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RESEARCH ARTICLE

Energy self-sufficiency and its significance: Japan's potential and some take-away lessons from Germany

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ABSTRACT

Fossil fuels have traditionally powered modern societies since the Industrial Revolution and our present day well-being have been achieved through such fuels. They are, however, finite in nature and quite harmful to the environment since they are the main source of global warming. Japan, Germany as well as many other countries are highly dependent on the import of oil, gas or coal and have to pay the world market price. Unsustainable extractions have brought fossil fuels under constraint and countries which want to (partly) mitigate this issue, should start investing in renewable energies and re-arrange their energy generation sector to a more sustainable system. A functional mix of renewable and conventional power plants can reduce the need for fossil fuels in the electricity generation sector, thus lessen the carbon dioxide emission while securing supplies and stability. The main aim of this study is to investigate Japan's potential for renewable energies and how to influence its energy generation sector with some take-away lessons from Germany. Qualitative and quantitative research designs were adopted to provide reasonable arguments to support the hypothesis that a fair share of its total (electric) energy demand could be achieved by capitalizing on renewable energy sources, while phasing out some old thermal power plants. A significant take-away lesson from Germany turns out to be adoption of more innovative energy policies and their constant upgrades. Patience with higher price of renewable energy sources during times that world oil prices significantly drops through political manipulation is another consideration.

Keywords: Fossil fuels, renewable energies, sustainability, policies, Japan, Germany

1. INTRODUCTION

At the outset, the authors would like to mention that this work was initially conducted as a master's thesis by the first author under the guidance and supervision of the corresponding author as part of the requirements of the German-Japanese dual degree program in International Material Flow Management (IMAT) [1]. After its initial success, the authors decided to collaboratively enhance and improve the work and transform it into a reputable journal article for its wider access. Considering that the first author comes from Germany and raised after the 1970's oil crises; corresponding author comes from a major oil producing country, have spent his entire professional career in Japan while observing how world politics have affected both major oil producing and consuming countries, we would like to share our findings in a sincere and scientific manner. In our modern world, energy is considered our lifeline and after observing how superiority complexes have used numerous gimmicks and politics to manipulate and control such lifeline, we would like to emphasize the importance of energy self-sufficiency and propose practical ways for its attainment. Japan's achievement of energy self-sufficiency using some take-away lessons from Germany will encourage other countries to pursue similar path, prepare the world for the complete depletion of fossil fuel in the near future, help prevent global warming and eventually enable each nation to control and manage their lifeline independently and without forced submission to tricks or dirty politics.

There are certain similarities between Germany and Japan in the sense that both are highly industrialized nations, have only scarce fossil fuel deposits (excluding Germany's access to lignite) and are thus dependent on fossil fuel imports to meet their energy demands. Such dependency on fossil fuel imports got

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tangible with the oil crises in the 70's for the first time. Since then Germany and Japan have diversified the energy sources of their electricity generation sectors. In 2011, the Great East Japan Earthquake and its follow up tsunami created a nuclear disaster at Fukushima Daiichi power plant. This accident led to a chain reaction of consequences after which the Japanese government decided to shut all of Japan's 54 nuclear reactors down for revision and suspend all plans related to nuclear power plant set up. The German government even passed a slow phase out of all nuclear power plants as a direct reaction to Fukushima incident [2]. Both countries have used different approaches to solve the discontinuation of nuclear power. Although Germany had already successfully implemented a feed-in-tariff (FIT) system and other policies, which have been carefully analyzed by governments around the world, prior to the nuclear phase-out, the newly decided phase-out puts more stress on the electricity generation system. In Japan's electricity generation strategy, compensation for electricity share of the shutdown nuclear power plants mainly come from obsolete – fossil fuel driven power plants, something which has led to increased spending on fossil fuel imports and higher CO2 - emissions [3]. Despite world market prices for fossil fuels being low in recent years [4], the additional spending has resulted in a negative trade balance and with the prices slowly recovering, such deficits could become worse. Given the finiteness of fossil fuels, the prices are likely to increase to even higher than prior peaks. Therefore, it would be a big mistake to rely on fossil fuels for too long, especially for countries that have no or limited fossil fuels resources.

In this paper we have analyzed the potential of renewable energies in Japan. The investigated energy sources are wind, water, solar, geothermal and biomass. With focus on national energy resources, Japan could reduce fossil fuel imports and simultaneously increase its independence from suppliers. Furthermore, CO_2 - emissions could be reduced as well. The above mentioned similarities with Germany are seen as opportunity to look at Germany's measures to restructure its energy generation sector. Some measure could be implemented in Japan in order to nourish the development of Japan's renewable energy sector and mitigate fossil fuel imports. Therefore, the main questions that we try to answer are: Where does Japan's renewable energy potentials lie and what measures which have been implemented by Germany could be applied in Japan in order to support the development of renewable energies?

2. HISTORICAL PERSPECTIVES AND TRANSFORMATION PROCESSES

Japan and Germany were among the list of countries which started to industrialize after the United Kingdom (UK) in the second half of the 19th century. In 1868, the Tokugawa Shogunate was overthrown, and with the emperor back in power, the Meiji Restoration put an end to the century long Japanese self-imposed isolation. This marks the starting point of the Japanese industrialization era [5]. In Germany some factories had been in operation since the early 19th century. However, first movements towards a broad industrialization era began to sprout after the pre-March revolution in 1848. After the German victory over France in 1870/71, the German Confederation was united under Prussia's lead to the second German Empire. With the unification and war reparations from France, the industrialization process was significantly nurtured. Areas of the empire with rich coal and iron ore deposits like the Ruhr area, the Saarland, Alsace-Lorraine and Silesia saw explosive growth rates in population and economic activity [6].

With the slowly upcoming electricity generation, water power plants were used to meet initial demand. However, due to steadily growing demand and the need of a water body for water power plants, larger power plants driven by coal, generated the main share of electricity. The energy and electricity demand continued to grow around the world, especially after the 2nd World War [7].

2.1 Expanding energy demand and diversification

Population growth and economic recovery in Germany and Japan lead to a constantly expanding energy demand which could no longer be satisfied by national resources as both countries are poor in fossil resources. Imported cheap mineral oil supplemented coal and slowly started replacing it as the main energy source in the second half of the 20th century [8]. Their low prices and wide availability led to an increasing dependence on the new fossil fuels, making them the driving force of global development. Thermal power plants generated the electricity needed for development by burning fossil fuels. Mineral oil was also crucial for transport and the chemical industries. This dependence became visible during the oil and energy crises of the 1970's.

A substantial mineral oil shortage during the first crisis in 1973 was caused by an oil embargo of the Organization of Arab Petroleum Exporting Countries (OAPEC) [9], which lead to a price increase from US$3 per barrel to nearly $12 per barrel globally by 1974 [10]. Price increase by four folds had many effects on industries and the global economy, one of which was greater interest in energy alternatives, namely renewable energy sources, nuclear power plants and national fossil fuel reserves.

Both countries diversified their energy generation sector and reduced their dependency on Middle Eastern mineral oil. Nuclear energy was seen as the most economical and useful solution, therefore governments prioritized the expansion of nuclear energy [11]. Despite the fact that dirty political manipulations lowered oil prices and many renewable energy projects which had been implemented during the height of the oil crisis were discontinued, the oil crisis increased awareness about the importance of energy self-sufficiency and generated incentives to develop energy efficient technologies for households and industries.

2.2 Impacts of the Fukushima Disaster

The Fukushima disaster refers to the nuclear meltdown in Fukushima Daiichi nuclear power plant which was caused by the Great East Japan Earthquake and its subsequent tsunami. This nuclear meltdown had major impact on Japanese and German energy policies. As a direct result of the Fukushima disaster, the previously cancelled German nuclear phase-out by the year 2022 was reconsidered and became a German law through strong public support [12].

Prior to the Great East Japan Earthquake in 2011, nuclear energy had an annual share of around 30% on Japan's electricity generation [13]. This share was scheduled to increase to around 40% in order to sustain energy supply security and mitigate carbon dioxide emissions [14].

However, most nuclear power stations in Japan were shut down after the accident. The share of nuclear energy on the annual electricity generation dropped to 2% in 2012 and to 0% in 2014 [13]. According to the Japanese Ministry of Economy, Trade and Industry (METI) only 3 of the 54 reactors are in operation [3]. The supply gap is mainly covered by thermal power plants which are fueled by mineral oil, coal or liquefied natural gas (LNG). But due to Japan's low self-sufficiency ratio of about 6% in 2014, the country heavily depends on fossil fuel imports. When electricity was also generated by nuclear power stations, the self-sufficiency level was at 19.9%. After the shut-down of all nuclear power stations, 88% of the energy carriers used for electricity generation in 2014 had to be imported, while only 9% of the electricity was generated by hydro power and 3.2% by renewable energies [3].

3. JAPAN'S ENERGY SECTOR AND ITS 2-GRID SYSTEMS

Japan has a rather unique electricity generation sector and grid systems. The country is split into 10 areas, each of which is managed by one company. Grid operation and electricity generation are both under the control of those companies. Up until recently, households had to purchase their electricity from the utility company in their area and were not able to choose their suppliers. However, since the liberalization of the electricity market in 2016 it has become possible for households to select their electricity provider [15].

Apart from its still inflexible electricity market, the electricity transmission network is split into two more or less independently operating grids. Its North-East grid which covers Tokyo metropolitan area operates at 50 Hz while its South-West grid runs at 60 Hz. Considering that transmission of electricity from one grid to another requires frequency conversion and there are only three frequency converting stations that connect the North-East grid to South-West grid, puts a limit on such transfer. Currently the Japanese frequency converting capacity is at 1.2 GW [16].

4. JAPAN'S RENEWABLE ENERGY POTENTIALS

Renewable energies (excluding large scale hydro power projects) were not part of Japan's energy source portfolio until 2011. In 2012, the share of renewable energies (excluding hydro) made up only 3% of its total national energy generation, just increasing by 1% compared to 1990 level [17]. A considerable large potential in national energy generation remains still untapped and Sovacool in 2011 concluded that a total of 324 GW renewable energies are feasible for Japan [18]. Onshore and offshore wind turbines account to 222 GW, geothermal power plants to 70 GW, additional hydro power plants (especially small scale ones) to 26.5 GW, solar energy to 4.8 GW and agricultural residue to 1.1 GW. Wakeyama and Ehara focused on the potentials of renewable energies in Northern Japan (Hokkaido, Aomori, Akita, Iwate, Niigata) which include wind, geothermal, micro-hydro power plants, biomass and solar power. Their results show that it is possible to generate enough energy in Northern Japan which not only can supply the need of the whole area sustainably but also have a surplus that can be transmitted to other parts of the country, especially to the densely populated Tokyo metropolitan area [19].

4.1 Wind power

Electricity generation is relatively new in the field of wind power. Although the first windmill used to generate electricity was built in 1887 in Scotland by Professor James Blyth, it took almost one century for the real potential of wind power to be acknowledged [20]. From small wind mills on top of buildings to large on- and offshore wind farms that are capable of generating hundreds of megawatts – even gigawatts in some cases – thus can feed vital electricity into the national grids. It is possible to build power stations with a power output of several MW (Offshore SIEMENS D-7 Platform 6-7 MW rated capacity). Although wind power is dependent on whether conditions, in the same manner that solar energy is, it has the advantage of being easier to predict. Hence, it is relatively easier to plan electricity supplementation with wind energy. With the Sovacool's estimated potential of Japan's wind power [18], this renewable source could contribute to the energy mix decisively.

Left side of Fig 1 shows Japan's onshore wind power potential and the right side indicates its offshore wind power potential. As can be observed, its onshore potential is limited, but the offshore is quite high. Although the onshore northern areas of Hokkaido and Tohoku can provide high enough wind speeds for large wind turbines, the southern part does not. On the other hand, the offshore potential is quite high, especially in the northern areas around Hokkaido and in front of the Izu peninsula (marked in red), where wind speeds of around 8.5 m/s or even higher have been recorded [21]. Some high yield zones are close to the mainland (lower right side, marked in red) and could supply electricity without long transmission lines. Except for a few cities, Hokkaido and Tohoku regions are not densely populated and areas around the Izu peninsula could be used to generate electricity for the highly populated areas in and around Tokyo or Nagoya.

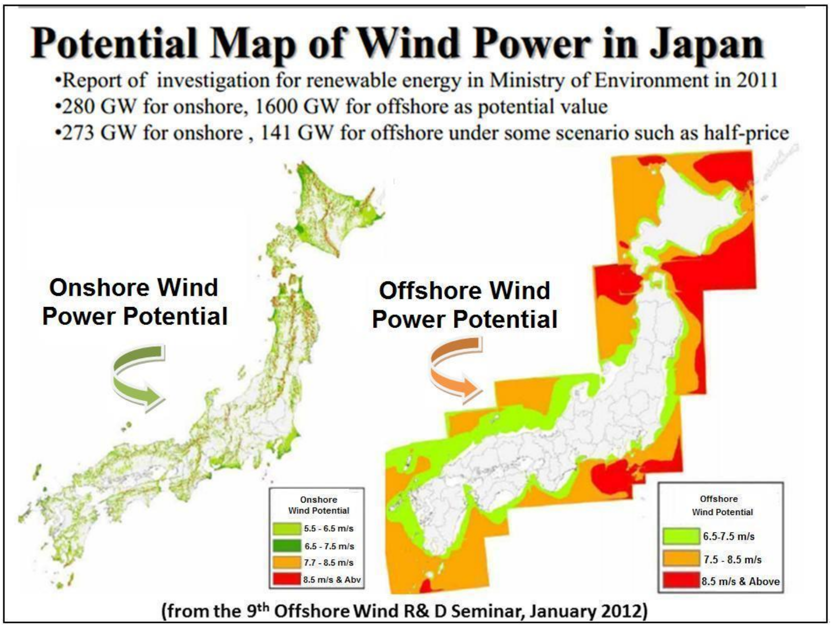

Fig 1. Potential Wind Power Map of Japan (Source: United Press International (2013) Japan plans biggest ocean wind farm)

4.2 Geothermal energy

Geothermal energy, defined as the heat from the earth, is a statute-recognized renewable source [22]. Originating from the earth's inner structures and radioactive decay, heat is generated and stored in the earth's crust. This energy can be used in direct and indirect ways. Direct usages are heating and cooling of private households or public buildings, greenhouse heating, relaxation and healthcare in spas, even cooking with the hot water or steam is possible. Electricity generation is an indirect use and can only be implemented when temperature and heat levels are high enough to run an attached steam turbine.

Japan is located right on top of the Pacific Ring of Fire. The tectonic activities not only cause constant earthquakes, but also contribute to a high volcanic activity. That is why geothermal energy in Japan is close to the surface, often even visible in form of hot springs, referred to as "Onsen" or steam rising up from crevices. Despite this, according to the IEA (International Energy Agency), geothermal energy with an installed capacity of 353 MW, contributed only 0.3% to Japan's electricity generation in 2013 [23].

Fig 2 shows all major geothermal power plants that were operated in 2012 by electric power companies. Majority of those plants are located in the northern area (Tohoku) and the southern island (Kyushu). There are just a few large ones, with the power plant Hatchobaru in Oita being the largest one (110 MWe). Compared to large conventional power plants, the power output is rather low, as most of those power plants can generate up to 500 MWe per block. However, the potential of geothermal energy is there and can be tapped.

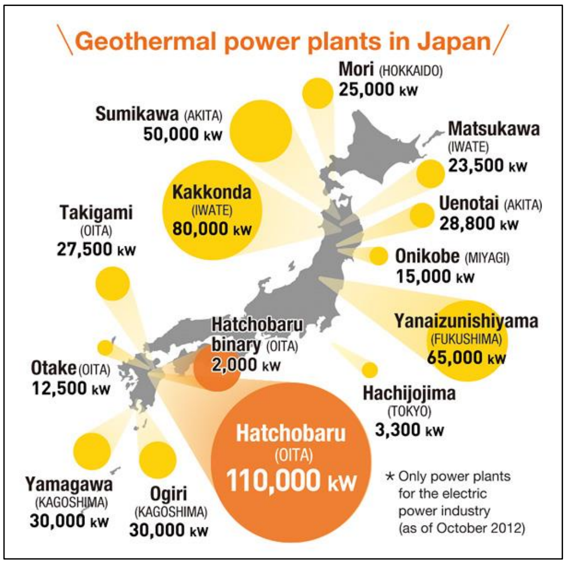

Fig 2. Geothermal Power Plants in Japan (Source: Mitsubishi Heavy Industries: Geothermal Power [2012])

4.3 Hydro power

Water power generates electricity through the transformation of kinetic energy of falling- or running water. Electricity can be generated by hydro power in various ways: conventional dams which store (usually) large amounts of water are able to generate large amounts of electricity. Run-to-the-river power plants, which use the speed of running water, are often found next to running waters, their sizes range from micro- to medium sized stations, depending on the amount of available water and flowing speed. Recent developments have led to pumped storage plants which are used to store surplus electricity in form of potential energy in water during periods of overproduction, and release the water to generate electricity during peak demand.

Water power can generate electricity steadily. Though its amount may fluctuate through the year, it is possible to feed into the base load or store energy for peak demands. This adaptive capacity makes water power appealing for a well equilibrated energy mix. However, large dams change the ecosystem of the affected area and are not usually seen as sustainable thus leading to the conclusion that large scale projects have to be carefully evaluated in order to prove their sustainability.

Hydropower is currently Japan's main renewable energy source and constituted 9% of its total electricity generation in 2014 [3]. Fig 3 shows the potential number of station in various sizes and the resulting power output. Since most feasible sites for large scale power plants have been exploited already, the future potential has to be utilized by small-scale or even micro hydro power plants, as Japan still has many sites suitable for that purpose. As indicated in Fig 3, the largest potential in terms of power output is in the category 10-30 MW while the largest potential in terms of number of stations is in the category 1-3 MW.

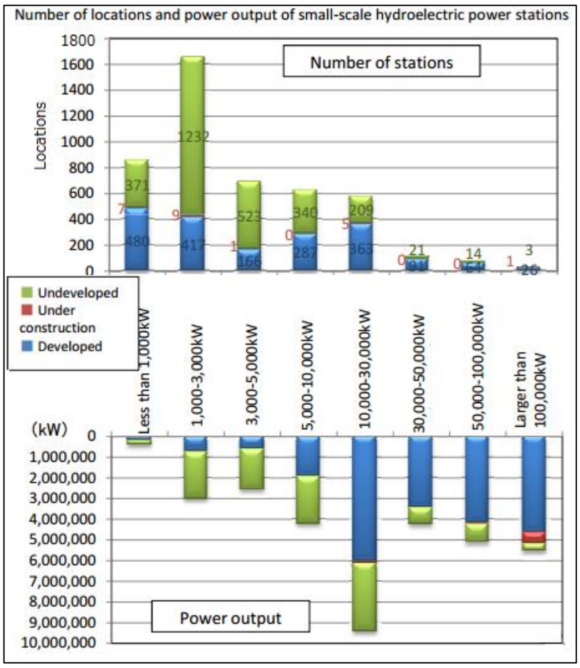

Fig 3. Locations and Power-Output of Hydropower in Japan(Source: METI (2012) Japan Renewable Energy)

4.4 Solar energy

Solar energy is radiant light and heat from the sun which are utilized by various technologies [24]. Solar heating, photovoltaic and solar thermal panels are used to generate electricity or heat, either in large-scale complexes or on the rooftop of private houses. The range of applicable solutions for solar technology is large.

Crucial for energy production, however, are optimal weather conditions and the intensity of the solar irradiation in the area. That means without sunlight, photovoltaic panels cannot generate electricity and solar thermal panels cannot heat up water. On the other hand, with provided sunlight, the panels can generate electricity and heat up water. Solar panels' performance, however, varies with changing weather conditions. Countries with a fairly large share of PV technology in their energy mix are highly vulnerable to fluctuations in their national electricity grid. Other power plant types are also needed so as to cushion sudden changes, keep the grid stable and ensure supply security. In general, weather-dependent renewable energy sources require other power plant types or energy storage systems since even their sudden surpluses of electricity may not necessarily be used at the time they are generated.

According to the IEA, Japan was the second largest market for solar growth in 2013 and 2014. During that time, 6.9 GW and 9.2 GW of nominal capacity were added to the already existing capacities, cumulating up to a total of 23.3 GW. With that notable amount of installed capacities, the country became the number three in terms of solar electricity generation in the world, behind China (28.2 GW) and Germany (38.2 GW). The currently installed capacity is estimated to be sufficient to supply up to 2.5% of the country's annual electricity demand [25].

The global horizontal irradiation map of Japan in Fig 4 shows the sun's average annual sum of irradiation between the years 2007 to 2012. As can be observed, the potential is high especially in its southern parts. The Ryukyu Islands (琉球諸島), Kyushu(九州), Shikoku (四国) and southern parts of the Japan's main island Honshu (本州) have high sun irradiation, between 1450 kWh/m^{2}and 1600 kWh/m annually (by comparison, Germany's average annual sun irradiation is around 1000 kWh/m). While Honshu's (本州) southern coast line is densely populated, other areas have vast unpopulated areas.

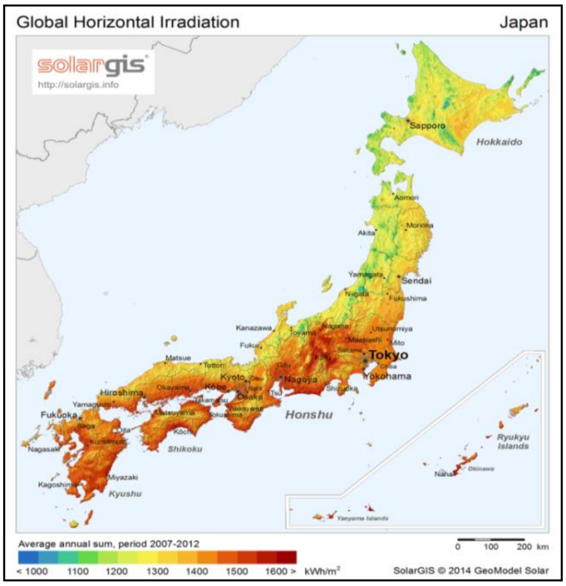

Fig 4. Horizontal Radiation of Japan(Source: Solar GIS Global Horizontal Irradiation Map: Japan)

Decline in production price (from over 980 Yen/Wp in 1993 to 380 Yen/Wp in 2011) and financial incentives offered the Japanese government made photovoltaic systems attractive for households [24]. Energy balance can be improved by placing solar panels on the currently unutilized rooftops, especially in urban areas.

4.5 Biomass

Biomass can be defined as any organic matter that can be renewed over time. In other words, biomass is stored energy. Through photosynthesis, sunlight, carbon dioxide and water, it can be turned into oxygen and simple sugars which are stored. Even though they emit carbon dioxide when burned they are considered to be carbon neutral. The main reason for biomass to be considered as carbon neutral is that fossil fuels are hydrocarbon deposits derived from organic materials of a previous geological time. They are fossilized biomass, and the containing carbon was removed from the atmosphere long time ago [26]. In other words, when burning new biomass it only emits the CO2 that it has recently absorbed from the atmosphere while fossil fuels release the stored carbon dioxide of previous geological time, implying a surplus to greenhouse gas particles of the atmosphere.

Biomass plants are versatile and almost anything can be used. Energy crops, food waste or human/animal residues contain a higher energy density and have been proved to be more efficient than simple greenery. Biomass can be utilized in form of gas (biogas plant) for heating, generating electricity or cooking, biofuel for transportation, chemical substitutes for fossil fuel based chemicals or in form of wood for heating. Its generation can be decentralized and operate completely independent from the electric grid. Its gas form can be used for either generating electricity or stored in the national gas grid or special containers and utilized when needed. The transportability and decentralized functionality makes it possible for biomass to be utilized almost anywhere in the world.

As shown in Fig 5, the potential for biomass utilization in Japan is enormous. In some areas, biomass is being utilized already while others require infrastructure before they can be utilized. According to the MAFF (Ministry of Agriculture, Forestry and Fisheries), forestry residue and agricultural residue are unused at the moment.

Possessing high potential for different renewable energy sources is a good opportunity for Japan to diversify its electricity generation sector and increase its independence from energy carrier imports. Wind and solar are fluctuating energy sources, dependent on the right weather conditions, they cannot be used for base load purposes. Geothermal power and hydro power are subject to seasonal change as well, but they can generate electricity day and night and therefore can be utilized for base load purposes. Agricultural residue and other biomass could be used for electricity generation, heat or gas production which can then be used for electricity generation or other purposes.

5. ENERGY POLICIES

Underlying renewable energy policies, their necessary fine tuning in response to the needs of the time and governmental commitments are extremely important for a successful renewable energy generation strategy. This section briefly examines German and Japanese energy policies.

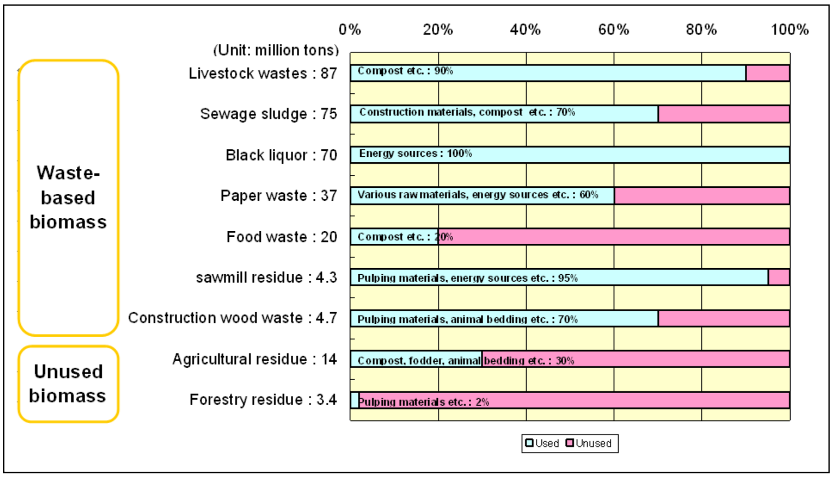

Fig 5. Japan's Biomass Usage and Potentials (Source: MAFF, basic plan for the promotion of biomass utilisation (2009))

5.1 German policies

The first pertinent German law which regulates the utilization of renewable energy in the German grid and adopted in 1990, is known as Electricity Feed-in Act and locally called the Stromeinspeisungsgesetz (StromEinspG). This law demands power utilities to connect renewable energy plants to the power grid and reimburse their owners for the generated electricity fed into the national power grid [27]. This regulation is still in place. With the liberalization of the electricity market, power utilities are no longer in control of the national power grid. Grid operators and power generators have to work together instead so as to guarantee grid connection and preferred feed-in for renewable energies.

German Renewable-Energy-Sources Act, locally called Erneuerbare-Energien-Gesetz (EEG), is the follow up of the StromEinspG and came into effect in early 2000. With the EEG, the grid connection was once more guaranteed to renewable energy plant operators together with a fixed purchase price for all generated electricity during the next 20 years. This feed-in tariff scheme promoted the development for all major renewable energy sources, and led to a fast development of wind and solar power in the first years. After its initial successes, the EEG has been revised regularly (in 2004, 2009, 2012, 2014 and 2017) and undergone major changes.

While the EEG successfully promoted the growth of renewable energies, the German (or European) power grid was not capable of keeping up with the constant expansion. Additional electricity being generated in the northern parts and demand for extra electricity in the southern parts, required increase in power transmission capacity of the grid for a successful transmission of the generated electricity to the consumers. Hence, an auction system was introduced for the first time in the EEG 2014 [28]. This auction system was even further enhanced in the EEG 2017 which nominates the lowest bidder to build the advertised capacity. First offshore wind park projects were already auctioned with zero subsidies [29].

The next pertinent German law after the EEG is its Energy-Saving-Regulation, locally called Energiesparverordnung (EnEV) and adopted in 2002. The aim of this regulation is to enhance energy efficiency of buildings. The idea is to increase energy savings through insulation and efficiency measures. According to Chiarello, most of the energy consumed in households is for heating (75%) and warm water (12%) - share of electricity utilization for other purposes is only 13% [30]. The EnEv is therefore enforced to reduce energy consumption for heating. Steady increase in energy efficiency of newly built houses and renovated buildings are planned to ensure a consumption reduction.

5.2 Japanese policies

The first subsidy system for residential photovoltaic (PV) electricity generation in Japan started as early as 1992 [31]. The PV promotion program continued until 2007 but ended thereafter presumably due to the price drop of fossil fuel in the world market. In 2012, however, a feed-in tariff system based on the German system was created in order to promote the development of renewable energies in Japan. It is important to mention that Japan's style of annually revising tariffs for each type of subsidized technology, has generated even faster changes in its electricity generation sector than Germany.

Another policy of Japanese government is to improve energy efficiency of household appliances. The Top-Runners program is used to promote the development of more efficient machinery like air conditioners, freezers, etc. Japanese government is strongly promoting IoT (Internet of Thing) technology for both automation as well as energy efficiency purposes.

6. SUMMARY AND CONCLUSION

Several renewable energy sources are available in Japan, allowing the country to implement an energy mix that can help power utilities and the Japanese government to commit to their 3E+S (Energy Security, Economic Efficiency, Environment + Safety) policy. Renewable energy sources could fill the energy gap created by shut down of its nuclear power stations. Although energy saving policies and fossil fuel driven power plants have filled such gaps for now, the additional money spent on fossil fuel imports has in return led to a negative trade balance and an increase in GHG (Greenhouse gases) emissions [32]. Instead of continuing this vicious circle of import dependency, out flowing funds and growing GHG emissions, some of the money spent on fossil fuels could get invested in the development of renewable energies. This can subsequently lead to the self-sufficiency of Japan's electricity generation sector, reduce the outflow of money outside the country and cut GHG emissions. The diminishing nature of fossil fuel, its crucial role for the Industrial Revolution, and the panic that it generated in the 1970's oil crises should not be forgotten. The proposed approach can eventually enable Japan to control and manage its lifeline independently and without forced submission to international political games.

6.1 Summary analysis

On one side, there are small hydro power plants and geothermal power plants which can be used in large quantities regardless of weather conditions, but have limited available construction sites. On the other side, there are solar and wind power which can be installed more flexibly in terms of location, but are dependent on weather conditions. Biomass – when utilized for gas generation – can serve as a buffer technology, because gas is storable and transportable. Its decentralized and transportable nature makes biomass utilization possible at any time and in part of the country. In terms of regions, the northern parts offer better conditions for wind energy, while the southern areas are more attractive for solar panels due to the higher radiation of the region. Geothermal and hydro energy are spread across the country as well as biomass which can be collected / produced in both urban and rural areas.

A FIT scheme has been proved to be a good approach to promote renewable energies. It has worked well in Germany, leading to a steep increase in renewable energies. The FIT approach in Japan which started around 5 years ago, has incentivized investments into renewable energies. The approach has enabled to increase its installed renewable energy capacity from 25 GW in 2012 to more than 50 GW in 2016 [31]. In fact, Japan's style of annually revising tariffs for each type of subsidized technology, has generated even faster changes in its electricity generation sector than Germany.

However, one of the major short comings in Japanese energy policy is its unresolved grid connection and feed in problem. While in Germany renewable power plants have to be connected to the grid and can feed in their generated electricity by law (or get compensated otherwise), there is no such law in Japan. The local power utilities decide whether to allow the connection of power plants to the grid or not and as well dictate the necessary requirements that have to be fulfilled. While German approach enable investors to rely on prior estimations and subsequently create higher investment reliability, the Japanese approach does not and may even discourage / prevent constant feed in approach.

Moreover, its current mid-term strategy favors a return to nuclear energy rather than a move towards renewable energies in order to increase the self-sufficiency. The latest Japanese energy plan of 2015 consists of two main pillars: Energy Conservation Promotion and Balanced Energy Supply. The energy conservation policies aim to reduce the volume of total electricity generation demand. The planned strategy for the energy mix of its electricity generation sector by 2030 consists of 27% LNG, 26% coal, 22-24% renewable energy, 20-22% nuclear, and 3% oil. The 22-24% share of renewable energies is split into 7.0% solar, 1.7% wind, 3.7-4.6% biomass, 1.0-1.1% geothermal and 8.8-9.2% hydro [33]. This implies that the share of its renewable energies is envisioned to grow from 15% in 2016 [31] to 20-22% in 2030 [33]. Even if we set aside the role of energy efficiency measures, this is still a conservative approach considering Japan's potential for renewable energies. Currently hydropower already generates 9% of the total electricity supplied to the grid [3]. Wind power, despite its large on-and offshore potential, planned to constitute only 1.7% to the energy mix. Although solar power, biomass and geothermal energy are going to increase, the planned levels are far below their extractable potentials in Japan.

Supply security and technical concerns, like increased control dynamics through the utilization of weather dependent renewable energies might have led to this decision. Because the German power grid is part of the synchronous grid of Continental Europe, the control and dynamics in Germany have increased with the continuous growth of volatile energy sources like wind and solar thus requiring power utilities to keep conventional power plants as reserves. Since Japan is not connected to an intercontinental power grid, the projected share of renewable energies will keep the control dynamics low, especially because large hydro power stations are already being used for base load purposes. Therefore, it seems that the latest energy plan favors a return back to the status of prior to 2011 in combination with a moderate share of renewable energies. Activation of overhauled nuclear reactors will reduce the amount of fossil fuels which otherwise have to be imported. Thus with only minor changes, the self-sufficiency rate would increase. Nonetheless, a more ambitious strategy could increase Japan's self-sufficiency rate further than what the current plan aims for and the potentials are there. Aside from its widely available renewable energy sources, Japan can also utilize its technological capabilities and numerous patents in order to boost up its national renewable energy usage [21].

6.2 Conclusion and future research

Considering Japan's both technological know-how in the field and the vast accessible energy potentials, a more ambitious energy strategy could work significantly better. Its advantages of possessing temperate climate in the north with strong wind power, tropical climate in the south with high radiation, the world third largest geothermal energy, and blessed with huge amount of offshore energy potential for being an island country, could be better utilized. The fact that biomass energy is referred to as sleeping giant among renewable energy sources, Japan has large population and blessed with greenery, rain and tropical climate, should not also be ignored. Policies that regulate grid connection and feed in sequences are critical for a controlled development. A nationwide uniform approach can lead to successful changes, without necessarily abandoning nuclear energy, but increasing its independence from fossil fuel and eventually achieving energy self-sufficiency. Some take-away lessons from Germany to Japan could be more innovative policies along with their constant enhancements and upgrades, and patience with the higher price of renewable energy sources during the times that world oil prices significantly drops through political manipulation. Fossil fuel is going to diminish and the independent control and management of lifeline is much more important.

Future work along this research can investigate Japan's potential for tidal energy as Japan has also huge potential for tidal energy because of its geographical location and being an island country. Although tidal energy technology is not yet fully developed and still expensive, with vanishing nature of fossil fuel, having access to enough energy, and being energy self-sufficient is going to be far more important.

REFERENCES

[1]. Huehn, P. Konstantin, "Japan's Renewable Energy Potential: Possible Ways to Reduce the Dependency on Fossil Fuels", MS thesis, Ritsumeikan Asia Pacific University, Beppu, Japan, August 2017.

[2]. German Federal Government, Der Weg zur Energie der Zukunft - sicher, bezahlbar und umweltfreundlich - https://web.archive.org/web/20111116042621/http://www.bundesregierung.de/Content/DE/__Anlagen/2011/06/2011-06-06-energiekonzept-eckpunkte,property=publicationFile.pdf (Last access: 2018.1.9).

[3]. METI (2016 a), Japan's Energy 20 Questions to understand the current situation, METI, Tokyo http://www.enecho.meti.go.jp/en/category/brochures/pdf/japanenergy_2016.pdf (Last access: 2017.11.20) 2016.

[4]. Papandreou, A., Ruzzenenti, F., "On the effects of fossil fuel prices on the transition towards a low carbon energy system" Part A, FESSUD FINANCIALISATION, ECONOMY, SOCIETY AND SUSTAINABLE DEVELOPMENT Working Paper Series No 89, http://fessud.eu/wp-content/uploads/2015/03/ Papandreou_Ruzzeneti_Effects-of-fossil-fuel-prices-on-transition-to-low-carbon-energy-part-A-working-paper-89.v2.pdf (Last access: 2018.1.9). 2015.

[5]. Honda, G., "Differential Structure, Differential Health: Industrialization in Japan", 1868-1 940, pp. 251 - 284 Health and Welfare during Industrialization, University of Chicago Press ISBN: 0-226-77156-3, 1997

[6]. Scriba, A., Kaiserreich "Industrie und Wirtschaft, LeMo Lebendiges Museum Online", Deutsches Historisches Museum, Berlin, https://www.dhm.de/lemo/kapitel/kaiserreich/industrie-und-wirtschaft.html (Last access: 2017.1.9), 2014.

[7]. Danilevich, Y.B.; Kirichenko, B.E.; Tikhodeev, N.N.,"History of Electric Energy Systems and New Evolution, UNESCOEOLSS", ELECTRICAL ENERGY SYSTEMS, http://www.eolss.net/outlinecomponents/Electrical-Energy-Systems.aspx (Last access: 2018.1.9), 2016.

[8]. Auer, J., "Energiemix in Deutschland im Wandel Treiber sind Energiewende und internationale Trends", Deutsche Bank Research, Aktuelle Themen Natürliche Ressourcen, ISSN 1435-0734, https://www.dbresearch.de/PROD/RPS_DE-PROD/PROD0000000000444456/Energiemix_in_Deutschland_im_Wandel%3A_Treiber_sind_.PDF (Last access: 2018.1.9), 2014.

[9]. Painter, D.S., "Oil and Geopolitics: The Oil Crises of the 1970s and the Cold War", Historical Social Research. Band Vol. 39, Nr. 4. GESIS – Leibniz Institute for the SocialSciences, Köln, pp. 190, 2014

[10]. Corbett, M., "Oil Shock of 1973–74", Federal Reserve History, https://www.federalreservehistory.org/essays/oil_shock_of_1973_74 (Last access: 2018.1.9), 2013.

[11]. Schiffer, H.-W., "Energiepolitische Programme der Bundesregierung 1973 bis 2017; Energiewirtschaftliche Tagesfragen Year 67", Issue 11 http://www.et-energie-online.de/Portals/0/PDF/zukunftsfragen_2017_11_schiffer.pdf (Last access: 2017.11.20) 2017.

[12]. BMU, "The Federal Government's energy concept of 2010 and the transformation of the energy system of 2011". Bonn, Germany: Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU), October 2011.

[13]. FECP, "Results and Prospects of Power Generation Volume by Source", Historical Trend of Power Generation Volume by Source in Japan, https://www.fepc.or.jp/english/nuclear/necessary/sw_necessary_02/index.html (Last access: 2017.11.20), 2014

[14]. World Nuclear Association, "Nuclear Power in Japan", http://www.world-nucle"ar.org/information-library/country-profiles/countries-g-/japan-nuclear-power.aspx (Last access: 2017.11.20), 2017.

[15]. METI (2016 b), "What does the liberalization of the electricity market mean? METI; Tokyo" http://www.enecho.meti.go.jp/en/category/electricity_and_gas/electric/electricity_liberalization/what/ (Last access: 20181.10), 2016.

[16]. EIA, "Country Analysis Brief: Japan; U.S. Energy Information Administration", https://www.eia.gov/beta/international/analysis_includes/countries_long/Japan/japan.pdf (Last access: 2017.11.20), 2015.

[17]. Kingdom of Netherlands, "Wind Energy Japan, Embassy of the Netherlands, Japan", https://www.rvo.nl/sites/default/files/Wind%20Energy%20Japan.pdf (Last Access: 2018.1.10), 2012.

[18]. Sovacool, B. K.. "Contesting the Future of Nuclear Power: A Critical Global Assessment of Atomic Energy", World Scientific, pp. 287, 2011.

[19]. Wakeyama, T., Ehara, S.. "Estimation of Renewable Energy Potential and Use-A Case Study of Hokkaido, Northern-Tohoku Area and Tokyo Metropolitan, Japan Sustainable Cities and Regions (SRC)", World Renewable Energy Congress 8-13 May 2011, Linköpping, Sweden http://www.ep.liu.se/ecp/057/vol12/012/ecp57vol12_012.pdf (Last access: 2017.11.20), 2011.

[20]. Price, T. J.. "James Blyth — Britain's First Modern Wind Power Pioneer, Wind Engineering" Volume: 29 issue: 3, pp. 191-200 Issue published: May 1, https://doi.org/10.1260/030952405774354921 (Last access: 2018.1.10), 2005.

[21]. Kojima, T., "How is 100% Renewable Energy Possible in Japan by 2020?" Global Energy Network Institute, https://www.geni.org/globalenergy/research/renewable-energy-potential-of japan/renewable_energy_potential_of_Japan_by_2020.pdf (Last access: 2017.11.20), 2012.

[22]. Kagel, A; Bates, D; Gawell, K, "A Guide to Geothermal Energy and the Environment, Geothermal Energy Association Washington D.C.", http://www.geo-energy.org/reports/Environmental%20Guide.pdf (Last access: 2018.1.9), 2007.

[23]. Oishi Takayuki, Kado Yasuyuki. "IEA Geothermal Implementing Agreement Japan Country Report"http://ieagia.org/wpcontent/uploads/2015/11/ IEAGIA-2014-Japan-Country- (Last access: 2018.1.9), 2014.

[24]. IEA, "Solar Energy Perspectives: Executive Summary"https://www.iea.org/publications/freepublications/publication/Solar_Energy_Perspectives2011.pdf (Last access: 2018.1.11), 2011.

[25]. IEA, "Photovoltaic Power Systems Programme Snapshot of Global PV 1992-2014", 2015.

[26]. Ashton, Sarah; McDonell, Lauren; Barnes Kiley; Longholtz Mattew, "Woody Biomass Desk Guide & Toolkit", National Association of Conservation Districts, http://www.nacdnet.org/policy/woody-biomass-desk-guide-and-toolkit?highlight=WyJiaW9tYXNzIl0= (Last access: 2017.1.9), 2015.

[27]. Salje, P.. Stromeinspeisungsgesetz. "Gesetz über die Einspeisung von Strom aus erneuerbaren Energien in das öffentliche Netz. Kommentar", Carl Heymanns, Köln, Berlin, Bonn, München, ISBN 3-452-24158-0, 1999.

[28]. Bartholl, C., "Auktionsverfahren im EEG – Was kommt Neues nach dem neuen EEG? Newsletter 1/2014" | Erneuerbare Energien, pp.10-11, https://unitedkingdom.taylorwessing.com/fileadmin/files/docs/pdf-german/Beitrag_Bartholl.pdf (Last access: 2018.1.9), 2014.

[29]. Wetzel, Stefan, "WELT Die brutale Kostenwahrheit über die Windkraft Branche", https://www.welt.de/wirtschaft/article163681001/Die-brutale-Kostenwahrheit-ueber-die-Windkraft-Branche.html (Last access: 2018.1.9), 2017.

[30]. Chiarello, G., "Energiesparen im Haushalt Energiespar- Tipps, BBZ Biel", https://www.energie-klimawerkstatt.ch/fileadmin/projects_EKW/2016_17/p_2943/ubungs_va_energie_sparen.pdf (Last access: 2018.1.11), 2017.

[31]. ISEP, "Status of Renewable Energies in Japan (August, 2017), Institute for Sustainable Energy Policies", Tokyo, Japan http://www.isep.or.jp/en/wp/wp-content/uploads/2017/08/ISEP20170827JapanStatus-EN.pdf (Last access: 2017.12.30), 2017.

[32]. Nakanishi, H., "Japan's Energy Situation and Policy, Ministry of Economy, Trade and Industry Agency for Natural Resources and Energy", Tokyo, http://www.pl.emb-japan.go.jp/keizai/documents/E0_2%20METI%20Nakanishi.pdf (Last access: 2018.1.11), 2014.

[33]. METI, "Japan's Energy Plan", METI, Tokyo, Japan, http://www.enecho.meti.go.jp/en/category/brochures/pdf/energy_plan_2015.pdf (Last access: 2017.12.30), 2015.