LUND UNIVERSITY • CENTRE FOR EAST AND SOUTH-EAST ASIAN STUDIES

Assessing Japan's renewable energy situation:

Can the Feed-In Tariff policy and the Energy grid situation constrain the future of renewable energy in Japan?

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Abstract

This thesis uses the principal-agent theory to analyse two interconnected problems within the Japan's renewable energy sector, namely the Feed-in Tariff (FIT) policy, and the energy grid issue. Following the Fukushima accident, while the nuclear power plants remained closed, Japan's renewable energy sector was able to experience enormous growth. The number of applicants for the FIT was greater than expected and the current cost of this policy has been higher than the original estimates. This financial burden will continue to grow, should this policy remain intact or if no other policy will take place. Another issue that the current renewable energy faces in Japan is regarding the newcomers being denied the access to the energy grid, as it would endanger the stability of already divided energy grid.

This energy grid issue, as well as the increasing costs of the FIT policy, both have a potential to eventually lead to the stagnation of Japan's renewable growth. Is this the breaking point for the future of renewable energy in Japan? Will the FIT policy become too expensive to maintain? Will the energy grid issue not allow further growth of renewable energy in Japan? These problems, if left unanswered, can have significant consequences for the future of Japan's renewable energy sector and therefore it is important to analyse, if they are getting the attention they require. Therefore, for Japan to further expand its renewable energy capacity, there is a need to tackle these issues; the current FIT policy, as well as the energy grid issue, since they are related, and either can have massive consequences for the future of renewable energy in Japan. By looking at this topic from the principal-agent theoretical framework, this thesis will analyse and give a better understanding regarding the issues that Japan's renewable sector has to deal with, should the proportion of renewables continue to grow. This thesis follows the structure of giving an overall overview of the topic, supplemented with the analysis of the existing literature review, using the systematic review and then specifically dealing with both FIT policy, as well as energy grid. The analysis conducted in this thesis, together with the principal-agent theoretical framework can provide us with a better insight over the complexity of the issues within Japan's renewable energy sector and provide us with a better understanding regarding the political, as well as economic struggles within the Japan's renewable sector.

Keywords: Principal-agent Theory, Energy Grid, Feed-in Tariff, Renewable Energy, Solar PV, Wind Energy, Systematic Review, Policy Analysis, Cost-effectiveness analysis

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List of Abbreviations

kW	Kilowatt
kW/h (kWh)	Kilowatt per hour
MW	Megawatt (1MW=1000kW)
GW	Gigawatt (1GW= 1000MW; 1 000 000kW)
TW	Terawatt (1TW=1000GW, 1 000 000 MW, 1 000 000 000kW)
TW/h (TWh)	Terawatt per hour
BWR	Boiling Water Reactor
CO_2	Carbon Dioxide
CPS	Concentrating Solar Thermal Power
DPJ	Democratic Party of Japan
EIA	U.S. Energy Information Administration
EPCO	Electric Power Company
FIT	Feed-in Tariff
FY	Fiscal Year
GDP	Gross Domestic Product
IEA	International Energy Agency
JAERI	Japan Atomic Energy Research Institute
JPEA	Photovoltaic Energy Association
LDP	Liberal Democratic Party
METI	Ministry of Economy, Trade and Industry
MITI	Ministry of International Trade and Industry
MOE	Ministry of Environment
NGO	Non-Governmental Organisation
NSC	Atomic Energy Commission
OECD	Organisation for Economic Co-operation and Development
PV	Photovoltaic
PWR	Pressurized Water Reactor
RE	Renewable Energy
RES	Renewable Energy Standard
RPS	Renewable Portfolio Standard
REN21	Renewable Energy Policy Network for 21st Century
¥	Japanese Yen

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1. Introduction

Some countries have the luxury of being self-sufficient when it comes to meeting their energy needs, while other countries have to import certain amount of their energy needs. Japan belongs to the latter group, as one of the most energy dependent countries in the world. In this context, the only answer for the Japanese policymakers to decrease the fossil fuels dependency, while increasing the self-sufficiency, has been nuclear and renewable sources of energy. Therefore, it is not surprising that for many decades, Japan has been heavily investing in the alternative sources of energy. However, while nuclear energy has been Japan's government favourite during the last couple of decades, the Fukushima accident changed this attitude, and after the implementation of the Feed-in Tariffs (FIT) policy[1] in 2012, Japan's renewable energy sector was able to expand significantly. Moreover, "as a domestic resource, renewable energy reduces import dependency and increases energy security by diversifying the energy mix. As a low-carbon source of energy, it also helps Japan to reduce its CO_2 emissions. Finally, renewable energy can also help to meet the government's stated objective of minimising the use of nuclear energy as far as possible "(IEA, 2016, 119).

While Japan's renewable energy growth can be considered as a major success when looking at the increased volume, many obstacles are starting to get more visible, despite still very impressive growth numbers. Economic issues, as well as other difficulties, such as the energy companies blocking the newcomers to join the energy grid, as well as the energy grid connection issue, stability of the renewable energy supply and the need for a smart grid are starting to become sounder and each of them have a potential to significantly hinder the future growth of renewables. The current government support for the restart of the nuclear power plants can be a dire threat to renewable expansion, that is also getting more expensive with each new obstacle it faces. Solar photovoltaic (PV) is the emerging renewable energy which in the recent years expanded the most in Japan. On the other hand, wind energy has the greatest install base over the world among the emerging renewable resources, yet it lacks severely behind solar PVs in Japan. Probably the biggest issue with the growth of renewables is the energy grid connection, where Japan is having problems, whereas in the energy grid division between East and West, but also in the interconnection of individual regions of

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[1]This policy goal is that the electricity market has to buy renewable energy at the decided premium above average prices for renewable energy which has been decided beforehand. These prices are usually fixed and offered under a contract which usually lasts 10-25 years (Dong, 2011; Chaturvedi, 2014).

Japan. The question arises, is this the breaking point for the future of renewable energy? Or is it just a temporary hindrance that will get fixed once it gets the attention it requires? Will the FIT policy prove to be too expensive for Japan to maintain? Will the energy grid issue not allow further growth of renewables? These major problems, if left unanswered, can have significant consequences for the future of Japan's renewable energy sector. By looking at these issue via the principal-agent theoretical framework, we can get a better understanding regarding these topics and why these problems emerged in such a specific way as they did in Japan.

1.1 The Aim of the Thesis

This thesis aim is to assess the Feed-in Tariff policy when it comes to both costs and benefits while raising and evaluating the issue of energy grid connection that hinders the future expansion of renewables. While the growth of renewables is undeniable, the costs and benefits of the FIT are not. Furthermore, what is becoming more problematic are the issues that were not considered as a significant obstacle before, especially the energy grid issue, thanks to which some energy companies do not allow newcomers to join the grid, especially in the parts of Japan that have the highest renewable potential.

1.2 Research Question

This thesis evaluates the FIT policy when it comes to both costs and benefits, as well as explaining the energy grid issue that currently hinders the future growth of renewables in Japan. The FIT policy is closely interlinked with the energy grid issue, as many FIT projects were not approved because of the limitations of the energy grid. This thesis will analyse, and evaluate both problems within the research question, using the principal-agent theoretical framework:

Are the issues of Japan's renewable energy sector, specifically the Feed-in Tariff policy and the energy grid getting the proper attention they require, or will any of these two constrain the future growth of renewable energy in Japan?

1.3 Delimitation

The structure of this thesis uses primary sources regarding the Japan's energy sector while delimits itself to the Feed-in Tariff policy which has been implemented in 2012 while giving an overview of the previous policies in the Japan's renewable energy field. As a result of the complexity of this topic, the main focus has been on the government policies while evaluating the economic costs based on a variety of government and NGO's reports and datasets. The issue of energy grid has been selected as a representation of the most important obstacle that hinders the growth of renewables under the Feed-in Tariff system in Japan.

1.4 Thesis contribution

The main contribution of this paper is that it gives more intra-disciplinary insight on the topic of Japan's renewable sector while evaluating the economic costs of the current Feed-in Tariff policy, while documenting and describing the obstacles that hinder the growth of renewables in Japan. It gives a policy prescription and points out the problems that Japan have to resolve if renewable energy growth should continue.

2. Theoretical Framework and Research Methodology

The ongoing situation within the Japan's renewable energy sector can be explained as a mixture of economic, as well as political influences, capable of shaping the existing energy structure, as well as the current and future energy policies. This thesis takes into consideration the institutional approach and regulatory policies connected to it, specifically looking at the financial situation within the Japan's renewable energy sector. The theoretical framework of this paper will follow the principal- agent theoretical approach to analyse two of the most imminent problems hindering the future of renewables in Japan, namely the FIT and the energy grid issue.

2.1 Principal-agent theory

Principal-agent theory follows the idea that one "agent" is capable of influencing and making decisions on behalf of the "principal". Or to simplify it, principal pays the agent for the services agent provides, while agent should act on principal's behalf. The dilemma happens when the agents are supposed to act on behalf of the principal, yet they also have their own interests to follow, which can be in direct contrast with the interests of the principal. Bøe and Gulbrandsen (2016, p95) explain the principal-agent theory as an "ubiquitous theory that has been applied to numerous types of relationships, and explains transactional arrangements between parties with divergent goals in the presence of uncertainty". This theoretical framework is especially fitting for the current situation within Japan's FIT, as well as energy grid issue, where both principal, as well as agent have to co-exist in the same sphere, while being dependant on each other and trying to balance their commitment towards each other with their own self-interests. When looking at the current energy situation, we can see many principal-agent relationships, such as the one between the shareholders and landlords or managers, however, for the sake of this thesis, the relationship we will be looking at is between the principal, in the context represented by the Japanese governmental sector - more specifically the METI, while agents are represented by residential sector(i.e. households), non-residential sector (i.e. private companies), as well as the energy companies, who are getting "paid" in the form of the FIT rates, while the principal expects the increased proportions of the renewables within the energy sector.

Principal-agent theory follows the idea, that it is important to take into consideration explicit assumptions about the individual agents and their behaviours. Bøe and Gulbrandsen (2016, p95) points out the three factors which should be taken into consideration: a) Goal conflict:

principal and agent do not necessarily share the same goals and their specific goal may be quite different from each other. b) Information asymmetry: principal usually have only a limited capability to observe the agent. c) Differential risk preferences: principal and the agent may act differently when it comes to the risk behaviour (p95). There is an assumption that both principal and agent have different goals to achieve as well as different levels of risks they are willing to take, therefore the outcome for the principal may not be maximized. Another important thing is that the agent will not always act in the best interests of the principal. The reason for that is that the agent will act opportunistically. Therefore, his goal will be primarily to maximize his profits, which is in contrast to the goals of the principal. The important feature of this agency theory model is that "interests of the principal and agent diverge and the principal has imperfect information about the agent's contribution" (Bosse and Phillips, 2016, p276).

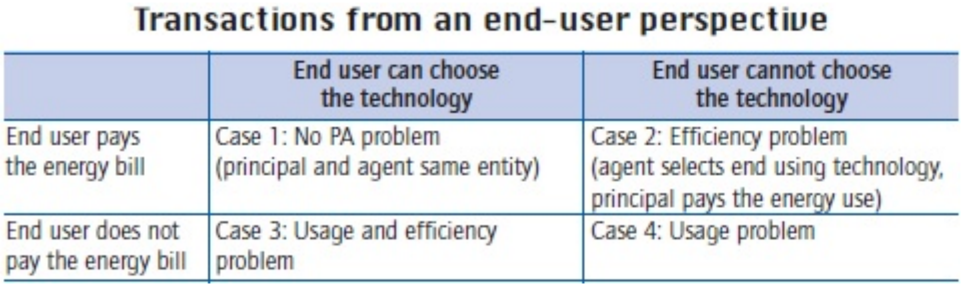
"These features define the problem, and the problem results in costs and inefficiencies ultimately borne by society, one principal at a time. While the costs to society are difficult to measure precisely, they are significant" (Bosse and Phillips, 2016, p276).

2.2 Theoretical context of the principal-agent problem - Japan's renewable energy

When focusing on this principal-agent relationship and taking into consideration assumptions that come from this relationship, we can create a theoretical framework which can be applied to the current situation of Japan's renewable energy sector. What needs to be taken into account with the principal-agent theory applied in the field of energy, is that it has been mostly used for the topic of energy efficiency (Krishnamurthy and Kriström,2015; IEA, 2007), whereas in this paper, principal-agent theory will be used to further evaluate the topic of Feed-in Tariffs, as well as the energy grid issue, where energy efficiency definitely plays a role, however this role is not in the core of these topics, therefore there is a need to evaluate this relationship from a slightly different perspective .

As Krishnamurthy and Kriström points out," the agent's decision leaves the principal with potentially higher electricity costs" (2015, p86). In this kind of scenario, each agent acts based on their own best interests, while the principal tries to get the outcome he seeks, which in the case of Japan's renewable energy can be for example the increased proportions of renewable energy, CO2 emissions and the costs of the FIT policy. It is important to realize that the different agents act in their own best interests, whereas the economic or political ones. Looking at the current situation from this framework can help to understand the economic, as well as political interests of different parties involved in the process, each trying to maximize the profits, while not necessarily taking into consideration the interests of the others.

Figure 1: The 4 Principal-Agent problems



Transactions from an end-user perspective

	End user can choose the technology	End user cannot choose the technology
End user pays the energy bill	Case 1: No PA problem (principal and agent same entity)	Case 2: Efficiency problem (agent selects end using technology, principal pays the energy use)
End user does not pay the energy bill	Case 3: Usage and efficiency problem	Case 4: Usage problem

Source: IEA, 2007, p 34

As can be seen from the figure 1, which was used by the IEA (2007) for the principal-agent framework to describe the landlord-tenant relationship, the Japan's current renewable energy system under the FIT can be also described under the case 3, where there is both the usage as well as efficiency problem. Since the principal, in this case the government pays for the FIT policy, while the agent (electricity companies, private companies, residential sector) can decide on the type of technology and the level of technological innovation, the current system faces both the usage, as well as the efficiency problems. Therefore, to structuralize this theory, as Pouryousefi and Frooman (2017) point out, this type of theory can be used as an analytic tool to outline "what might happen in the absence of ethical behaviour" (p164), or for the sake of this thesis, what are possible consequences of the current structure, where appointed agents primarily focus on accomplishing their own goals and interests, while not necessarily taking into consideration the interests of the principal, nor the possible benefits for the entire system.

2.3 Analytical framework

2.3.1 Policy Analysis

Policy analysis in this thesis is used to analyse the influence of the FIT policy on the expansion of renewables, especially solar PVs and wind energy, while also assessing the issue of the energy grid connection. The evaluation criteria of this analysis include cost, net benefits, effectiveness, efficiency, administrative ease and political acceptability of the FIT policy (Patton et al., 2012). This analysis should be the most suitable one to focus on the FIT policy, while also evaluating the previous government policies regarding renewable energy, whereas through the inclusion or exclusion in a variety of research and development projects or the level of support for different renewables.

2.3.2 Cost-effectiveness analysis

Cost-effectiveness analysis of renewable energy in Japan under the FIT gives a better understanding from the economic perspective the current and future tendencies regarding the total energy mix in Japan. Unlike cost-benefit analysis, in which everything gets a monetary value, which in the case of renewable energy can be very biased to measure.
Cost-effectiveness analysis is a preferred method since the “benefits or disbenefits are difficult to value” (Tuominen et al. 2015, p424)

2.3.3 Systematic review

For the sake of assessing the existing literature regarding this topic, systematic review has been implemented. Because of the amount of data written on the subject of Japan’s renewable energy and more specifically the FIT, as well as the data regarding the individual renewables in Japan. For the method of analysis of this type of information, the systematic review seems to be the most suitable choice, as it collects, critically analyses and compares these documents. Systematic review involves identifying, synthesising and assessing the evidence to create an empirically derived answer to the research question (Bryman, 2012; Hagen-Zanker et al., 2012).

2.4 Sources of Data

The primary source of data used in this thesis is the same as data either used or produced by a variety of respected organisations, such as Japanese METI (Ministry of Economy, Trade and Industry), MOE (Ministry of the Environment), MIAC(Ministry of Internal Affairs and Communication) IEA (International Energy Agency), ISEP(Institute for Sustainable Energy Policies), REN21(Renewable Energy Policy Network for 21st Century), EIA (U.S. Energy Information Administration) and JPEA (Japan Photovoltaic Energy Association). Other sources of data include the Waseda’s University library collection books, such as Ruud (2014), Dent (2014), Vivoda (2014), Zehner (2012), Ekins et al. (2015) and also many the articles from ScienceDirect online journal and other, academically respected journals on the topic of renewable energy.

2.5 Estimates, Modelling and Costs

Various sources used in this paper are using estimates, which tend to be consistent, therefore for claims that use vastly different data (i.e. Zehner), it is important to take into consideration the ways to obtain various types of datasets and evaluate the quality of these claims. When giving a better idea by modelling the alternatives, it is possible that different estimates may result in vastly different models, which needs to be taken into consideration while assessing these models.

This thesis investigates different agents that are shaping renewable energy in contemporary Japan. The main focus is on the influence of the FIT policy and whether the obstacles renewable energy, especially solar PVs and wind energy has to face in Japan are economically as well as politically feasible to overcome or not. Especially since the nuclear power plants are slowly being restarted, this is already having some negative consequences for the Japan's renewable energy expansion. Combining it with the issues of Japan's energy grid as well as land requirements for renewable energy expansion creates a difficult situation in Japan's renewable energy development.

When looking at the financial costs, we may enter the grey zone, where each report represents different data numbers, unless various reports are quoting from the same dataset. The important thing when looking at the financial costs is not only the costs of construction but also the additional costs such as the cost of land, labour force, maintenance. Most of the time, this increases the costs above the levels stated in the articles and data sets, such as REN21(2016, p65), which is a renewable energy policy network, with datasets developed to be more pro-renewable than for example an information report provided by Ozzie Zehner (2012), who is much more negative regarding renewable energy costs and effectiveness(pp 11,17, 44-45, 50). Therefore, where the truth regarding the costs lies, moreover, is there one single truth?

2.6 Data Accuracy and Consistency

All the data used in this thesis has been provided from valid, academically credited sources, such as government reports, non-governmental organisations(NGO's) and academic journals. However, what needs to be taken into consideration is the possibility of biased reports, or using the type of statistical data that may not show the real situation, but rather the scenario that the author may aim for. Different types of data will be taken into consideration to give the reader the possibility to understand the difficulty of this topic when it comes to the relevant data and how easily they can be shaped based on the preferences.

2.7 Ethical Considerations

The research presented has been done with the absence of the interviews. All ethical considerations have been taken into account while working on this thesis. The data presented in this thesis was collected following the ethical guidelines defined by the Swedish Research Council. The emphasis has been focused on the consistent style of quotation and referencing, to correctly represent empirical and theoretical material.

3. Background information and literature review

Renewable energy consists of a group of energies that can be grouped under a single "renewable" brand. It is important to realize that different types of renewable energy will not end up in the same situation when the government policies are implemented, for a variety of reasons, such as the costs, technological difficulty, land restraints and geographic conditions. The first part of this chapter will focus on the background information, which will explain specific types of renewable energy in Japan, with the main focus on solar PVs and wind energy, as well as an explanation of the situation regarding hydropower and geothermal energy. Then, the reasons for the government decision of implementing the Renewable Portfolio Standard (RPS)[2] and then to replace it with the FIT policy will also be explained. Afterwards, the literature review will take place, giving a better insight on the post-Fukushima development of renewable energy in Japan.

This chapter will give a better understanding regarding the government position and it will explain different types of renewable energy. It is important to understand the linkage between the government policies and overall energy decision-making and what consequences these linkages can have on the future of specific types of renewable energy.

3.1 Specific types of renewable energy

3.1.1 Hydropower

Hydropower is the most used source of renewable energy since it is a highly flexible technology, capable of fast response inside the energy power grid, hydropower can easily meet sudden changes in energy demand (Olz et al., 2007, p 24). In 2015, it rose by 28GW and the total world capacity is 1064GW. The main share of the growth is from China, where the hydropower increased by 16GW (REN21, 2016, p22).

[2] Contary to the FIT, in the case of RPS, renewable energy can be increased by the government dictating the energy utilities to produce a certain percentage of the electricity from renewable sources. It can be considered as a quantity regulation, letting the market determine the reasonable price. This means that the electricity companies can be ordered some quota, meaning a certain percentage of the electricity that is sold to the consumers has to be from renewable sources of energy (Dong, 2011; Chaturvedi, 2014).

On the other hand, ocean energy is struggling. In 2015, ocean energy capacity, mostly from tidal waves was at 530 MW(0.53GW). This technology is facing financial difficulties and there was at least one case when a company had to declare bankruptcy (REN21, 2016, p22).

Hydropower as a source of renewable energy has been well-spread in Japan. "Hydroelectric plants were attractive because once the dam and turbines are built, the only costs associated with them are mostly operational costs and maintenance. Annual droughts lowered the water levels of many rivers, making electric output variable and regularly causing blackouts during the summer when the water was at its nadir and demand at its zenith. Developing this resource, moreover, could not continue unabated. By the mid-1950s, most of the easily dammed sites had already been developed "(Nelson,2011).

This is also a reason why the proportion of renewables in Japan was declining over the years (graph 2, p22), which is understandable since the consumption of the energy grew, while the capacities of the hydropower, the largest source of renewables in Japan, was reaching its peaks. Therefore, the proportion of renewables was steadily decreasing in regards to the total power production share.

3.1.2 Solar energy

Solar energy is most commonly used for electricity generation, water heating and space heating. This is done via either solar photovoltaics or concentrating solar thermal power systems that can capture solar energy. The global solar energy market rose in one year by 50GW, and in 2015 the solar PV production capacity was at 227GW. China, Japan, and the United States were the ones with the most capacity added.

Solar photovoltaics (PV) converts sunlight into electricity. It can exist either grid connected, standalone or integrated into the buildings. Solar PV's are exposed to external influences, such as the weather season, diurnal time period from the dawn to dusk and also from other influences, such as clouds or fog. As a result, if the proportion of the solar PV's in the energy grid is significant, the need for more flexible grid or energy storage is required to avoid electricity distortions (Olz et al., 2007, p 23).

Concentrating Solar Thermal Power(CSP) is the second type of solar system that converts the sunshine heat into electricity. It provides electricity especially in areas that have many hours of direct sunshine with as little of interference, such as clouds and haze as possible. These areas usually have peak demand during the day, because of the use of air-conditioning systems, which match the CSP peaks well. However, since the heat storage technologies are currently economically not feasible, the CSP is usually supplemented by other sources of energy in the later hours after sunset and has been relatively limited by the geographic location (Olz et al., 2007, p 24). However, for the sake of this thesis, since Japan's focus is on PV sector, CSP will be excluded from the further analysis.

Japan was able to achieve 11GW of solar energy to be added to the grid, increasing the total capacity to 34.4GW. However, the residential market only grew by 0.9 GW, and the rest of the growth was achieved by the commercial and utility scale projects. The big obstacle is the scarcity of the available land for large-scale plants. During the hot summer days, solar PV accounted for 10% of the electricity demand in Japan and in 2015 it represented 3% of total power generation. One of the issues is that the volume of solar PV projects exceeded the capacity of the grid, which forced the government to revise regulations and allowed energy utility companies to decline access to the grid for the newcomers. However, despite the obstacles, the possibility of future Japan's energy market liberalisation allowed the solar PV to grow nevertheless (REN21, 2016, p23, 60).

3.1.3 Wind energy

Dent (2014) claims that from the theoretical standpoint, global wind energy potential is second to only solar energy and greater than all fossil fuels combined(p127), while arguing that the future expansion plans suggest that the wind energy will become significant strategic industry, especially in East Asia (Dent, 2014, p127). From the global perspective, wind energy is a leading new type of renewable energy (non-hydro) and accounted for the largest portion of new energy in both Europe and the United States and second largest in China. In 2015, wind energy around the world rose to 433GW, which represents a growth of 63GW from the year before. Wind power capacity depends directly on the speed of the wind at which wind turbines operate. The usual speed is between 2.5 to 25 m/s. Wind power is not available at the times of low wind speed, however, it is also unavailable at the times of very high wind speed, primarily to prevent damage to the equipment. This is why the annual power output for wind energy rarely surpasses 45% (Olz et al. 2007, p 25). When it comes to offshore wind energy, it grew by 3.4 GW to 12GW in 2015. However, from the numbers, it seems that offshore wind energy is currently used primarily in Europe - 89% of added capacity and 91% of total operating capacity. To give us a better idea, Germany added 2.2GW of offshore wind energy, whereas Japan added 3MW (REN21, 2016, p76).

With the potential of wind energy in mind, the question arises: why is the expansion of both onshore and offshore wind energy in Japan so underperforming?

Before the introduction of RPS, energy power companies imposed the introduction limitation quotas on wind energy, essentially limiting the exposure to financial risks, since the generation costs were high at the time. The energy generated above the quotas was competitively tendered. This unique system was first used by Hokkaido and Tohoku energy power companies since these two had high wind resources (more information in chapter 5, see map 4, graph 8, pp49-50). Later on, this was also emulated by other Japan's energy companies, and they essentially got control over how much wind energy will be produced each year. Since the energy companies were not very fond of adding wind energy to their generation portfolios, the government was in a difficult situation when trying to expand the wind energy sector. As Dent explains, "in 2003, the power company quotas amounted to just 330MW, while the bids tendered totalled 2,400 MW" (2014, p148). The 2003 RPS law obliged the energy companies to generate minimum quantities of electricity from renewables that they set for each year. However, RPS did not expand the growth, but instead, the wind energy capacity slowed down. Further subsidies were not introduced, and the 2009 financial crisis was another setback for wind energy (Dent,2014, p148).

There were no further government policies implemented to support wind energy from 2009 until the FIT scheme extended to include the wind and other renewables in July 2012. Despite the fact that this FIT can be considered a very generous source of renewables, based on the international comparison of different countries FIT, the other obstacles hindering the expansion of wind energy remains. Energy companies can refuse wind farms connection to the energy grid, and the strict regulations on the use of land as well as environmental laws hindered the build-up of new wind power farms. However, not everything regarding the future of wind energy is negative. Theoretical potential of wind energy in Japan has been estimated at 1800 GW (Kojima, 2012, p28). In 2012, the government announced of ¥43.4 billion of state support towards the development of wind energy in the upcoming years, as well as ¥25 billion for energy grid extension and ¥15.1 billion on offshore wind development. It shows that a possible shift in Japanese government policy is happening and the approach of rapidly increasing the installed capacity is occurring (Dent,2014, p149).

3.1.4 Geothermal energy

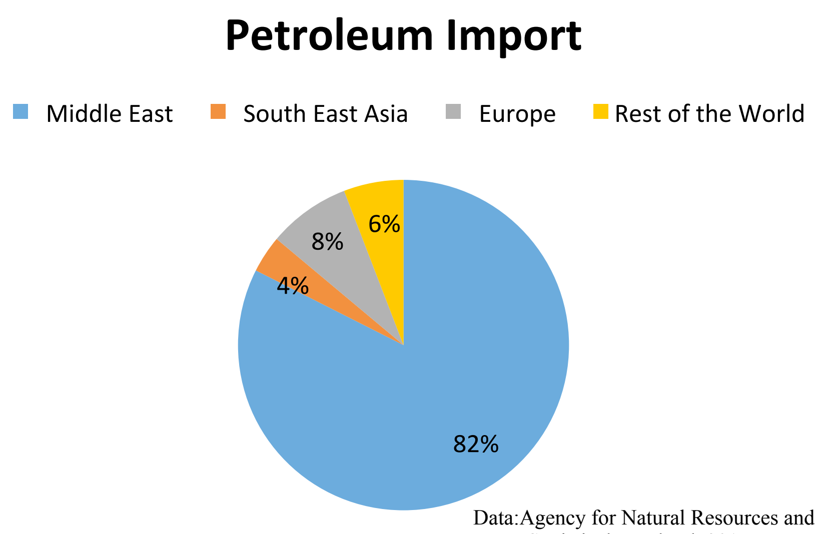
Geothermal energy is interesting primarily because it provides constant source of power, therefore unlike solar PVs and wind energy, variability is not an issue for geothermal energy and it can be considered as a stable source of energy. From the global perspective, geothermal energy produced 13.2GW of energy in 2015, which was 315MW more than the previous year. In many areas, geothermal energy is largely untapped, however near-surface geothermal heat is accessible only in limited areas worldwide (Olz et al., 2007, p 24).

In Japan, there are currently 18 geothermal power plants with a total capacity of 0.5 GW. However, Japan being one of the most volcanic countries in the world, it has a significant geothermal potential for the future with around 200 volcanos, as well as 28 000 hot springs. Sachio Ehara, chairman of the Geothermal Information Institute, said during the interview for VICE (2016,p1) "We have enough to power 20 big nuclear power plants," since "Japan is a land full of volcanoes"."With nearly 200 volcanoes, Japan has one of the largest geothermal reserves in the world. If this naturally occurring heat were to be harnessed and converted into power, it could generate 10% of Japan's energy needs right away", however the Japan Spa Association Charman, Masao Oyama argued, that "geothermal energy and onsens will never co-exist because geothermals would take these resources"(VICE, 2016, p1). The potential of geothermal energy has been estimated at 14 GW, which does not include the area of national parks, where supposedly 80% of resources is located (Kojima, 2012, p 35). However, because of the problematic issue of Japanese onsen (spa), it is not expected that the geothermal energy in Japan will increase in the near future.

3.2 Historical Background in Japan

It is not far-fetched to claim that Japan has a total dependence on the import of its energy needs. Since Japan is an island state, this import has to be delivered via the sea-lanes. Japan can be described as a resource-poor country and based on International Energy Agency (IEA) statistics, in 2015 Japan imported 93.7% of its total energy supply, the highest among the developed countries (IEA, 2016). Graph 1 shows that the majority of the petroleum import (82%) is from the Middle East, which is not considered as a safe and stable location to import your energy needs.

Graph 1: Japan's Petroleum Import



Data:Agency for Natural Resources and Energy
Japan Statistical Yearbook 2017

3.2.1 Beginnings of alternative sources of energy in Japan

As the third largest economy in the world, energy security is national security, and therefore it is not surprising that the critical issue of Japan's energy dependency was one of the leading political agendas of various Japanese governments (MIAC, 2017). Herberg (2013) claims that because of its long-lasting dependency, Japan made progress to strengthen its national security over the past 40 years. The first step was to diversify the energy sources, especially to decrease its oil consumption. Since the Japan's economic miracle was powered by the oil consumption, the 1970s-oil crisis led Japan to a recession and since then; the energy mix diversification away from oil has been steadily progressing. During that time, the three energy sources that were pushed forward were natural gas, coal and nuclear power. Each of these three energy sources expanded rapidly, especially nuclear energy rose from nothing to 30 percent of total electricity in 2010 and nuclear industry became an export powerhouse with a significant nuclear power generation capability in Japan as well. Therefore, it is important to understand the deeply-rooted dependency and the government support towards nuclear energy.

Another way that Japan was strengthening its energy security was by improving the energy efficiency. Japan had the highest energy efficiency in the world when it was able to improve by 40% between the 1973 and 2009 when looking at the energy used per GDP per capita. (Herberg, 2013, pp 304-305).

In the recent years, there has been an increased support for the introduction of variable renewables, especially solar PV and wind energy in many nation's energy mixes for a variety of reasons, whereas it is because of the environmental concerns or energy security (Komiyama, Otsuki, Fujii, 2015, 537). Needless to say, support for renewable energy expansion in Japan is nothing new, despite the fact that historically, hydropower has been the most influential renewable energy sources and will remain renewable energy source with the largest proportion in Japan at least until 2030 (METI,2015). However, traditional hydropower energy in Japan reached its capacity ceiling, and there is seemingly not much space for additional growth (Nelson,2011). This is why other sources of renewable energy, so-called variable renewables are necessary if Japan's renewable energy proportions should grow.

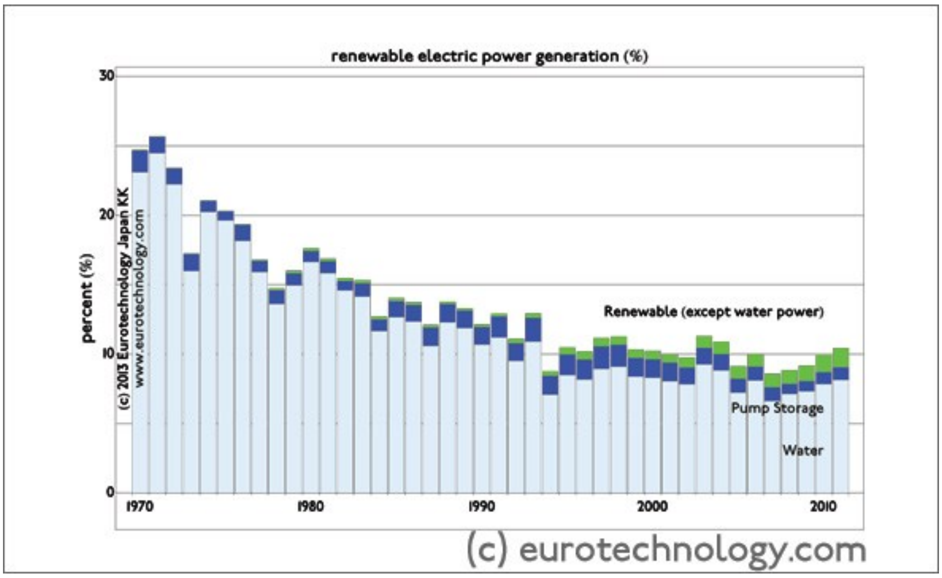
When trying to understand the current position of renewable energy within the energy generation mix, we have to first look to the past. This is because unlike with fossil fuels, renewable and nuclear energy are both part of the so-called alternative sources of energy, which are more dependent on the initial investments and different agents, and therefore it takes longer for them to establish their position in the energy generation mix. The framework of principal-agent is especially important to consider when looking at the progress of different renewables. To understand the reasoning behind Japan's government decision-making process, when looking at the situation of different sources of renewable energy, we have to take a look at the most influential landmarks that shaped it within Japan.

Despite the fact that Japan nearly reached its maximum potential with hydropower energy, other sources of renewables were thought of as the projects of the future. In March 2002, the Japanese government announced the plan to rely more on the nuclear energy, as it set up a goal to meet with the Kyoto protocol's reduction of the greenhouse emissions. The plan was to increase the proportion of nuclear energy by 30% as additional nine up to twelve new nuclear power plants were supposed to be built by 2011. However, as we know now, this did not happen as only five new nuclear reactors were built. Similarly, in 2006 the importance was also put on the development of Generation IV of nuclear reactors and the focus was on the sodium-cooled fast breeder reactors (FBRs). The Monju FBR prototype reactor had many difficulties, including the 1995 sodium leak accident which at the time in charge Power Reactor and Nuclear Fuel Development Corporation tried to cover up what was one of the first major nuclear accidents in Japan, resulting in a massive public mistrust regarding the nuclear power (Pollack, 1996). Just before the restart of the Monju reactor in 2008, WikiLeaks released three videos[3] of the 1995 accident, despite the fact that the officials denied the existence of any videotape showing a spill and claiming that the accident was just a minor one (Salzberg and Tokita, 2008). Issues like these helped to undermine the public trust towards nuclear energy while creating an energy investment space for new sources of energy.

3.2.2 Japan's past solar PV and wind energy policies

When looking at Japan's renewable energy, it is important to differentiate between the traditional hydropower and the other types of renewable energy, the so-called variable renewables, such as wind energy, solar PVs, and geothermal energy.

Graph 2: The proportion of renewables in the electricity generation mix



Source: eurotechnology.com

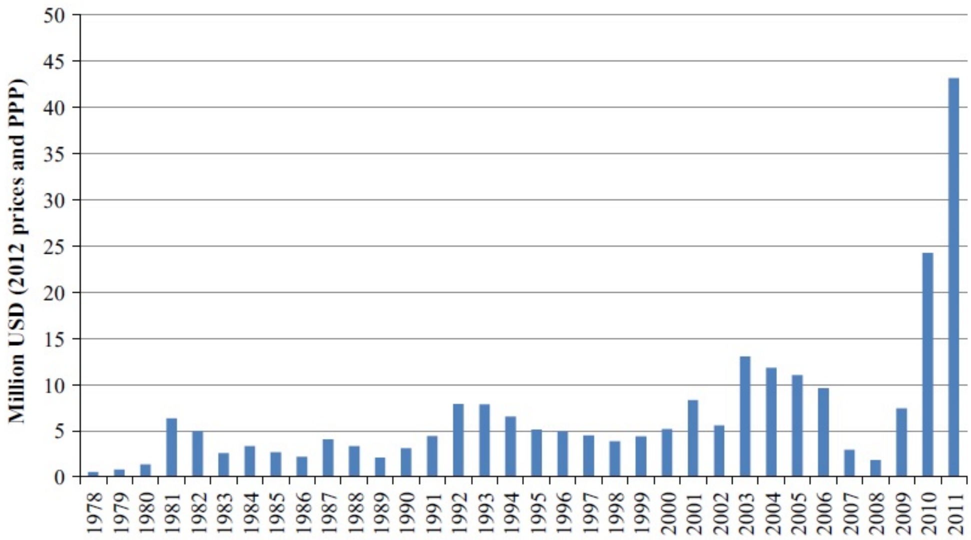
As graph 2 indicates, these variable renewables were not used in large numbers, and their proportion was historically not very significant. "Hydroelectric plants were attractive because once the dam and turbines are built, the only costs associated with them are largely operational and maintenance. Annual droughts lowered the water levels of many rivers, making electric output variable and regularly causing blackouts during the summer when the water was at its nadir and demand at its zenith. Developing this resource, moreover, could not continue unabated" (Nelson,2011). Graph 2 shows that since the 1970s, renewable energy has been on a decline. The reason for it is because while the energy consumption in the country

[3] The three videos are available for download at: Wikileaks (2008) The Monju Nuclear Reactor Leak [Online] Available at: https://wikileaks.org/wiki/The_Monju_nuclear_reactor_leak [Accessed: 22.4.2017].

grew, the only source of renewable energy has been the hydropower, which has been hitting the production ceilings. Therefore, a project regarding variable renewables has been supported by the government, since there was a need to decrease the fossil fuel dependency.

In 1974, the Ministry of International Trade and Industry (MITI) established and funded the Sunshine Project. This project had a goal of providing a significant amount of energy from non-fossil fuels by the year 2000. It focused on four main technologies: solar, geothermal, coal and hydrogen. Very generous government budget further increased after the 1979 oil crisis, as well as after the 1981's solar thermal project failure. It was thanks to this project that the solar PV manufacturing industry in Japan prospered and current solar giants, such as Sharp, Sanyo and Kyocera became the major world solar PV producers. (Muhammad-Sukki et al.,2014, p637; Mizuno, 2014, p1000). On the other hand, despite the potential of wind energy, Japan's wind energy market can be described as a huge disappointment in comparison to other OECD (Organisation for Economic Co-operation and Development) countries (Dent,2014, p147). The main reason for the lack of growth within the wind sector is Japan's focus on the solar energy. The attention and resources of government, companies and research organisations have been focused on solar energy, leaving wind energy investments to be mainly supported by private enterprises. However, in recent years, the government showed increased support for the wind energy, especially offshore wind, since the onshore wind turbines are facing difficulties, as the best onshore wind turbines are located in the remote locations of Hokkaido, with only a very limited grid connection to very populated places in Japan(Dent,2014).

Graph 3: Japan's government research and development funding for wind energy (1974-2011)



Source: Mizuno,2014, p100

Regarding government policies, for over 20 years, the only source of government support for wind energy has been the sunshine project which started in 1974 (Dent,2014, p147), however since wind energy was not chosen as one of the primary technologies to focus on, the budget for wind energy was much smaller than other sources of energy that were a priority in the project (Mizuno, 2014, p 1000). In 1996, the government's New Renewable Energy Target was set for wind energy, with a goal of 3GW by 2010, which was not achieved. In 1998, a subsidy scheme for research and development of wind farm development was introduced, however this project lasted for only a couple of years, and in the mid-2000s it got cancelled and the funds relocated to "improve the grid performance and energy quality" (Dent,2014, p148).

This approach changed in the last decade, where METI's published roadmaps in 2007, 2008 and 2009 included wind energy as a focus of technological development. As part of Energy Innovation Program in 2008, the budget for wind energy in Japan skyrocketed, as can be seen from the graph 3 (Mizuno, 2014, p100).

3.3 Literature review

The previous part of this chapter gave an explanation regarding the technological, political and economic background of Japan's renewables. This part will instead discuss the post-2011 situation, while showing the differences within the current academic field on this topic. As a reason of that, this part will follow the systematic review type of analysis, as it collects, critically analyses and compares different documents written on this topic. Systematic review involves identifying, synthesising and assessing the evidence (Bryman,2012; Hagen-Zanker et al., 2012). The reason for this style of review, is that it follows the principal-agent theoretical framework more closely, as it shows the complexity of this issue within the academic circles, the formation of the principal-agent relations, as well as points out the positions of different academic authors regarding this topic. Since agents are not necessarily following the same goals as the principal, we can observe the principal-agent relationship divide that happened after the Fukushima accident, especially after the implementation of new energy policy.

Firstly, there is a need to explain the position of METI and how it's position changed. METI represents the structural core, as it is the primary energy policy making body and its decisions were mostly in favour of nuclear energy (Moe, 2011), while the energy companies were following its lead. The future plans seemed that this portion would only grow further (World

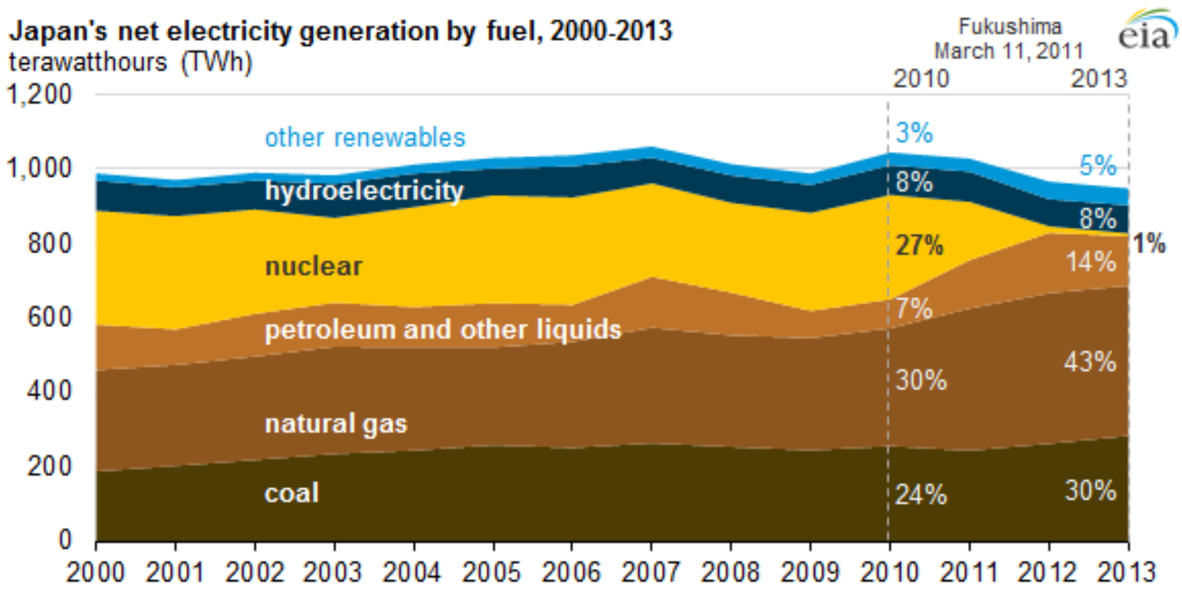
Nuclear Association, 2017). It was one accident that managed to change this position and gave renewable energy a chance to expand.

3.3.1 The Fukushima disaster

The Great East Japan Earthquake occurred on 11 March 2011, causing a massive earthquake with a magnitude of 9.0 and a tsunami which struck a wide area of coastal Japan. This disaster hit the Fukushima Daiichi nuclear power plant, operated by Tokyo Electric Power Company (TEPCO). The earthquake damaged the energy power access, and the tsunami caused the destruction of operational and safety infrastructure within the power plant. It was a catastrophic disaster and also a serious event within the energy security of Japan (Amano, 2014, 1).

In May 2011, DPJ's Prime Minister Naoto Kan proposed a rapid expansion of renewable energy, suggesting a goal of 20% of Japan's energy needs to be secured from renewables. Later, he followed German example of total phase-out of nuclear reactors (Stockwin,2012).

Graph 4: Japan's net electricity generation, 2000-2013



Source: EIA (2015)

Before the Fukushima accident, as graph 4 indicates, nuclear energy accounted for 27% of Japan's total electricity. Following the Fukushima accident, the DPJ government decided to implement a policy to suspend all of the nuclear power plants in Japan. Therefore, in May 2012, the nuclear energy production was at 0%. (Hayashi and Hughes, 2012, Stockwin, 2012). This rapid loss of nuclear energy production shares within the total energy generation mix meant that the government and especially energy suppliers were left with only a little option to prevent the energy blackouts, especially in the Kanto area. In July 2011, The Energy and Environment Council was established by the DPJ. With the DPJ's new energy policy, the Energy and Environment Council ruled the 2040 nuclear phase-out policy. The estimated costs from the METI for the increased power generation costs from the shutdown of nuclear power plants would rise by over ¥ 3 trillion per year, which is roughly 0.7% of Japan's GDP if the situation would continue (World Nuclear Association, 2017). On the other hand, Suzuki uses data from Institute of Energy Economics in Japan and claims that during the fiscal years of 2011 and 2012, Japan had to pay ¥3.6 trillion due to the shutdown of nuclear power plants (2015, p 595). Different report argues that the price of the electricity would eventually rise by 15% would the nuclear power plants not restart (Hayashi and Hughes, 2012).

Interestingly, International Energy Agency (IEA) report describes Japan's renewable energy as both "strategic opportunity and practical challenge" (IEA, 2016, 119). However, while an attempt has been made to increase the proportion of renewables in the wake of the Fukushima accident, as the Graph 4 clearly indicates, it was not renewable energy that ended up subsidizing the drop-off of nuclear power generation, but rather fossil fuels. This gap that nuclear energy left after all the reactors suspended their function had large consequences. Not only for the government budget, where an estimated cost ranges between ¥3 trillion and ¥ 3.7 trillion annually (Suzuki,2012; World Nuclear Association 2017; METI; 2015; Hayashi and Hughes, 2012), but also to the international obligations, such as Kyoto Protocol CO_2 emissions reductions, where it became apparent that Japan will not be able to meet its reduction targets Ribault (2015). The IEA (2016, p32) data report indicates that if by 2030, the 20% - 22% share of nuclear energy should be replaced by renewables, the electricity costs would rise by ¥4.3 up to 4.8 trillion annually. In the case, that nuclear would be replaced by fossil fuels, it would cost around ¥0.8 to 2.2 trillion annually; however, the CO_2 emissions would increase exponentially. Therefore, we can see that not using nuclear energy can have significant government budget consequences. However, it creates a perfect policy window to reorient Japan's energy strategy towards renewable energy, while the general public, which developed strong anti-nuclear sentiment, would not mind paying the costs of those renewable policies (Brand, 2013).

3.3.2 FIT or RPS?

Since the fossil fuels based energy portfolio is becoming unsustainable, the growth of renewable energy was able to expand quite rapidly. However, technological uncertainty, long pay-back time period as well as illiquid assets with regulatory dependencies and uncertainties make renewable energy unattractive and often also unsuitable for investors (Polzin et al. 2015, p99). To limit market failures and to make a compensation for economic and technological weaknesses of renewable energy, many policymakers confronted this situation with a variety of options how to stimulate the growth of renewable energy. The most common type of support has been Renewable Energy Standard(RES), which contains both RPS as well as FIT (Chaturvedi, 2014; Polzin et al. 2015). However, since one size does not fit all, especially when determining renewable energy future and both of the policies, RPS and FIT showed its pros and cons. It all comes to the country-specific factors to determine which policy or a combination of them is the most effective (Chaturvedi, 2014).

Japan's renewable energy is facing divided opinions, especially over its FIT effectiveness and costs. Primarily the post-Fukushima growth of renewables attracted many researchers from a variety of different research backgrounds, each providing different and many times opposite insight over this topic. When it comes to the contemporary situation regarding renewables, there is no clear answer to the question of whether the benefits outweigh the expenses when it comes to the FIT as well as the investment costs of the future energy grid interconnection in Japan.

When looking at the global perspective, Chaturvedi (2014) claims that since fossil fuels based energy system became unsustainable, the agenda which supports the growth of renewable energy was able to spread in recent years. However different countries adopted different policies to promote renewable energy (RE), with the most common one being Renewable Energy Standard(RES), which contains both RPS as well as the FIT. These policies can be applied regionally, however also by the entire country, as is the case of Japan. Many scholars (Chaturvedi, 2014, Tveten et al.,2013; Bolkesjø et al.,2014; Jenner et al. 2012) argue that the FIT system is more efficient than the RPS system to promote renewable energy expansion. FIT advantage is the flat price system which is guaranteed over a contracted period, which can bring lots of investment opportunities, because of the stability of the investment, which helps with rapid expansion, as was the case of Japan after 2012. However other environmental economists' scholars (Fischer and Newell, 2008, Dong, 2012, Jaffe et.al.

2005) argue that the FIT does not encourage innovation since prices are guaranteed, while RPS is more market-based, in comparison to the FIT's non-market approach, since prices in the case of the FIT are controlled by respective governments, whereas RPS prices are dictated by the market. For these scholars, RPS is far superior to FIT, since RPS promotes technological development. From the theoretical perspective, we can apply FIT policy on the principal-agent framework, as the production capacity is left in the hands of the agents.

Chaturvedi (2014, p57) points out two questions while looking at both FIT and RPS systems, namely: "Does setting an RE (Renewable Energy) target increase production of RE thereby effectively reducing emissions? "and "Do the benefits (both social and economic) outweigh the costs incurred to secure an FIT system? "

In the recent years, there has been an increased support for the introduction of variable renewables, especially solar PV and wind in many nation's energy mixes for a variety of reasons, whereas it is because of the environmental concerns or the energy security (Komiyama et al. 2015, p 537). As such, current academic research gives a differentiated picture regarding the support for renewable energy (Polzin et al., 2015). The wind and solar power seemingly do not bring the same level of risks as are the risks regarding the oil spills and contamination from drilling. However, "renewable energy, even when operating properly, can have particularly outsized impacts on land" (Levi, 2013, p 487). Generating 1 kilowatt of solar power requires 100 to 250 square meters of land, whereas the onshore wind energy would require 1000 square meters. In contrast, coal-fired power would require 1-10 square meters whereas gas-fired power would require 0.5 to 5 square meters (Levi, 2013). While the technologies, such as the off-shore wind are using water-area places and the fact that land requirements for renewable energy are decreasing, the initial gap is an obstacle which is hard-to-overcome, particularly in the places such as Japan, with only a limited available land, which is many times not grid-connected.

3.3.3 Economic costs of renewables

The especially contested topic for renewable energy expansion is when it comes to calculating the costs, which for many pro-renewable authors is one of the proofs of the advantages of renewable energy (Muhammad-Suki et al.,2014). On the other hand, other scholars argue that due to high costs and negative economic impacts, the usage of renewable energy supporting policies is debatable (Bolkesjø et al.,2014; Zehner, 2012). A good example of showing the difficulty of assessing the actual economic costs of renewable energy is when looking at the different scholars' previous works as well as the way to get those numbers in their calculations. For example, Muhammad-Suki et al. (2014) calculation of solar PV costs shows that the numbers and results are not corresponding to reality and can be biased based on the interpretation, since as it is explained by the authors,

"To ease the calculation, a number of assumptions are made: (i) each site is retrofitted with solar panels with a capacity of 4 kW for residential installation and 100 kW for non-residential installation; (ii) the installation cost is paid in full at the beginning of the project no loan is taken to fund it; (iii) the solar panel maintains 100% performance during the contract period; (iv) 100% of the electricity is exported back to the grid" (p640).

Taking into consideration the difficulty of calculating actual production costs, as well as predicting future costs where the proportions of renewable energy should be higher, these assumptions have to be made. However, giving overly positive prognoses will automatically make it not possible for data like that to be realistic and each point of assumption can be compromised. An argument that the Sun cannot shine for 24 hours automatically negates the 100% performance assumption. REN21 report estimated that in 2015, the global Levelized[4] Cost was approximate "USD 0.06/kWh for biomass, USD 0.08/kWh for geothermal, USD 0.05/kWh for hydro and USD 0.06/kWh for onshore wind". In comparison, fossil fuels have costs of "between USD 0.045/kWh and USD 0.14/ kWh", while "solar PV projects were regularly delivering electricity for just USD 0.08/kWh "(REN21, 2016, 81). When it comes to the price, Zehner (2012) argues against the claims that overall prices of renewables, such as solar PVs are dropping, since solar panels only account for half of the cost for a solar system, other expenditures, such as "insurance, warranty expenses, materials, transportation, labour did not get cheaper. Low-tech costs are claiming a larger share of the high-tech solar system price tag". Therefore, in the current situation, having solar energy creating some challenge for fossil fuels is not even optimistic, but rather delusional while having its

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[4] "Renewable energy systems "fix" your energy cost in time: Once installed, it will provide years of energy - "Levelized Cost" is the average cost of this renewable energy.
Levelized Cost = Net Cost to install a renewable energy system divided by its expected lifetime energy output.
For example: If a solar energy system costs $10,000 to install (after all rebates) and it provides 100,000 kWh of electricity over its life, then the Levelized Cost of the solar energy system is $10,000 / 100,000 kWh = $0.10 per kWh"(Solar-Estimate, 2017)[Online] Available at: (http://www.solar-estimate.org/showfaq.php?id=261)[Accessed: 21.4.2017].

negative effects on environment – “mining, fabrication, delivery, maintenance and disposal” (Zehner, 2012, pp 11-12, 28-30). Meanwhile, REN21 claims that “Solar PV is now competing head-to-head, without financial support, even in regions with abundant fossil fuels“(REN21, 2016, p81). It is clearly visible there is a difference of opinions among the academic community when it comes to renewable energy and how easy it is to shape the data regarding renewable energy to one’s liking, agenda or message they want to share. Renewable energy, just as any other type of energy bring positives and negatives, obstacles as well as advantages. Because of this divide within the energy sector regarding this topic, considerable focus should be placed on these aspects that can easily decide the possible consequences for the agents, as well as the government. What is important to realize is that the goals of the government are not necessarily related to the goals of the variety of agents that are capable of shaping the future proportions of energy.

3.3.4 Post-Fukushima

The Fukushima accident ruined public image of nuclear energy, and together with the implementation of the FIT, Japan’s renewable energy was able to expand rapidly. Despite the fact that Japan’s support and investment towards renewable energy have been done for decades, only hydropower managed to obtain significant share within the Japan’s energy mix. Hydropower will remain the most used renewable energy source in Japan for the near future (METI,2015). When looking directly at Japan and its most recent renewable policy, Brand (2013, p227) and Muhammad-Sukki et al. (2014) points out that the Japanese FIT rates are twice as high as in Germany, therefore creating high investment security. However, Japan also faces its own, unique problems when it comes to the expansion of renewable energy. One of the significant issues that remain to be solved is regarding the connection to the grid, and since consumers already have to pay for renewables surcharge on their electricity bills, since the FIT scheme is financed by the consumers, “with an average increase in the electricity bills of ¥100 per month “(Muhammad-Sukki et al.,2014, p638), it is hard to estimate the willingness of the public to support extensive and extremely costly energy grid expansion.

It is therefore on point to ask, since renewable energy is becoming costlier and the electricity prices in Japan are continuously getting higher since the Fukushima accident; is it possible that the negative public attitude towards nuclear energy will eventually decrease, as some counterbalance to the steadily more expensive renewable energy? Or maybe just as in the past where Japan expanded the nuclear energy in the 1970s and 1980s, the eagerness of the nuclear plants' restart may not happen because of the energy concerns, but rather because of the money that came with them for the local governments (Johnston, 2011; IEA, 1981).

As an example, in Kagoshima prefecture, as many other prefectures hosting nuclear power plants became over the years' dependent on nuclear energy. A city near Sendai nuclear power plant, Satsumasendai annually receives over $12 million from the nuclear industry. Satsumasendai Chamber of Commerce and Industry estimated that the restart of the nuclear power plant would annually bring $25 million to the local economy (Katsuta, 2015, p1). DPJ's nuclear phase-out policy provoked a strong reaction from the industry sector, which feared that the increasing electricity prices that were already among the highest in the world would have increase because of the phase-out policy and stated that there should be 20-25% of total electricity from the nuclear power plants to avoid negative economic consequences (Hayashi and Hughes, 2012).

After the successful electoral results, in December 2013, the LDP issued a 20-year perspective draft on the Energy Basic Plan, where one of the key points stated that nuclear energy is considered as an important energy source and will be used continuously in the future since it is considered as a stable, safe and affordable energy resource. Following month in January 2014, Japanese Prime Minister Shinzo Abe had his speech where he confirmed that the nuclear power plants would be restarted if they will be able to pass the substantial safety regulations which will be issued by the Nuclear Regulations Authority that hail themselves as one of the strictest in the world (Onose, 2014). While the public polls conducted before and after the Fukushima accident suggested that the public opinion shifted heavily against the nuclear energy[5], even those polls were not able to unite when producing the results regarding how the public perceived the future of nuclear energy, especially when asked in locations directly profiting from the nearby nuclear power plants[6], or in the case that

[5] Washington Post (2015) claims that "Before the 2011 disasters, about 65 percent of the country supported expanding nuclear power. That proportion has flipped: Today[2015], fully 70 percent of respondents in regular polls want to end nuclear power in the country". Available at: http://wapo.st/2glJ0um [Accessed: 16.12.2016]

[6] AlJazeera(2015) wrote that "NHK on the Sendai restart - the first plant to pass newly created safety tests - found that in Satsuma Sendai 49 percent of those surveyed approved, 44 percent disapproved. In the surrounding districts, which are not favoured with government financial incentives, only 34 percent approved, with 58 percent against. And in the rest of the country 32 percent approved of the restart, while 57 percent disapproved ". Available at: http://bit.ly/1z7Ff3h [Accessed: 16.12.2016]

the price[7] was also part of the question. As Boyd (2015) points out, despite the government's positive attitude towards nuclear energy, Shinzo Abe did not decrease the support for renewables, despite the costs associated with this policy. Using the principal-agent framework, the LDP government in this context is the agent of the public, in this case principal. Following the framework of the principal-agent, government is forced to act in a way the public wants it to, however it is not directly controlled with the way how the government will achieve these goals. To a certain extent, the electoral base is capable of controlling the government decisions, however to a larger extend the government is free to follow the results it wants. These results may include the stable and safe source of energy, political power gains and other economic and political interests, while trying to maintain the public support necessary to achieve its own interests.

3.4 Conclusion

Solar energy, as well as geothermal one, has been part of the sunshine project, which enjoyed a very generous financial budget, that established Japan as one of the dominant solar energy powerhouses at the time, while Japanese companies became the most dominant solar PV producers. On the other hand, wind energy has been severely underinvested and never a core of the research and development in Japan. As a result, wind energy is heavily underdeveloped in comparison to other OECD countries, and it has been only since 2009 that wind energy funding budget has increased rapidly. Meanwhile, solar PV's were the core of the Japan's research and development in the energy sector for many decades. Therefore, it is not surprising that solar industry was able to expand faster than the other variable renewables. In 2010, Japan's policymakers began the project of replacing RPS with FIT that became the standalone renewable policy with its adaptation in 2012. This full-scale renewable funding transitioned into a rapid expansion of Japan's renewables.

The Japanese government has a deeply rooted interest in supporting the alternative sources of energy. The question is, whether this interest comes from the social pressure of its electoral base, or either from different agent's political or economic goals. Based on the statistical data, nuclear energy is still an economically more efficient source of energy, however renewable energy has been met with an increasing public support. The Fukushima accident

[7] World Nuclear Association(2016) "A poll taken in February 2015 by the Mizuho Information & Research Institute of Japan asked whether or not the respondent would use nuclear-generated electricity if the costs were the same or less than they were that month, and 67% said "yes". Only 32% replied in the negative". Available at: http://bit.ly/1MP7od8 [Accessed: 16.12.2016]

helped to weaken the position of nuclear energy and push forward renewable energy, however, government costs are increasing rapidly, while the" cheaper "nuclear energy has been undergoing a process of the restart of some of the power plants, while other will remain closed.

However, as can be seen, the academic opinions towards the future of renewables is not as united as one may think. The main argument is usually regarding the feasibility of renewable projects, as well as costs of them. Japan's case is even more divided, taking into consideration the situation regarding the expenses of the FIT policy, energy grid issue that hinders future expansion, as well as the situation regarding nuclear energy. These issues make the future of renewables in Japan more unclear than in other countries. With the slow but sure restart of some of the nuclear power plants, a question may arise whether or not it will have any influential consequences for renewables in Japan, whether positive (i.e. decrease of overall energy costs, CO_2 emissions reduction) or negative ones (i.e. competing with cheaper source of energy, getting lesser share in energy research and development).

4. Feed-in Tariff

Japan's FIT system came to power in July 2012 and because of its high purchase prices, it became rapidly popular, with over 1 200 000 applications in the first year. The majority of these applications were for the solar PV installations (The Economist, 2014; Mizuno, 2014, Iida, 2015).

As was mentioned previously by Bøe and Gulbrandsen (2016), regarding the principal-agent theory, which explains the relationships between different parties that follow divergent goals in the presence of uncertainty, where the FIT policy is a great example of it. In this situation under the FIT policy, the decision-making body is not directly responsible for the growth of renewable energy, but rather different agents are, while being dependant on each other, balancing their self-interests with the obligations related to their role. Table 1 shows us the approximate prices of the different renewables during the implementation of the FIT tariff system. When taking into consideration the installation and maintenance costs together with the individual tariff rate, it is clear that solar PVs has been economically most appealing with the highest profit/cost ratio among the variable renewables included in the FIT.

Table 1: Feed-in Tariff Scheme in Japan

		Solar PV		Wind Energy		Geothermal		Small and Medium Hydraulic		
Capacity		10kW or more	Less than 10kW	20kW or more	Less than 20kW	15MW or more	Less than 15MW	1MW-3MW	200kW-1MW	Less than 200kW
Installation cost (¥/kW)		325 000¥ /kW	466 000¥ /kW	300 000¥ /kW	1250 000¥ /kW	790 000 ¥ /kW	1230 000¥ /kW	850 000¥ /kW	800 000¥ /kW	1000 000¥ /kW
Operation and maintenance (per year)		10 000¥ /kW	4 700¥ /kW	6 000¥ /kW	-	33 000¥ /kW	48 000¥ /kW	9 500¥ /kW	69 000¥ /kW	75 000¥ /kW
Tariff (kWh)	tax inclusive	42¥ /kWh	42¥ /kWh	23,10¥ /kWh	57,75¥ /kWh	27,30¥ /kWh	42¥ /kWh	25,20¥ /kWh	30,45¥ /kWh	35,70¥ /kWh
	tax exclusive	40¥/ kWh	42¥ /kWh	22¥ /kWh	55¥ /kWh	26¥ /kWh	40¥ /kWh	24¥ /kWh	29¥ /kWh	34¥ /kWh
Length		20 years	10 years	20 years	20 years	15 years	15 years		20 years	

Data: METI, 2012

Therefore, it is not surprising, when looking at table 2 that focuses on the capacity, as well as table 3 that compares actual production, where both clearly show that the majority of renewable energy installation growth is from the solar PV's. The rise can be most notably seen from the FY2012 onwards, when the highly rewarding FIT system began to subsidy renewables. However, it is also visible that the non-PV sources of renewable energy did not enjoy the same growth and geothermal energy, which is by many experts considered as having an enormous potential in Japan (Olz et al., 2007; REN21, 2016; VICE,2016; Kojima, 2012) actually slightly decreased.

The usage of Binary Geothermal power plants[8] may help to expand geothermal energy in the

[8] Binary geothermal power plants, or "Onsen" Binary plants, are using chemical fluids which can boil at a lower temperature in comparison to water. The produced heat vaporize, which drives the turbines that run the

future (Movellan, 2015). Nevertheless, when looking at the overall electricity production in Japan in table 3, it can be clearly seen that renewable energy share in Japan is still only a fragment of the fossil fuel one. We can also see that as a result of the shutdown of the nuclear power plants, the gap from the nuclear energy was filled by fossil fuels, as well as by decreasing the overall electricity consumption. This means that renewable energy has a large potential to maintain bigger share than it has now, possibly by absorbing the gap that was left by nuclear energy.

Table 2: Renewable energy generation capacity in Japan, (in MW)

Technology	2000	2004	2008	2009	2010	2011	2012	2013	2014
Hydro	46324	46737	47341	47243	47736	48418	48934	48932	49597
Solar PV	330	1132	2144	2627	3618	4914	6632	13599	23339
Wind	84	769	1756	1997	2294	2419	2562	2645	2753
Waste	1322	1501	1501	1501	1501	1501	1501	1501	1501
Geothermal	533	535	532	535	537	537	512	512	508
Total	48593	50674	53274	53903	55686	57789	60141	67189	77698

Data: IEA,2016, p122

Table 3: Electricity generation by source, 2010-2015 (TWh)

Year	Coal	Oil	Natural gas	Nuclear	Hydro	Wind	Geo-thermal	Solar	Biofuels, waste	Total
2010	309.6	101.1	318.6	288.2	82.2	4.0	2.6	3.8	30.2	1139
2011	291.2	166.4	387.9	101.8	83.2	4.6	2.7	5.2	30.9	1074
2012	314.1	195.2	409.1	15.9	75.5	4.7	2.6	7.0	31.8	1056
2013	348.9	160.2	407.6	9.3	75.1	4.3	2.6	14.3	33.6	1059
2014	348.8	116.4	420.8	-	81.8	5.0	2.6	24.5	35.5	1036
2015	342.7	90.8	395.2	9.4	85.1	5.3	2.6	36	41.8	1009
%,2015	34%	9%	39.2%	0.9%	8.4%	0.5%	0.3%	3.6%	4.1%	100%

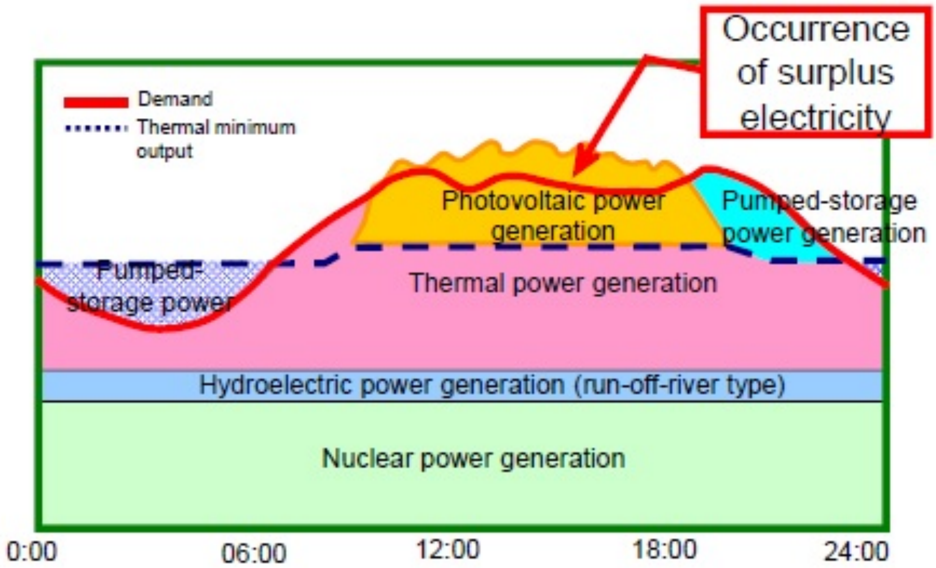
Data: IEA,2016, p94

Graph 5, created by METI (2010) in one of the documents focusing on the FIT before it was implemented, which can show us how the decision-making body saw the future proportions of the electricity during the average day once the FIT would take place. We can clearly see that the stable "core" should have been the nuclear generation together with the hydropower and that the solar PVs were supposed to be used for the peak season during the day. Thermal power was expected to be used based on the needs during the day, primarily to avoid the blackouts. This clearly indicates that renewable energy (except hydropower) was not thought of as a "core player" during the time when there was only an idea how the FIT should look

generators. The benefit is that this is a closed-loop system; therefore nothing gets emitted to the atmosphere. Since it can run on lower temperatures than the water boils(100 degrees Celsius), it is a very suitable source of geothermal energy(Movellan, 2015).

like, but rather as a fill-in to decrease the use of the CO_2 emission heavy thermal power. This may explain why the current renewable energy is starting to face troubles - under the proposed FIT form that ended up implemented– nuclear energy was thought of as a stable core, while renewable energy was supposed to cover the peak demand during the day. Nevertheless, highly rewarding framework allowed renewable energy, especially solar PVs to expanded rapidly, primarily because of the substantial public support for the expansion of renewables, despite the economic burden that came with it.

Graph 5: How the energy situation should have looked like before the Fukushima accident changed it



Source: METI (2010)

4.1 Different results of FIT for solar PVs and the rest

While the FIT could also be seen as a way of boosting domestic economy via the domestic solar PV producers, as can be seen from table 4, the demand for solar PVs modules was much more overwhelming than the domestic producers could supply. Since FY2013, the majority of the PV modules used in Japan were imported. The peak for the PV modules has been in the 2014FY when 9.2 million modules were used in total, while the domestic production was on 3.4 million while imports were at 5.8 million. However as was shown in table 2 and 3, solar PVs grew exponentially as a result of the FIT, but other renewables were not capable of following the success of solar PVs, and as a result, they fell significantly behind.

Table 4: JPEA quarter module cell production

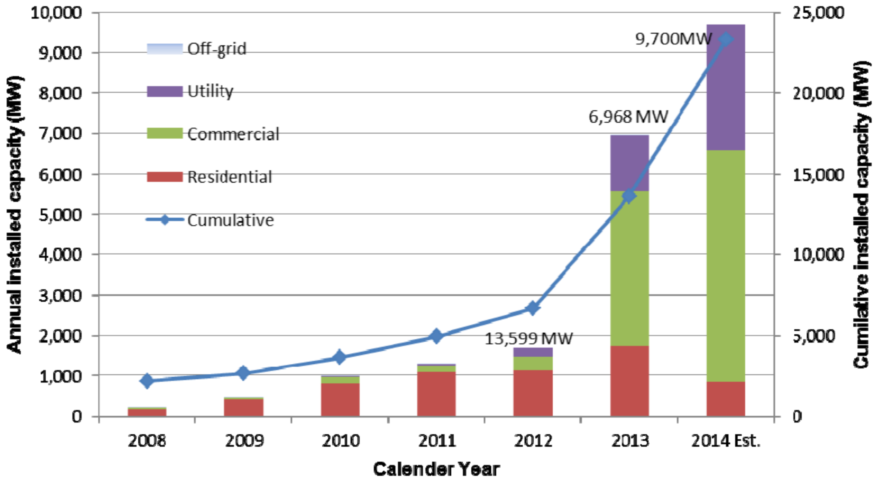
		PV Modules Domestic Use			Overseas Shipment
		Produced in Japan	Produced Overseas	TOTAL	
2012	1st quarter	325 451	119 838	445 289	101 862
	2nd quarter	439 787	187 185	626 972	93 510
	3rd quarter	666 947	336 266	1 003 213	101 510
	4th quarter	933 774	800 203	1 733 977	103 318
	Fiscal year 2012	**2 365 959**	**1 443 492**	**3 809 450**	**400 200**
2013	1st quarter	728 917	924 956	1 653 873	9 960
	2nd quarter	876 737	1 197 900	2 074 637	37 747
	3rd quarter	897 046	1 145 657	2 042 703	20 362
	4th quarter	1 228 729	1 545 790	2 774 519	11 576
	Fiscal year 2013	**3 731 429**	**4 814 303**	**8 545 732**	**79 645**
2014	1st quarter	751 102	1 130 926	1 882 028	126 028
	2nd quarter	906 087	1 480 342	2 386 429	180 109
	3rd quarter	802 267	1 436 290	2 238 557	222 081
	4th quarter	951 151	1 758 160	2 709 311	127 463
	Fiscal year 2014	**3 410 607**	**5 805 718**	**9 216 325**	**655 681**
2015	1st quarter	539 354	1 072 785	1 612 139	125 436
	2nd quarter	593 782	1 183 045	1 776 827	202 024
	3rd quarter	616 623	1 148 703	1 765 326	310 711
	4th quarter	898 207	1 084 178	1 982 385	181 862
	Fiscal year 2015	**2 674 966**	**4 488 711**	**7 136 677**	**820 033**
2016	1st quarter	421 672	763 296	1 184 968	181 464
	2nd quarter	582 435	1 082 196	1 664 461	150 430
	3rd quarter	544 383	1 077 846	1 622 229	95 621

Data: Japan Photovoltaic Energy Association (JPEA) Reports, 2012-2016

Nevertheless, we can also see that despite still very impressive numbers, both domestic and overseas portions started to decline following year and from the available data it does not look that it will change for the FY2016. Iida from the Institute for Sustainable Energy Policies claims that by the FY2014, the FIT approved in total 87GW of renewable energy, solar PV represents 94% of the share, while the solar PV facilities producing 1MW or more accounted for half of it (Iida, 2015, p5). Despite the FIT support for renewables, only solar PVs were able to dramatically expand in Japan, leaving other renewables behind, because of variety issues non-solar PVs have to face in Japan. As graph 6 shows, most of the installations from FY2013 has been from the non-residential sector, where solar PVs are used for commercial purposes. Unlike residential ones, where customers predominantly buy domestic solar panels, the solar PVs used for commercial purposes are mostly driven by price, therefore, making the proportions of foreign solar panels used in Japan's solar PVs to increase rapidly (Hahn, 2014, p12).

METI and Ministry of Environment(MOE) assessed that wind energy, both onshore and offshore had far greater potential in Japan than any other source of energy. However, more than 95% of facilities that started to operate under the FIT were solar PVs, while 94% of approved renewables were solar PVs as well (Mizuno, 2014, p 1005; Iida, 2015, p5).

Graph 6: Installed PV capacity in Japan



source: Yamaya et al.;2015, p1

Dong (2011) points out that wind energy has the world's greatest install base and is usually the most favourable source of new renewables, primarily because of its lower costs[9]. This is in direct contrast to Japan, which decided to vigorously push forward solar PVs, despite the price advantage of wind energy. However, Japan is in a different situation to other countries, whereas it is the land distribution, energy grid connection or the billions of yen invested in the solar PVs, as opposite to the underinvested wind sector. Because of that, wind energy is facing many obstacles and is growing at much lower numbers in comparison to solar energy. Mizuno (2014) claims that it is not a result of tariff levels or resource potential, but rather because of the difference of lead-times. Wind energy, as well as geothermal energy both have many regulations that need to be followed to get any development permit in Japan and because of these bureaucratic issues, the vast majority of renewable installations under the FIT has been done by solar PVs. While the wind, as well as geothermal energy, have a significant potential in Japan, different regulations, which can be either costly or time-consuming to overcome helps solar PVs to maintain its dominant position within the FIT.

4.2 Economic aspects of FIT

As is visible from the table 5, renewable energy under the FIT system is heavily subsidized. But this is primarily true for the solar PV sector, which has a long history of support since the times of the Sunshine project. What is the reasoning behind this specific principal-agent relationship, that primarily supports one type of renewable energy while not the other? Is there either economic, or political interest to support specific type of renewable

[9] EIA(2016, p 86) International Energy Outlook Data shows that in 2012, world production of wind energy was 520 billion kilowatt-hours, while solar energy was at 103 billion killowatt-hours, geothermal at 63 billion kilowatt-hours.

energy? For example, in comparison to the table, the price of the nuclear power in Japan should be around ¥8.5 per kWh[10]. On the other hand, in the 2012 fiscal year, the most popular new source of renewable energy, which is solar PV was subsidised by the FIT at the ¥42 per kWh for those solar PV's with the output of less than 10 kW (IEA,2016). However, the power utilities in Japan started to claim to be overwhelmed by the number of applications and began to fight back, which was also supported by METI. Many of them blocked the accession to the transmission grid for the new applicants (The Economist, 2014).

Table 5: FIT changes FY2012-FY2016

			Purchase prices (JPY/kWh) (tax excluded)						Purchase period
			FY2012	FY2013	FY2014	FY2015 Apr.-Jun.	FY2015 Jul.-Mar.	FY2016	
Solar	Less than 10 kW		42	38	37	33		31	10 years
	when output control system are required					35		33	
	Less than 10 kW (+ energy storage system)		34	31	30	27		25	
	when output control system are required					29		27	
	10 kW or more		40	36	32	29	27	24	20 years
Wind	Onshore	Less than 20 kW	55	55	55	55		55	20 years
		20 kW or more	22	22	22	22		22	
	Offshore				36	36		36	
Geothermal	Less than 15,000 kW		40	40	40	40		40	15 years
	15,000 kW or more		26	26	26	26		26	
Hydro	Fully new facilities	Less than 200 kW	34	34	34	34		34	20 years
		200-1,000 kW	29	29	29	29		29	
		1,000-30,000 kW	24	24	24	24		24	
	Utilize existing headrace	Less than 200 kW			25	25		25	
		200-1,000 kW			21	21		21	
		1,000-30,000 kW			14	14		14	
Biomass	Wood (general), agricultural residues		24	24	24	24		24	20 years
	Forest residues	Less than 2,000 kW	32	32	32	40		40	
		2,000 kW or more				32		32	
	Wood waste from buildings		13	13	13	13		13	
	Municipal waste		17	17	17	17		17	
	Biogas		39	39	39	39		39	

source: created by IEA (2017), using METI data

Kyushu Electric, the company that supplies electricity to 9 million customers, was the first one to start these countermeasures. It happened after more than 72 000 new solar power producers were trying to register before the deadline, securing the FIT guaranteed price before it would decrease for the next fiscal year. No new applications were accepted to join the grid, especially because of the claims to test the reliability of supply from the solar PV

[10] "The Institute of Energy Economics of Japan in 2011 put the cost of nuclear electricity generation at ¥8.5 per kWh taking into account compensation of up to ¥10 trillion ($130 billion) for loss or damage from a nuclear accident. Later in the year a draft report for Enecan estimated nuclear generation costs for 2010 to be ¥8.9 per kWh (11.4 US cents). This included capital costs (¥2.5), operation and maintenance costs (¥3.1), and fuel cycle costs (¥1.4). In addition, the estimate included ¥0.2 for the additional post-Fukushima safety measures, ¥1.1 in policy expenses and ¥0.5 for dealing with future nuclear risks. The ¥0.5 for future nuclear risks is a minimum: the cost would increase by ¥0.1 for each additional ¥1 trillion ($13 billion) of damage. The ¥8.9 figure was calculated based on a model nuclear power plant using average figures from four plants operating over the period since the 2004 estimate, with an output of 1200 MWe and construction costs of ¥420 billion ($5.4 billion)"(World Nuclear Association).

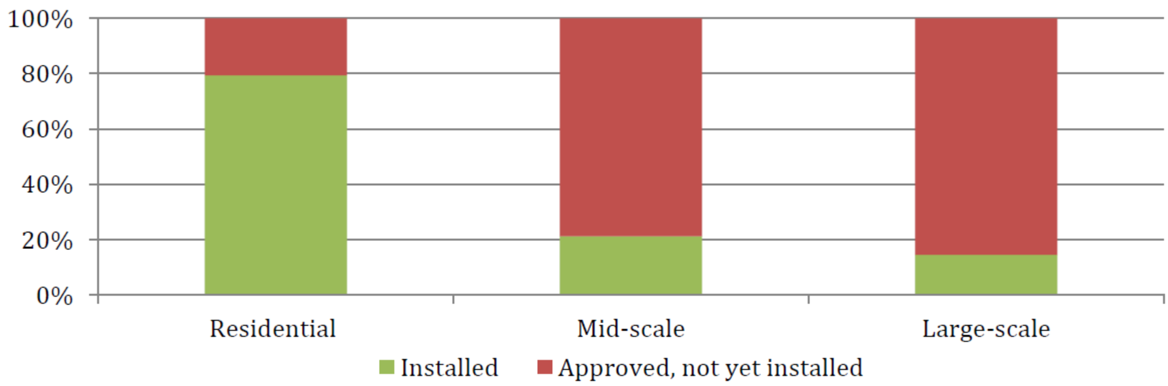
producers. However, cases like that raised the doubt whether Japan will be able to succeed with the plan to increase renewable electricity share to the set targets by 2030.

What is becoming more problematic is the rapidly increasing costs of the FIT in Japan. While in FY2012 the cost of the FIT was ¥130.3 billion, in FY 2013 the expenditure rose to ¥654,7 billion and in FY 2014 it could be staggering ¥2.7 trillion if all the applications would have been approved and started to produce in the same fiscal year. Since many energy companies stopped allowing some newcomers to join the grid, "The FIT System increased the introduction of renewable energy but in an unbalanced manner, centred on solar power. The required cost for this system amounted to 2.3 trillion yen throughout FY2016 with the monthly burden on an average household reaching ¥675" (METI, 2016, p26). Meanwhile, the outlook for the FIT costs in 2030 has been estimated to be between ¥3.7-4 trillion (METI, 2016, p26; Hahn, 2016, p 6, Komiyama and Fujii, 2017, p596). However, as Komiyama and Fujii (2017) take notice, this 2030 cost estimation counts that the electricity prices will decrease as renewables, electricity savings as well as nuclear energy will replace part of the fossil fuel consumption.

4.3 FIT Amendments and the 2016 Amendment

As table 5 showed, the FIT system had changes in each fiscal year, but these changes were exclusively for solar PVs and no other sources of energy. The reason for that is that unlike other renewables, the prices for solar PVs were set lucratively high to be interesting as an initial investment opportunity and to increase the proportions of renewables rapidly. And since solar PVs do not have to deal with the regulatory and environmental assessments which can prolong the time before the plant becomes functional, they became ideal investment opportunities.

Graph 7: Total amount of approved and installed PVs capacity, 2014



Source: Hahn, 2014, p21

However, as Hahn (2014. p 21-22) points out, non-residential PV installations take significantly longer time to be built, for a variety of reasons, such as grid connection issues which will be discussed in the next chapter, as well as land ownership issues, while some developers are trying to profit from waiting until the prices of the equipment will drop. Some even try to sell their purchasing price agreement, since the FIT purchase prices of solar PVs are dropping. As a result, we can see that in 2014, the vast majority of non-residential PVs were waiting to be built (graph 7).

Table 6: Japan's number of power plants, maximum capacity and electricity generated in 2010 and 2014

Source of Electricity	Number of Power Plants in 2014	Maximum Capacity in 2014(in megawatts-MW)	Total electricity generated in 2010(in in thousands of megawatts –hours MWh)	Total electricity generated in 2014(in in thousands of megawatts –hours MWh)
Hydro	1702	49597	90681	86942
Thermal	2579	193356	771306	955352
Nuclear	16	44264	288230	-
Wind	287	2750	4016	5038
Photovoltaic	1704	4085	22	3808
Geothermal	15	508	2632	2577
Total	**6303**	**294560**	**1156888**	**1053717**

Data: Japan Statistical Yearbook 2017

On the other hand, the data in table 6, used from the Japan Statistical Yearbook 2017, calculating the data of facilities that produce more than 1000kW, shows that in 2014, the maximum capacity of electricity from non-residential solar PVs was the highest among the variable renewables. However, the total electricity generated from non-residential PVs in 2014 was well below the one produced by the wind energy.

Because of some issues regarding the non-residential projects, a new Renewables Energy Special Measures Act Amendment regarding renewable energy was passed and most of the provisions came to power on 1st of April 2017. The main changes were regarding the time limit when the new power plants have to become operational. Before, there was no time-frame, which resulted in the majority of non-residential projects approved, yet not installed, as Graph 7 shows. However, under the amendment, all new, but also already approved projects should become the subject of the deadlines. The new amendment also gives METI the power to revoke the certification it gave if the supplier does not follow METI's guidelines. Another significant change is that METI can now set the tariff rates for the upcoming years as well, unlike before where it could only set prices for the upcoming fiscal year. The last important thing in the new amendment is the establishment of the auction system for large PV projects, where different companies compete for the right to provide the fixed amount of power (Umeda, 2016). These new mechanisms should result in decreased total price of the FIT, as it should slowly become more price-competitive in the near future in in comparison to the other sources of energy. This new Renewable Energy Special Measure Act Amendment can be considered as a regulatory framework of the principal, that is trying to control the future behaviour of the agents, while limiting the potential drawbacks from the unlimited time-frame, which allowed agents to follow the wait-and-see approach while having their contracts already approved.

4.4 Conclusion

Looking at the FIT from the principal-agent theory, the FIT is being used by the agents in a way that it not so-beneficial for the principal. Nevertheless, thanks to the economically generous FIT policy, renewables were able to grow much faster than in the previous years. However, solar PVs counted for the vast majority of new installations, as other renewables had to deal with a lot of bureaucratic obstacles, making them economically not attractive for the commercial sector seeking fast return of the invested capital. The substantial economic burden that comes with the FIT is rising each year, that results in decreasing the FIT rates with each new amendment. Since wind energy was facing a variety of obstacles, over 94% of the FIT installations has been solar PVs, despite the previously mentioned benefits of the wind energy. "If all the projects for which METI has had applications went ahead, Japan could leave most of its nuclear stations switched off, notes Mika Ohbayashi of the Japan Renewable Energy Foundation, a think-tank. But so far just 12% of them have been installed, and much of the rest may prove uneconomic "(The Economist, 2014). If other, non-solar-PV renewable sources of energy were able to expand in higher numbers, it may help the principal to decrease the economic burden of the FIT, or at least make it more cost-effective in the long run.

Despite the impressive growth of renewables, especially solar PV, the numbers are still small when taking into consideration the entire electricity production of Japan, which is dominated by fossil fuels. While the principal-agent goal conflict is clearly visible, other two factors should be clearly mentioned. Right now, the risk behaviour shapes the agents to focus on the solar PV's, as that currently presents the highest stability and the lowest risk potential for the agents. However, more and more agents are starting to focus on other, non-solar PV renewables and it is up to the government to allow them to expand more significantly in these sectors. When it comes to the information asymmetry, principal's most useful way of controlling and observing agents is via the FIT rates and the 2016 amendment allows the principal to have a higher observational as well as control potential over the agents, however outside of these, the principal has only limited power to shape and observe the behaviour of the agents.

Therefore, as has been shown, in the current situation, variable renewables are heavily dependent on the FIT system without which it would be hardly possible for them to compete with other sources of energy. Therefore, the question arises: For how long can the proportion of renewable energy grow, together with the energy prices before it hits the price ceiling? And will it grow until it becomes too expensive, or will it be stopped by something else? Despite the vast number of non-residential PV applications waiting to be built, there is a problematic issue that is preventing many of these PVs from becoming operational, namely the energy grid problem, thanks to which many of these non-residential applications has not been approved.

5. Japan’s Energy grid issue

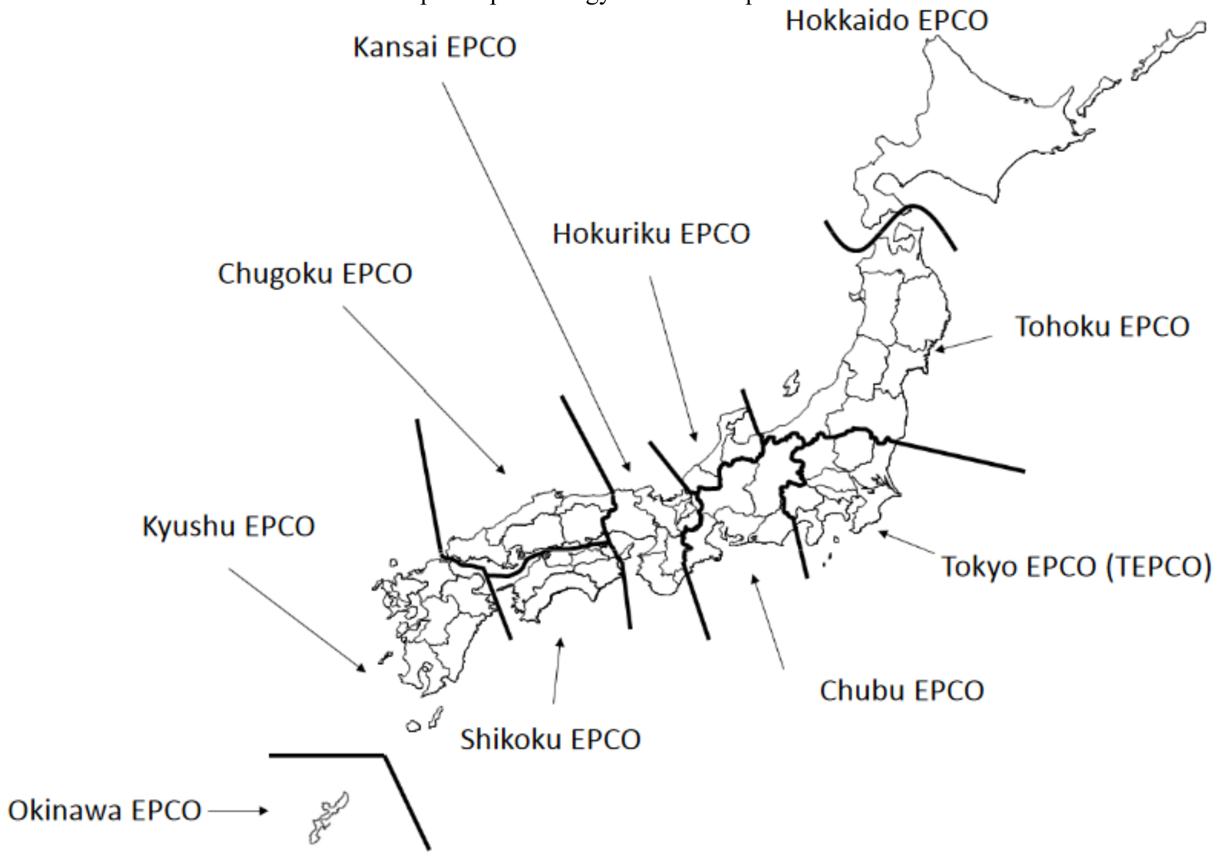
This chapter will focus on the issue of the actual access to renewable energy via the energy grid, which is seen by many scholars as the biggest challenge when it comes to renewable energy growth in Japan (Komiyama et. al. 2015, Komiyama and Fujii, 2017; Rodrigues et al. 2016; Kawakami and IIjima, 2013). The issue of power energy grid is not a new problem. However, this obstacle is very closely related to renewable energies, since in Japan’s past, there was only a small energy transmission between individual parts of Japan, making them energy independent (map 1). The energy grid issue is something that Japan will have to deal with if it plans to increase the proportions of renewable energy. Rundell (2014) further adds that this power grid issue proved to be more complicated than initially expected and many Japan’s energy companies do not allow more applicants to join the energy grid. In this aspect, the relationship between principal and agent came to a unique situation, where the energy companies, responsible for the electricity availability started to block the new agents, which is direct contrast to the main purpose of the government’s FIT – expansion of renewables. The opportunistic mentality of the agents is in contrast to the principal, who’s main goal should be to maintain the stable, secure and cost-effective renewable energy.

Rector and Plenderleith (2011) argue that the energy grid became the key issue Japan needs to focus on. Creating a stability in the energy grid, proves to be one of the biggest obstacles for the expansion of renewable energy. Levi (2013, p 488) adds up that the energy grid connection is very challenging and it became a massive barrier for renewable energy, since the most suitable areas for renewable energy do not have established connection to the grid and the buildout of new transmission infrastructure is facing many obstacles, such as an environmental resistance, as well as the necessity to build this infrastructure while crossing a large number of individual properties. Rundell (2014, p1) also claims that at the time of writing of his paper, “although 23GW of renewable power has now been approved only 4GW is in commercial operation “.

5.1 Electric Power Companies and the energy grid division

Japan’s electricity market is divided into regional areas (map 1), and each area is controlled by the separate regional power utility company, so called Electric Power Company(EPCO). These EPCOs are responsible for their utilities providing its generation, transmission, and distribution. RPS which was the policy before the FIT, focused on the individual EPCOs, giving them targets to be met each year regarding the amount of renewable energy they produce. This way, they could control the production of renewable within their sphere of influence (Rodrigues et al., 2016, p84). In this aspect, the EPCOs were the primary agents of the principal. Negishi (2016, p1) comments that the enormous Japanese renewable expansion is starting to slow down, as the resistance from utilities, since they are meeting their capacity limits (table 7), is starting to be more open. There is a concern about renewable energy project costs, especially in the today's time of cheap fossil fuel imports, as well as the issue of the grid stability with too many renewables joining the grid.

Map 1: Japan Energy Power Companies



Source: Yamazaki, METI 2013.

Table 7: Possible Capacity and FIT Approved

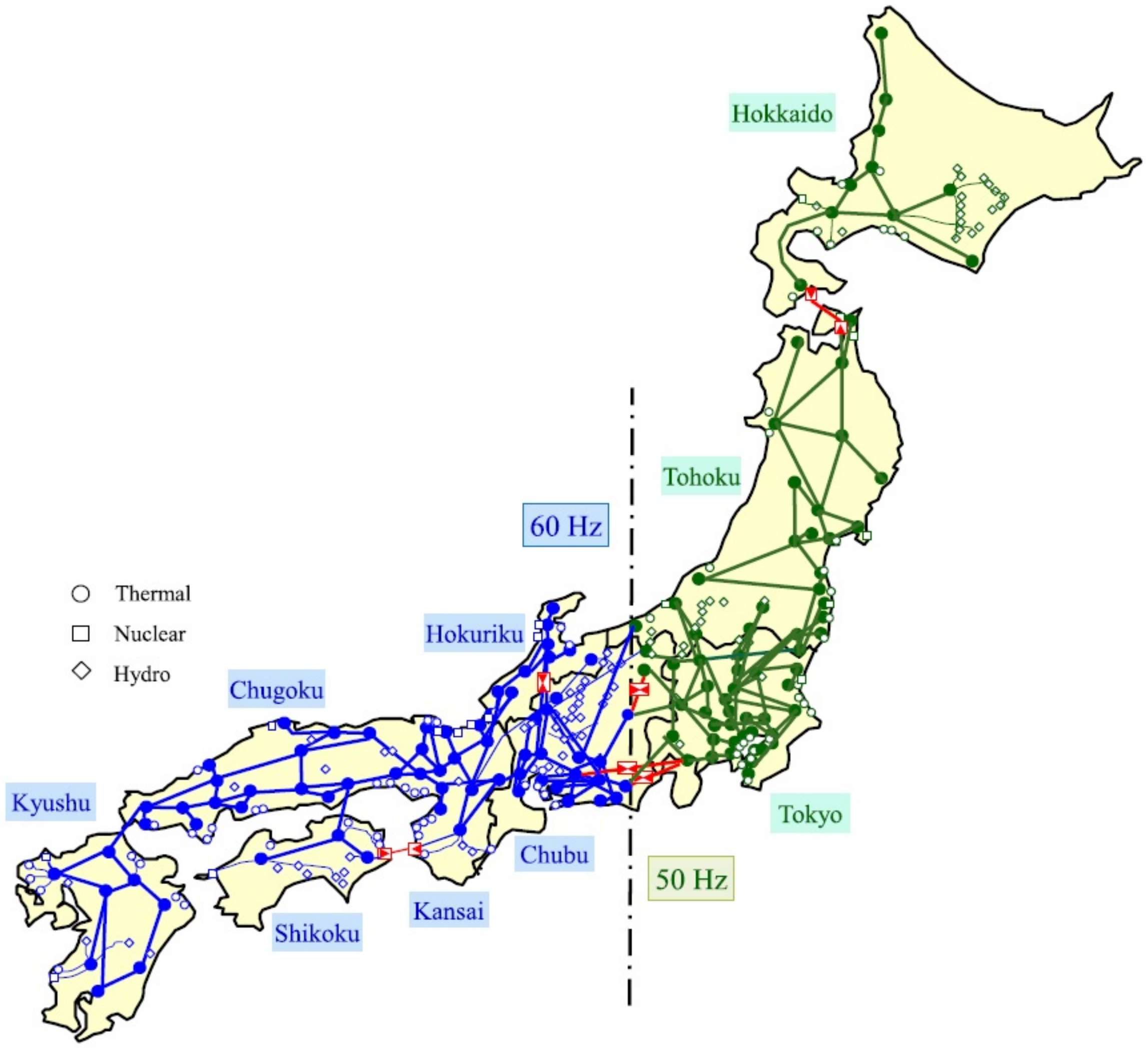
Energy Power Company	Possible Capacity (GW)	FIT approved capacity as of October 2014(GW)	Minimum Demand /Peak Demand in Summer(GW)
Hokkaido Electric Power Company	1.17	2.87	3.08/ 4.59
Tohoku Electric Power Company	5.52	10.76	7.91/ 13.6
Tokyo Electric Power Company		18.58	24.01/ 49.8
Chubu Electric Power Company		9.19	11.46/ 24.5
Kansai Electric Power Company		4.99	13.47/ 26.7
Hokuriku Electric Power Company	0.7	0.98	2.52/ 5.2
Chugoku Electric Power Company	5.58	5.32	5.54/ 10.6
Shikoku Electric Power Company	2.19	2.5	2.65/ 5.3
Kyushu Electric Power Company	8.17	17.76	7.88/ 15.2
Okinawa Electric Power Company	0.356	0.57	0.68/ 2.1

Data: Yamaya et al. 2015, p3

There is also a growing problem of "not in my backyard"[11] attitude of many citizens, that push for renewable energy, however only when renewable energy facilities are close to their living areas, which starts to get problematic, considering the population density and mostly mountainous terrain of Japan. Solar energy is facing the issue of too many approved projects, which created difficulties in many regions, since if approved projects started running, it could result in an energy grid instability, since the number is larger than the current energy grid can handle (table 7).

[11] Cases such as Himeji City citizen suing solar power plant over glare and heat (Kaneko, 2016) [Online] Available at: https://www.japantoday.com/category/national/view/man-sues-solar-panel-plant-over-glare-heat-from-reflection [Accessed: 22.4.2017]

Map 2: Modelled network of high-voltage power transmission line in Japan



Source: Komiyama, Fuuji, 2017, p598.

One of the biggest issues for the spread of renewable energy in Japan is the energy grid connection between the individual power energy companies (map 2), as well as the energy grid difference between East and West. The issue of the separate energy grid can be tracked back to the 19th century when early electricity power companies were small and localized. Tokyo area imported power generators from Germany that worked on 50 Hz, while Osaka electricity providers imported 60 Hz generators from the United States. At that time, people did not think about the compatibility as they never imagined the possibility of connecting electric system at such a considerable distance. However, the electricity generation from both Osaka and Tokyo started to spread, eventually making the entire Japan wired under different source generators, eventually making the country electrically separated. The attempts in the 20th century to unify the energy grid were dismissed as too costly (Gordenker, 2011). This type of divided energy grid, together with the EPCOs enjoying a significant amount of sovereignty made the different parts of Japan quite isolated from each other, with only an insignificant electricity transmission (Table 8).

Table 8: Operating capacity of regional power transmission lines

Name of the power line	Capacity (in 1 MW)	
Kitahon line	600(HK→TH)	600(TH→HK)
Somafutaba line	1500(TK→TH)	5 000(TH→TK)
Minamifukumitsu line	300(CH→HR)	300(HR→CH)
Echizenreinan line	1300(KS→HR)	1600(HR→KS)
Miehigashioumi line	2500(KS→CH)	1200(CH→KS)
Anankihoku DC line	1400(KS→SH)	1 400(SH→KS)
Honshi line	600(SH→CG)	600(CG→SH)
Yamazakichizu line	2000(CG→KS)	1350(KS→CG)
Nishihariokayama line	2000(CG→KS)	1350(KS→CG)
Kanmon line	2780(KY→CG)	300(CG→KY)
Shinshinano FC	600(TK→CH)	600(CH→TK)
Sakuma FC	300(TK→CH)	300(CH→TK)
Higashishimizu FC	300(TK→CH)	300(CH→TK)
*HK: Hokkaido, TH: Tohoku, TK: Tokyo, CH: Chubu, HR: Hokuriku, KS: Kansai, CG: Chugoku, SH: Shikoku, KY: Kyushu.		

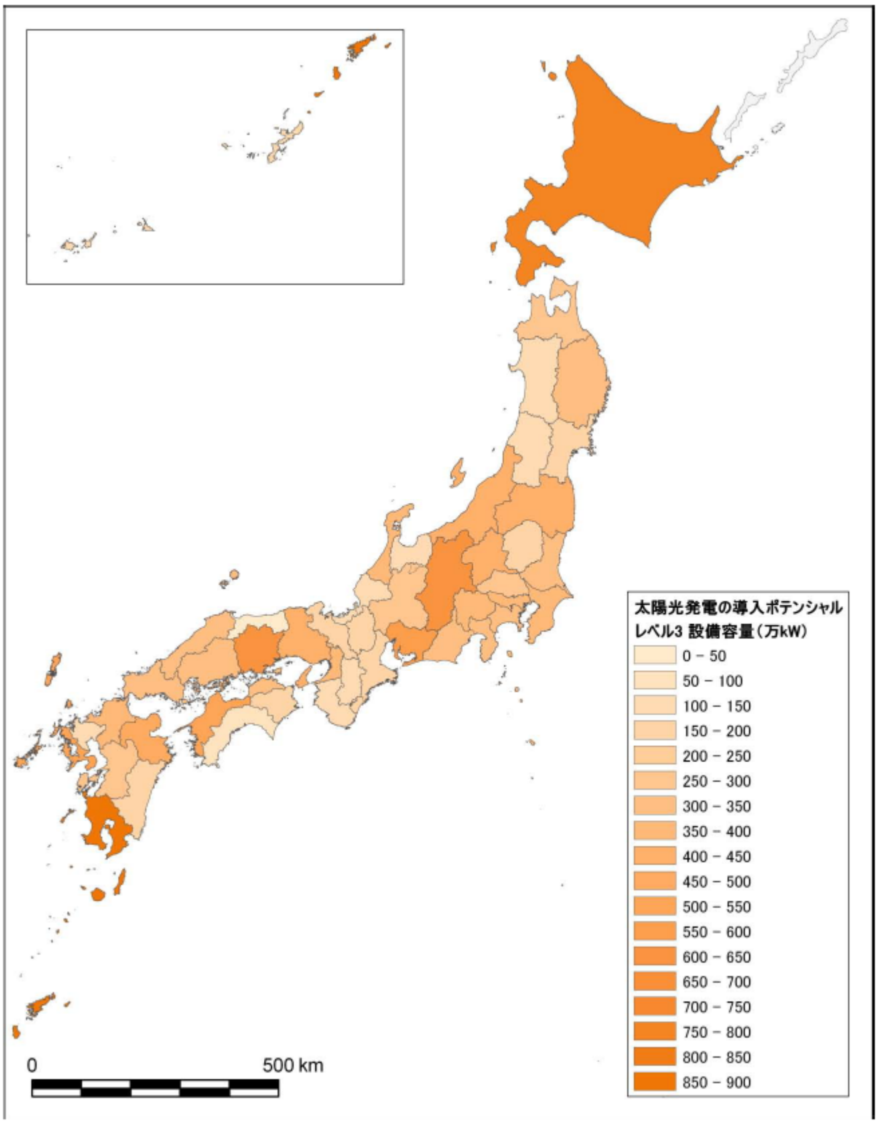
Data: Komiyama, Fuuji, 2017, p599

However, the Fukushima nuclear accident and the following implementation of the FIT rapidly changed the energy landscape. This small hindrance has not been very problematic, however, suddenly it emerged as a crippling issue about which not many paid attentions to before and in the wake of the Fukushima accident many people did not understand why Western part of Japan won't transport part of its energy production to the East (including Tokyo area) that had one-third of the electricity generation unavailable, which resulted in the blackouts (Rodrigues et al., 2016).

5.2 Suitable Areas

When the RPS scheme ended in June 2012, the following FIT policy changed the leading agents responsible for the proportions of renewable energy from EPCOs to the private sector while increasing the share of renewables rapidly, nevertheless, geographically unequally throughout Japan. When looking at the most suitable areas, both wind energy and solar energy have different potential in various parts of Japan.

Map 3: Solar energy introduction potential in Japan in tens of thousands kW



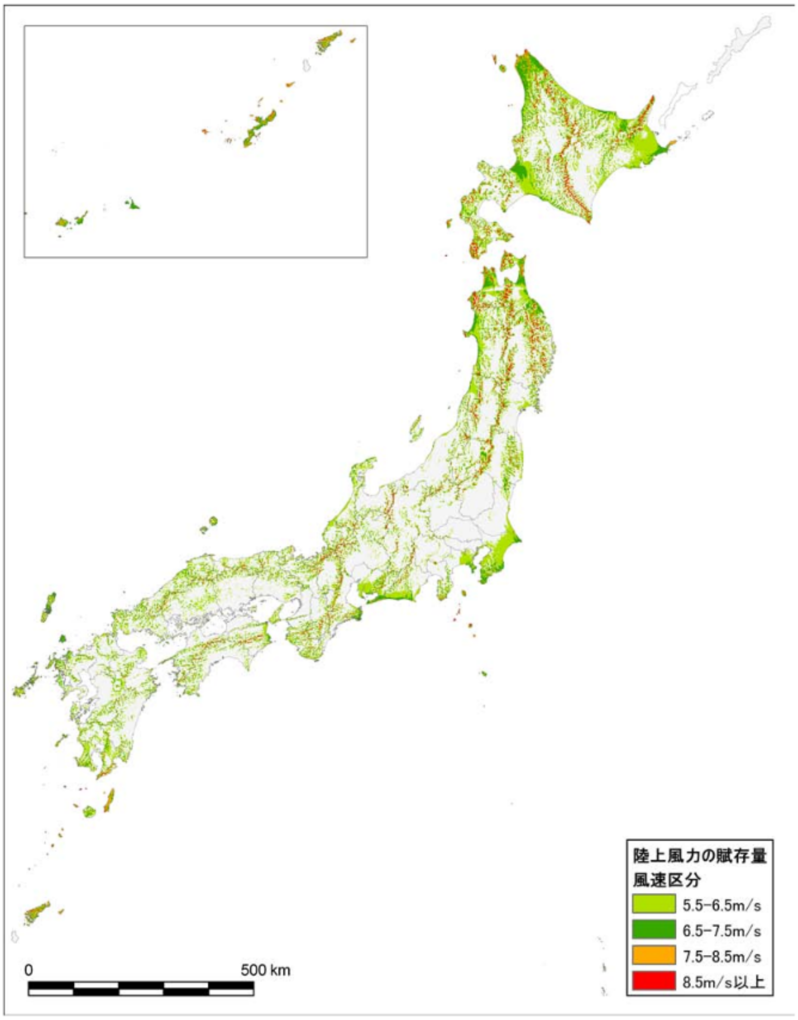
Source: MOE, 2010, p 82

As map 3 shows, the highest potential for solar PVs is in Hokkaido and Kyushu, however as is shown in Table 8, both of these regions have only limited capabilities of transmission to other regions, namely Hokkaido has a capacity of 0.6GW and Kyushu 2.78GW, which is nowhere near the levels of their actual potential. Therefore, the non-residential producers of renewable energy are facing another obstacle in the access to the grid. Some EPCOs are being overwhelmed with the applications, as 90% of them has been concentrated on 5 out of 10 EPCOs, making the utilities to boycott solar PV agreements (Hahn, 2014, p28-29).

With a majority of the non-residential solar FIT agreements still being in the process of approved, but not installed (graph 7), academics such as Hahn argue that in the indefinite future date, the non-residential FIT application will be deferred. Utilities defend this decision with the reasoning of protecting the grid stability from the oversupply. However, this is not the case for residential sector and to a smaller extent for small solar farms, since the energy grid connection is easier to facilitate (2014, p28-29).

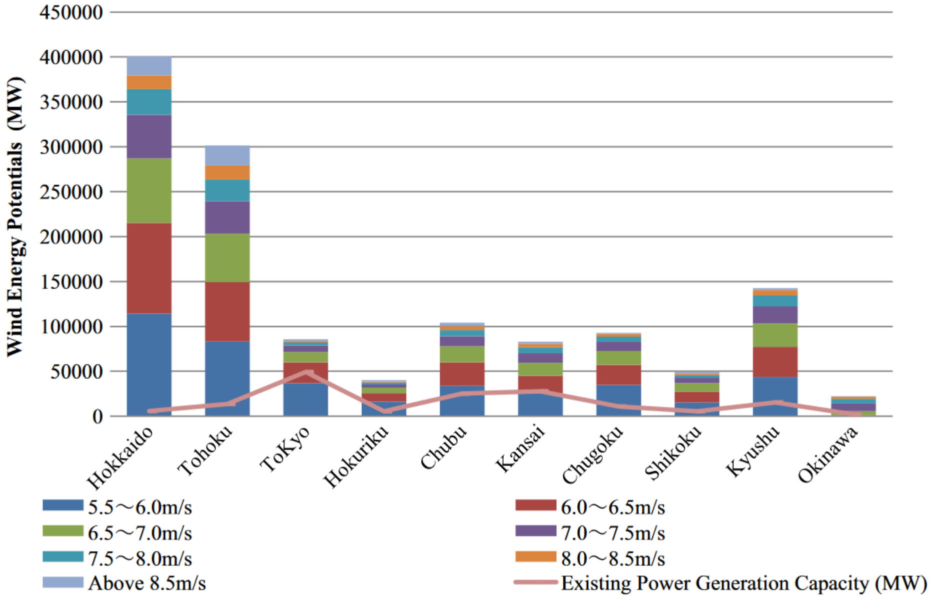
As for wind energy, the potential of Japan, as was mentioned before is very high as the geographical location is suitable for the build-up of wind turbines. As map 4 and graph 8 shows, regions such as Hokkaido, Tohoku and Kyushu are much more suitable for the build-up of wind energy. According to Mizuno (2014), Hokkaido region potential reaches 400GW, while Tohoku region is at 300 GW, followed by Kyushu at nearly 150GW. However, despite the impressive FIT growth and considerable potential of wind energy, the problem of each electric company working as a separate entity, or agent, remains.

Map 4: Map showing the on-shore wind power distribution



source: Ministry of Environment (MOE) 2010, p97

Graph 8: Wind energy potential and existing capacity in 2014



source: Mizuno (2014), data by MOE (2010)

As map 2 showed, the energy grid connections between regions is in most cases quite weak, which is a bothersome thing for the expansion of renewable energy if the regions with the highest potential (map 3, map 4, graph 8) are also the ones most isolated when it comes to the energy grid connection(table 8). “This may additionally reduce acceptance of renewable energies if they[people] also have to pay for the expansion of the grid infrastructure “(Brand, 2013, 229-230). Based on the METI estimates in 2010, when introducing the FIT system, household costs were estimate at about ¥150 - ¥200 per month, ten years after the introduction of the system (METI, 2010), which is much less than the actual expenditures of this policy.

As Esteban, Zhang, Utama (2012) pointed out, that one of the biggest limitations that Japan has to face when it comes to the expansion of renewable energy is the land constraints and therefore many future renewable goals can face significant challenges in this aspect. Only around 7% of the land is suitable for irrigation, as most of the country is quite mountainous. Therefore, any significant expansion of solar or on-shore wind energy could result in a scenario where a substantial amount of the irrigated land would be covered by solar panels and wind turbines (p29). Expansion of renewables such as solar PVs and wind energy brings lots of technical difficulties to control the energy grid and flexible resources should be implemented, such as rechargeable batteries, backup generators, demand response and expansion of power line capacity (IEA,2016; Komiyama, Fujii, 2017, p 596).

5.3 Battery energy storage and Smart Grid

As was already showed before, the output fluctuations caused by renewable energy generators such as wind turbines or solar PVs can create energy power grid instability. The current system in Japan shuts down residential PV energy input if the number of PVs exceeds the grid load to maintain the quality. One of the possible, countermeasures is battery storage system that can significantly negate this weakness of renewables (Kawakami, Iijima, 2013; Yoshida et al. 2015). The residential PV load that would otherwise go to waste can be stored instead. This would help to shift the peak demand of electricity, as thanks to the battery system, the surplus of PV would be discharged when PVs are not producing energy. However, under the current system, it is important to realize the weakness of the battery energy storage systems. The two types of aging factors have to be taken into consideration. The first one is the cycle degradation which occurs when the battery is repeatedly charged and discharged. The second one is the calendar degradation which occurs when the battery is kept at the high voltages (Yoshida et al.,2015, p 266).

The extensive research was done by Yoshida et al. regarding the battery energy storage, and the results show that the current battery storage system is more energy effective than cost effective (2015, p270). This means that under the current FIT system, there is not much to offer for the electricity producers to invest into the battery systems; if the returns of investment would be minimal. Therefore, one of the principal's goals - the increase of renewable energy, is not necessarily the same as the one of its agents - the economic profit. Because of this relationship, it is difficult for the principal to increase the share of renewables in this way, since it is not in the direct interest of its agents.

When it comes to smart grid, it is probably the most suitable, yet technologically challenging way of how to safely expand the proportions of renewable energy while not threatening the stability of the energy grid (Mah et al. 2013). In simple terms, smart grid is a high performing electric power network that uses information and communication technologies for the sake of energy management which goal is to minimize primary energy consumption levels as well as CO_2 emissions, while guaranteeing the stable supply of energy (Hayashi, 2014, p 20).

One of the biggest challenges of a smart grid connection is moving from small, local demonstration project to the development of large scales ones. These large-scale projects can create protected space networks where cost reduction, technological innovation and market competition for variable renewables is secured until they can become economically and commercially viable option which would be able to compete with the established sources of energy (Mah et al. 2013, p727).

The first Japanese model can be described as "government-led[12], community-based[13] and business-driven[14]" (Mah et al., 2013, p 729). These projects were completed in 2015 and moved to the next phase of building smarter communities based on the obtained data from the residents, as well as business operators that participated in these demonstrations (Lamotte, 2015).

5.4 Conclusion

Energy grid issue in Japan presents an enormous problem when it comes to increasing the proportions of renewable energy. Following the theoretical framework of principal-agent theory, it is clear that the goals of the principal are not shared with the agents, which creates the status quo within the energy grid issue. While the obstacle of 50-60Hz can be improved by the expanding the number of converting facilities, what should be done is to increase the grid connection between individual EPCO's as well as to improve the overall grid coverage, especially in the regions of Hokkaido, Tohoku, and Kyushu. These regions are the most suitable ones to increase renewable energy consumption. In the current form, many of the EPCO's are already reaching their capacity, and therefore it is important to resolve this challenge in the near future. However, because of the current principal-agent relationship within the current energy sector in Japan, there is only a small initiative at this point to deal with this problem, especially since the agents are looking for to act opportunistically, mostly seeking imminent profits, and the innovation and expansion of the energy grid may not be such a sound business model, with high levels of risk regarding the increased costs of the projects while under the construction being very plausible.

Another possible alternative is to deploy a battery system that would be capable of storing the extra capacity that was produced in a certain day period and use it in later hours, as is commonly applied in the residential sector. However, the deployment of this kind of batteries in the non-residential sector can be more problematic, since these batteries are more energy

[12] Japanese government made initiatives on the development of smart grids via the implementation of policies, government intervention and creating a partnership with the private sector as well as local governments. Budgets for the four project were 126.6 billion, while the government was paying 65% of it, and private sector covering the rest(Mah et al., 2013).
[13] The four projects were located in Kansai Science City, Yokohama, Kitakyushu and Toyota City
[14] Business sector had a prominent role, it was a source of capital investment and innovation, determining role and scale of each smart community (Mah et al., 2013)

effective than cost effective, which is not a sound option for the commercial producers, as these agents business strategy is usually profit-oriented, rather than to make their electricity plants more energy effective, as well as cost effective. Therefore, in this case there would be a need for a new government policy that would be able to tackle this issue, as under the current regulatory system, principal's capacity to observe and make the agent act in a way the principal wants is quite limited.

When it comes to the idea of Japan's smart grid, it is still in the phase of local demonstration projects and therefore more data has to be collected for Japan to attempt deploying full-scale smart grid project, making the idea of full-scale smart grid connection a process that will take many years, if proved as economically feasible.

6. Conclusion and further recommendations

Looking at the topic of this thesis from the principal-agent theoretical framework can give us a better understanding of the current situation within the Japan's renewable energy sector. The current FIT system helped to increase the proportions of renewable energy, however it gave more powers to the agents, at the expense of principal's powers.

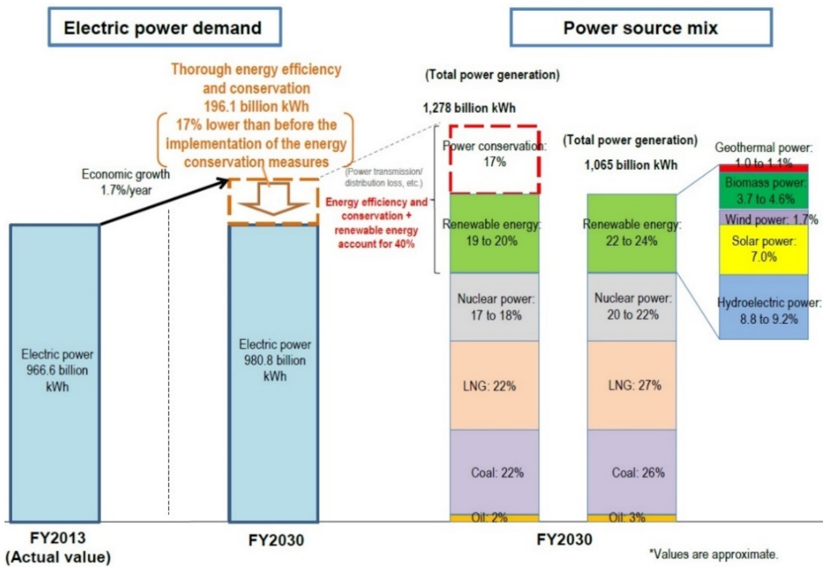
Can the current FIT, as well as the energy grid situation constrain the future of renewables in Japan? Looking at it from the principal-agent theoretical framework, it is clear that the different agents pursue different goals to achieve, while trying to co-exist in the same sphere following their own self-interests. However, if Japan wants to increase the proportions of renewable energy in a feasible way that would not result in harming the economy, there is a need to revise its government policies and tackle these two issues that have been presented in this thesis. Despite the impressive growth of the solar PVs in Japan, other sources of new renewables are lacking behind because of the variety of issues they are facing. Decreasing the bureaucratic difficulties for establishment of new wind and geothermal plants could result in much faster growth, especially considering the potential Japan has in both geothermal, as well as wind sector. The FIT policy has been more successful in increasing the proportions of renewable energy in comparison to previously replaced RPS, however the situation with nuclear energy losing its support also played a significant role in this growth and the Japanese government had the opportunity and the blessing of the public to rapidly increase renewable energy proportions despite the costs connected to it.

The FIT was successful in expanding solar PVs, especially the residential part, however, the vast proportion of non-residential projects are still just in the development phase, facing a broad range of difficulties. However, the FIT was not able to increase the proportions of other sources of energy to the same extend, despite the significant potential of the wind as well as geothermal energy in Japan. One of the reasons wind as well as geothermal energy were not able to copy the growth of solar PVs is the long process, starting from acquiring the permit to building the energy power plant until the actual build-up, which is not very appealing for the private investors seeking a quick return of the invested capital.

However, the biggest obstacle, which was not that relevant before the Fukushima accident and following renewable expansion is the issue of grid connection. This is especially important to resolve, since the places which are the most suitable for the expansion of renewable energy under the FIT are usually in remote areas, facing the issues of not having access to the energy grid. The issue of separate EPCO regions not being sufficiently connected is also an obstacle, especially for the cases of Tohoku, Kyushu, and Hokkaido, which also happen to be the ideal regions for the expansion of renewable energy. The limited power grids in these areas are not capable of exporting renewable energy potential to other places, therefore new installations are facing issues of energy companies declining their entries into the energy grid.

While nuclear energy is slowly being restarted and government being entirely supportive of it, it currently does not look like nuclear energy will become a threat to renewables. Instead, both renewable energy as well as nuclear one should both be considered as an alternative to the fossil fuels, which are not a safe, long-lasting option for Japan. Considering the fundamentally different purposes for the Japan's policymakers, where nuclear energy has been thought of as a base-load energy source, renewable energy in Japan still have a significant buffer zone, since fossil fuels are still the vast majority of the Japan's electricity production and according to the METI's 2030 Long-term Energy Supply and Demand Outlook, the fossil fuels are expected to keep the dominant position within the Japan's electric sector (graph 9).

Graph 9: METI's 2030 Targets



METI (2015) Long-term Energy Supply and Demand Outlook, July 2015, p8

As a result of the rising costs of renewable energy in Japan through the FIT, it may be crucial for the policy makers to decrease the FIT costs, as well as to tackle to problem of meeting the supply and demand, which can happen by either increasing the energy grid connections or seeking other, technological answers, such as battery storage system. However, the most important thing right now is for the decision-making body to increase the expansion of other, non-solar PV sources of renewable energy, where wind energy has the largest potential, with also the lowest costs out of the available renewable sources in Japan, which could help to decrease the FIT cost. However, for Japan to be capable of doing that, the expansion of energy grid connection is a must, especially since the most suitable regions for renewable energy development – Tohoku, Kyushu and especially Hokkaido have issues of admitting newcomers because renewable energy has been already on maximum, if they want to keep the energy grid stable. With only a limited capability to export this energy to different parts of Japan, renewable energy growth may come to a halt. The establishment of smart grid can also drastically increase the proportions of renewable energy in Japan. However, it is still only in the testing phase, with four communities using the smart grid connection.

Therefore, to sum it up, Japan is facing the crucial decision of how the future of renewables may look. The principal-agent framework can give us a better understanding regarding the complexity of this topic, as well as explaining why different agents are not necessarily sharing the same goals as the government(principal). The principal-agent theoretical framework showed that for Japanese government to continue support the expansion of renewable energy, there is a crucial need to reform the current system, before the expenses of the renewables would increase too much to maintain. While the FIT system was able to expand the renewable energy in Japan, the agents do not necessarily follow the same goals as the principal and therefore there is a need for another regulatory system, which would help the principal to maintain higher levels of control, make the agents act not only in a profit-based way, but also to support technological innovation, cost-effectiveness as well as to create a stable and secure energetical system, in which the proportions of renewable energy would be able to grow in a way that would not put too much burden on the Japanese economy and governmental budget. There is a need of tackling the fundamental issues that can have fatal consequences for renewable energy if they are left unanswered. The long-term energy outlook developed by METI on graph 9 shows that both renewable energy, as well as nuclear energy would still be behind the fossil fuels when it comes to the total share. However, it is important to tackle the current issues so that the proportions of renewables in Japan can meet the 2030 targets in a sustainable way.

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