9～H29/5	経年により水車発電機を取替する必要があるため。
	利賀川第一1号機	1.54	水力	5/20～10/30	侵食摩耗によりガイドベーン軸受部の取替えが必要であるため。
	利賀川第二1号機	3.17	水力	5/18～10/29	侵食摩耗によりガイドベーン軸受部の取替えが必要であるため。
北陸電力	和田川第二2号機	6	水力	5/16～8/15、 9/11～11/17	経年による変圧器取替を実施する必要があるため。
	新中地山2号機	4	水力	5/16～11/27	経年による水車・発電機のオーバーホールを行う必要があるため。
中国電力	俣野川3号機	30	揚水	H27/11～H28/7/4	経年に対応した水車・発電機の細密点検を実施する必要があるため。
九州電力	黒川第一	2.72	水力	4/14～未定	熊本地震に伴う設備被害による停止
	小丸川1号機	30	揚水	8/2～H29/3	経年による水車発電電動機解体修繕工事が必要なため。
	小丸川2号機	30	揚水	8/3～8/18	1号機の水車発電電動機解体修繕工事に伴う工事が必要なため。
	天山1号機	30	揚水	8/19～9/30	経年によるサイリスタ始動装置の取替え等が必要なため。
	天山2号機	30	揚水	8/19～9/30	経年によるサイリスタ始動装置の取替え等が必要なため。

Source: Electricity Supply-Demand Verification Subcommittee (2016)

Due to the need of efficient technology and experience to perform these types of large-scale refurbishment, European companies specialised in this type of hydropower might benefit from joining hands with the existing approved large-scale hydropower suppliers to the big regional EPCOs in an attempt to provide low-cost, high efficiency turbine upgrades to these aging facilities, e.g. two Pumped-Storage Hydropower plants have been taken offline from 1 April 2016 onwards for a "long time" due to aging after more than 40 years in service[182].

Besides the list of refurbished hydropower facilities shown in the above image, another example of such a finished refurbishment can be found in the KEPCO-owned Okutataragi Pumped-Storage Hydro Power Plant. This power plant that was originally built in 1974[183], was refurbished as to allow for variable speed operation instead of just fixed-speed.

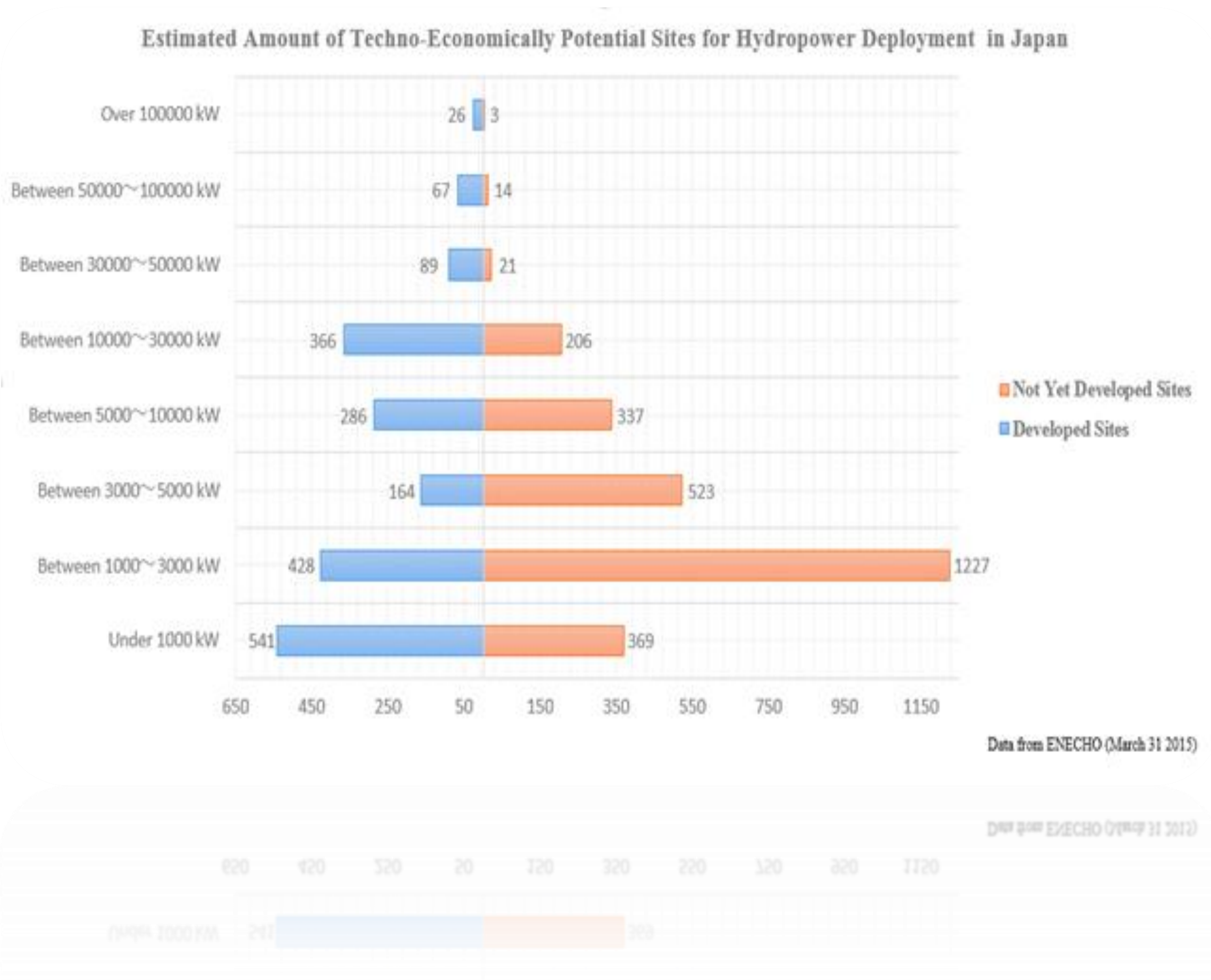
Nevertheless, with its long history in the development of large-scale hydropower, Japan has accumulated a range of experience and know-how in the sound and safe development of this technology as well as in slightly more recent hydropower innovations such as variable-speed hydropower[184]. European companies could also benefit from forming technological and research partnerships with existing Japanese companies to share experience and improve their own technology and continue advancing the potential of hydropower technology.

[181] ENECHO (December 16, 2015) p 62
[182] Electricity Supply-Demand Verification Subcommittee (2016), p 23
[183] http://www.kepco.co.jp/corporate/profile/community/himeji/images/okutataragi_a4.pdf p 2
[184] Akiyama (2015), p 12

2.2.5.2. Medium- and Small-Scale Hydro

In the previous chapter, we talked about the challenges in the Japanese market for new small hydropower market entrants. While there still are many challenges related to just the installation of small hydro and to the renewable energy market in general, as was also mentioned in the chapter about the Japanese Feed-in-Tariff, the Japanese government has made it clear they want to help increase the share of renewable energy in their energy mix towards the future. Because of this, the Japanese government is currently tackling certain pressing issues. One of these issues is the **FIT rate system**.

While the current FIT system exists as a system where its rates get renewed each year, thus only giving certainty for one fiscal year, the METI has previously announced that it would be implementing a new system based on advance notice of FIT rates for several years in advance. The system will also be changed in other ways, including the way certain solar PV electricity producers can get access to the market etc. In order to facilitate the implementation of (small) hydro projects, the Japanese government will also be making it obligatory for local authorities to release any data related to the rivers in their jurisdiction. This should effectively decrease lead time by decreasing the time needed for companies interested in installing commercial hydro power generating machines, and thus decrease the lead time of hydro power related installations in general.



Secondly, Japan is a country still filled with **untapped potential sites** in terms of small and medium-scale hydropower. As explained in previous sections, depending on the research paper, and the technology[185], the amount of economically feasible sites differs greatly. However, no matter the final number, while the share to the total electricity output might be small in comparison to other renewable energy resources, the potential for foreign supply of small-scale hydro is clear. Related to this, the Japanese government has decided to have local government bodies start surveying local rivers to analyse river flows and decrease lead times necessary to find potential deployment sites by publicly handing out this information to interested companies.

Thirdly, Japan offers many funds for the development of small and medium hydro projects[186]. The presence of so many ways to co-cover the initial costs is also related to the **change** that is **happening within Japan** itself. While Japan, as is the case for other western countries as well, has been focused on building a centralized energy grid, recent trends and METI papers have shown that the market will increasingly evolve towards a localised grid system in the long-term, which is where local power supply and consistent power baseload will become increasingly more important.

Here, the Japanese concepts of *Chisan Chisho*[187], *Chiho Zosei*[188] and *Chiho Fukkatsu*[189] are increasingly making an appearance in Japanese local communities. *Chisan Chisho* refers to the local production of a good, to be used locally, a concept similar to *Chisan Zosei*. *Chiho Fukkatsu* refers to the activities aimed at reinvigorating the Japanese localities that have increasingly become left behind for industrially more active cities. In order to try to achieve these three aspects, local communities have increasingly started to initiate the deployment of small hydropower in the hopes of attracting more business and reinvigorate the community[190]. An example of these aspects can be found in the previously mentioned 'Stadtwerke'.

This sentiment is also shared by the Japanese government as can be noted from the "Cabinet Decision on the Bill on the Partial Revision of the Act on Special Measures Concerning Procurement of Electricity from Renewable Energy Sources by Electricity Utilities" released in February 2016[191]. As RE integration increases over time, the share of RES has balanced more towards business-use RET. In order to increase the amount of RES from and for local communities, it is thus important for the government to effectively take care of the remaining impediments making it hard for implementation of non-business-scale RET such as small hydro.

Thanks to the different types of funding mentioned earlier, local communities also have found more financial security when attempting these types of projects, thus effectively increasing the local demand for small hydro. Many communities in Japan unfortunately only have sites with very low water heights, which is where companies such as the new entrant Kyowa Consulting come in, specialising at the moment in only one type of small-hydro power machine specifically aimed at sites with those very low head.

Lastly, it is worth reiterating that European small-scale hydro turbines are said to have a considerable cost- and efficiency-advantage over Japanese companies' turbines. The average cost of turbines in Japan, according to sources well-informed on both the European and Japanese market, can go up to almost **double or triple the price** for an equivalent turbine depending on factors such as output kW, turbine type

[185] Medium-, Large- or Small-scale hydropower. Low, Very-Low or other types of Head etc.
[186] Ishida (June 22, 2016)
[187] In Japanese: 地産地消
[188] In Japanese: 地方創生
[189] In Japanese: 地方復活
[190] Nonomura (2014), p 42
[191] ENECHO (February 9, 2016)

etc. While this price does not include shipping, import costs etc. encountered for European turbine exports, especially for smaller scale turbines, the price difference can more than make up for the additional costs.

> *"Europe is a market leader in small hydropower technology and it is the second highest contributor to the European Renewable Energy Mix. The EC's renewable energy roadmap identifies small hydropower as an important ingredient in the EU future's energy mix."* [192]

Furthermore, as mentioned before, due to their size Japanese small hydro manufacturers are only capable of producing a small amount of turbines every year, and waiting times in Japan can go up to two years depending on the manufacturer, making European producers with cost-advantages and faster delivery times extremely attractive to potential Japanese customers.

To conclude, the Japanese small hydropower market holds much current and even more future potential for European manufacturers interested in both setting up their own subsidiary or a joint venture in Japan, as well as for cost-effective manufacturers interested in solely exporting their turbines.

Nevertheless, it is important for these manufacturers to make the first step in the Japanese market and actively represent themselves at renewable energy events, consortia, small hydro associations to make the necessary contacts and get potential customers interested who might not be well-informed enough to know the advantages European companies hold over their Japanese counterparts.

[192] IRENA (June 2012), p 16

2.2.6. Technological and Research Opportunities

"Although hydropower technologies are mature, technological innovation and R&D into variable-speed generation technology, efficient tunnelling techniques, integrated river basin management, hydrokinetic silt erosion resistant materials and environmental issues will provide continuous improvement of environmental performances, and in many cases, cost reductions. [193] *"*

Hydropower has been around in Japan since almost as soon as the electricity market has been created and has evolved to a point that the large-scale hydropower electricity market will be relying mostly on refurbishments and upgrades if no additional large-scale dams and similar civil works are set to be put into place. In Europe, both large scale and medium and small-scale hydropower have also very much advanced over the past decades. Nevertheless, there still remain opportunities for technological and research collaborations between Japan and the EU in this field.

Even with the level of maturity of hydropower in Japan, Japanese manufacturers are still invested in researching technology to increase hydropower efficiency, decrease costs and thus make the deployment of hydropower turbines on all scales increasingly interesting. As technology progresses, so will the potential economic feasibility for hydropower development. As mentioned in the previous chapter, Japan is a country that has proven to be an effective environment for innovation and technology, and European hydropower researchers would benefit greatly from partnering up with researchers or existing Japanese hydropower manufacturers to work on solving the many remaining problems and inefficiencies left to be addressed.

On the European side, hydropower and the improvement of the field has been a continuing interest, and has made available in the past via the Horizon 2020 programme calls related to the upgrade of existing hydro dams with pumped hydro and also further research going into low head hydropower.

Topic	Date	Description
Hydrolowhead: PROFITABLE LOW HEAD HYROPOWER[194]	**2015-11-01 to 2017-06-30**	"Small hydro energy plays a key role in power generation worldwide, but installing conventional turbines at a micro level is currently not very attractive because of the large initial investment and their low efficiency. The project participants' "regenerative variable speed control system" works at variable speed with an installation time between 1 and 2 days, reducing civil works by 80%. The pay back for the final clients (Mini-hydroelectric plants, Aquaculture Companies, Wastewater treatment plants) is 4 years. The final product is planned to be capable of generating the maximum amount of electricity with a constant efficiency (75%) and will be further used as demonstrator plant for their customers worldwide."

[193] IRENA (June 2012), p 5
[194] http://cordis.europa.eu/project/rcn/200005_en.html

HyPump: Enabling Sustainable Irrigation through Hydro-Powered Pump for Canals[195]	**2016-08-01 to 2017-01-31**	"aQysta will develop and demonstrate a large-scale system for canals that can serve the needs of irrigation communities in Europe. This will be achieved by integrating the patent-pending Barsha Pump with the Hydrostatic Pressure Wheel concept, which is up to 90% efficient, compared to only 29.6% maximum efficiency of floating waterwheels and has been successfully proven as a prototype in both lab conditions and in field. This novel HyPump system will be designed as a size-scalable concept, allowing for several variants according to the specific needs of the targeted customers in Europe, and will allow users to benefit from up to 6-times increase in agricultural yield (compared to rain-fed irrigation) and up to 70% savings on operating costs with respect to standard fuel or electric pumps. Furthermore, the proposed solution will drastically reduce the environmental footprint with respect to conventional pumps and is at least 2 times less capital intensive compared to solar alternative."
HydroKinetic-25: Commercialization of a viable and proven HydroKinetic Turbine that will harness the power of the world's rivers, canals and estuaries in a sustainable, innovative and cost-effective way.[196]	**2016-03-01 to 2016-08-31**	The HydroKinetic-25 is an innovative, hydro renewable energy device designed to harness low-carbon, reliable and affordable energy from riverine and estuarine environments. Unlike other established forms of hydropower, no height differential, or 'head' of water, is needed to generate adequate power from the flow of water. This avoids expensive and disruptive civil works. Due to its small size and ease of deployment and maintenance, this renewable energy device opens up huge new market opportunities in terms of river energy generation where it previously was not possible. As a company scaling quickly with growing global ambitions, DesignPro has a vision to bring this device to the marketplace and make a meaningful impact towards lowering carbon emissions and contributing towards improving the world's energy crisis.

[195] http://cordis.europa.eu/project/rcn/205127_en.html
[196] http://cordis.europa.eu/project/rcn/201764_en.html

Chapter 3. Marine Energy Market

3.1. Introduction

Over the past years, a lot of attention has been given to RET such as Solar PV and both onshore and offshore wind energy as energy resources of the future energy mix. Compared to the ease of implementing solar PV, other renewable energy sources are arguably less advantageous due to the comparatively higher amount of hurdles to be overcome before these alternative RET can generate income. However, as is the case with wind energy, marine energy, and more specifically tidal and wave energy, hold much global potential on both an industrial and economic point of view.

As new RET is implemented into the electricity grid, characteristics such as energy output variability and foreseeability greatly influence the ease to which a RET can[197] be effectively used into current energy power grids. As we will see in this chapter, in the case of marine energy, the drawbacks certain other RET experience are relatively smaller, making them reliable energy power sources with the potential to become as cost-effective as other more commercially advanced and mature energy sources, as we will see in this chapter.

As the marine energy market in Japan is still in its starting years, having accumulated a slight delay over its European counterpart, it is difficult to look at the prices and the market as such. However, it is possible to extrapolate information for this market by looking at the (offshore) wind energy, initial domestic marine energy projects and other energy markets as some of the challenges and opportunities are similar for this market as well.

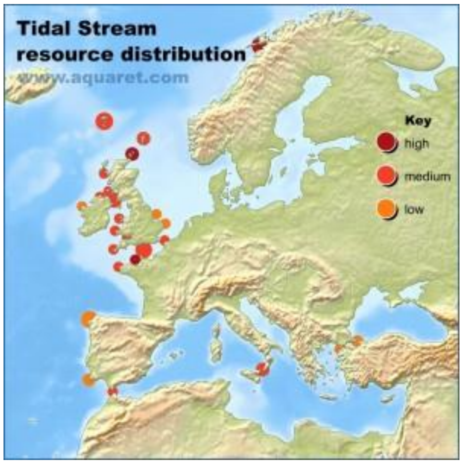
This chapter will handle on the potential of so-called marine energy, also known as ocean energy, ocean power, or even marine hydrokinetic energy and more specifically wave energy, tidal and ocean current energy in the Japanese market. As marine energy is still not as fully matured as hydro energy which was handled in the second chapter of this report, we will also review certain types of marine energy technology out there on both the Japanese and European side[198], some of the relevant legislation and a short overview of the stance on marine energy in Japan, recent trends and aspects to take into account for potential market entrants. While marine energy usually also encompasses offshore wind, ocean thermal, salinity and other energy sources, these are not part of this report's scope and will thus not be included in this chapter.[199]

[197] Currently there are still a number of barriers in the Japanese electricity grid hampering the increased use of renewables. Please refer to the previous two chapters for a more detailed explanation.

[198] Both the commercially advanced European technology as well as the early stage technology that was either developed in the past or still in the process of being developed in Japan.

[199] We urge people interested in the offshore wind energy market to refer to other reports such as the report written by former MINERVA research fellow Ines Heger, accessible via the *EU-Japan Centre of Industrial Cooperation*'s website.

3.1.1. Types of Wave Energy



One of the two[200] marine RES we will be talking about in this report is wave energy.

Waves are formed by winds blowing over the surface of the sea. The size of the waves generated will depend upon the wind speed, its duration, and the distance of water over which it blows (the fetch), bathymetry of the seafloor (which can focus or disperse the energy of the waves) and currents. The resultant movement of water carries kinetic energy, which can be harnessed by wave energy devices.

The best wave resources occur in areas where strong winds have travelled over long distances. For this reason, the best wave resources in Europe occur along the western coasts, which lie at the end of a long fetch (the Atlantic Ocean). Nearer the coastline, wave energy decreases due to friction with the seabed, therefore waves in deeper, well-exposed waters offshore will have the greatest energy.[201]

Similar to Japan's '*Sunshine Project'*, a project started by the Japanese government to promote the research of certain types of RET, wave energy started becoming the target of intensive research in the 1970's after the oil crisis caused an increased interest in alternative energy sources for energy generation. But as oil prices decreased, over times so did the interest in wave energy research, with only a small amount of actual development occurring before the 21st Century[202].

While wave energy can become somewhat variable depending on geospatial characteristics, such as the presence of other nearby wave energy generation devices, this can be diminished greatly by taking into account the spatial geography of said other wave energy generating devices, contrary to other RET such as solar PV and wind energy, research has confirmed that wave energy will not experience the same amount of variability in electricity output. [203].

As with any renewable energy source, marine energy generating technology comes in many shapes and sizes. In the case of wave energy, we can identify a few main technologies currently used and/or being developed[204]:

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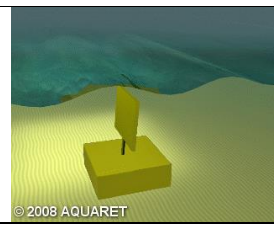
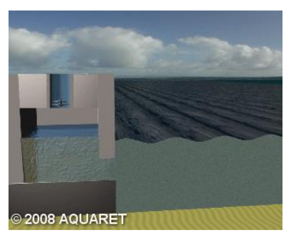
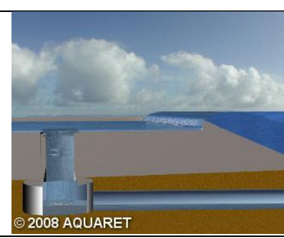
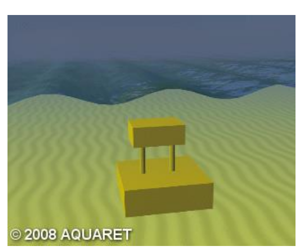
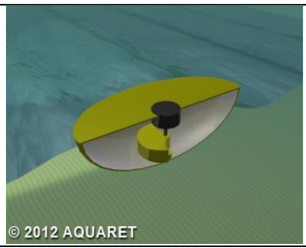
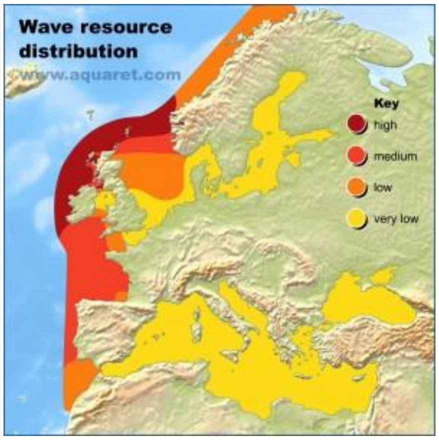
[200] Three, including ocean current energy.
[201] http://www.emec.org.uk/marine-energy/
[202] Aquaret (2008b)
[203] Oregon State University (January 7, 2015)
[204] Aquaret (2008b) and EMEC

TYPE	DESCRIPTION	IMAGE	EXAMPLE
Attenuators	Long floating devices that work perpendicular to the direction of the wave, this type of wave-generating technology ‘rides’ on the waves as it captures the energy from the motion generated between its two extremes as wave pass-by		**Pelamis** (UK)
Point Absorbers	Floating structures that absorb the energy of waves from any direction due to the vertical motion generated from waves passing from any direction. Buoy-type designs with smaller scales than other wave energy generating technologies.		**Corpower** (Sweden)
Oscillating Wave Surge Converters	Structures acting similarly to a pendulum as the arm moves with the water particles’ movement caused by wave motion on the surface.		**AW Energy** (Finland)
Oscillating Water Column (OWC)	Similar to the point absorber wave energy generating device, this technology absorbs energy produced by water entering a partially submerged hollow structure that causes the water column rise and fall, with the air on the inside compressing and decompressing. This in turn allows the air to flow and to rotate the turbine on the inside.		**Voith Hydro Wavegen** (UK)
Overtopping/Terminator Device	Similar to a reverse OWC-type wave energy-generating device, water enters a hollow storage reservoir from the top, and passes through a low-head turbine as it flows back into the sea.		**JAMSTEC** (Japan)
Submerged Pressure Differential	Attached to the seabed, the vertical motion of this submerged device caused by the movement of the waves brings a pressure differential on the inside of the device causes fluid to run through the system and generating electricity as it goes through.		**M3Wave LLC.** (USA)

Bulge Wave	Moored to the seabed as well, this tube filed with water causes pressure variations along the length of the tube creating a bulge in the tube which grows bigger, increasing in energy as it heads towards the low-head turbine at the bow, with the water returning to the sea.		**Checkmate Seaenergy UK Ltd** (UK)
Rotating Mass	The heaving and swaying caused by the movement of this device generates two forms of rotation that in turn generates energy.		**Wello OY** (Finland)
Others	These comprise devices that have a very unique and very different design from the other types of technology mentioned here.		**IHC Tidal Energy/Tocardo** (Netherlands)

3.1.2. Types of Tidal Energy

The second of the two marine RES this report will be talking about is tidal energy[205].



Tidal streams are created by the constantly changing gravitational pull of the moon and sun on the world's oceans. Tides never stop, with water moving first one way, then the other, the world over. Tidal stream technologies capture the kinetic energy of the currents flowing in and out of the tidal areas. Since the relative positions of the sun and moon can be predicted with complete accuracy, so can the resultant tide. It is this predictability that makes tidal energy such a valuable resource.

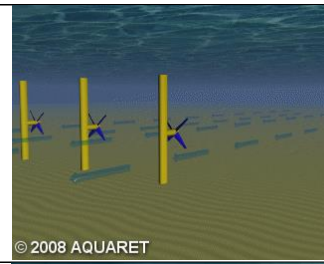
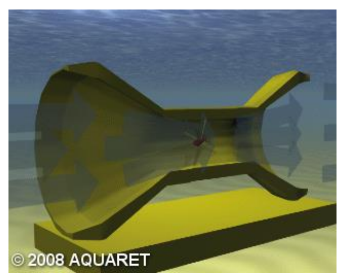
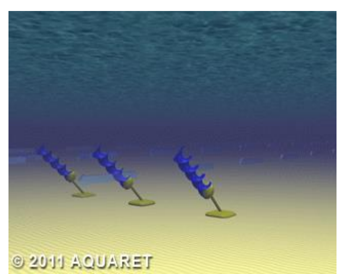
The highest (spring) tidal ranges are generated when the sun, moon and earth are in line. Water flows in greater volumes when attracted by this combined gravitational pull. The lowest (neap) tidal ranges are generated when the sun, moon and earth describe a right angle. The split gravitational pull causes water to flow in lesser volumes.
Tidal stream resources are generally largest in areas where a good tidal range exists, and where the speed of the currents are amplified by the funnelling effect of the local coastline and seabed, for example, in narrow straits and inlets, around headlands, and in channels between islands.[206]

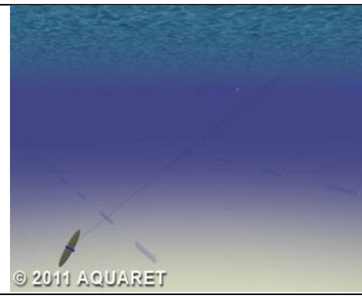
While tidal energy is not a new concept, the relatively new technology that is tidal energy, the younger brother of the marine energy family, became the object of a lot of R&D around the 1990s, and has become the most technologically advanced of the two marine energy RET described in this report[207].

As tidal energy works based on the movement of the tides, tidal energy's concept forms a big opportunity, and at the same time a big challenge, as tides in the sea and oceans, change directions twice a day. This change in movement from the tides causes a need to be able to generate energy from two directions in order to generate the most energy out of these bi-directional flows. However, similar to run-of-river hydro power, which is sometimes also counted as marine energy, tidal stream technology can also be used in rivers and ocean currents, taking into account certain differences due to the environment, which makes it possible for tidal energy generating devices to double dip into the potential energy generated of one country. Unlike tides in the sea, in the case of ocean and river tides the devices do not need to be able to accommodate the change in flow, as tides only flow in one direction in these environments.

As with any renewable energy source, tidal energy generating technology also comes in many shapes and sizes. In the case of tidal energy, we can identify a few main technologies currently used and/or being developed[208]:

[205] And to some extent ocean energy, which is further away from commercial deployment, but nonetheless similar to tidal energy.
[206] http://www.emec.org.uk/marine-energy/
[207] Aquaret (2008a)
[208] Aquaret (2008a) and EMEC

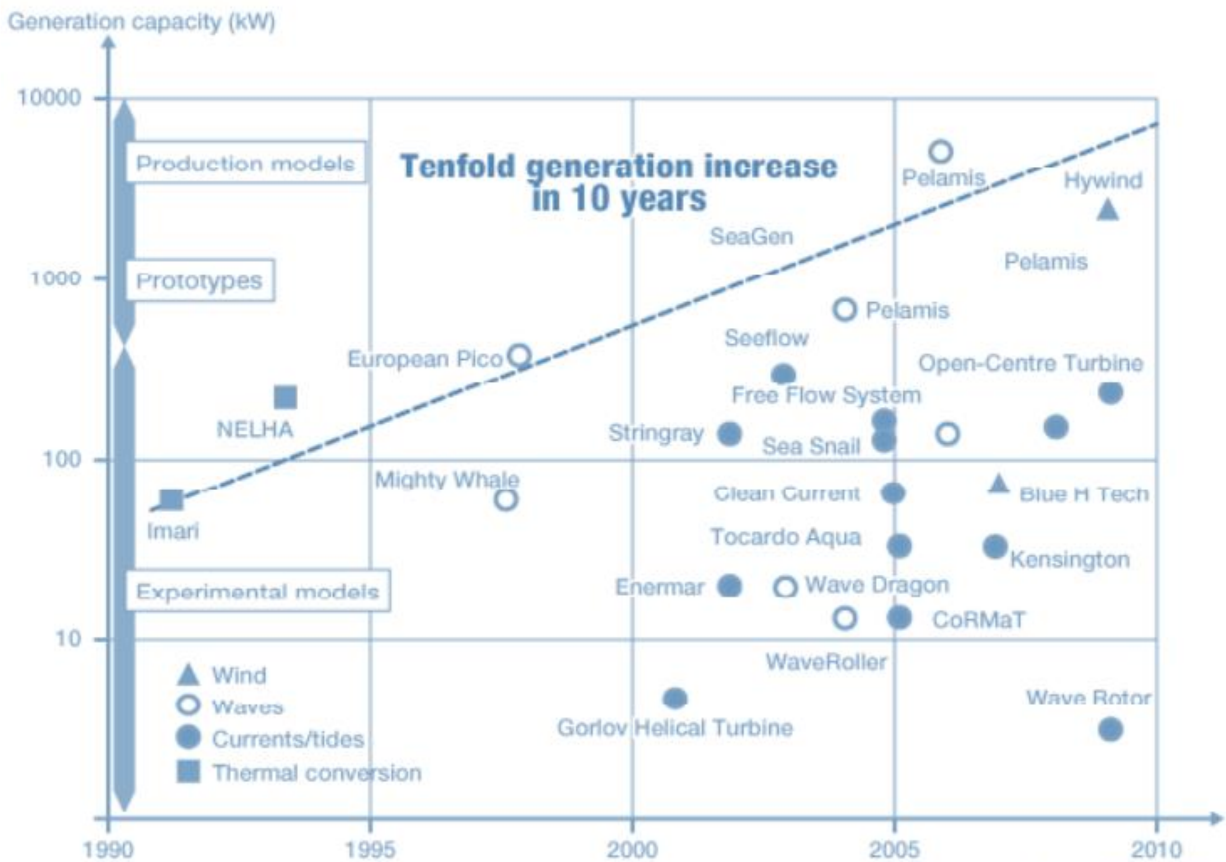
TYPE	DESCRIPTION	IMAGE	EXAMPLE
Horizontal Axis Turbine	Similar to conventional wind turbines, these devices are placed in a tidal stream causing the turbine to rotate about a horizontal axis.		**Hydro-Gen** (France) **Tocardo** (Netherlands)
Vertical Axis Turbine	Similar to their horizontal axis counterpart, a turbine is placed in a tidal stream, causing the turbine to rotate, but using a vertical axis.		**Current2Current** (UK)
Oscillating (/Reciprocating) Hydrofoil	The oscillating motion used to produce electric power is caused by the lift created by the flow of either side of a wing from the tidal stream.		**UEK Corporation** (USA)
Enclosed Tips (Venturi Effect)	This tidal energy generating device works similar to certain types of hydropower technology, as tidal flow is concentrated through a funnel-like collecting device, which causes the flow of water to turn the turbine on the inside.		**OpenHydro** (France/Ireland) **Alstom Hydro** (France)
Archimedes Screw	A helical corkscrew-shaped device that draws power from the upward movement of the tidal stream and the stream's movement through the spirals, turning their turbines.		**Flumill** (Norway)

Tidal Kite	A slightly newer design that consists of a special kite-style device mounted to the seabed, carrying a turbine below the wing, moving in a figure-eight shape, which increases the speed of the water that flows through the turbine.		**Minesto** (Sweden)
Others	These comprise devices that have a very unique and very different design from the other types of technology mentioned here.		**Tidal Sails AS** (Norway)

3.2. Marine Energy in Japan

As briefly mentioned in the previous section, marine energy is not new to Japan. After the oil crisis in the 1970s, Japan made stints in the marine energy market as well, which brought about the OTEC project Imari and the Japanese 'Mighty Whale' wave energy power conversion project which ended up also being used as a breakwater off the coast of Mie Prefecture's Gokasho Bay, but unfortunately did not reach the desired LCoE below ¥140/kWh[209]. In the meantime, foreign companies in Britain, Portugal and Norway continued with the research and development of their own systems, and many other projects followed suit.

While European marine energy power generation advances were fuelled by very long-term goals supported by dire global warming predictions, the fear of the North Sea petroleum production and the expected job creations in this field, Japan seemed to not have been influenced as much by some of these goals since we can deduce from the 2010 outlook on the country's 2030 energy supply outlook that the government was planning on increasing reliance on nuclear power, thus reducing the need for foreign fuel imports and other fuel sources greatly[210].



Source: Kinoshita T. (via nippon.com)

[209] Kinoshita (2012)
[210] Kinoshita (2012)

3.2.1. Market

Due to the technology's relative immaturity and the inexistence of an actual market similar to other RES, we will be looking at the marine energy market in Japan by analysing the estimated output potential in Japan, the interest in the technology, the business, research and industry potential as well as giving an overview of the past and present endeavours on both the private and public side of the market and examples of secondary markets with synergistic natures that can also be tapped into as the market grows.

In the next section we will be looking at the output potential for wave, tidal stream and ocean current energy in Japan. It is important to note, however, that these estimates are only as good as data that was made available for them and should thus not be seen as final due to their reliance on the assumptions backing them.

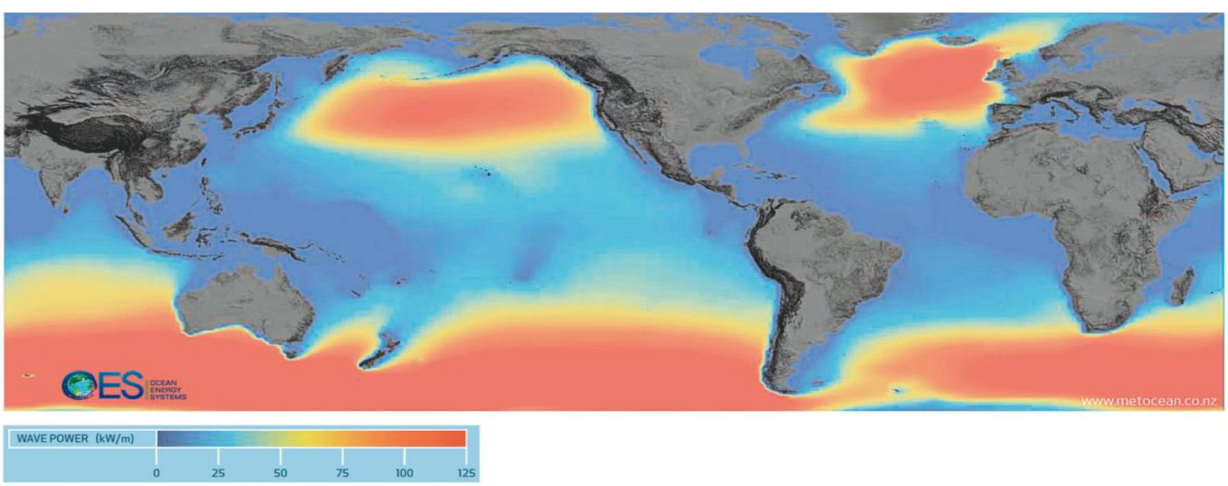
3.2.1.1. Output Potential

Based on a study performed by the NEDO[211] in 2011, we can make a first estimate on the potential for both wave and tidal stream energy in Japan. These calculations are all based on certain assumptions and externally made available data to calculate the potential generational output, but if not mistaken, it is clear that wave energy represents a bigger potential than tidal current energy. Looking at a map representing the estimated wave power on a global scale we can see that the majority seems to be concentrated around the northeastern coast of Japan.

Table 6: Wave Energy Potential Estimates in Japan

WAVE Energy POTENTIAL IN JAPAN	Physically Available Amount	Input Potential	Annual Generation Potential
Maeda, Kinoshita et al. (1979)	-	50 GW	-
Takahashi et al. (1989)	-	36 GW	-
Wave Energy Generation Review Commission	300-400 GW	-	-
NEDO (Current Technology) (2011)	195 GW (Up until 100km offshore)	5.4 GW	19 TWh
NEDO (Future Technology) (2011)		24.9 GW	87 TWh

Source: NEDO (2013)



Source: NEDO (2013)

[211] The New Energy and Industrial Technology Development Organization

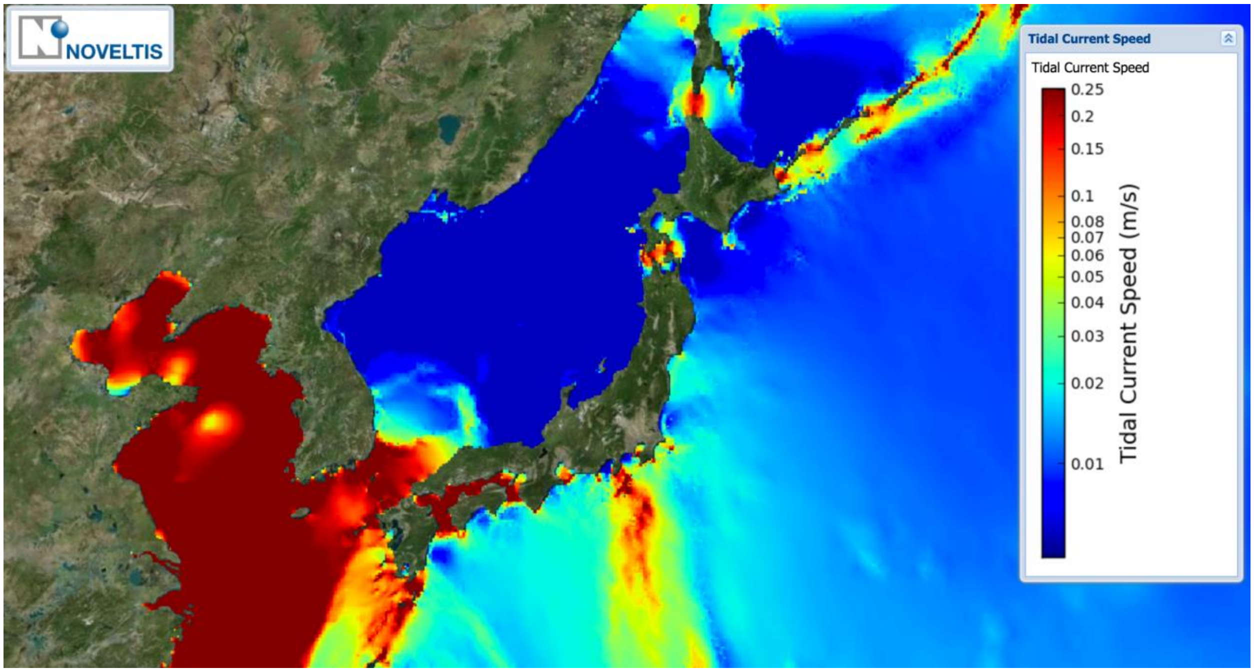
In the case of tidal energy, the generation potential is much lower than the potential for wave energy, and the potential is mostly concentrated around the southern part of Japan and other places. Nevertheless, similar to the wave energy potential calculated above by NEDO, these calculations rely heavily on available data and should be taken only as a primary estimate towards the potential marine energy in Japan.

Furthermore, with the potential for extrapolation towards ocean current energy, the development of tidal energy with an eye on using relevant experience, technology and know-how for the development of ocean current energy should also be taken into account.

Table 7: Tidal Energy Potential Estimates in Japan

TIDAL ENERGY POTENTIAL IN JAPAN	Physically Available Amount	Input Potential	Generation Potential
NEDO (Current Technology) (2011)	22 GW	1.9 GW	6TWh
NEDO (Future Technology) (2011)			

Source: NEDO (2013)



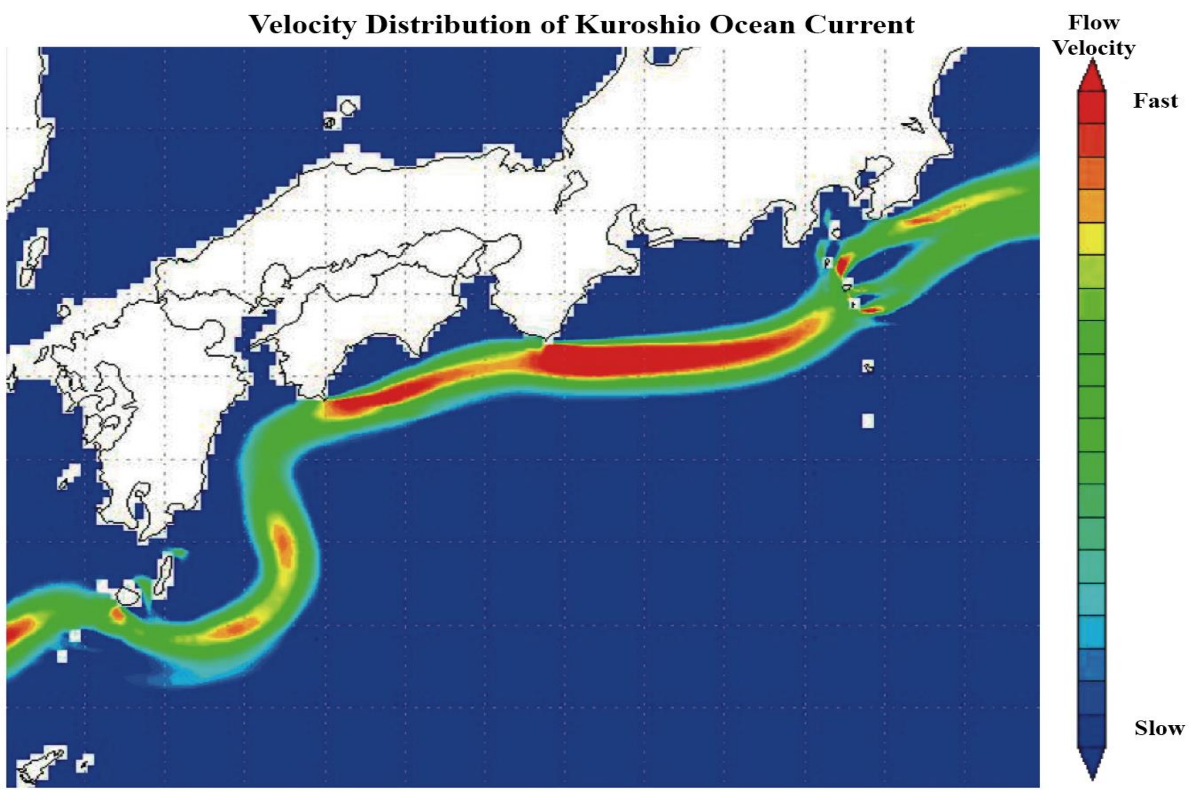
Source: NOVELTIS

In case of Ocean Current energy, the biggest estimated potential for ocean current energy in Japan is said to lie in the Kuroshio Ocean Current, which runs on the eastern side of Japan and has been the target of much research in Japan.

Table 8: Ocean Energy Potential Estimates in Japan

OCEAN CURRENT ENERGY POTENTIAL IN JAPAN	Physically Available Amount	Input Potential	Generation Potential
NEDO (Current Technology)	205 GW	1.3 GW	10 TWh
NEDO (Future Technology)			

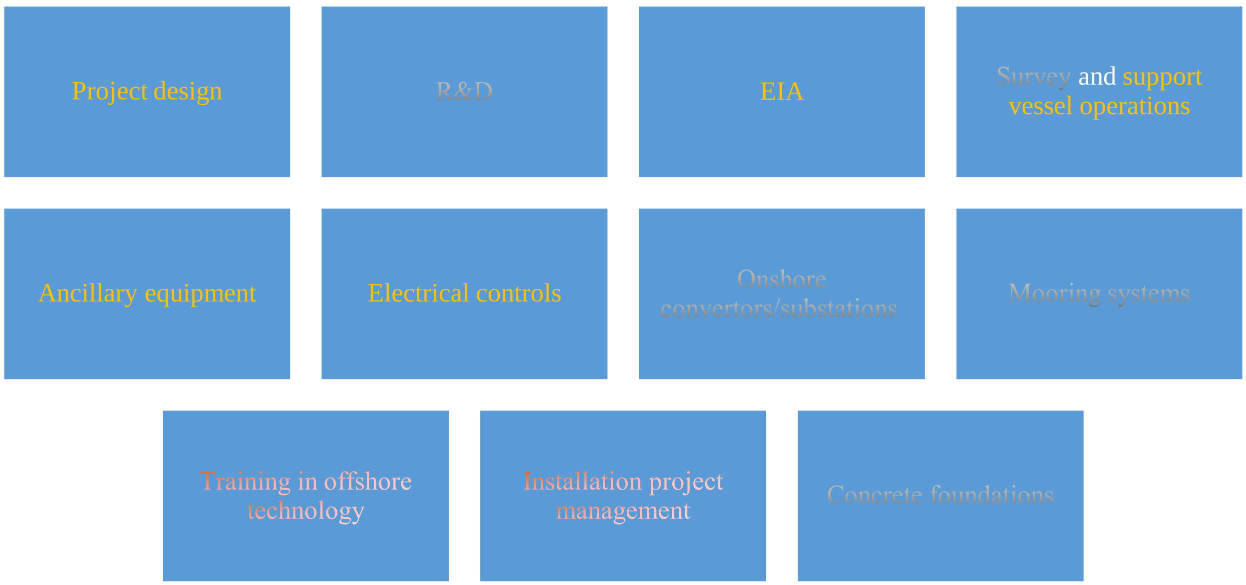
Source: NEDO (2013)



Source: Toshiba (2013)

3.2.1.2. Business, Research and Industry Potential

Due to the lack of active producers of marine energy[212] in Japan, there is currently a significant opportunity for marine energy developers to settle before the market matures. However, the lack of available funding in the form of a FIT is an important challenge in this sector. For business opportunities, Japan currently lacks enough expertise in certain parts of the marine energy supply chain. These kinks represent opportunities for both domestic and foreign companies to fill, as the Japanese market readies itself to welcome its first full-scale tidal and wave turbine (arrays) to the Japanese market.



Due to the comparative lack of experience in these types of offshore marine energy generation installations, the Japanese marine energy market supply chain contains a few kinks in different parts of the more advanced part of the supply chain such as the electrical controls, ancillary equipment, training in the offshore technology etc. The potential here would lie in offering possibilities of joint ventures and other business models to add to the existing options in the Japanese supply market. The experience of many of the established European marine energy development companies and the European field-testing sites such as the EMEC should also prove to be beneficial towards the creation of an EIA and facilitate the final deployment procedure needed to follow for future projects.

While one could argue that compared to the European output in marine energy technology, the Japanese market also lacks R&D expertise, and that Japan has not yet succeeded in achieving the development of the cost-effective tidal and wave energy turbines it was hoping to create by 2020, it is equally important to point out that the Japanese market has nonetheless shown in the past a great inclination towards high level of R&D in general and innovative ideas in marine energy technology as well. Its high-level of technological know-how and innovation would however form an opportunity for companies to work together in continuing to improve the existing technology.

[212] Besides the companies involved either in government-funded projects, the independent academia-led projects and consortia and clusters such as the NAMICPA cluster.

- ➢ Survey and support vessel operations

While not as extensive as foreign companies, from its previous projects funded by the government, we can assume that Japan has already accumulated some experience in surveying and support vessel operations and has an extensive vessel operation market. Nevertheless, the current market seems to be lacking in available cable installation vessels.

- ➢ Ancillary equipment

Japan lacks some ancillary equipment such as wave-measuring sensors, or sub water profile markers such as the ones offered by companies such as Tritec, or *North Sea Systems*'s 'Cablefish' and eventual innovative energy storage technology.

- Electrical controls and Onshore convertors/substations

Due to the high level of required know-how, certain electrical controls might need to be produced by foreign companies themselves. Electric cabling is also not yet extensively unavailable in the domestic Japanese market as far as we could find out.

- ✓ Mooring systems

As we will see later in this chapter, Japan will be handling this part of the supply chain in the upcoming MOE-funded project with OpenHydro.

- Training in offshore technology

Due to the lack of experience, foreign companies could provide the necessary training of Japanese human resources in offshore technology.

- ✓ Concrete foundations

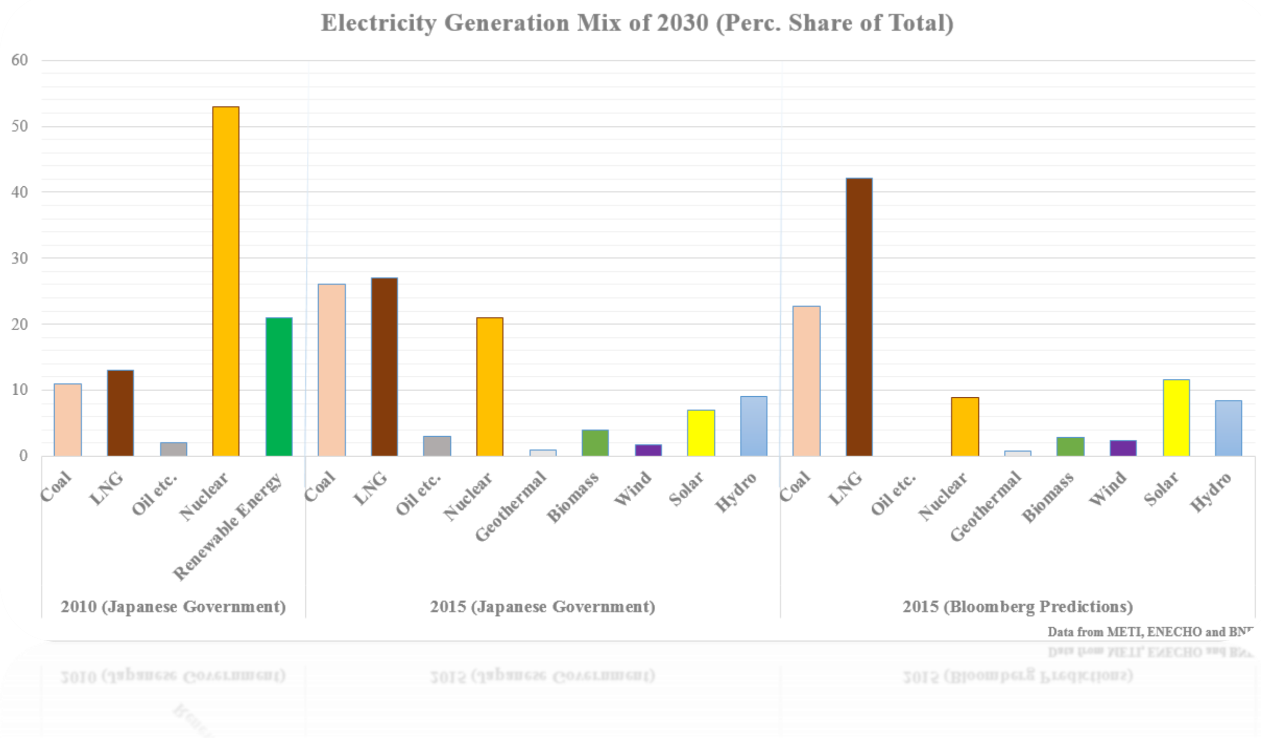
Similar to mooring systems, in the upcoming tidal turbine deployment organized by the MOE with Open Hydro, the Japanese side will be

- Installation project management

Due to the current lack of experience and know-how in the above fields in Japan, the installation project management could also represent a potential part of the supply chain for foreign companies to complement the marine energy related supply chain.

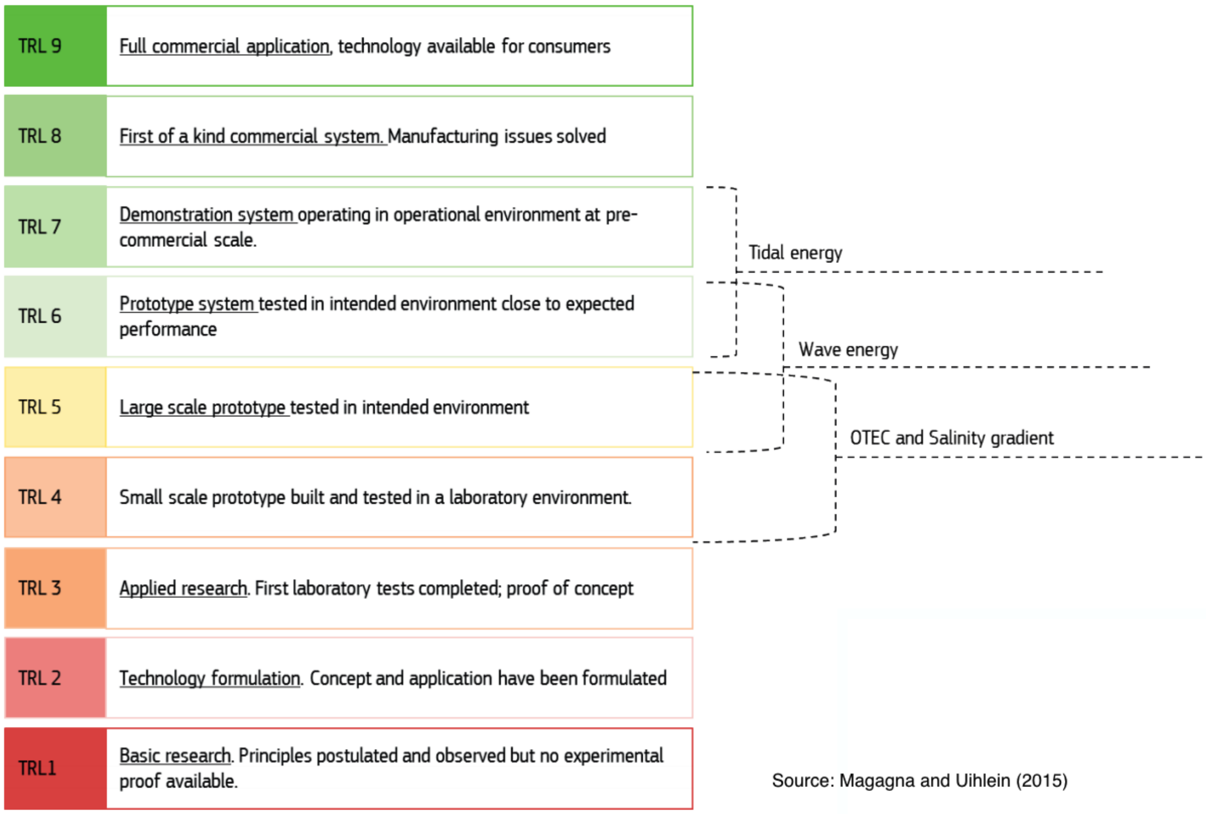
3.2.1.3. Interest

On the Japanese front, we can notice discrepancies between what the public sector interest is in ocean energy and the private sector. In the public sector, we should first point out the 2030 Energy Demand and Supply Outlook report brought out in July 2015.



This 2030 outlook that was also mentioned in a previous chapter, aimed at giving a view of the 2030 energy supply and demand as envisioned by the Japanese government, reveals no input from marine energy besides (off-shore) wind energy. While it is difficult to take into account a market that has not been created yet and that is still maturing even in foreign countries, this does not give potential market investors a good impression of the government's investment towards this sector.

Nevertheless, the government has funded many projects related to the development of domestically produced marine energy in Japan through the METI, MOE and NEDO joint projects in order to win back what some players on the Japanese market have called a delay of many years; in terms of TRL, while European technology is closing in on TRL 8-9 for certain tidal energy technologies, Japan's domestic, non offshore wind, marine energy technology is currently at TRL 4 for less than a handful government funded projects.



Source: Magagna and Uihlein (2015)

The Japanese government has also taken the necessary steps to allow for the development of marine energy through the nomination of seven potential sites made for the purpose of RD&D in the marine energy sector.

Table 9: Official Marine Energy Testing Field Sites in Japan

Prefecture	Place	Type of Energy
Niigata Prefecture	Coast of Awashimaura-mura	Ocean Current, Wave, Floating Wind
Saga Prefecture	Coast of Kabeshima, Karatsu	Tidal Stream, Floating Offshore Wind
Nagasaki Prefecture	Coast of Hisakajima, Goto	Tidal Stream
	Coast of Kabashima, Goto	Floating Offshore Wind
	Coast of Ejima and Hirashima, Saikai	Tidal Stream
Okinawa Prefecture	Coast of Kumeshima	OTEC
Iwate Prefecture	Coast of Kamaishi	Wave, Floating Wind

Source: www.kantei.go.jp

While commendable, these projects can only be described as an attempt of the Japanese industry to reinvent a wheel that has already been developed for over a decade in foreign countries. In the end, many of these projects were however not entirely successful, leaving the government to bring in foreign technology for a four-year project.

On the private sector, interest in marine energy is growing, as we can see through the creation of the NaMICPA which we will be discussing in more detail later in this chapter, and information given by an anonymous interviewee revealing that an existing electricity power supplier has come into contact with their company to buy some of their existing ready-to-be-deployed marine energy technology.

The increasing proactivity by the Ocean Energy Association – Japan, or OEAJ[213], also shows the increase in interest by a key organisation in this sector via the recently announced mission between the Embassy of the Netherlands in Tokyo and the OEAJ, from October 24 to October 27, including a special visit to the "Offshore Energy 2016" to take a look at the lay of the land in marine energy[214].

On June 9, 2016, a new academic research group was also formed called the 'Hirazuka Marine Energy Research Group', with the aim to create efficient, low-cost wave energy generating device based on a previously built prototype by Tokyo University in the Iwate Prefecture, using a ¥1 000 000 000 fund coming from private sources and using subsidy money from the government aimed at the Chiho Zosei[215]. Other noteworthy academic groups highly invested in the marine energy include the Saga University Institute of Ocean Energy that organizes many ocean energy related events

[213] The OEA-J is an organisation that aims to help build a society with sustainable energy through the development of marine energy resources, through the sharing of information, the organisation of lectures, the promotion of international cooperation, the promotion of research and business development and other related activities
[214] NOST (2016)
[215] Town News (June 16, 2016)

3.2.1.4. State of the Art: Project Pipeline

Marine energy RET have been the target of much R&D since around the first oil crisis in the 1970s. In the case of Japan, being able to harvest the potential energy of the seas could potentially bring about large amounts of electricity to a country looking to continue to grow economically would be of great economic and industrial interest. However, as the years passed, interest in the field waned and development stagnated to a point of almost standstill in the 1990s. On the opposite side lies Europe, which continued to develop technology in the field of marine energy and managed to create innovative technologies, creating a gap in the technological advancement of tidal and wave energy.

There are many challenges with ocean energy technology that are the subject of increasing RD&D effort. Some of the costs can be reduced over time by increasing scale and learning from operation; additionally, technology improvements, cheaper materials and standardized material are expected to contribute to increased cost competitiveness of the ocean energy technology. Greater improvements in reliability, capacity factors and costs are also expected to be realized within the next ten years.[216]

In Japan the majority of the more advanced marine energy related projects are lead by the MOE, METI in cooperation with the NEDO. Funding from governments are handed to the NEDO which is in charge of helping manage the individual projects lead by Japanese consortia lead by several Japanese companies.

We can identify two big groups of projects funded by the government and managed by the NEDO, with an eye on becoming part of the world leading countries developing marine energy, several projects were taken on and funded by either the METI or the MOE with the cooperation of the NEDO for the correct management of the projects.

[216] Stark, Pless et al. (February 2015), p 28

Table 10: A Non-Exhaustive List of Publicly-Funded Tidal and Ocean Energy Projects

Funding Organisation	Project Name	Generation Type	Involved Companies
NEDO - METI - MOE	Ocean Energy Generation Experimental Research Project (Experimental Research)	TIDAL	MODEC
		TIDAL	Kawasaki Heavy Industries, Okiden
		TIDAL	Oshima Shipbuilding Co. Ltd., Science Research
		OCEAN CURRENT	*IHI, Toshiba*
		OCEAN CURRENT	*Mitsubishi Heavy Industries*
		TIDAL	*Chuden, Penta Ocean Construction, Hiroshima Institute of Technology*
NEDO - METI - MOE	Next Generation Marine Energy Generation Technology Developmental Research Project (Component Research)	OCEAN CURRENT	IHI, Toshiba, Mitsui Global Strategic Studies Institute, Tokyo University
		TIDAL	Saseba Heavy Industries Co. Ltd., Tokyo University, Kyushu University
		TIDAL	Nakajima Propeller, Penta Ocean Construction, Hiroshima Institute of Technology
		TIDAL	Kyowa Consultants + 4 Organisations
		OCEAN CURRENT	Mitsubishi Heavy Industries
		TIDAL	Chuden, Penta Ocean Construction, Hiroshima Institute of Technology
MEXT	Tohoku Revival Project	TIDAL	Tokyo University
NEDO	New Energy Technology Venture Business	TIDAL	Okayama University (Associate Professor Shinji Hiejima)
MOE	Project for Promotion of Realization of Tidal Current Power Generation	TIDAL	Kawasaki Heavy Industries, Toa Corporation, Furukawa Electric Co. Ltd., Kyushu University
		TIDAL	Mitsubishi Heavy Industries

The chart above shows the majority of the tidal and ocean current energy related projects funded by a public organisation or government body. The projects in cursive are currently still active while the other projects were either given a one-time prize and thus not funded anymore in the literal sense of the word[217], or were cancelled due to not passing the desired feasibility stage-gate of the relevant project. In the case of the 'Ocean Energy Generation Experimental Research Project', the final goal was to perform experimental research towards the development of an energy system with a final potential generation cost of ¥40/kWh. In the case of the 'Next Generation Marine Energy Generation Technology Development Research Project', a group of component research projects, the goal was to perform component research to achieve component technology with a generation cost ¥20/kWh by 2020.

From what we have seen in this and previous chapters, Japan is home to an environment that encourages innovation in many fields. In the case of marine energy, despite the lack of commercial advances in the field until a few years ago, academic research towards tidal, wave and ocean current energy has been on going.

Besides the previously mentioned Saga University and Hirazuka research groups, another recent example of a non-government funded research project is a project lead by Professor Katsutoshi Shirasawa from the Okinawa Institute of Science and Technology Graduate University.

[217] Such as the Hydro-Venus tidal generation project given under the "New Energy Technology Venture Business" prize to Okayama University.

3.2.2. Legislation

As can also be made clear in the second chapter of this report, Japan is a country with very strict regulation and legislations that can form big hurdles to the ease of deployment of certain types of RES. In the case of small hydro, many laws formed challenges to the installation of this relatively young RES. However, as deployment continued, and the use and importance of these RETs became clear, the many branches in the Japanese government concentrated on improving these challenges to make the legislation easier to pass, and/or to make the legislative grey zone entirely transparent to avoid problems encountered by certain companies in the past.

In Europe as well, some main non-tariff barriers for the marine energy industry comprise the:

- Consenting Process; and the
- Environmental Impact Assessment.

Ensuring consenting processes are administered in a suitable, timely and transparent manner while maintaining the integrity of the environment via the correct implementation of the EIA as deployments become more elaborate is a big discussion point[218]. However, unlike European countries where these types of measures are often made in advance, Japanese markets are often handicapped by a shorter vision as markets start implementing change only as they are needed. In the E.U., targets for these types of energy have already been set since around 2010 with the individual member states' NREAPS detailing their future targets of marine energy output.

In the case of the marine energy market in Japan, legislation surrounding offshore marine energy has started to be revised with the onset of increasing use of offshore wind energy deployment in Japan. While it is possible certain legislative measures will not be optimized until Japan actually sees its first type of tidal stream, tidal barrage and/or wave energy generating device deployed, the past of other RET shows us the government has shown an interest in making the deployment as efficient and easy as possible.

This lack of a clear vision on the EIA for marine energy in Japan represents an opportunity for foreign companies such as the EMEC to enable the Japanese market to develop methodologies adjusted for Japanese soil and taking into account the relevant stakeholders that need to be included in the assessment of projects in this field.

[218] O'Hagan, A.M., Huertas, C. et al (2016), p 181

3.2.2.1. Installation

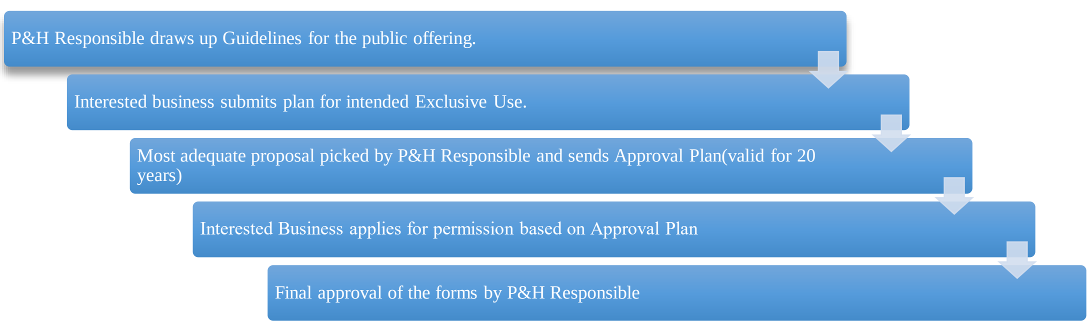
As is the case for any electricity generating device, the first law to adhere to for marine energy is the Electricity Utility Law, including the need to submit necessary application forms to receive the approval to construct the device, the need to notify the lead engineer on a new project and the notification of the applicable safety regulations.

Besides the Electricity Utility Law and EIA that is always necessary to adhere to, there are also other laws that the marine energy business will need to follow before being able to fully install a new device. As tidal and wave energy come in all shapes and sizes and still a new market for Japan, it is possible that these laws and regulations will be changing over time, however, it is worth noting at least the current existing laws that will most likely apply to certain types of marine and tidal energy, based on the experience of previous projects related to marine energy.

Ports and Harbour Act.

In 2016, the Japanese MLIT, announced the revision of the *Ports and Harbour Act*. Intended as a way to deal with the increase in the demand for offshore space for the deployment of offshore wind energy, the change in this law also has an influence in the potential for deployment of certain types of marine energy.

Previously not accounting for the need of spatial usage inside Japanese ports and harbours to accommodate the deployment of marine energy, the revision now brings clarity to the regulatory ownership of this space, and with it the possibility for parties responsible for the management of the ports and harbours, to use an approval-based, public tender application system to private companies, to "rent out" the space within these areas for the sake of energy generation[219][220]. This exclusive use agreement allows for a twenty-year usage of the allocated space after final approval[221].



This revision of the Port and Harbour Act will not be applicable to all types of tidal and wave energy, but it might prove a useful change to other types of tidal energy generating devices similar to the one offered by e.g. Dutch company *Tocardo* which can retrofit part of its catalogue to existing structures such as bridges, dams, dikes and other existing port and harbour structures.

With its high amount of rivers, tidal current turbines that use the flow of rivers to generate electricity in Japan represent a big opportunity for companies developing this type of energy. To the extent of our knowledge, this type of energy generation has not yet been deployed in Japan, and as such the installation might encounter the same hurdles as ROR-type small hydro had encountered in the past, and be subject to the same regulations.

[219] Prime Minister's Official Residence (May 13, 2016)
[220] MLIT (s.a.)
[221] Ishida (June 21, 2016)

Ship Safety Law

Based on a report done for the tidal by a publicly funded consortium led by Japanese company Toa Electric, we can also determine that other laws might also be of relevance to marine energy installations but are either still being reviewed as to their relevance to marine energy devices or are dependent on the type of marine energy device.

One such example is the Japanese '*Ship Safety Law'*. This law aims to ensure the safety of ships by regulating the equipment, structure etc. of floating structures such as ships and others based on internationally established rules. We assume that this law will especially be of concern to marine energy devices with floating parts.

Construction Standards Law

Similarly to the Ship Safety Law, the Construction Standards Law was added to a report submitted by the TOA Electric-lead consortium on a publicly funded tidal energy project as one of the potential laws for the tidal project to adhere to.

In this case, it was mentioned that the application of this specific law was being reviewed to see whether or not it would be necessary for future marine energy installation to adhere to this law by submitting, amongst others, a Construction Confirmation Application.

3.2.2.2. Environmental Impact Assessment

In the case of environmental legislation, Japan still has a long ways to go before being able to fully accommodate the deployment of non-offshore wind energy-type marine energy.

The Environmental Impact Assessment law, which is an important and potentially time-consuming step for businesses to pass before being able to install their energy generating devices and facilities, currently does not yet include marine energy technology outside of offshore wind energy, which has only officially been added to the EIA as a target category in recent years[222].

Furthermore, while offshore wind is already being developed in Japan and has been added to the EIA targets, the lack of clarity surrounding the measures needed to take into consideration for the EIA can still be seen as a potential hinder for installation of this technology, and the Japanese government is thus still in the process of improving the level of clarity surrounding these types of projects.

Furthermore, a 'guidebook' for business developers is planned to be made available by 2018 based on the experience of previous deployments. The government hopes that by introducing such a guidebook, showing a more streamlined EIA, the initial lead time of three to four years for wind energy[223] will hopefully decrease to half that[224].

While the EIA currently does not include marine energy, previous projects run by the NEDO and the METI and MOE reveal that it is also necessary for this technology to implement local stakeholders in a way similar to other energy related projects.

[222] EIA (2012), p 4
[223] Onshore and offshore
[224] Ishida (June 21, 2016)

3.2.3. Challenges and Opportunities

As with any market, the Japanese market both holds challenges and opportunities that potential entrants are required to take note of before entering this, yet not fully existent, market. In this section we will be going over some of the challenges and opportunities for the Japanese marine energy market.

- **Natural Environment**

Besides its very generous Feed-in Tariff system for renewable energy, Japan is also known for its extreme natural environment. Harsh weather conditions are possible a significant challenge for foreign marine energy technology to overcome, as these conditions might not have been taken into account when tested in foreign installation sites. It is therefore important to take into account the following factors when looking into entering the Japanese marine energy market.

Unlike floating offshore wind turbines, tidal and wave energy generating devices are sometimes subjected to the installation using fixed mounts. The Seismological Society of Japan reports that Japan experience somewhere between 1000 to 2000 **earthquakes** per year, with that number even running up to 10681 in 2011, including the many aftershocks that happened after the Great East Japan Earthquake of March 11.[225] Depending on the effect of earthquakes on different types of marine energy base mounts, this natural phenomenon paired with frequent tsunamis might lead to an extra challenge for certain types of existing foreign wave and tidal energy technology not only during the installation stage, but also in the O&M and other phases post-installation.

While not as frequent as earthquakes, Japan is also often subjected to typhoons. Data from the Japan Meteorological Agency[226] shows us that since 2001, Japan has known an average of almost three typhoons per year. The impact of typhoons on certain marine energy generating devices must also be considered before implementing them. Here, depending on the type of marine energy used, it might be useful to look at previous research and the on-going offshore wind projects to attempt to extrapolate any useful information from these for tidal and wave energy generating devices.

Lastly, it has also been uttered in previous research and experimental projects featuring retrofitted-style tidal energy devices that due to the environmental atmosphere own to the neighbouring seas in Japan, the device that was used for a feasibility study, located in the sea off Ikitsuki in the Nagasaki Prefecture, had suffered from a significant level of biofouling.

In order to look into solving this problem, during a research study done by Katsuyama et al.[227], it was found that covering the device with an anti-fouling paint had helped ward off sessile organisms from latching on. However, it is necessary to take the duration that this paint lasts and the necessary steps to be taken during regular O&M to most efficiently avoid this kind of latching of organisms on devices deployed in Japanese waters where the higher temperature cause this kind of organisms to thrive on.

[225] http://www.zisin.jp/modules/pico/index.php?content_id=128
[226] http://www.data.jma.go.jp/fcd/yoho/typhoon/statistics/landing/landing.html
[227] Katsuyama, Kobayashi et al. (2014)

- **Local Stakeholders**

With Japan's main food product being fish and its extensive use of its offshore areas for other economic activities such as shipping, it goes without saying that the shipping industry and fisheries in Japan are significant stakeholders in the decision of implementing certain types of marine energy. Previous projects developments supported by the METI, MOE and NEDO stumbled on this problem when assessing the potential installation sites.

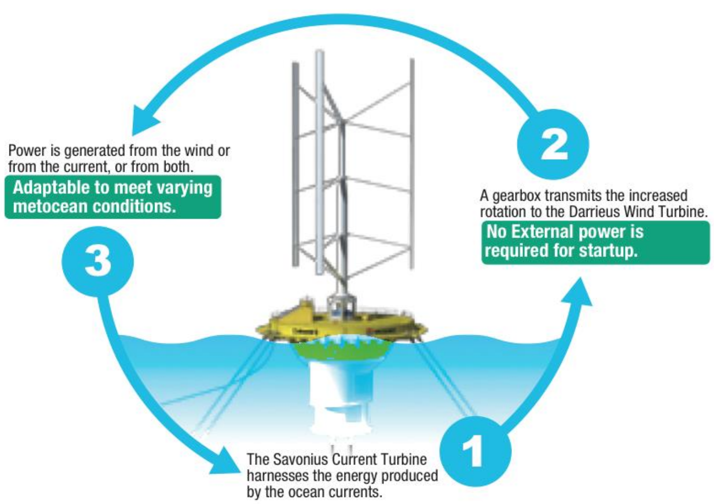
In the case of the tidal energy project run by MHI, the official 2015 report mentioned that, due to the need to concord with the local fisheries' needs, the places it was allowed to install their devices had been limited to a few, less advantageous sites with lower potential output due to lower rates of flow which had a significant impact on the project's CAPEX[228].

In the case of the tidal project with Toa, its official report for 2014 indicates similar issues encountered with the local fisheries. Looking at the assessment checklist for the potential locations, the "Comments from Locals" column mentioned non-favourable conditions for two of the four potential sites that were assessed; with a note indicating a discrepancy between the community's opinion and the local fisheries[229].

+ **Synergies**

As we can also see with RET such as hydro energy, wave and tidal energy also offer many possibilities for potential hybrid systems and general synergies with other sectors. While the marine energy market, being in its early infancy years, offers much potential for growth towards the future, as renewable energy becomes increasingly more important for developed and developing countries to sustain their energy needs.

The potential of combining different types of RET or RET directly similar to the NEDO-funded[230] project by MODEC, the SKWID[231], or using some sort of electricity storage similar to what is already available for hydropower in the form of pumped storage hydro can also make certain types of renewable energy integrated systems more interesting to develop, especially if the Japanese electricity market is headed towards a more distributed grid structure.



[228] MHI (2016) p. 9.5-2
[229] In the end, the sites that had unfavourable conditions were not chosen
[230] This innovative project ended in 2015.
[231] MODEC (2013)

In the case of tidal energy, depending on the type of tidal energy technology used is the flow of electricity not only foreseeable but is the potentially generated electricity output also somewhat constant, contrary to solar and wind energy which are known for their variability making them relatively harder to effectively integrate into the current structure of electricity power grids.

Innovative European storage-type technology such as the Nottingham University prototype for a submerged compressed air electricity storage system[232] would allow RES such as marine energy to also act as a battery similar to the way pumped hydro storage helps the resource to be used as a "blue battery".

The marine energy market also offers the possibility of synergies with the European satellite data market as well as Marine Spatial Mapping systems similar to the "MaRS System" by European company, *The Crown Estate*[233]. This type of data and mapping system might help better plan the spatial allocation of the previously mentioned storage bag location, the location of wave energy devices, offshore wind devices and other marine energy generating devices by also taking into account related information. The importance of an efficient allocation of marine energy devices can not only be seen in offshore wind energy generating devices, but also in wave energy devices wherein the effect of "shadowing" and the distance between two devices etc. can greatly affect electricity output generated by these devices.

Lastly, innovative technologies such as *North Sea Systems'* CableFish system[234] would also provide extra help with parts of the installation process of marine energy devices, potentially lowering the barriers to entry in even rough natural ocean environments such as Japan.

+ **Appointment of Local Testing Sites and Resolved Interest**

Following the success of testing sites such as the EMEC in Scotland, and in order to aid research and development by offering potential sites to domestic Japanese tidal and wave energy developers to test their inventions, the Japanese government appointed several sites in around Japan as testing sites for the use of marine energy testing, further showing their commitment towards creating a robust marine energy market.

Assisted by the *European Marine Energy Centre* itself and Orkney-based environmental consultancy firm, Japan now has a total of seven sites located in five prefectures, with three of the seven sites located in Nagasaki. Being well known for its heavy machinery and shipbuilding industry, and blessed with much potential marine energy, the city of Nagasaki has been aiming to grow its appeal to marine energy producers by aiming to create an environment not only for testing but also for the local production of marine energy machinery in the future.

+ **Hub to Asian Market**

Similar to many other markets, the interest in entering in the Japanese market not only lies in the potential this market itself holds. Indeed, potential entrants interviewed for this report mentioned that their interest in the Japanese market did not lie only in its own domestic demand, but also as a means to start off an expansion to other Asian countries.

The Japanese market, with its high level of know-how in numerous industries that are synergetic to the marine energy market, and its high level of technical expertise and history in manufacturing and heavy industry and geographic location makes it a very interesting country for companies to use as a base to form a larger Asian hub.

[232] de Jong, M. (July 10-11, 2014)
[233] http://www.optimum.uk.com/case-studies/energy-and-utilities/mars-project.php
[234] http://www.northseasystems.com/products-services/cablefish

NPO法人 Nagasaki Marine Industry Cluster Promotion Association
長崎海洋産業クラスター形成推進協議会
NaMICPA

Related to the previous point, Nagasaki's NaMICPA, or the "Nagasaki Marine Industry Cluster Promotion Association", is an association made up of local Nagasaki businesses, similar to the industrial cluster formed around the EMEC in Orkney, U.K. With the support of the local businesses experienced in the heavy machinery and ship building industry, the experience from the EMEC and foreign company Aquatera itself in managing this local marine energy cluster[235], and located at a port with a strong international presence, Nagasaki represents a big opportunity for foreign companies looking to enter both the Japanese domestic market and other countries' as well. NaMICPA is also a key player in the last point representing potential for foreign companies.

+ **Increased Interest in Foreign Technology**

Lastly, the Japanese marine energy market has increasingly been looking at foreign technology for its marine energy related needs. With the end of many Japanese projects related to the development of domestic marine energy production, it seems that the Japanese market has finally opened up to the possibility of embracing foreign technology. During the June "Renewable 2016" event in Yokohama, Japan, foreign companies OpenHydro and the Carbon Trust, had been invited to make a presentation about the situation of marine energy in Europe and about the lessons learned from offshore renewables. Being the only non-Japanese companies in the marine energy sector present at the Ocean Energy Forum, it clearly showed the interest Japanese stakeholders have in foreign markets.

Later, on July 25, it was announced that a Japanese consortium comprising of Japanese companies *Kyuden Mirai Energy*, *Nippon Steel & Sumitomo Metal*, the previously mentioned Japanese NPO NaMICPA, and French company *OpenHydro*'s Japanese subsidiary *OpenHydro Technology Japan*, would provide and deploy the country's very first tidal energy turbine[236]. The project is planned to start later this year with extensive surveying to help "*provide a reference for the build-out of commercial-scale tidal arrays in Japan*[237]" and is planned to last until 2019, with 2018 being the planned date for the actual deployment of the tidal turbine.

The experience and expertise gained from this project and the survey that will begin this year, will also prove to become useful for the creation of appropriate measures for the Environmental Impact Assessment for future projects such as these and for the estimate of appropriate FIT rates to further promote the use of commercial-scale European technology to further increase the share of RES in the Japanese energy mix.

Key elements of the turbine such as the blades, the key magnetic parts, the TTC etc. will be built in Europe, and then shipped to Japan, where *OpenHydro Technology Japan*, founded in May of this year, will be managing and overseeing the delivery of this very first demonstration project and will also work on future commercial scale projects. For this project, the base will be manufactured locally by *Nippon Steel & Sumikin Engineering*.

[235] Tidal Energy Today (2015)
[236] MOE (July 25, 2016)
[237] Open Hydro (2016)

However, in the future, *OpenHydro* is looking to completely manufacture commercial-scale array devices locally in Japan which is bound to bring economic opportunities to both the Japanese heavy industry, thus fostering "*local skills and expertise*", as well as the European market as they are able to export their expertise in the field to Japan and other countries and learn from the experiences of their technology in different waters and adjust the technology to those different environments.

The project, that will be managed by incumbent *Kyushu Electric*'s subsidiary; *Kyuden Mirai Energy*, also shows the growing interest in private Japanese firms to incorporate this new type of energy into the Japanese electricity grid even though the Japanese government previously showed little sign of integrating tidal or wave energy before 2030.

For wave energy, American company Ocean Power Technologies will be licensing its PB3 PowerBuoy to Mitsui Engineering and Shipbuilding and jointly develop and test an advanced control algorithm with the aim to assess increased wave energy capture and electric power generation for potential entrants in the Japanese market and its surrounding countries[238].

[238] ReNEWS (June 1, 2016)

Chapter 4. Conclusion

General Recommendations

As we have seen from the previous chapters, the Japanese market has become more accommodating towards renewables in recent years through many legislative changes to old laws and through the use of more financial instruments such as the Feed-in Tariff.

Nevertheless, many changes still need to be made on a local, prefectural and governmental level for all renewables to grow at rates similar to what the solar power industry has seen since the implementation of the FIT in 2012. With falling oil prices, we might expect investments in renewables to decline, but in the Joint Statement released by the METI after the G7 Kitakyushu Energy Ministerial Meeting, the 3E+S[239] on the role of investments in the renewable energy sector, the importance of energy investment, including investment in supportive innovative technologies to encourage clean energy and energy efficiency, was reaffirmed.[240]

We hope that the prospective of a cleaner future, lower energy prices, safer and more diversified energy mixes and growing employment in the renewable energy sector will continue to drive policies and stakeholders to continue to work towards the integration of existing and upcoming RET. As mentioned in a previous chapter as well, this will need continued work towards

- ✓ The promotion of increased competition in the newly liberalised electricity market via the use of certain market instruments;

Giving the chance to PPS with an eye on renewable energy supply to participate in the electricity market should boost the demand for renewable energy and increase the potential for both foreign and domestic players in RES to

- ✓ The review of out-dated and inefficient laws and regulations that potentially hinder the smooth deployment and subsequent integration of renewables, in order to obtain a better designed regulatory framework with less bottlenecks;

Similarly to some of the laws encountered by the Japanese small hydro business, it is important to look at the potential bottlenecks in Japanese administration and legislation well in advance.

- ✓ The promotion of both public and private upstream investments in Japan;

Having adequate financial instruments available for the growth of RES that have heavy initial costs could alleviate the potential business investments risks and increase the interest in renewable.

- ✓ Increasing cooperation and engagement on a regional and international level and creating more opportunities towards more international cooperation between domestic and foreign companies, researchers etc. to help work towards the problems of tomorrow, today;

[239] Energy security, Energy efficiency, Environment and Safety
[240] METI (May 2, 2016), p 2

Similar to investment, creating more opportunities for engagement on a regional and international level through international joint research and increased opportunities for Japanese and European stakeholders to meet would generate more potential market opportunities on both sides and enable positive knowledge transfer in the long run. It might also represent an opportunity for relevant stakeholders on the Japanese side to become more aware of the actual state of the market and be more open to the use of this technology.

- ✓ Increasing transparency of policy commitment on renewable energy sources' future;

Bringing a clear view on the future of the market in order to positively influence the confidence of potential business investors.

- ✓ Promoting the creation of technical and human resources to support the RET;

In order for the market of the future to work efficiently tomorrow, it is necessary to cultivate the necessary technical resources and human capacity today.

Recommendations for the Hydropower Market

Japan is increasingly getting more open and accommodating towards renewable energy other than solar. Nevertheless, there remain a few tasks to be dealt with before renewable energy sources can grow to a same extent as Solar PV. The future seems bright however, and the conditions favourable enough for foreign small hydropower companies to make the leap to the Japanese market.

The Japanese government has taken count of the existing remaining bottlenecks and is going to be addressing them in the (hopefully) near future. Nevertheless, in order to make the necessary contacts, preparations, as well as in order for foreign companies to fully enjoy the increase in demand for small hydro, it is recommended to take advantage of the available methods to enter the Japanese market such as the ones introduced at the end of the first chapter of this report.

Foreign companies dealing in VLH (or turbines under 100 kW especially), and with other cost-effective small hydro should also take advantage of the relatively low amount of potential supply in Japan and current long waiting times that have occurred due to said supply constraints in Japan, and proactively seek out partners in Japan via either the participation in Japanese renewable energy related events, by contacting players such as J-WATER (or the Japanese Small Hydro Power Association) or through existing players in the market to complement their existing supply offer similar to what existing foreign firms in the Japanese market have already done and are increasingly doing.

Companies with an interest in the large-scale hydro market are recommended to make contacts with existing players in the hopes of creating a business venture beneficial to both the existing supplier and the foreign company as it would otherwise be deemed very hard to enter this very closed-off market.

Recommendations for the Marine Energy Market

While the marine energy market in Japan is currently still in the progress of being built, it is advised for foreign companies with interests in the Japanese and Asian markets to proactively seek out Japanese partners using methods to enter the Japanese market such as the ones introduced at the end of the first chapter of this report.

The Japanese market shows a bright future potential for renewable energy, and with its wide range of heavy industry companies, and its currently inexistent domestic production of (at least) parts of the wave and tidal energy supply chain, foreign companies with technologically advanced projects can take advantage of this to enter the Japanese markets as one of the first companies in this growing industry , starting locally in places such as Nagasaki which is increasingly trying to attract marine energy players, and to expand to other regions later on.

Taking advantage of the existing funds for research into tidal and wave energy from various sources such as the various Japanese ministries and the NEDO could also benefit foreign companies, similar to the MOE project with OpenHydro supplying the turbines. This will however most likely require a Japanese subsidiary and a cooperation with other Japanese companies.

We recommend companies to contact relevant stakeholders such as the OEA-J (Ocean Energy Association - Japan) introduced in Chapter 3 of this report and to increasingly participate in events to showcase their technology and possibly raise awareness.

Making connections with relevant companies similar to the Aquatera and Shibuya Diving partnership[241], and with academics in the Japan, or to partner up with companies that could be complementary to the foreign company's part in the marine energy supply chain potentially creating an opportunity to make the first step in this market. In order to fully grab the potential of the Japanese market it is of the utmost importance, however, to act as an early settler and start establishing the necessary groundwork in order to be able to function to the company's full extent once the market is entirely ready to accommodate more commercial activities.

[241] ReNEWS (April 14, 2016)

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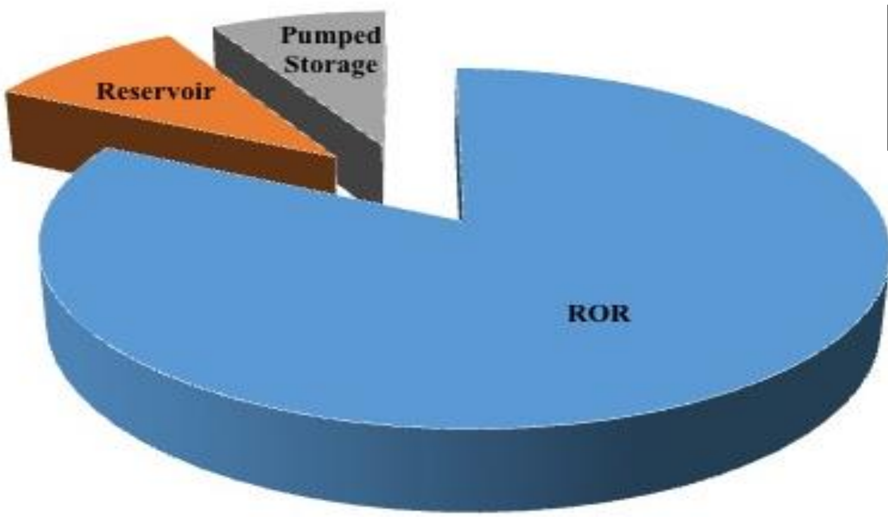
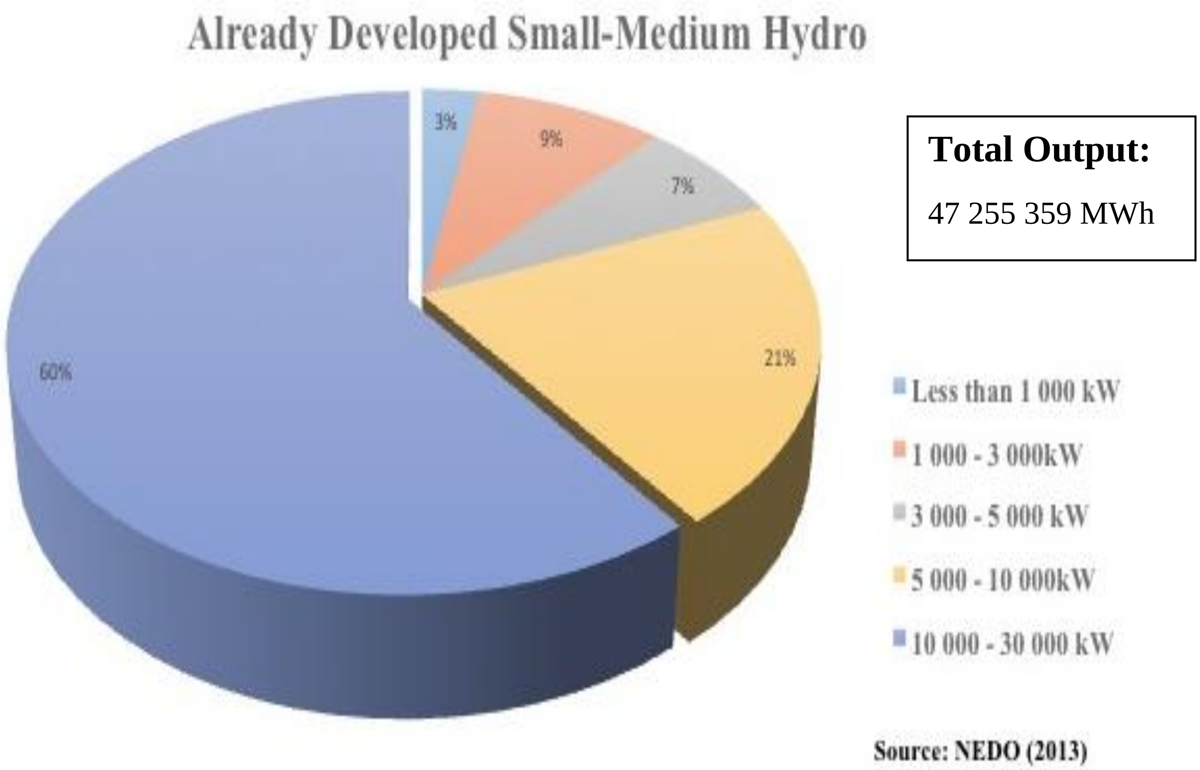
Structure of Hydropower Output for Japan in 2015



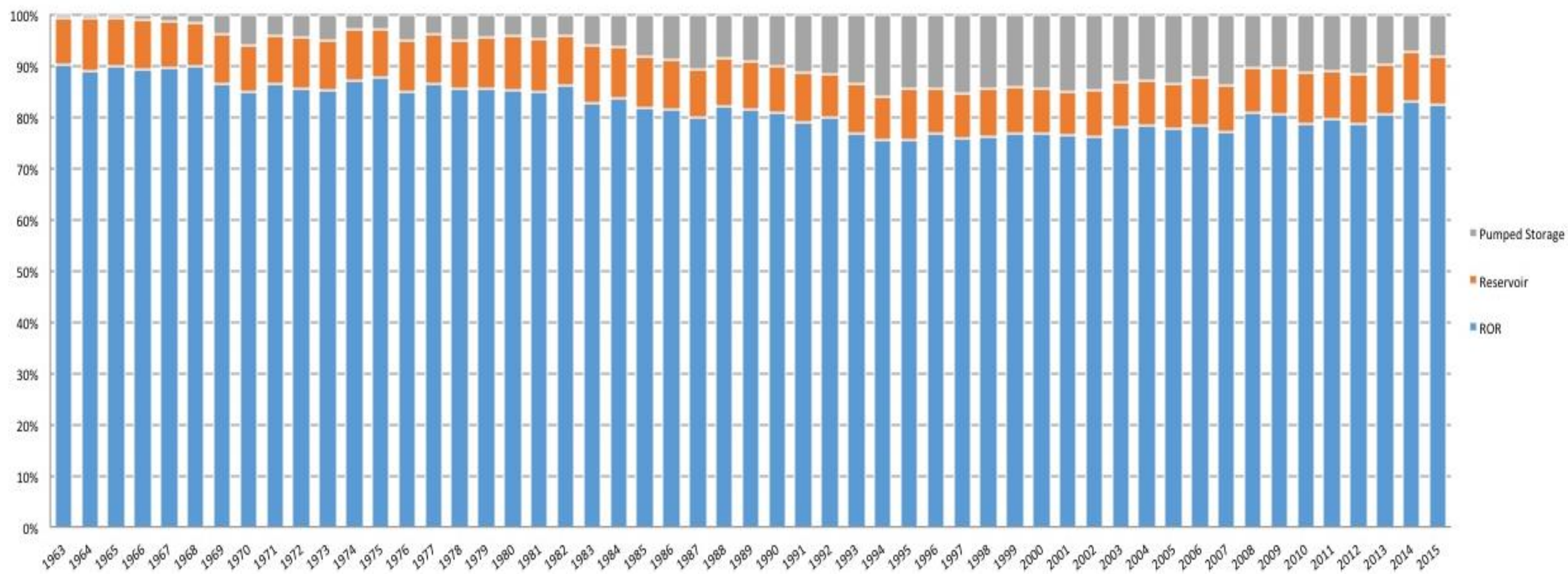
Total Output:

63 906 732 MWh

Data from FEPC (http://www.fepc.or.jp/library/data/tokei/index.html)]


Already Developed Small-Medium Hydro
Total Output:
47 255 359 MWh
3%
9%
7%
21%
60%
Less than 1 000 kW
1 000 - 3 000kW
3 000 - 5 000 kW
5 000 - 10 000kW
10 000 - 30 000 kW
Source: NEDO (2013)

Structure of Annual Hydropower Production in Japan per Type (Stacked)



Data from FEPC (http://www.fepc.or.jp/library/data/tokei/index.html)]

RES	Subcategory	Scale	FY 2012	FY 2013 (March 29)	FY 2014	FY 2015		FY 2016	Purchase Period
						Until July 1	After July 1		
Solar	Household	< 10 kW (output control equipment needed)	42	38	37	33	33	31	10 Years
	Household	<10 kW (output control equipment not needed)				35	35	33	10 Years
	None-households	10 kW or more	40	36	32	29	27	24	20 Years
Wind	Onshore	< 20 kW	55	55	55	55	55	55	20 Years
		20 kW or more	22	22	22	22	22	22	
	Offshore Wind				36	36	36	36	
Biogas			39	39	39	39	39	39	20 Years
Biomass	Wood (unused)	< 2000 kW	32			40	40	40	20 Years
	Wood (unused)	> 2000 kW	32			32	32	32	
	Wood (general)		24	24	24	24	24	24	
	Wood (waste materials of buildings)		13	13	13	13	13	13	
	Waste materials		17	17	17	17	17	17	
	Methane Fermentation		39	39	39	39	39	39	
Hydro	Installing fully new facilities	< 200 kW	34	34	34	34	34	34	20 Years
		Between 200 and 1000 kW	29	29	29	29	29	29	
		Between 1000 and 30000 kW	24	24	24	24	24	24	
	Utilizing existing head race channels	< 200 kW			25	25	25	25	
		Between 200 and 1000 kW			21	21	21	21	
		Between 1000 and 30000 kW			14	14	14	14	
Geothermal		< 15000 kW	40	40	40	40	40	40	15 Years
		> 15000 kW	26	26	26	26	26	26	

Data from METI (www.meti.go.jp)