Green Energy: The Megasolar System at NHK's Shobu-Kuki Radio Broadcasting Station

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1. Introduction

In 2007, NHK drew up an environmental action plan and began working on a range of environmental protection measures to reduce its carbon footprint. As a result, we have been actively working on the introduction of energy-saving facilities and solar power generation.

Although solar power can be expected to provide clean renewable energy without using fossil fuels, it requires solar panels to be installed in places where there is plenty of sunshine. Although solar power facilities have been installed at NHK headquarters in Tokyo (240 kW) and at regional broadcasting stations throughout Japan (10 kW), these facilities are relatively small due to lack of space. To accelerate its environmental action plan, NHK decided to set up a "Megasolar" large-scale solar power generating system at the Shobu-Kuki Radio Transmitting Station, which has sufficient space for installing the facilities and also consumes large amount of electricity on-site. After thorough preliminary investigations and preparatory work, full-scale operations were started in August 2012. Table l lists the specifications of this system. (Photo 1)

2. Preliminary study for the installation of Megasolar facilities at a radio transmitting station

The Shobu-Kuki Radio Transmitting Station (Photo 2) is one of the largest medium-wave transmitting stations in Japan, and serves NHK's two radio channels (NHK Radio 1 and NHK Radio 2) to 21 million households mainly in the Kanto and Tokai areas. For the efficient emission of radio waves, grounding wires are buried underground in a pattern that radiates outwards over a large area from the surface of the antenna mast. The empty ground above these grounding wires was used for solar power generation.

Studies of adverse impacts between the transmitting facilities and the Megasolar system were conducted prior to the construction of the Megasolar system. This study included electric field strength

Table 1: Specifications of the Megasolar power plant at Shobu-Kuki Radio Transmitting Station

Site of equipment	Saitama Prefecture
Maximum power generation	2,000 kW (2 megawatts)
Annual power generation capacity (estimated)	2 million kW/h per year (equivalent to about 20% of the power used by the transmitting station, or enough for 500 ordinary households)
Reduction in CO_2 emissions (estimated)	1,100 t/year
Framework	Steel structure, attachment angle 20°
Panels	Monocrystalline silicon, 247 W × 8,120 panels
Inverters*	500 kW × 4

* Devices that convert the DC electricity generated by the panels into AC

Photo 1: NHK Shobu-Kuki Megasolar power plant

Photo 2: NHK Shobu-Kuki Radio Transmitting Station

Figure 1: Schematic view of framework

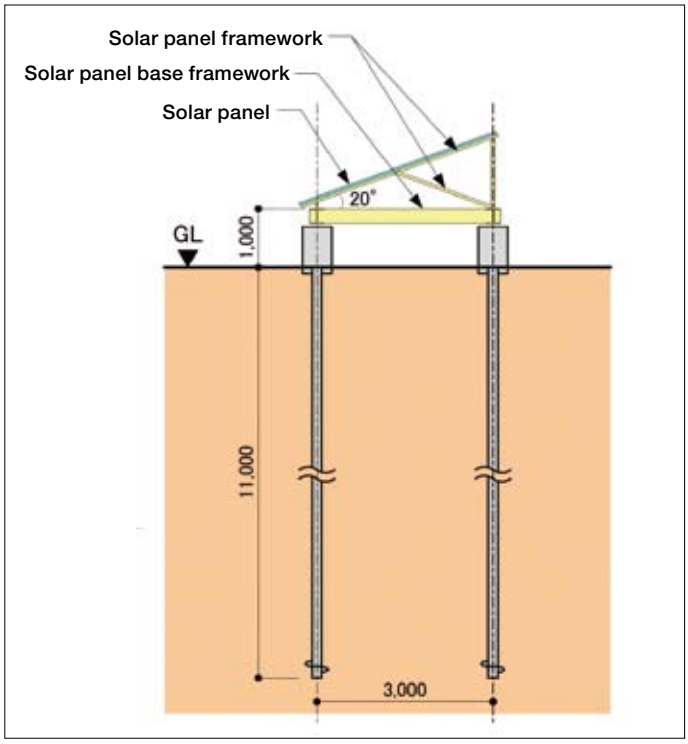


Photo 3: Winged steel pipe piles

Photo 4: Foundations and framework provided with expansion joints

Photo 5: Lightning protection system for solar panels

simulations of the broadcast waves and experimental verifications with a smaller 10 kW solar power system.

3. Megasolar facility

3.1 Equipment layout

The solar panel facilities were built at the south side of the transmitting site to avoid the shadow of the broadcast antenna while mitigating the effects of shadows from tall trees at the south-west boundary of the site and ensuring sufficient space for future renewal of the antenna guy wires. The panel tilt angles and the gaps between panels were designed to suit this site.

3.2 Solar panels and outdoor electrical equipment framework

The site used to be rice paddies, so the ground is very soft and is required to retain rainwater temporarily during heavy rainfall. Therefore, the equipment was installed at a height of 1 m above ground, and was built on piles sunk down to a relatively hard layer at a depth of 11 m below ground level (GL). Steel pipes were used for the pile foundations because they are low-cost, convenient for construction and can be installed without excavation. The ends of the steel pipe piles were wing shaped so as to resist the upward pulling forces to which they would be subjected during strong gales. (Photo 3, Figure 1)

The base framework was designed to deflect no more than 30 mm so as to avoid damage caused by contact between the framework and solar panels when the entire framework flexes under the load (wind loading + weight) from the panel supporting framework. Horizontal braces were also installed to increase the horizontal stiffness so that the framework behaves as an integral structure during strong gusts. Furthermore, since the framework has a maximum length of 117 m, some of the foundations were provided with expansion joints as a mechanism to absorb thermal expansion and contraction caused by changes of temperature. (Photo 4)

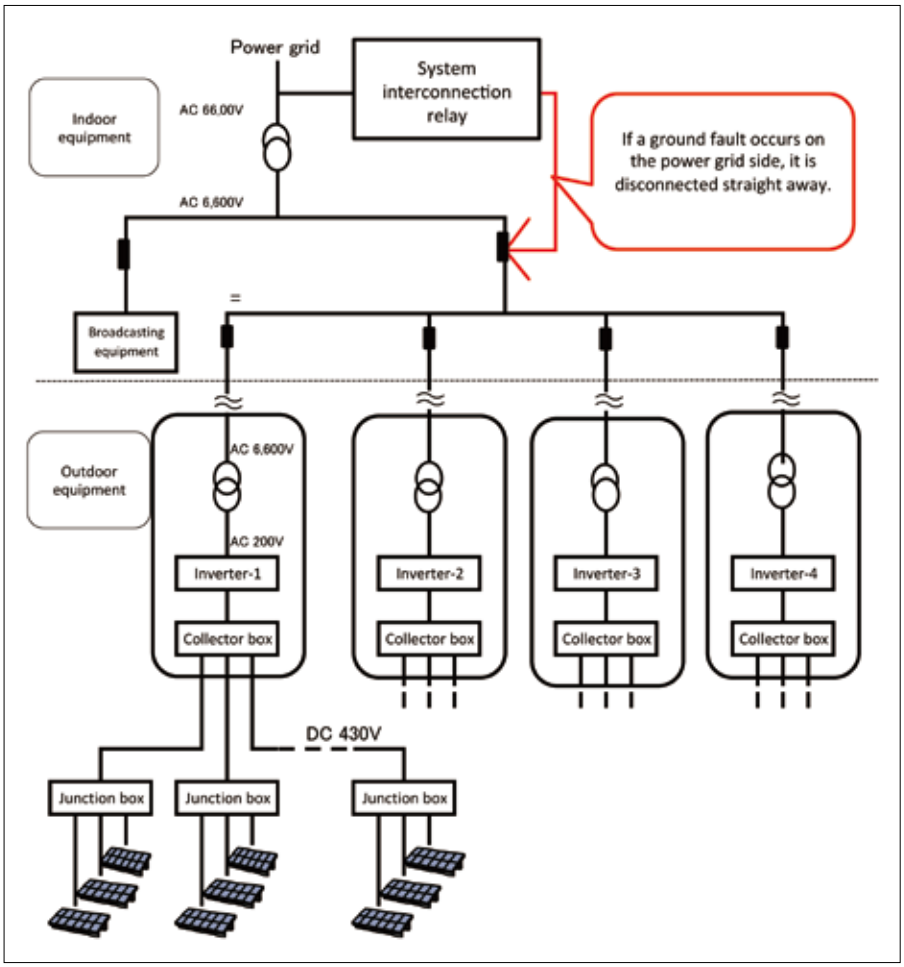
3.3 Lightning protection system for solar panels

To protect the solar panels from lightning strikes, overhead ground wires were provided above them. These wires are connected to the framework, and grounded through all the foundations. (Photo 5)

3.4 Outdoor power supply equipment

Fourteen solar panels (247 W each) are connected in series and input to four inverters as a supply of approximately 430 V DC. The panels are thus grouped into base units of 56 panels (14 across and 4 deep), and the generated electricity is gathered at

Figure 2: Schematic view of the Megasolar power plant at NHK's Shobu-Kuki Radio Broadcasting Station



a junction box attached behind the panels of each base unit.

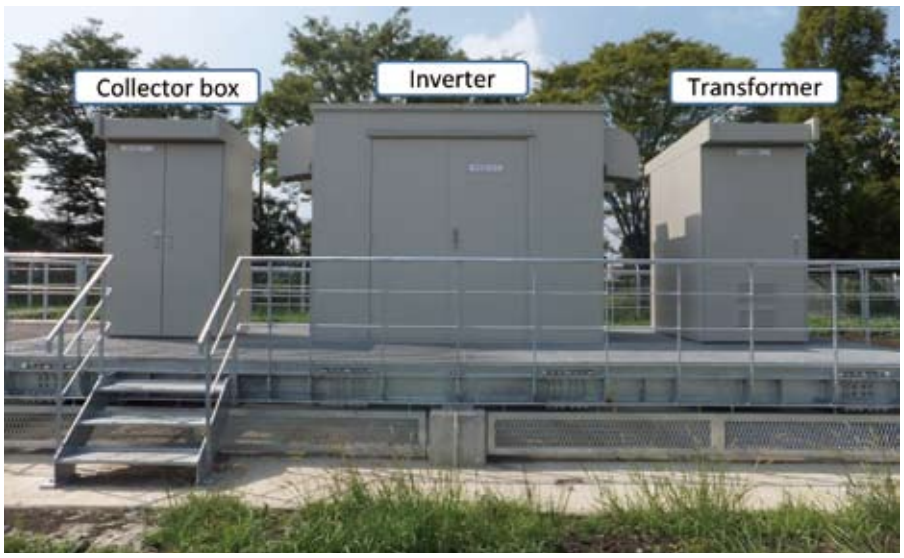
All the electric power is gathered by a junction box in the collector box in the cubicles of the power supply equipment (Photo 6), and is input to the inverters. In the inverters, the power is converted to 200 V AC and then boosted to 6,600 V by a transformer before being sent to the indoor equipment. The voltage is stepped up so as to reduce the cable losses between the outdoor power supply equipment and the building (a distance of more than 200 m). Outdoor 500 kW power supply facilities are installed at four locations.

3.5 System interconnection

Each set of outdoor power supply equipment is joined to the indoor equipment via a separate power supply cable, and is fed to the transmitter as well as to the power grid. Thus, the power generated by the Megasolar system is initially used by the equipment inside the broadcasting facilities (including the transmitters), but when more electricity is being generated than can be used on-site, it will be fed into the public electricity grid. When the solar generated power is insufficient (e.g., at night), the station purchases power from the public electricity grid.

During the construction of the Megasolar system, it was decided that additional relays for interconnection control would be installed in order to avoid unintentional reverse flow from the Megasolar system to the power grid. The reverse flow of power generated by the Megasolar system to the public electricity grid is automatically controlled to be stopped immediately when a fault occurs on the power grid side. This control method ensures that the broadcasting facilities are not disconnected, so that the broadcasting equipment can continue to operate in any case. (Figure 2)

Photo 6: Cubicles for power supply equipment



3.6 Impact after installation

Since the Megasolar system was installed, we have observed no particular changes in the electric field strength of broadcast waves or degradation of broadcast quality. (Figure 3)

Figure 3: Changes in the electric field strength

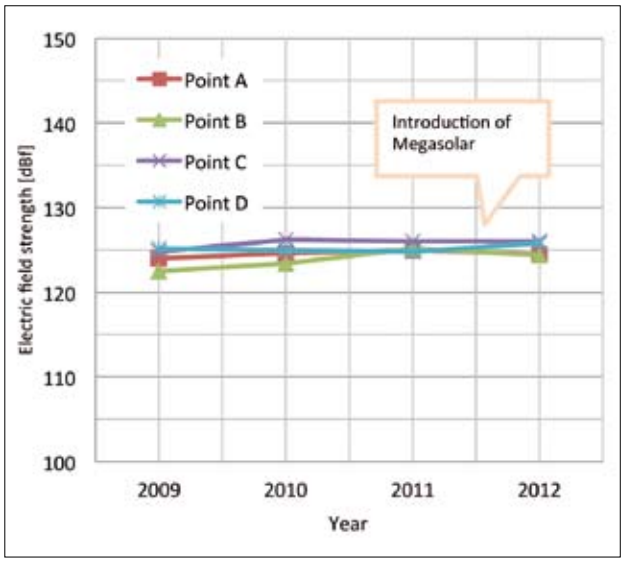


Figure 5: Megasolar power generation performance (September 2012 – March 2014)

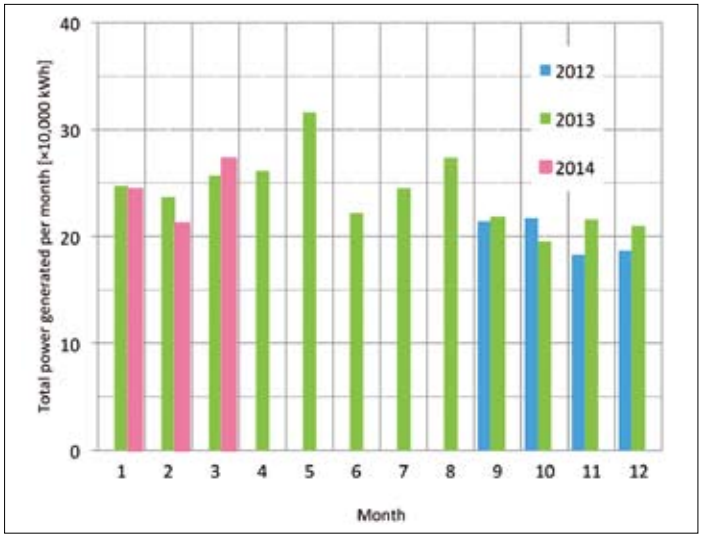
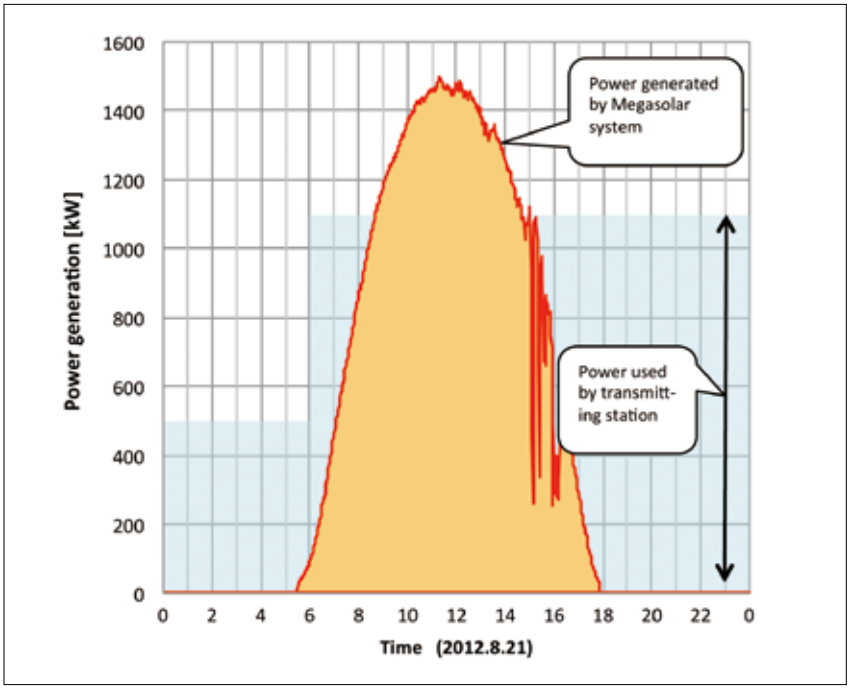


Figure 4: Megasolar power generation performance (August 21, 2012)



Although there is some induction of broadcast signals on the lines between the solar panels and the junction box, the induced voltage is as small as 8 Vp-p in a 430 V DC power supply, and has not caused any problems since the beginning of its operation.

4. Power generation details

4.1 Power generated per day

On a sunny day, the power generated by the Megasolar system starts climbing at sunrise, reaches a peak at about midday, then decreases and finally stops at sunset.

The Shobu-Kuki Radio Transmitting Station consumes 1,100 kW of electricity during the daytime, and about 500 kW at night when NHK Radio 2 goes off-air. When the Megasolar system generates electricity that exceeds the consumption of the station, the excess power is fed into the public electricity grid. At other times, electricity is purchased. The amount of electric power generated by the system may drop suddenly when, for example, the sun goes behind a cloud. In such a case, the electricity from the power company compensates to ensure continuous broadcasting. (Figure 4)

4.2 Operational results

The Megasolar system has been operating continuously without any problems since it was first put into service 20 months ago. The total amount of electricity generated over 19 of these months (from September 2012 to March 2014) was approximately 4,400 MWh. This is equivalent to about 20% of the station's power consumption.

The amount of electricity generated in 2013 was approximately 2,900 MWh, which is 1.4 times the original estimation. The power generation performance is shown in Figure 5.

5. Conclusion

To reduce out CO_2 emissions and suppress the peak daytime electricity demand, a 2 MW Megasolar system was installed at the NHK Shobu-Kuki Radio Transmitting Station, which is the largest radio medium wave transmitting station in Japan. The construction was successfully completed without any disruption to the transmission of broadcast services, and there was also no effect on the broadcast waves after installation. The amount of electricity generated by this system is exceeding expectations.

NHK hopes that the operational data from this Megasolar system will contribute to future natural energy projects.