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# Small and Micro-Scale Hydropower in Japan
## A Solution to Energy Transition?

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**Abstract** Although it has abundant water resources (small and micro-scale hydropower), whose potential is high according to surveys, Japan did not benefit much (compared to solar PV) from the Feed-in-Tariff scheme implemented in 2012 to more effectively support renewable energies. In a country whose energy self-sufficiency has always been low and is even lower since the Fukushima accident, this may seem somehow surprising. Based on available surveys, literature on renewables, some interviews with smart communities' local authorities or researchers in Japan, this paper aims at discussing what the main issues relevant to explain this paradox are. It argues that reaching the government estimates towards 2050 will probably need more actions, incentives and, moreover, a simplification of regulations, especially those on water management, whose complexity is a major break to local promoters to engage in small and micro-scale hydropower projects, while local production/local consumption probably is one of the main issues for further development.



**Keywords** Japan. Small and micro-scale hydropower. Renewable energies. Feed-in-Tariff. Water management and regulation.

## 1 Introduction

Hydropower is an old and mature industry that played an important role in the electrification and modernisation of many countries, including Japan. Overtaken by thermal or nuclear power generation, it remains the largest renewable energy (RE) worldwide, accounting for more than 16% of the electricity generated and, moreover, for some 85% of the total production of renewable energies (IEA, International Energy Agency, 2016).[1]

1 Cf. URL https://www.iea.org/topics/renewables/subtopics/hydropower/ (2017-02-24).

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Quite diversified an industry, it can be divided into several categories according to the size (large, medium, small, mini, micro), but also according to the type and/or function of the infrastructure: run-of-river (few or no storage capacity), reservoir (storage capacity) and pumped storage power plants (PSP).[2] All this depending on configuration or topography, as the International Energy Agency (IEA) states: "the boundaries between these categories can be blurry, as plant configurations are numerous and have characteristics that fall under multiple categories, thus making a complete classification challenging" (OCDE/IEA 2015, 151). Although other RE can also be categorised: PV rooftop panel/mega-solar, isolated wind turbine/turbine farm, or on-shore/off-shore, the case of hydropower appears more complex. Also, even though it is a renewable energy, it is not a new one, which means that hydropower as a whole is not included in RE promotion schemes as it is the case of solar, wind etc. However, since global warming and the reduction of $CO^2$ emissions have become important stakes, leading to a greater interest for RE, a distinction is made between large , which is not included, and small/micro scale, which is included.[3]

## 1.1 Japan's Water and Renewable Energies Context

The industrial development, the rapid economic growth and the correlated modernisation of the country on the one side, and the large urbanisation accompanying the population increase on the other side jointly contributed to a huge increase in electricity demand, which until the '50s was for more than a half satisfied by hydropower generation, Japan being well provided with water.

Indeed, with some 2,700 rivers coming down from mountains, 600 lakes, some of which being rather large, and abundant precipitations,[4] Japan – which is poor in fossil fuel resource – appears, on the contrary, rather rich as far as water resources are concerned. According to the Minister of Land, Infrastructure, Transport and Tourism (MLIT), statistics[5] based on an average of 1,971-2,000 annual precipitation in Japan is approximately 650 billion $m^3$, of which approximately 230 billion $m^3$ (35%) is lost through

**2** Water can be pumped up from a lower level reservoir to a higher one for release at a later time or come from natural inflows.

**3** According to countries, the generation volume over which a plant is considered as large might differ as we will see later. The absence of distinction in the past and of a clear definition makes statistical analysis difficult.

**4** They are not balanced all over the year and often take the form of torrential rainfall leading to disastrous floods (in the past but even still now).

**5** See URL `http://www.mlit.go.jp/tochimizushigen/mizsei/water_resources/contents/current_state.html` (2015-04-12).

evaporation. Of the remaining 420 billion $m^3$, which is theoretically the maximum amount that can be used by humans, the amount effectively used is approximately 83.5 billion $m^3$, roughly 20% of inventory of water resources (2,004 numbers). Around 88% is obtained from rivers and lakes while some 13% is obtained from groundwater. Approximately 15% is used for industry and 19% for domestic purpose while agriculture accounts for some 66% of the total. This is due to the importance of rice paddy in Japanese agriculture and the correlated irrigation needs that led to the construction of kilometres of waterways. These are today, in addition to other types, seen as a large potential for small/micro scale hydropower (thereafter SMSH) further development

Climate change imperatives and the need for an energy transition are on the agenda in Japan as elsewhere. Hydropower, whose share in the electricity mix has declined over time – the country having turned to oil then nuclear power generation since the ’60s –, again attracts more attention from policy makers, especially since the Fukushima accident has accelerated the interest for RE.

Actually, while Japan, strongly hit by oil shocks in the ’70s, has started early researches on RE, their share in the electricity mix remained quite low (especially if we exclude large hydro). It is only after the Fukushima accident that, among other measures to come such as a complete reform of the electricity sector, a Feed-in-Tariff (FiT) has been implemented to more effectively support RE development. SMSH has been included in the scheme aside all other new RE (solar, wind, geothermal, biomass). However, although it helped new projects to come into being at the local level, this did not lead, like for solar PV, to a huge expansion of infrastructures. In a country that is rich in water but whose energy self-sufficiency has always been low and is even lower since Fukushima, it may seem somehow surprising.

## 1.2 Aim and Limits of the Paper

Based on available surveys, literature on RE, some interviews with smart communities’ local authorities[6] or researchers in Japan, this paper aims therefore at discussing what the main issues relevant to explain this paradox are. It will concentrate on SMSH that, apart from technical issues, is receiving little attention in the academic literature.

6 Interviews did not specifically focus on small/micro scale hydropower. They were part of a research program on smart communities, based on studying smart-grids experimentations at the local level, including energy saving and introduction of RE, mostly solar energy or biomass (cogeneration). The scarcity of micro hydropower projects in experimentations raised questions that this paper tends to answer.

Indeed, most papers or books on RE in Japan[7] tend both to analyse policies or evaluate achievements compared to other countries and/or to explain the reasons for solar relative success under the FiT. Wind usually serves as a counter example due to its fast development in some countries such as Denmark or Germany compared to its contrasting straggler situation in Japan. PV generation – which is the FiT winner – or eventually wind – which is sharing some difficulties with SMSH – will be used as a reference in some parts, but our aim is not to compare SMSH with any other RE.

Also, entering in detail into all the hydropower categories would go beyond the scope of this paper. Therefore, the distinction is made between large and SMSH, while reference to the type or function is indicated only when relevant. Pump storage type, which is excluded from the FiT and usually assimilated to large hydro, also appears out of the limit of the paper even though numbers might be agglomerated in some of the surveys used whatever in terms of installed or potential capacities. This does not mean pump storage and, more broadly speaking, hydropower as storage capacity for other RE is not an important issue as we will briefly see in conclusion. Quite the contrary, it would be worth to do researches specifically dedicated to this issue.

The paper is organised as follows. Point 2 will describe the situation of hydropower both in its historical and present situation and in its distribution between large and small installations. Through surveys and government scenarios, it will then estimate what the potential for future development is. Point 3 will look at the legal/regulation and institutional frameworks, first in terms of incentives (RPS and mainly FiT) and second, on the opposite, in terms of breaks to its expansion. The regulatory issue, namely the role of water regulation, whose complexity makes it difficult or risky for local communities' promoters to engage in, will be given a special attention. Finally, point 4 will conclude on some challenges for SMSH or more broadly speaking for RE future development.

## 2 The Japanese Energy Background and the Evolution of Hydropower Generation

Since 1951, the electricity business in Japan is in the hands of 10 regional power utilities (EPCOs-Electric Power COmpany, cf. box 1), which entertain deep relations with MITI (Ministry of International Trade and

7 Among others see: Ikki, Kurokawa 2001; DeWit, Iida 2011; Huenteler, Kanie, Schmidt 2012; Moe 2012, 2014; Lovins 2014; Midford 2014; Dent 2014; Mizuno 2014; DeWit 2015.

Industry)/METI (Ministry of Economy, Trade and Industry) bureaucrats whose great majority are pro nuclear (at least they were before Fukushima). These vested interests as argued by De Wit and Iida (2011), or the collusion between industry and bureaucracy, also called the 'nuclear village', have always played in favour of a *status quo*, promoting nuclear power and suppressing renewables as Jeff Kingston (2012, 2014) states.[8] The historical background of the electricity sector and the evolution of the energy strategy of Japan have to be understood keeping this in mind.[9]

Box 1. The electricity utility business: history and liberalization

The electricity utility business grew along with the modernization and development of the industry and before World-War 1 some 700 electric companies were competing of the market. After the War, they merged into five major electric companies which later, during World-War 2, were integrated into a power generating and transmitting state-owned company (Nihon Hassōden Kabushiki-gaisha, or Nihon Hassōden K.K.) and nine state-controlled distribution companies. After the second war, the electric utility sector was restructured again and 9 regional private companies were established in 1951 while a 10th one has been added after Okinawa retrocession to Japan in 1972. Each general but regional power company was given full responsibility to supply electricity to its region but benefited from a monopolistic position on its territory. Two frequency systems coexist in Japan: 50 Hz for Hokkaido, Tohoku and Tokyo EPCOs and 60 Hz for the others.* Transfer between regions being limited EPCOs have the responsibility to balance supply and demand in their respective areas. This structure did not change over time even though some deregulation occurred in recent years. In 1995, independent power producers (IPP) were allowed to provide electricity wholesale services; in 2000, electricity retail supply was liberalized for users which demand exceeded 2 MW; in 2004 this volume was reduced to more than 500 kW, and again in 2005 to more than 50 kW. Despite these successive liberalization attempts, newcomers' share remained very limited at 3.53% in FY2012** and EPCO still are de facto in a monopoly situation in their region.

Following the Fukushima nåuclear accident which clearly enlightened the weaknesses of the electricity business, a more comprehensive three-phased reform has been voted at the Diet in November 2013. It has been implemented in April 2015 with the creation of a Nationwide Transmission System Operator (TSO) for coordinating cross-regional electricity supply and of a New Regulatory Authority to establish rules for grid utilization. The second phase has been scheduled for April 2016 with full liberalization of the retail sale of electricity, while the third one obliging power companies to spin off their power transmission and distribution sections into separate units will take effect in 2018-2020.

*At the time of Fukushima accident, the conversion capacity was of 1,035,000 MW.

**For more details on the past steps in liberalization of the electricity sector cf. Mizutani 2012.

8 The 'nuclear village' is composed of politics (in fact LDP-Liberal Democratic Party), bureaucracy (mainly MITI/METI in charge of energy) and industry (utilities, big corporations or nuclear vendors and their representative organisations), but, according to Kingston (2012), also media and academia. However, such relationships are not limited to energy, this 'iron triangle' existing in many sectors.

9 Japan is not the only country where such relationships between utilities and state can be enlightened. Hasegawa (2014), for example, emphasises the similarities with France quoting the book *La vérité sur le nucléaire* by Lepage ('The Truth about Nuclear Power', 2011).

## 2.1 The Historical Background

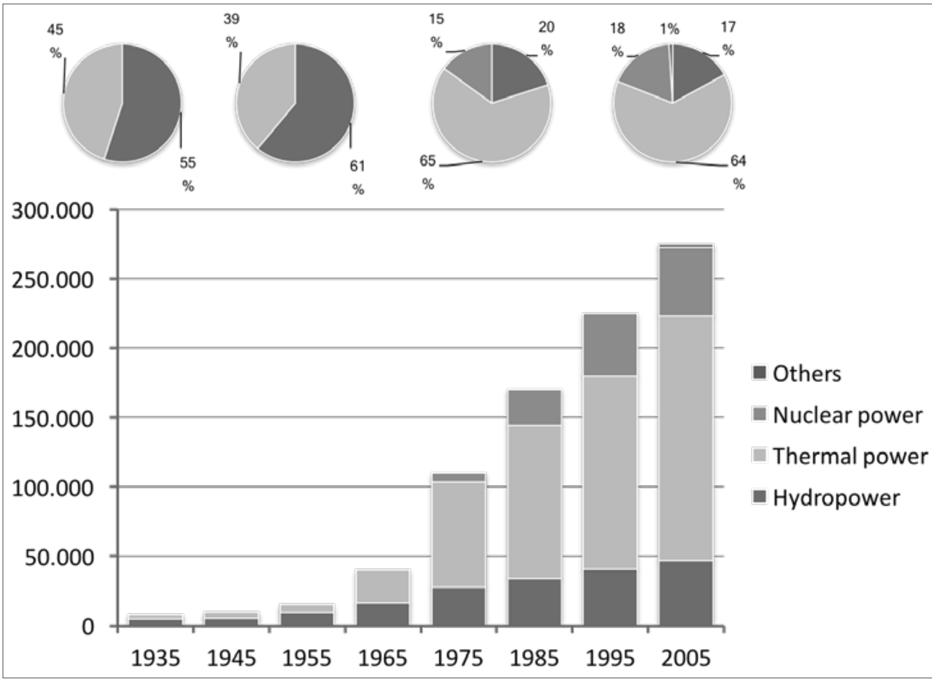
Electricity production from water started early in Japan and can be traced back to Meiji era when techniques from the industrial revolution were introduced leading to the construction of modern and higher dams,[10] or large water control devices. This allowed an increase of the agricultural land, a drastic decrease of the intensity and frequency of floods, and the start of power generation. In 1888, the first private plants were built to generate power to be used locally. In 1907, a first public facility started operating in Yamanashi prefecture and supplied Tokyo at some 75 km distance while few years later, in 1914, the *Inawashiro* plant supplied Tokyo at a distance of 225 km (Dent 2014). In the ’20s, technological advances led to the construction of dams and weirs with modern designs. Although contributing mainly to irrigation, they plaid their role in developing hydropower (cf. Roy 2006).

With thirteen generation plants in operation at the end of the ’30s, hydropower represented 55% of the level of power generation that was still low in 1935. Most were run-of-river type supplying based-load electricity or small regulating pond type supplying peak-load electricity. In the ’40s, agricultural cooperatives actively promoted small-scale hydropower development to introduce electricity in rural areas (Inoue, Shiraishi 2010). After World War 2 (1945-1955), multipurpose dams (flood control, water supply and hydropower generation) appeared and the government gave priority to large scale hydropower generation that, shared in the mix, raised to 61% in 1955 with some 10,000 mW installed capacities, one of the highest volume of the world (Dent 2014).

However, in the ’60s, to address the massive increase in electricity demand, Japan turned to oil (later to LNG). In addition to the very low price of oil, building thermal generation plants took less time even though it was able to produce higher electricity volume. Therefore, although electricity generated from oil might be a little more expensive – 10 to 17 yens/kWh against 8 to 10 for hydro (Inoue, Shiraishi 2010) – they appeared to be better able to cope with the increasing demand. Therefore, although hydropower generation capacity doubled between the ’50s and the ’80s, its share decreased over time and in 1963 fossil fuel power generation took the lead to finally exceed hydropower generation in the electricity mix (fig. 1).

**10** The first one, using concrete, was 30m high, while the first for power generation was completed in 1910: *Chitose* no. 1 Dam in Hokkaido (JCOLD, Japan Commission on Large Dams 2012).

Figure 1. Transition in output from each power resource in Japan (FY)




Source: JCOLD (s.d.)[11]

However, this led to a high dependency rate on imported fossil fuel (76% in 1973). The oil shocks revealed the country's energy vulnerability but the government main response was to accelerate the construction of nuclear plants. In the meantime, however, new large scale hydropower plants were also built. Large national research programmes such as 'Sunlight' (1974) or 'Moonlight' (1978) were launched, addressing both issues: energy efficiency and RE (as an alternative to oil). These programmes integrated in the 'New Sunshine' programme in 1993, even though they focused also on geothermal, clean coal and hydrogen,[12] and were mainly concentrated on solar energy,[13] which had some supporters within MITI due to their

11 FY stands for fiscal year. In Japan, the fiscal year starts on April 1st and ends the next year on March 31st. So FY2005 correspond to April 2005 to March 2006.

12 Wind was not a priority at that time even though some research started in 1978 but with smaller budget (cf. Mizuno 2014).

13 See Ikki, Kurokawa (2001) for more details on these programmes and solar historical development.

estimation of exports potential.[14] The support to solar industry continued over time giving to Japan a leadership in terms of the PV installed or in terms of production, but the increasing electricity demand – especially in the residential and business sectors – led to search for more high volume generation solutions. In 2005 subsidies for residential PV purchasing have been cut and the interest for solar slowed down. As a result, Japan was overtaken by Germany as global leader for PV installed or generated capacity and by China for world production and exports, although Japanese companies have recently regained some of the lost distance.[15]

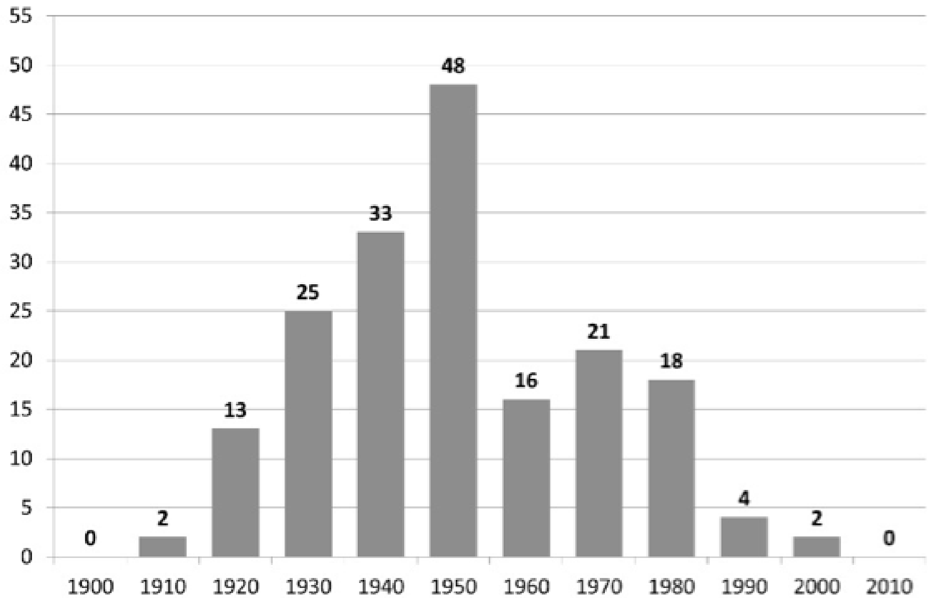
To address the energy dependency and global warming issues in the late 1990s-early 2000s, Japan's main strategy was again to increase its nuclear production and hydropower share felt to some 17% in the mid-2000s. Sure, with 34,270 mW capacity (17%) and 60 million mWh (7%) supplied in 2005 (JCOLD sd), Japan was still one of the country where hydropower generation is important. But, as figure 2 shows, most large hydropower generation plants have been installed up to the '80s. Since the '90s, the sector got few support from government. This did not prevent power companies and J-Power[16] from building some new infrastructure, but with 1162 hydropower plants in Japan (2005), it has been considered that almost all possible sites had already been exploited. The remaining possible ones were said to be in remote areas making construction difficult and, therefore not economically efficient.

**14** See Moe (2012) who analyses why solar industry, linking energy policy to industrial policy of MITI, could develop, whereas wind (remaining outside the vested interest structure) could not.

**15** For a complete but summarised description of solar development in Japan, see Dent (2014, 183-8).

**16** After World War 2, when *Nihon Hassoden K.K.* was dismantled and split into 9 private companies (cf. box 1), they had not enough funds to invest in R&D. In 1952, the Electric Power Development Company (EDPC) was established as a government agency for this purpose. In 1997, it was privatised and in 2004, it went public and was listed on the Tokyo Stock Exchange. Now J-Power (Electric Power Development Co, *Dengen Kaihatsu Kabushiki-gaisha*) is a wholesale electric utility mainly producing electricity from hydraulic (58 hydropower plants, around 20% of hydropower market) and coal (7 thermal power plants) resources. It also has a few wind farms and is investing in geothermal.

Figure 2. Number of sites according to year of operation start (+ 30 mW and pump-storage excluded)




Source: NEF 2014, 8

Apart from this techno-economic reason, large hydropower dams have often been seen as a symbol of pork-barrel politics due to collusion between politicians, bureaucrats and construction companies (Johnston 2011). If adding the environmental impact of large hydro, whatever in terms of water quality, or in terms of deterioration in the river environment, biodiversity and landscape, although it is a renewable energy, it does not have a good nor an eco-friendly image. This is of course one of the issue that matters with population tending to oppose to new construction.[17] In addition to environment, the advantages the community could enjoy from the power companies' project is not always foreseen. A project that was 'good for Japan' had more chance to be accepted in the past,[18] but now it also has to be 'good for the community' to get local population cooperate in its development.[19]

**17** A NIMBY (Not in My Back Yard) reaction as described in the literature for nuclear plants also worked for hydropower plants (on the impact of NIMBY, see Lesbirel 1998; Scalise 2004).

**18** As a matter of fact, subsidies were given to localities accepting the construction of a plant, in that sense it was also economically good for the community (see Hasegawa 2014)

**19** Based on interviews.

The recent controversy about the *Yanba* dam in Gunma prefecture seems a good illustration. Indeed, the *Yanba* dam, which is in fact an old project first dedicated to flood prevention before hydropower generation had been added, has become a symbol of a huge financial and political mess. Started more than 60 years ago, the project, which had already cost a lot and seen population relocated after having abandoned their long fight, was halted by the DPJ when it came to power in 2009. Population who had already endured the social damages was expecting economic benefits from the dam construction and again opposed to the decision. It just restarted in 2015 and is scheduled to be terminated in 2019.

Even though new dams construction and large hydropower plants seem to have reached their limits and even if, as usual, increasing nuclear share was at stake before Fukushima, the global warming imperatives (re)opened opportunities. Actually, compared to other sources, hydropower, which does not emit $CO^2$ during production, is also emitting less for facilities operating over the lifetime of a plant: 11 g $CO^2$/kWh for hydropower, 25 g for wind, 38 g for solar PV[20] (KEPCO). Around mid-2000s, the Japanese government launched surveys to estimate existing and additional potential for new hydropower development. Surveys confirmed that large hydro projects potential was quite limited, but emphasised the huge number of untapped sites for small to micro scale facilities.

## 2.2 SMSH Generation: Definition and Operational Sites

There is no official definition of small-scale hydropower in Japan. According to IEA (2010), large hydropower plants are those generating more than 300 mW, while for example the New Energy and Industrial Technology Development Organization (NEDO) put the limit at 100 mW or more (Inoue, Shiraishi 2010). For its part, the New Energy Foundation (NEF, 2014)[21] uses a distinction between less or more than 30 mW in its surveys (cf. table 1). Depending on organisations and even on surveys or schemes, the definition may vary making comparison difficult although subcategories are often done according to power output.

If taking the IEA definition – usually used by the Natural Resources and Energy Agency (ANRE) of the Ministry of Economy, Trade and Industry

**20** Nuclear stands at 20 g $CO^2$/kWh. In terms of comparison, coal, which emits 864 g $C0^2$/kWh during production, stands at 79 g for facility operation, while oil is respectively at 695 g and 43 g (KEPCO, `http://www.kepco.co.jp/energy_supply/energy/newenergy/water/shikumi/index.html` (2015-12-23).

**21** New Energy Foundation, created in 1980 to promote new energies, proposes policies and supports development. For example, the NEF administrates an interest subsidy program for the construction of hydropower plants.

(METI) – operational SMSH plants (under 10 mW) are 1,369 (2012) with a total installed capacity of 3,518 mW, generating annually 18,802 million mWh (Esser, Liu, Madera 2013).

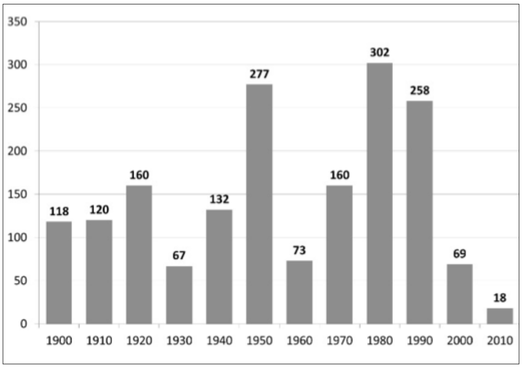
Table 1. Classification of hydropower generation facilities by power output

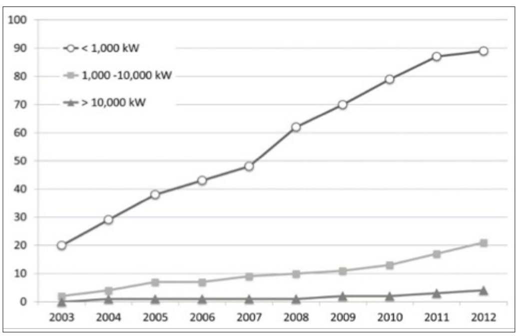
| Classification | IEA | NEDO | NEF |
|---|---|---|---|
| Large hydropower | > 300 mW | > or =100 mW | > 30 mW |
| Medium hydropower<br>Run-of-river<br>Dam and reservoir | 10-100 mW<br>100-300 mW | 10-100 mW | |
| Small hydropower | < 10 mW | 1-10 mW | < 30 mW |
| Mini hydropower | / | 0.1-1 mW | |
| Micro hydropower | / | < 0.1 mW | |

Source: IEA 2010; Inoue, Shiraishi 2010 for NEDO; NEF 2014

According to NEF, there were 1,754 small and medium facilities (less than 30 mW) in operation in Japan in 2010. As figure 3 (up) shows, there are two periods before and after the ’60s with around half of them constructed in each. The ’60s mark a cut in construction of small-scale facilities probably because of the priority given to large-scale ones since the ’50s. After the oil shock, a new wave of construction occurred both on a large (fig. 2) and small scale (fig. 3 up) due to Japan oil dependency and revealed vulnerability coming out from the shock. But what is interesting to note is that rather few were constructed in the 2000s, although global warming was already on the agenda. This seems to confirm that utilities were considering that all efficient sites had been tapped but also that the priority of the time remained nuclear power’s further development. However, as figure 3 (down) shows, while SMSH new infrastructure (especially less than 1,000 kW) were quite few in early 2000s, the number of sites developed regularly increased all along the decade for a total output capacity (excluding > 30 mW sites) of 9,627 mW and a total generated volume of 47.25 billion mWh (table 2). Since the 2000s and more over the mid-2000s, SMSH development has been conducted locally by organisations: private companies (out of the 10 power companies), NGO, local bodies (municipalities, public corporations[22] etc.) or even individuals.

22 Land-use Improvement Unions in Japan created under the Land Improvement Act in 1949 to promote the ‘modernisation’ of rice field arrangements and that have exclusive rights to use irrigation water have developed most hydropower facilities constructed during last decades. Some of the Unions are now starting to expand their water rights to generate electricity from irrigation channels. See for example the case of *Nasunogahara* Land-use Improvement Union’s (NLIU) in Tochigi Prefecture (Suwa 2009).




Figures 3-4. Number of site per year of operation start (less than 30 mW, pump-storage excluded, between 1900s and 2010s) (since the 2000s by size). Source: NEF 2014, 8, 24

Table 2. Hydro electricity generated from existing sites of less than 30 mW

| | Already developed | | |
|---|---|---|---|
| | **Number of sites** | **Power (mW)** | **Volume (mWh)** |
| Less than 1,000 kW | 495 | 209 | 1,325,855 |
| 1,000 to 3,000 kW | 423 | 755 | 4,239,359 |
| 3,000 to 5,000 kW | 166 | 625 | 3,289,008 |
| 5,000 to 10,000 kW | 285 | 1,928 | 9,947,390 |
| 10,000 to 30,000 kW | 367 | 6,110 | 28,453,747 |
| **Total** | **1,736** | **9,627** | **47,255,359** |

Source: NEDO 2014, chapter 8, page 19

## 2.3 Estimating Further Potential

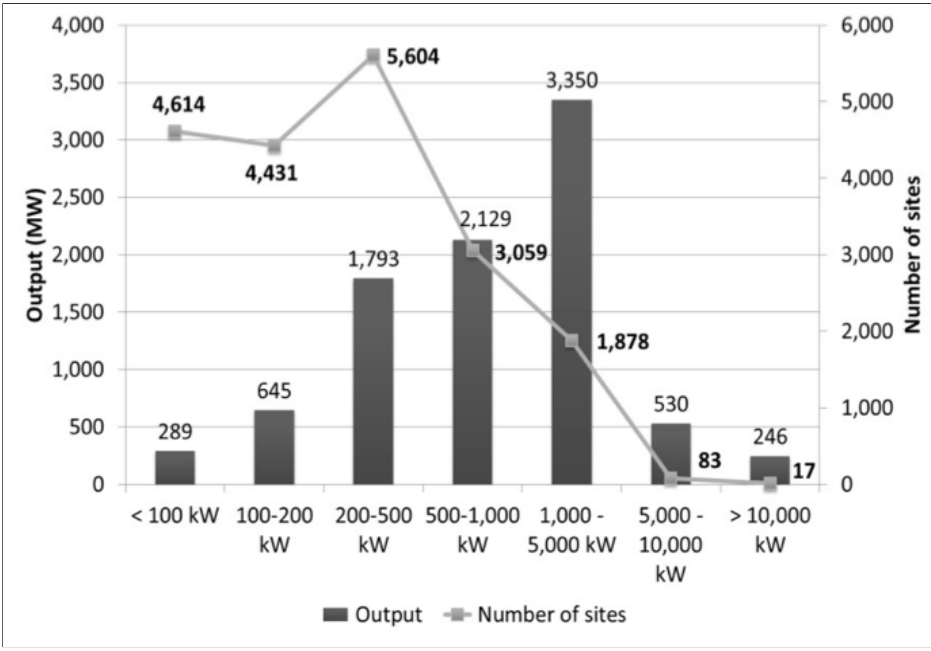
The renewed interest for renewables in the 2000s and the concern about limits of untapped hydropower sites led several organisations to conduct surveys in a way to estimate the real potential capacity of SMSH the country could rely on. According to NEDO (March 2004), Japan had 2,717 sites not yet tapped with a power output of 12,000 mW (Inoue, Shiraishi 2010). Most of these sites were considered as having an output of less than 30 mW. In March 2009, NEF carried out another survey to estimate the potential by using untapped heads[23] in already existing dams, conduits and so on, which were not taken into account in the former survey. Dams or other hydraulic structures aiming at flood control, irrigation or water regulation have a head that could also be used for hydropower generation. These heads remained often untapped because they are usually lower (generally less than 5 m high) than those used by large hydropower plants (generally above 15 m high). As lower head means lower power output per unit of water flow, their generation capacity is of course lower, questioning their economic efficiency. Recently, however, new technologies[24] have been developed to make low head sites more economically viable. This survey identified 1,389 sites with a still untapped head for a total power generation output of 330 mW (around 27,449 million mWh), among which 958 having a power output of less than 100 kW were micro-scale sites. Inoue and Shiraishi (2010) consider that these surveys might not give an exact image of the real potential of hydropower since the first survey excluded mountain streams and small rivers that were presumed to be economically inefficient, while the second one was based on interviews with property owners and did not include the energy produced from running water in channels.

Finally in 2011, the Ministry of Environment (MOE 2012) conducted a survey on renewable energies including hydropower, which shows that some 19,686 untapped sites in river channels were existing in Japan for a total of 8,982 mW output capacity. But, as figure 4 shows, most identified potential sites are small scale ones with an output of less than 5,000 kW. As stated by the World Small Hydropower Development Report (Esser, Liu, Masera 2013), Japan's agricultural waterways (irrigation) have a total length of 400,000 km. If considering their exploitation, their theoretical potential is estimated at 5.7 billion mWh, meaning with an improvement of run-of-river generation technologies but more incentives, SMSH development could grow further.

**23** The vertical difference between high water and low water levels is called ‘a head’.

**24** Such as, for example, variable-speed turbines that reduce production and installation costs or very low head turbines that reduce the cost of infrastructure.

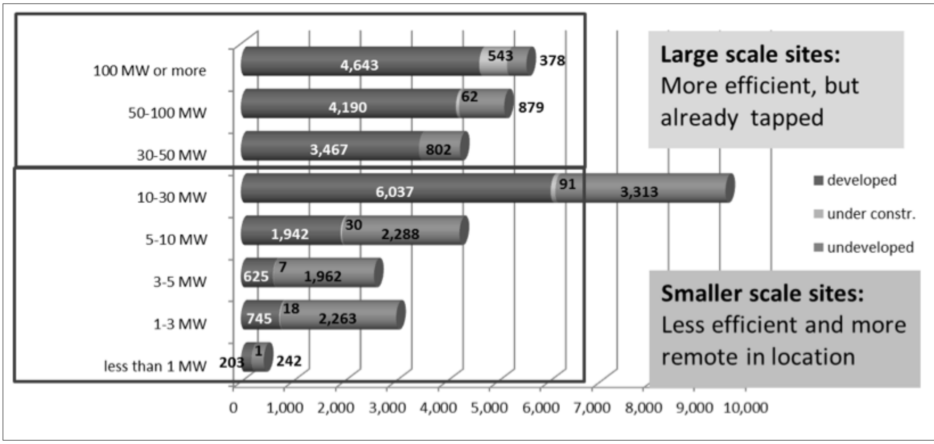
Figure 5. Hydropower potential (in river channels, excluding existing facilities)




Source: MOE 2012, 73

Based on data by METI/ANRE, for its part J-Power seems to confirm that large scale sites are mostly tapped but, as figure 5 shows, 3,313 sites are considered to be still undeveloped in the category 10 to 30 mW that according to NEF's classification still belongs to SMSH although under IEA's or NEDO's ones it is in the medium-scale hydropower category.

Figure 6. Development of hydropower generation in Japan




Source: J-Power 2013 (data from METI, ANRE, www.enecho.meti.go.jp/category/electricity_and_gas/electric/hydroelectric/) (2015-05-09)

Although both estimations are not comparable (river channels/untapped existing heads), what is also interesting to note is the difference in the number of sites of less than 1 mW output estimated at 242 by METI (and J-Power), while the MOE counts 17,708 potential sites in river channels. This might be an illustration of power companies' strategy for which micro-scale facilities and river channels are not efficient enough to be taken into account. Indeed, under a certain output, introduction to grid appears too expensive to power companies while local production for local consumption is not considered as a distribution alternative.[25] This seems confirmed in J-Power presentation on hydro and geothermal development in Japan stating that "previous subsidies and Renewable Portfolio Standard (RPS) schemes were not enough to promote development of smaller sites" (2013, slide 3). Like most renewable energies whose generation volume is small, small-scale hydro has the demerit for companies that, distribution infrastructure's cost being the same whatever the size of the facility, the smaller it is, the higher the cost per unit is. Solar roof-top panels do not really face such a difficulty, since it is easy to connect to grid through the house or building connection. On that issue, SMSH, often located in rather remote areas far away from high consumption centres, shares the same difficulties as wind.[26]

**25** Although decentralised systems have been experimented in Smart Communities demonstrators (Faivre d'Arcier, Lecler 2015) Japanese law does not allow exchanging electricity between neighbours, making it necessary to connect any renewable energy generation system to the grid.

**26** For a detailed analysis in the case of wind, see Mizuno 2014.

## 2.4 Government Scenarios: from Large to Small Hydro

According to the above mentioned surveys on hydro potential in Japan, several scenarios were elaborated by MOE (2012) to estimate the contribution that SMSH could have in the future in the domestic electricity generation, depending on the incentive schemes which could be implemented.

The first scenario proposes 3 different simulations per type of facility and depending on tariff or subsidies (table 3):

- scenario 1.1 simulates the potential with a fix price at 15 yens/kWh and a purchase period of 15 years;
- scenario 1.2 also simulates the potential with a fix price at 15 yens/kWh but with a purchase period of 20 years;
- scenario 1.3 simulates the potential with a fix price at 20 yens/kWh and a purchase period of 20 years.

The second scenario simulates the potential in the price condition of scenario 1.2 but with technologies upgrading and leading to a large reduction in installation costs.

For their part, supported scenarios estimate the potential integrating incentives for equipment cost with an objective of a PIRR (Pooled Internal Rate of Return) higher than 8%.

- support 1.1 considers that 1/3 of cost is subsided while price is fixed at 15 yens/kWh (before taxes) for 15 years purchase period;
- support 1.2 also considers that 1/3 of cost is subsided but that price is fixed at 20 yens/kWh (before taxes) for 15 years;
- support 1.3 also considers that 1/3 of cost is subsided but that price is fixed at 20 yens/kWh (before taxes) for 20 years.

The second supported scenario is based on a reduction of 50% of generation cost and 20% of engineering works, subsided at 1/3 with price fixed at 15 yens/kWh for 20 years.

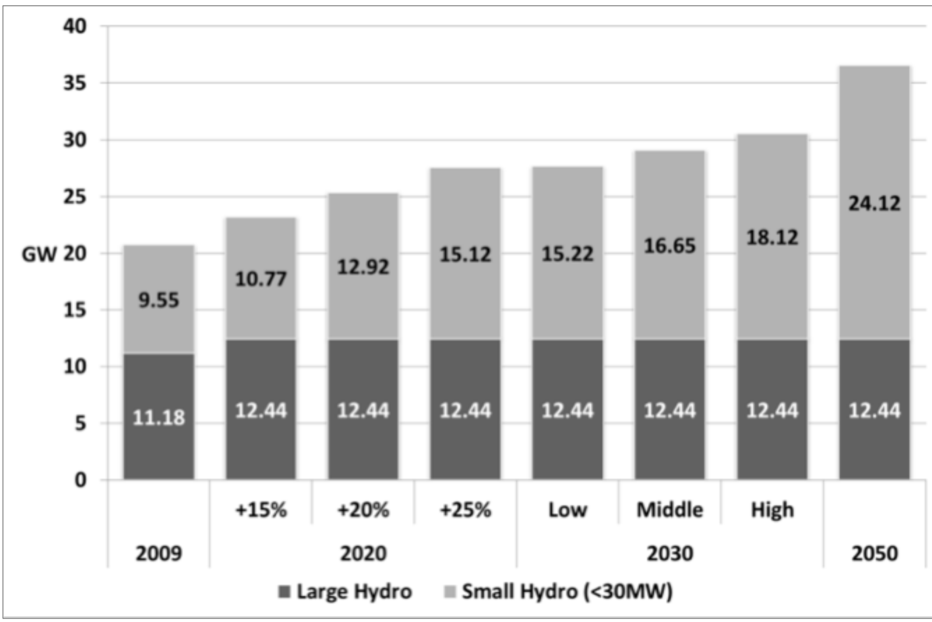
Table 3. Hydropower potential according to incentives type (mW)

| | Existing | Potential | Introduction potential scenarios | | | | Introduction potential / type of support scenarios | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Scen. 1.1 | Scen. 1.2 | Scen. 1.3 | Scen. 2 | Support 1.1 | Support 1.2 | Support 1.3 | Support 2 |
| Run-of-river | 16,550 | 13,980 | 900 | 2,130 | 2,840 | 4,060 | 2,430 | 4,410 | 5,170 | 7,100 |
| Agri channels | 320 | 300 | 160 | 200 | 200 | 240 | 220 | 250 | 260 | 290 |
| Conduits, industrial water | 180 | 160 | | | | | | | | |
| Total | 17,050 | 14,440 | 1,060 | 2,330 | 3,040 | 4,300 | 2,650 | 4,660 | 5,430 | 7,390 |

Source: NEDO 2014, 12

According to MOE (2012), if all potential sites of less than 30 mW are developed from now until year 2050, then small hydro could represent 14,570 mW, meaning that the output capacity would have been multiplied by 1.5 compared to 2009. NEDO (2014), based on above MOE scenarios, has computed some estimations to 2020-2050 (fig. 6). These projections clearly show that potential is on SMSH side that, depending on incentives, might exceed large hydro in 2020 or later. Considering the evolution since these scenarios were done, achieving such results seems however difficult.

Figure 6. Comparing large and small hydro potential: 2020-2030 and 2050. Simulation based on 2009 numbers and above scenarios




Source: NEDO 2014, chapter 8, page 15

## 3 Small-scale Hydropower Promotion and Development: Between Incentives and Regulations

After the oil shocks, numerous laws focusing on energy saving, promotion of alternatives to oil and introduction of renewables have been enacted, often then amended or revised[27] but, while Japan has become a leader in energy efficiency that has been a priority of public policies, RE did not really progress. The shock provoked by the Fukushima accident positively created a window of opportunity to change the strategy and the structure inherited from the past.[28]

In the immediate post Fukushima context, the DPJ, running the country at that time, announced a progressive phase-out of nuclear power plants. EPCOs have been weakened and some METI bureaucrats' beliefs have shaken. With the complete stop of all nuclear plants and the dependency rate on imported fossil fuel having grown up, from a 62% in 2010 to an 88% peak record in 2014, but also with the population opposition to nuclear restart[29] or at least in favour of a phase out over several decades (Midford 2014), RE were more seriously put on the agenda with, as it was mentioned before, the implementation of a FIT that succeeded the 2002 Renewables Portfolio Standards Law, which was little constraining for utilities. Also, although not directly addressing RE promotion, the three-phased electricity business reform (cf. box 1) is supposed to help their introduction.

## 3.1 Energy Legal and Promotional Framework: from Renewable Portfolio Standard to Feed-in-Tariff

The Law on Use of New Energy by Electric Utilities also called 'Renewables Portfolio Standards Law' (RPS Law), which was promulgated in June 2002,[30] made it an obligation for electric power companies to use a fixed amount (set for 8 years but revised every 4 years) of new energies: solar, wind, SMSH (stations up to 1 mW capacity), biomass and geothermal. The target for 2010 was set at 12.2 million mWh corresponding though to a very low standard of 1.35% of national electricity supply (Kawabata 2009, slide 9).

**27** Law Concerning the Rational Use of Energy (1979) amended in 1983, 1993, 1998, 1999, 2002, 2005 and 2008; Law Concerning Promotion of Development and Introduction of Oil Alternative Energy (1980); Law Concerning Special Measures for Promotion of New Energy Use (1997), amended in January 2002; Law Concerning the Rational Use of Energy and Recycled Resources Utilization (2003); Bill on the Promotion of the Use of Non fossil Energy Sources and Effective Use of Fossil Energy Source Materials by Energy Suppliers (released in March 2009).

**28** Some authors are sceptical about the capacity to change the system, see for example Samuels 2013.

**29** In a country that is not accustomed to them, huge demonstrations against nuclear took place and lasted even after LDP return to government. See among others Kindstrand, Nishimura, Slater 2012; Hasegawa 2014.

**30** See DeWit, Tani (s.d.) for an analysis of RPS Law adoption.

Three options are offered for them to fulfil their obligations:

- generate power by renewable resources by themselves;
- purchase new energies from others;
- have another utility take over their obligations.

A report was compiled in 2007 by the RPS Law subcommittee and recommendations were done leading to some improvement in the law, among which: SMSH and geothermal power generation categories were expanded, namely to include power generation using water for river maintenance with a capacity of 1,000 kW or less. New energies utilization target has been raised at 16 million mWh for 2014 (Kawabata 2009, slide 9), a still quite low level.

The 'Act on Special Measures concerning the Procurement of Renewable Electric Energy by Operators of Electric Utilities' (no. 108, August 2011)'s goal is to establish a 'Feed-in-Tariff' in Japan by constraining electric utilities to purchase electricity generated from renewable sources (solar, wind, SMSH, geothermal and biomass) based on a fixed-period contract with a fixed price decided by METI. It took effect in July 2012.[31]

In order for a supplier of Renewable Electricity to benefit from the Act, the suppliers have to obtain the approval of METI by complying with criteria set in 'implementing regulations' (also drafted by METI).[32] The price and term for power purchase agreements vary according to the type of renewable, the installation mode and scale of the facilities and some other factors (table 4). A 'Procurement Price Calculation Committee' was set to advise METI about the right pricing. The Act allows operators of electric utilities to charge extra fees to end users, in proportion to the amount of energy they use (surcharge fixed at 1.58 yen/kWh in 2015). The Act also set exceptions to the obligation to purchase the full amount of Renewable Electricity generated by suppliers if there is "a likelihood of unjust harm to the benefit of operators of electric utilities", "a likelihood of the occurrence of damage to securing the smooth supply of electricity" or "a just reason as set forth in the Implementing Regulations" (for more details see Graffagna, Mizutani 2011 or Anderson Mori & Tomotsune 2012).

**31** Since 1992 electrical utilities used to buy renewable energy from local producers through a voluntary basis system (surplus electricity purchase menu to foster solar power). The menu was amended in 1996 to also include wind power (DeWit, Tani s.d.)

**32** Hydropower facilities eligible to certification are those of less than 3 mW output as a total of power generators installed. Pumped-storage facilities are excluded.

Table 4. Japan's Feed-In-Tariff for Hydropower compared to photovoltaic since implementation in 2012

| | (yen / kWh) | 2012 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|
| **Hydropower** | | | | | |
| More than 1,000 kW /under 30,000 kW | Installing fully new facility | 25.2 | 24 | 24 | 24 |
| | Utilizing existing canals | | 14 | 14 | 14 |
| More than 200 kW /under 1,000 kW | Installing fully new facility | 30.45 | 29 | 29 | 29 |
| | Utilizing existing canals | | 21 | 21 | 21 |
| Under 200 kW | Installing fully new facility | 35.7 | 34 | 34 | 34 |
| | Utilizing existing canals | | 25 | 25 | 25 |
| **Photovoltaic power** | | | | | |
| More than 10 kW | | 42 | 32 | 29* | 24 |
| | | | | 27** | |
| Under 10 kW | When generators are not required to install output control equipment | 42 | 37 | 33 | 31 |
| | When generators are required to install output control equipment | | | 35 | 33 |
| Under 10 kW (solar cogeneration) | | 34 | / | / | / |

* April to June 30th
** From July 1st

Source: DLA Piper 2012 for the year 2012; METI/ANRE 2015 for the years 2014 and 2015; METI home page for 2016: `http://www.meti.go.jp/english/press/2016/0318_03.html` (2017-10-05)

NB For Hydropower: purchase period is 20 years. For PV of 10 kW or more: 20 years (for non-household customers); for PV of 10 kW or more 10 kW or less: 10 years (for household customers)

Fixed at an attractive level, the tariffs incited not only households but also companies to invest in new energies. The number of applicants has been important and between July 2012 and March 2016 a total cumulated capacity of 88,750 mW has been approved by METI under the FiT, of which some 33,140 mW have been installed.[33] PV projects represent most of the part of approved capacities, the great majority of which concerns small PV generating less than 10 kW (roof-top panels etc.). But on the other end of the scale 1,265 projects of more than 2,000 kW (mega-solar) have also been approved. As a result, the PV capacities installed and registered under the FiT between July 2012 and March 2015 are huge (table 5). This

33 See Table 5, NB 2 for more precision about these numbers.

increase in solar energy to be integrated in the grid led 5 power companies (to start with Kyushu Electric Power Company) using exceptions allowed by the Act to announce a suspension of new FiT agreements during fall 2014.[34] For anti-nuclear movements, the timing of Kyushu Electric was in question, the announce having been made only few days after the approval of the Nuclear Regulation Authority to restart two reactors in its Sendai plant (Kagoshima prefecture). Activist heavily criticised the 'as usual collusion' between METI bureaucrats, power companies and politicians, including Prime Minister Abe whose position in favour of nuclear is well known (see *The Japan Times* of 17th October 2014 and 2nd January 2015). In response, the METI/ANRE has revised tariffs for solar and also partially amended the FiT scheme.[35]

Table 5. PV and hydro power capacity approved under FiT and capacity installed since July 2012

| **(Unit: mW)** | **Annual Certified Renewable Energy Capacity under FiT** | | | | **Annual Operational Renewable Energy Capacity under FiT** | | | |
|---|---|---|---|---|---|---|---|---|
| | **FY2012** | **FY2013** | **FY2014** | **FY2015** | **FY2012** | **FY2013** | **FY2014** | **FY2015** |
| Photovoltaic < 10 kW | 1,420 | 1,270 | 1,100 | 860 | 970 | 1,310 | 820 | 850 |
| Photovoltaic < 10 kW | 15,990 | 36,410 | 17,180 | 5,710 | 700 | 5,740 | 8,570 | 8,310 |
| Wind | 800 | 240 | 1,250 | 550 | 60 | 50 | 220 | 150 |
| Small hydro | 70 | 230 | 360 | 120 | 0 | 0 | 80 | 70 |

Source: From Japan Renewable Energy Foundation (JREF) based on METI/ANRE Renewable Power Plant Certification Status, online (`http://www.renewable-ei.org/en/`) (2017-10-05)

NB 1. The photovoltaic capacity (10 kW and over), that was registered but cancelled afterwards, is not included on the data of registered renewable energy capacity under FiT.
NB 2. Until the end of March 2014, cumulative capacity of operational facilities included all the facilities having started operation from July 2012. This includes plants not registered under FiT. From April 2014, cumulative operational capacity represents only the capacity of the facilities registered under FiT.

Although all other renewables including small-scale hydropower (table 5) also benefited from FiT, capacities installed or registered under the

**34** Kyushu, Okinawa, Hokkaido, Shikoku and Tohoku Electric Power Companies estimated that, if the power capacity from all applications were to be connected to the grid, the total power flowing through the grid would make it difficult to maintain a stable electricity supply, the capacity exceeding the daytime power demand during fair weather hours in spring and autumn (for more detail, see Edahiro 2014; JREF 2014).

**35** A partial amendment of the FiT scheme was adopted by the National Diet in 2016 and will be effective in April 2017. Among others, it introduces an authorisation system for solar PV projects that includes a procedure to check the project feasibility and a requirement for maintenance and inspection during the project.

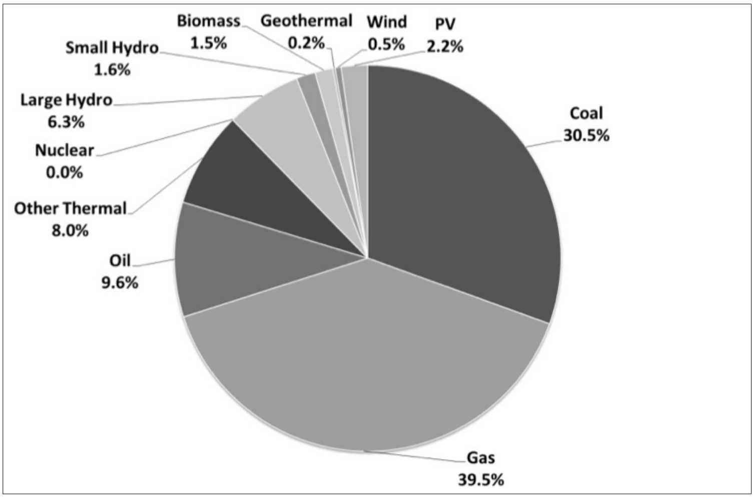
scheme remain far from those of PV. Of course, if we include large hydropower capacities that are not eligible under FiT, hydropower (large 7.1% and small 1.7%) is still the more important renewable source representing 8.9% of the electricity generated in FY2015 while photovoltaic (large mega-solar and small PV) stands at 3.3% (fig. 7).[36] Altogether, electricity generated from renewable sources (large hydro excluded), whose share was quite small (3.5% in FY2009 before Fukushima and 4% in FY2012), progressed faster since FIT, and finally have reached 7.3% in 2015. But, while a great number of potential sites for SMSH projects have been identified by surveys as we have seen before and, although they were not affected by any tariff change, the FiT incentive impact is quite small, even smaller than for wind (see table 5).

Several reasons can explain why incentives worked for solar generation to a much larger extend than for SMSH. It may come from a lack of support from power companies for whom, considering that most 'economically efficient' hydro site had already been tapped, restarting nuclear power was indeed a better option, anyway more suitable with usual vested interests. Another reason might be financial; the engineering and equipment costs (initial costs), which are high in case of hydropower facility,[37] might explain why local promoters of renewables have often preferred investing in solar to address the global warming issue. Tariff, which is lower if compared to solar especially until last FiT revision, might not be attractive enough, while purchase period of 20 years appears short if we consider the lifetime of facilities.

**36** 0.3% in FY2010 (ISEP, JSF 2011) and 0.7% in FY2012 (ISEP 2014).

**37** Even though investment cost heavily depends on type and infrastructure size.

Figure 7. Domestic electricity generation by source, FY2015




Source: ISEP 2016, URL `http://www.isep.or.jp/wp/wp-content/uploads/2016/08/fig3.gif` (2017-10-05)

Even though all these factors play their role in explaining why the impact of FiT was limited as far as SMSH is concerned, the regulatory framework also has to be taken into account to fully understand the problem. A SMSH project not only has to deal with energy constraints, but also has to go through water legislation to get all needed authorisation. These being quite complex and time consuming, SMSH projects' leadtime is much longer than PV's, making the investment more risky. This creates a real bottleneck to SMSH development and partly explains why, among the projects registered under the FiT since 2012, very few are in operation several years after (see table 5).

## 3.2 Water Legislation and Management

For an hydro facility, whatever its size, the resource is water and, indeed, water use rights are strictly regulated in Japan. Also, the most numerous untapped sites remaining for small to micro-scale projects are run-of-rivers or irrigation channels type; they are also concerned by laws dedicated to rivers, water supply for agricultural use, and environment legislation, making the landscape even more complex.

River administration can be traced back to the Edo era when measures had been taken to prevent flood, but at the time it remained locally administrated. After the Meiji restoration, the centralized administration led to enact the first river law or ‘old River Law’ (1896). The law was then revised several times to adapt to changes, but in the ’60s it appeared necessary to review it fundamentally. The new River Law was then enacted in 1964. It was revised several times without major changes. The law covers all aspects of river administration. Consistent with river administration since the early times, the law is motivated by the two main objectives: to control river flooding and to ensure availability of river water for daily and industrial use (for a complete analysis of the river law see IDI 1999). Under the law, rivers are classified in two main categories with sub-groups and different administration levels: ‘Class A river systems’ and ‘Class B river systems’.

Class A refers to those systems that are important for the national economy and people’s lives and that are, therefore, administrated by the Minister of Construction (MLIT now). Class B concerns other rivers systems administrated by the prefectural governors. Class A is further subclassified as ‘Trunk rivers’ and ‘Others’; ‘Others’ being also administered, except for approval of certain specified water rights, by the prefectural governors. Also, some sections of small tributaries of both class A and class B rivers might be administrated by the mayors of cities, towns, and villages. Class A includes 13,798 rivers grouped in 109 river systems (approximately 87,150 km) while class B includes 6,931 rivers grouped in 2,691 river systems (approximately 35,720 km). Some small rivers are not included and are administrated by mayors. The River Law stipulates that any utilization of land and river water within the sections defined by the River Law must obtain approval from the designated river administrator.

The River Law serves as basis for water management but, once water is withdrawn from the river channel, it is managed under different other laws.[38] Finally, SMSH facilities might also relay on the ‘Environmental Impact Assessment Law’ (no. 81, 1997),[39] which aims at ensuring that proper consideration is given to environmental protection issues relating to a project that changes the shape of the terrain or involves the construction of a new structure.

All these laws are of course not under the same jurisdiction as figure 8 shows. Measures concerning water resources are implemented by a number of government ministries (and several bureaus inside) and agencies.

**38** Water supply law, industrial water law, industrial water supply business law, water pollution control law, sewerage law, specified multipurpose dam law, water resources development promotion law, law concerning special measures for reservoir areas, law concerning the Regulation of Pumping-up of Groundwater for Use in Buildings etc. to name only some of them.

**39** Environment Impact Assessment Law (EIA) applies to the upper scale of SMH category: 22,500 kW-30,000 kW power plants; or reservoir area of 75 ha-100 ha, EIA class 2; see MOE (s.d.). Wind is also requested EIA while PV is not (Mizuno 2014).

The MLIT is in charge of the overall development of water resources:

- development of comprehensive water resources policies such as the Comprehensive National Water Resources Plan and the Water Resources Development Basic Plan;
- water resources development, and maintenance and management of river facilities;
- utilization and conservation of river water;
- development and management of sewerage facilities.

The MOE for its part is in charge of:

- development of guideline, policy, and planning on water conservation;
- water pollution measures (river, groundwater, etc);
- ground subsidence measures;
- environmental Quality Standards setting.

The Ministry of Health of:

- supervision of domestic water supply utilities;
- regulation on domestic water supply facilities.

The METI of

- supervision of industrial water supply utilities;
- regulation on industrial water supply facilities.

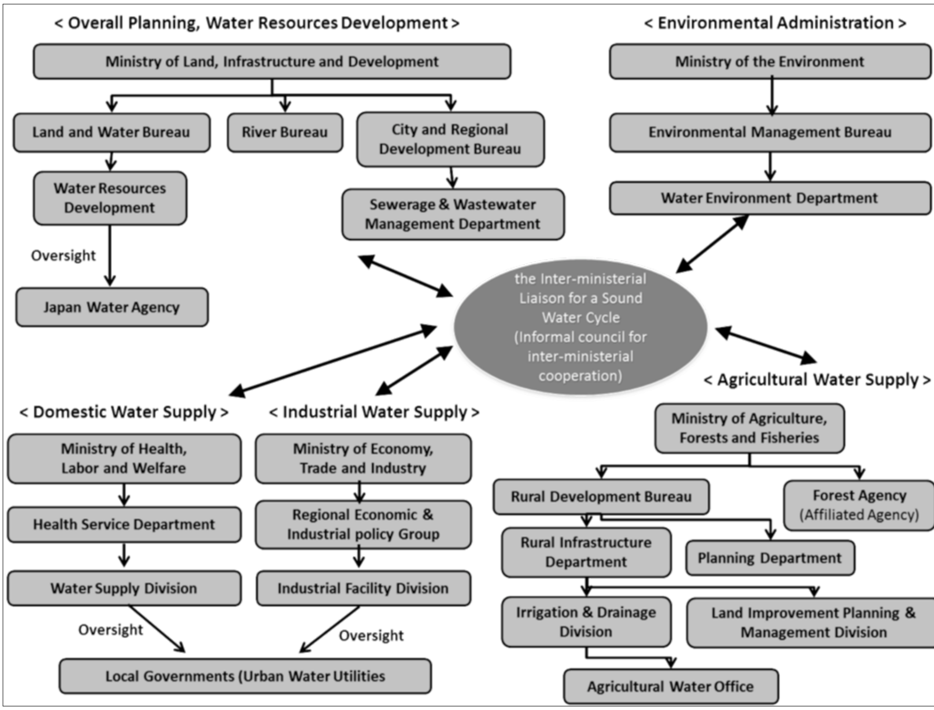
The Ministry of Agriculture of

- regulation on agricultural water;
- conservation of Forest for water resources;
- and, at the bottom, local governments operate, maintain and manage urban water utilities and existent facilities and, as we have seen before, some rivers.

The Japan Water Agency, which is an 'Independent Administrative Agency',[40] is also involved in water management. The Agency is in charge of providing a Stable Supply of Safe, Quality Water at a reasonable price. Therefore, it is engaged in the construction and refurbishment of major dams for water utilization (for domestic, industrial and agricultural water supply) and river management purposes (flood control, maintenance and promotion of normal functions of water flow), etc.

40 Supervised by: MLIT; Minister of Health, Labor and Welfare; Minister of Agriculture, Forestry and Fisheries; and METI.

Figure 8. Water regulation and management structure




Source: World Bank 2006, 5

Although the Water Resources Department of MLIT acts as the overall coordinator in adjusting measures for water supply and demands reservoir area development, an Inter-ministerial Liaison Council (Informal council for inter-ministerial cooperation) has been created to study how procedures could be simplified.[41]

But, for the moment, in such a complex and fragmented responsibilities landscape, getting all the needed information and authorisations is a kind of obstacle course for SMSH projects promoters. This tends to make the preparation phase very long lasting and finally increases implementation cost. Suwa, for example, considers that "a lack of awareness among policy makers, together with overly restrictive regulations for agricultural water usage, is currently making smaller hydropower generation commercially unattractive" (2009).

**41** His missions are said to be meant to: "Form a basic awareness on necessary measures and policies for a sound water cycle" (World Bank 2006, 5).

## 4 Conclusion

Water, which Japan is rather well provided with, is a resource the country could rely on to ensure a better energy security, reduce importation of primary resources and limit $CO^2$ emissions. The post-Fukushima context appears as favourable to further development as SMSH now is promoted like all other renewables, namely through the FiT. But, despite the fact that surveys have shown the potential is high, the expansion remains quite limited, especially if compared with PV whose registered projects as well as operational capacities have grown fast since FiT implementation in July 2012.

Japan's power utilities own hydropower plants since a long time and large manufacturing corporations such as MHI, Hitachi or Toshiba who clearly have relations with METI are also involved in manufacturing equipment and facilities for hydropower generation. Hydropower, whose plants construction has been in the past eligible for subsidies like thermal and nuclear ones (Hasegawa 2014), has been an insider of the vested interest structure (Moe 2012), but untapped sites are for the most part micro-sites meaning that generated volumes are very small, often too small to interest power companies for whom integrating electricity to the grid would generate too high per kWh costs. Therefore, utilities' rather positive attitude to certain hydropower categories might not be extended to low production volume, remote areas location and uneasy connection to grid SMSH projects, even more if they are run-of-river or irrigation channels types, meaning that they do not have any storage function.

In fact, power companies, facing the obligation to integrate on the grid more electricity from new renewables,[42] have interest in developing hydropower, but the type they are the most interested in is pump storage facilities. Thanks to their fast ramping up capability, PSP which Japan has the world's largest installed capacity[43] (NHA 2012), can be used to instantly balance supply and demand, ensuring grid reliability. Using electricity produced by other energies when demand is low, and restituting it to the grid when demand is high, they work as storage capacity. According to US NHA, it is foreseen as "the only commercially proven technology available for grid-scale energy storage" (2012, 2), while for Eurelectric, "hydropower provides the most efficient energy storage technology, and the only existing large-scale storage technology" (2015, key messages). Although Japan seems to promote storage batteries more than PSP, the

**42** Government forecasts for 2030 are based on a return to nuclear to 20-22% of the electricity mix, 22-24% for RE including large hydro meaning 14-15% without.

**43** Some 26GW (NHA 2012). PSP developed in Japan in the early '90s to adjust supply from nuclear or thermal generation to demand.

latter might play an important role in a further development of new RE especially after the full implementation of the electricity reform.

For the moment, NGO, citizens associations and local authorities appear to be the most interested in valuing local water resources, but water regulation makes it necessary to get water rights before launching any project and to prove water quality (such as land and environment) will not be endangered by the structure build so as the land and environment. Water (and agricultural land, environment) management is, as we have seen, complex in Japan and obtaining all needed authorization appears as an absolute puzzle that takes a lot of time. The lead-time of projects, much longer than in the case of solar, is an issue that projects' promoters are pointing out.[44]

For example, Fukushima Prefecture has set the goal of increasing the total output capacity of micro-hydropower plants from the pre-disaster level of 14,400 kW to 40,000 kW in FY2030. As of October 2014, only six projects have been certified under the FIT system. "This is partly due to utilities restricting access to the power grid, and partly to complicated procedures for obtaining water rights" wrote Ueda Toshihide, a senior staff writer of Asahi, based on interviews with local micro-hydro projects holders in the prefecture (Asahi shinbun, 1st October 2014).

The issue for SMSH projects actually is local production/local consumption. This is of course possible but what to do with surplus if any? Community micro-grids have been experimented and some derogation has been given to test electricity exchanges between a group of houses like in Kitakyushu's smart community project.[45] But, apart from such experiments, electricity regulations do not allow individuals to exchange between or to sell it to neighbours. Also, FiT is an incentive if electricity is sold to power companies at an attractive price, but if electricity is consumed locally, the only incentive is to reduce the bill from the grid usage. The unbundling (reform 3rd phase) should ease new entrants to propose their services while smart-grid technologies and the diffusion of smart-meters, home energy management systems (HEMS) etc. should also bring a certain decentralization of distribution and the introduction of more RE. If this move should favour the local production/local consumption approach and so be suitable to further SMSH expansion namely in rural areas, the impact on price (electricity + related services) for customers remains unclear.[46]

**44** According to Mizuno (2014), this is also a problem for wind, which is of course not concerned with water legislation but also has to deal with a complex regulation framework.

**45** Based on the interviews and observations of Kitakyushu's smart community.

**46** Some voices advocate that unbundling will lead to fragmentation of the sector in terms of services and value chain, implying new business models, more local energy policies and management, but also a need for coordination and for regulation changes. See for example Fuentes-Baracamontes (2016), who discusses this business model, cost and regulation is-

Although Japan has numerous rivers, long irrigation channels, abundant precipitation and a certain number of multipurpose dams whose heads remain untapped, reaching the government estimates towards 2050 even in the lowest scenario, will probably need more actions, incentives and simplification of regulations, for local or small promoters to invest in SMSH. Big companies (power companies, etc.) have the legal forces to go through such complex procedures, but individuals or even rural associations do not. Recognised as one of the major breaks to further expansion of SMSH but also of wind although the concerned laws concerned (Mizuno 2014), a revision of procedure now is on the agenda, while the electricity reform with its second phase liberalization of retail but moreover with its third phase unbundling is expected to have a great impact on the local production/local consumption, but it is still too early to know.

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