Energy Scenario Proposal for Decarbonizing Japan

Part II: 100% Renewable Energy

Executive Summary

WWF Japan

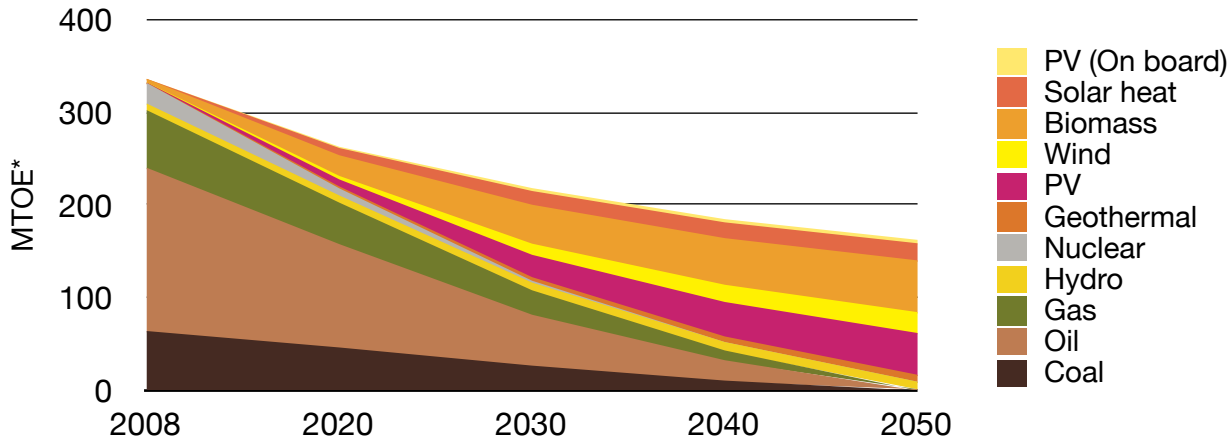
SUMMARY JPN 2011

Introduction

This is an Executive Summary for WWF Japan's *Energy Scenario Proposal for Decarbonizing Japan: Part II 100% Renewable Energy*. The Energy Scenario Proposal has four parts and this is the second part. The purpose of the whole Energy Scenario Proposal is to look at Japan's possibility to achieve 100% renewable future. This Part II examines **the potentials of renewable energies** and assesses whether it is **possible to meet the overall energy demand** presented in *Part I Energy Efficiency*.

WWF Scenario shows it is technically possible to meet the energy demand with renewable energies available in Japan by 2050, if potential of renewable energies are appropriately developed. It would of course require significant efforts and there are some key conditions assumed in the scenario. One of such conditions is that all the electricity grids are interconnected and there is no barrier for transmission of electricity from renewables by 2050. This could be a challenging condition but it is safe to assume it can be done by 2050, if there is a political will to do so. Overall, the WWF Scenario shows 100% renewable future is possible by 2050.

Figure 1. Energy Supply in the WWF Scenario



Source: WWF Japan. *MTOE = million tonnes of oil equivalent

1. Assumption and Methodology

To examine the possibility of achieving 100% renewable future, WWF Scenario takes the following four steps.

1. Estimate the potentials for improvements in energy efficiency and the truly required energy demand in the future (this part has been done in *Part I Energy Efficiency*).
2. Make an assumption of gradual phase-out of nuclear power plants. Among 54 existing nuclear power plants, 29 will be phased out immediately due to safety concerns (e.g. located in highly vulnerable place for earthquakes) and the remaining power plants will be phased out after 30 years from the start of operation.
3. Assess the potential of renewable energies in Japan and examine the possibility of meeting the demand in each sector (i.e. industry, household, commercial and transport sectors).
4. Simulate the electricity supply and demand for the year 2050 throughout 24/7 during the 350 days in the Dynamic Simulation model (see below).

The Japanese Ministry of the Environment has published a comprehensive report on the potentials of renewable energies and the WWF Scenario uses the report to estimate the potential of each renewable energy. Several constrains are assumed from sustainability point of view on the potentials (e.g. no use of geothermal within National Parks, etc.). For some renewable energy sources where there are no data in the MoE report (e.g. biomass and PV for household), the WWF Scenario is making its own estimates drawing information from other official sources.

In this Scenario, "renewables" include wind, solar, biomass, small-/medium-sized hydro, geothermal and solar thermal. Although we do not deny other renewables such as ocean energy, they are not included simply because there is no sufficient, reliable data.

2. Energy Supply from renewables

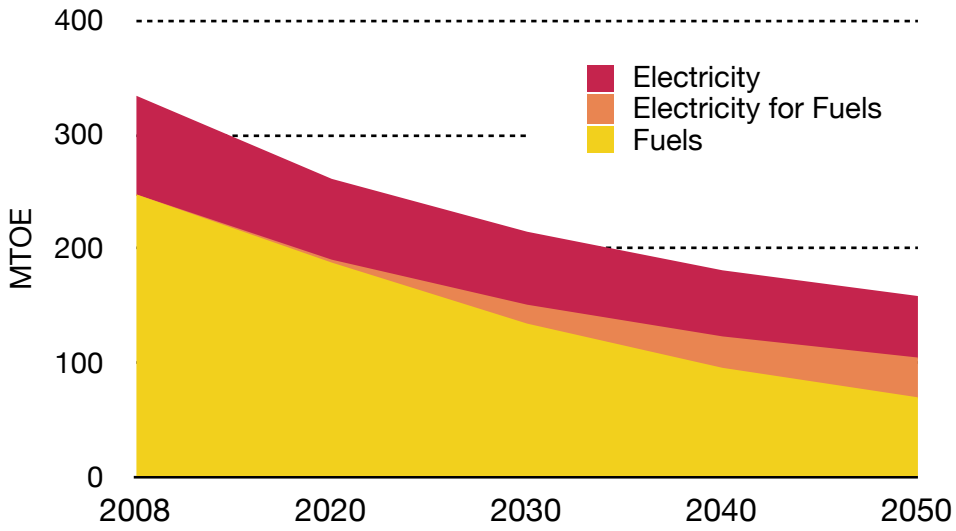
2.1. Electricity and Heat/Fuel

Despite the recent focus on electricity after the Fukushima accident, the share of electricity in final energy consumption is about one forth and the rest is either heat or fuel use. To achieve truly 100% renewable energy system, the WWF Scenario considers *both* electricity and heat/fuel.

As the first step, electricity and heat/fuel demand are divided for each end-use sector (industry, household, commercial and transport). Then, it is examined whether energy demand in each sector can be met with renewable energies available to the sector.

For heat/fuel demand, solar thermal and biomass are used but electrification of some of the demand and use of hydrogen from excessive supply of renewable electricity are assumed. Figure 2 shows the structure of energy supply.

Figure 2. Supply structure of electricity and heat/fuel



Source: WWF Japan.

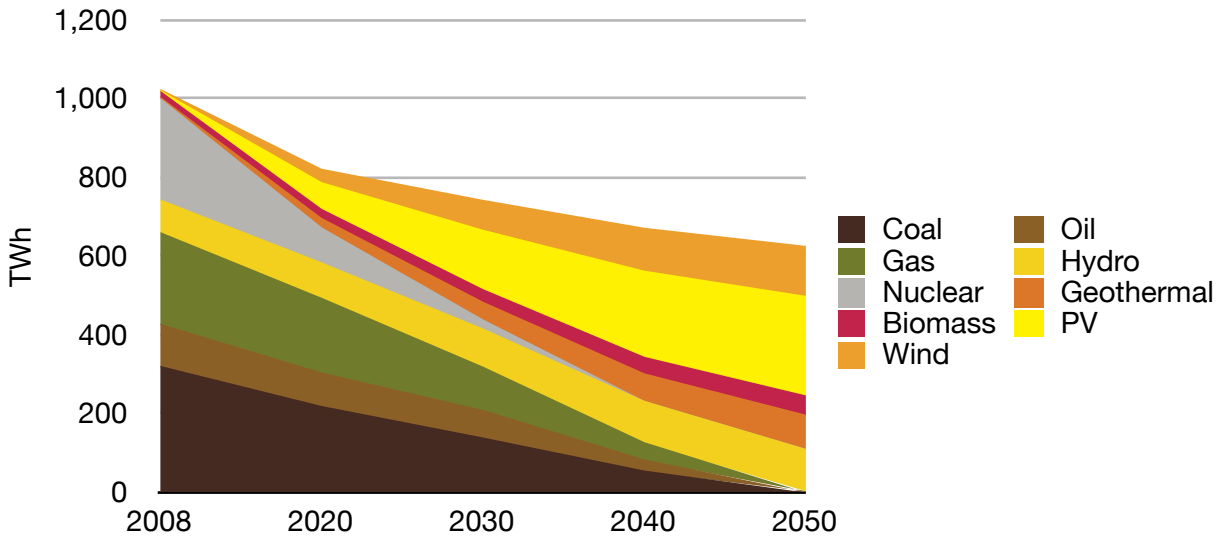
2.2. Renewables to meet electricity demand

Figure 3 shows the supply structure of electricity in the WWF Scenario towards 2050. Fossil fuels and nuclear will be gradually phased out and all the electricity demand will be met by renewable energies by 2050.

As explained above, the WWF Scenario assumes to replace some of heat/fuel demand with electricity and hydrogen produced with electricity. Figure 3 does not include such electricity for fuel use but only include electricity for genuine electricity demand.

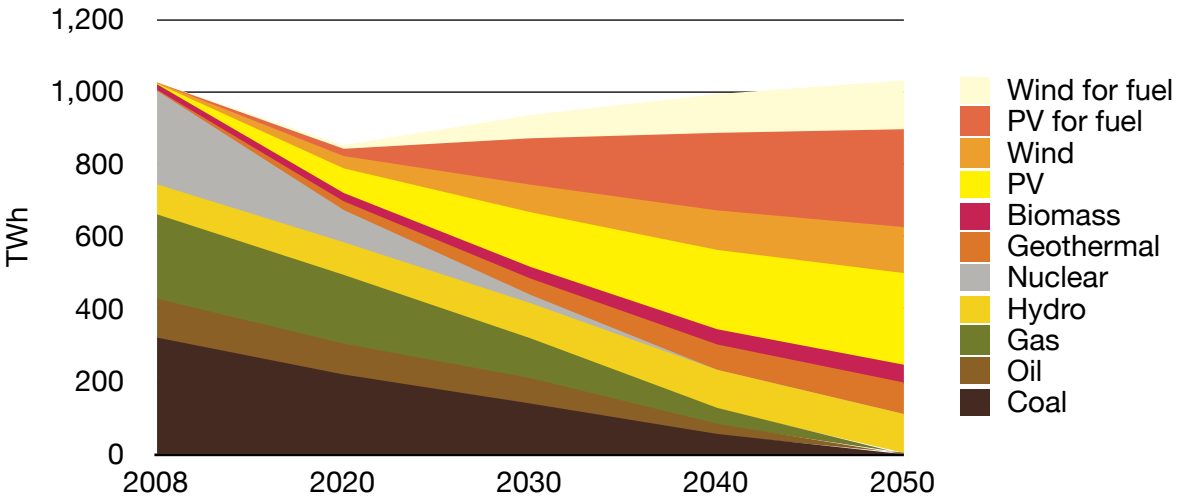
Figure 4 includes the electricity demand for heat/fuel. The additional demand is basically assumed to be met with excessive supply of electricity from solar and wind during the time when the demand is low.

Figure 3. Electricity supply structure for genuine electricity



Source: WWF Japan.

Figure 4. Electricity supply structure (including electricity for fuel use)



Source: WWF Japan.

Because of this conversion from heat/fuel to electricity, the supply level of electricity will rise up to he same level as today despite the fact that massive energy savings are assumed in the scenario.

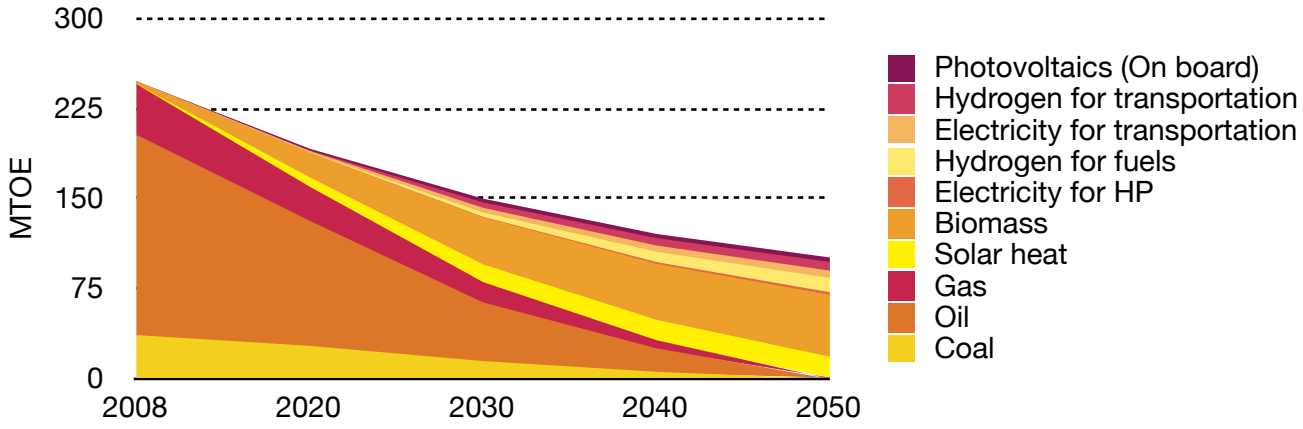
2.3. Renewables to meet heat/fuel demand

In the WWF Scenario, three sources of heat/fuel are considered. First is renewable heat such as solar thermal and biomass. Second is electrification of heat and fuel. Third is hydrogen produced from renewable electricity.

Most of the heat and fuel demand will be met with solar thermal, biomass and electrification but will be supplemented with hydrogen. For example, high temperature heat demand in industry needs to be met either biomass or hydrogen.

For transport sector, all the passenger vehicles will become either electric vehicles (EV) or fuel-cell vehicles (FCV). Although the WWF Scenario does not assume much use of biofuels for passenger vehicles, for those fuel demands which inevitably require liquid fuel such as aviation and shipping, biofuels will be used. In addition, rooftop solar for vehicles are assumed to be used.

Figure 5. Supply structure of heat and fuels in the WWF Scenario



Source: WWF Japan.

2.4. Hour-to-hour supply-demand simulation of electricity in 2050

One of the typical criticisms against renewable-based electricity system is that wind and solar are unreliable because electricity generation from those sources fluctuate and harms the stability of electricity grid.

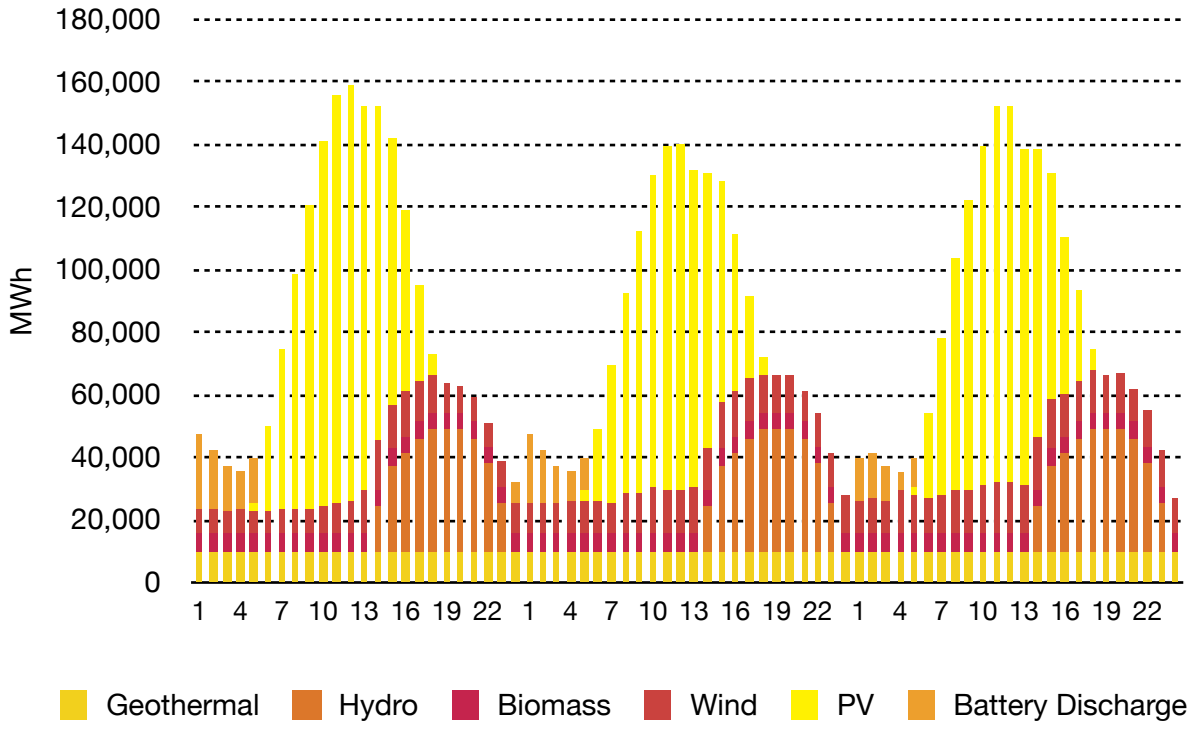
To respond to this, simulation was run to examine whether supply from 100% renewable electricity system can match the demand on a hourly basis, 365 days during the year of 2050. It is assumed that electricity grids in Japan are all interconnected and there is no barrier for transmission by 2050.

On the supply side, the simulation uses weather data from AMEDAS, which provides solar and wind data fro 842 locations in Japan, and calculated hourly electricity generation from solar and wind. On the demand side, monthly data of the 10 power companies' generation in 2008 and a typical demand curve for one day are used to produce demand curve for 365 days.

The simulation shows that it is possible to match the supply and demand of electricity in the renewable-based electricity. In addition to the key assumption above on the grid interconnectedness, the simulation also shows that 300 GWh-equivalent batteries, together with the use of pumped hydro (originally used for nuclear), would eliminates the necessity of thermal capacity for back-up and that the best ratio of solar and wind to supplement each other would be 2:1.

Figure 6 shows an example of three day demand-supply curve of the 365 days.

Figure 6. Electricity demand-supply (example of May 23-25)



Source: WWF Japan.

2.5. Overall supply (electricity and heat/fuel combined)

Overall supply structure is shown in Figure 1 (p.1) and Table 1 below.

Table 1. Overall supply structure

MTOE	2008		2020		2030		2040		2050	
	MTOE	%	MTOE	%	MTOE	%	MTOE	%	MTOE	%
Coal	64	19%	46	18%	27	12%	11	6%	0	0%
Oil	176	52%	111	42%	55	25%	22	12%	0	0%
Gas	62	18%	45	17%	26	12%	11	6%	0	0%
Hydro	7	2%	8	3%	8	4%	9	5%	10	6%
Nuclear	22	7%	8	3%	2	1%	0	0%	0	0%
Geothermal	0	0%	2	1%	4	2%	6	3%	7	5%
PV	0	0%	8	3%	24	11%	37	20%	45	28%
Wind	0	0%	4	1%	12	6%	19	10%	23	14%
Biomass	4	1%	22	8%	42	19%	50	27%	56	34%
Solar heat	0	0%	8	3%	15	7%	17	9%	18	11%
PV (On board)	0	0%	1	1%	3	1%	3	2%	4	2%
Total	336	100%	263	100%	218	100%	185	100%	163	100%

Source: WWF Japan.

4. CO_2 Emission

CO2 emissions in the WWF Scenario reaches zero in 2050 as all the energy sources become renewables. Table 2 shows the CO2 emissions and the rate against the 1990 levels.

It should be noted that this only represents CO2 emissions from energy use. Non-energy CO2 and other greenhouse gases are not included in this scenario. Nonetheless, the fact that this scenario achieves 25% reduction by 2020 means ambitious emission reduction in Japan is still possible.

Table 2. CO2 emissions in the WWF Scenario

	1990	2008	2020	2030	2040	2050
CO2 Emissions	1,059	1,168	797	447	179	0
% to 1990 levels	0%	10%	-25%	-58%	-83%	-100%

Source: WWF Japan.

5. Policy Recommendations

5.1. Clear and ambitious renewable targets

To give policy directions, it is crucial to have clear and ambitious renewable targets for both electricity and heat/fuel. Based on the WWF Scenario, targets in Table 3 can be suggested for electricity and heat/fuel.

Table 3. Renewable targets based on the WWF Scenario

		2008	2020	2030	2040	2050
Renewable Target	Electricity	11%	30%	50%	80%	100%
	Heat and Fuel	1%	15%	40%	55%	100%

Source: WWF Japan.

5.2. FIT and other policies to support

To support speedy and steady growth of renewables, Feed-in-tariff (FIT) introduced in August 2011 will be a key instrument. There will be regular reviews of the tariff levels every year and a comprehensive review after three years since its inception. It is vitally important to have appropriate levels of tariffs so that various renewables can achieve sustainable growth, drawing lessons from proceeding examples in other countries.

In addition to FIT, issues around priority access and priority dispatch as well as conflicts with existing regulations (e.g. restriction of usage of agricultural land for different purposes) have to be resolved in a timely manner.

5.3. Electricity system reform

One of the key assumptions in the WWF Scenario was interconnectedness of the electricity grid in 2050. To achieve this condition, the current electricity system has to be fundamentally reformed. Such reform should include debundling of electricity generation, transmission and distribution, establishing a central control center for renewables, setting up a demand-supply forecast system.

5.4. Policies to enhance renewable heat use

While policies and measures to promote renewable electricity have been gradually arranged, renewable “heat” remains largely neglected. Given the fact that the heat sector will keep being considerably large in the energy demand, policies have to be prepared in the sector too, including ones for utilization of hydrogen.

5.5. Explicit decision to phase out nuclear

The Fukushima accident unequivocally showed nuclear power is not sustainable. It is not just that nuclear power plants are vulnerable to earthquakes and tsunamis but also the poorness of management and responses to the accident was severe. The unsolved issue of nuclear waste further makes it less desirable source. The government has to make an explicit decision to phase out nuclear.