Field Test of "Green Base Station" Designed for Environmental Friendliness and Reliability during Disasters

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1. Introduction

After the Great East Japan earthquake, NTT DOCOMO announced its intention to create a "Green base station" in May of 2011 - an environmentally friendly mobile telephone base station designed to withstand disasters. In March of 2012, operations such as solar panel power generation were tested using a prototype green base station in NTT DOCOMO's R&D center [1]. To deploy commercial versions of the green base station, solar panel power generation characteristics, and large capacity battery charging characteristics must be evaluated in an actual mobile base station under a range of weather conditions. To those aims, we began field testing green base stations in April of 2013 by installing extra green base station facilities in operational mobile telephone base stations in three locations (Kanagawa prefecture, Tokyo and Yamanashi prefecture), once stability of the operating green base station facilities had been confirmed in the R&D center. In this article, we describe the advantages of the green base station and its structure, provide an overview of the field test sites in which green base stations were installed, and discuss the effects of solar panel power generation characteristics.

2. Green Base Station Structure

Figure 1 shows the green base station structure. In contrast to existing mobile telephone base stations that normally use commercial power, or use battery power during a disaster (during a blackout), green base stations are designed to use an independent and environmentally friendly power source (mainly solar power generation) both under normal conditions and during disasters. As shown in Fig. 1, a green base station can be achieved by adding the facilities shown in the green frame to an existing mobile telephone base station. Structural elements of the green base station facility are shown below.

(1) Solar panels

Solar panels with more generation capacity than the power consumed by the base stations were installed for the green base station field tests. If the solar panels are positioned to collect sufficient sunlight, the mobile telephone base stations can run on solar panels alone.

(2) Large capacity cycle-type*1 batteries

Large capacity cycle-type batteries with more than twice the storage capacity of the float-type^{*2} lead batteries^{*3} used in existing mobile telephone base stations were installed in the green base

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^{*1} Cycle-type: A battery system involving cyclic charging and discharging.

^{*2} Float-type: A type of battery that charges as power is supplied to the load, and discharges during a power outage.

^{*3} Lead battery: A battery that uses lead materials for the positive and negative electrodes. These are inexpensive compared to other types of battery, but are large and heavy.

•Topics•



Figure 1 Green base station structure

stations (nickel hydride batteries^{*4} and lithium ion batteries^{*5}). These batteries provide backup power to the base station for a long time (from14 to 16 hours), and are space-saving.

(3) Green power controller

The green power controller installed in the green base stations can be operated by remote control to combine the three power sources used in the base station (commercial power, solar power and battery power). The controllers also enable visualization of power such as the amount generated by the solar panels and the amount remaining in batteries. Green base station operations differ from existing mobile telephone base stations in that large capacity cycle-type batteries are always actively used. Following are examples of power control.

Peak shift control

During fine weather in the daytime, communications can be ensured with mobile telephone base stations operating on electricity generated by solar panels alone. If more power is generated than required by the base station during the day, the extra power is stored in the batteries for use at night.

Night-time power usage control

Using cheap off-peak power available at nighttime to charge batteries and then using that battery power during the following day can reduce base station power costs.

The green power controller enables direct current power generated by solar panels to be used as it is, which reduces loss - losses that result from converting direct current to alternating current (approximately 10% of all power), thus enabling more efficient power usage.

Increasing the number of green base station facilities has the following advantages.

^{*4} Nickel hydride battery: These batteries use nickel for the positive electrode and solid metal hydride for the negative electrode (a hydrogenstoring metal). These batteries are very safe because both the electrolyte and electrodes are non-flammable.

^{*5} Lithium ion battery: These batteries use metallic lithium oxide for the positive electrode and carbon for the negative electrode, and are characterized by their high energy density and low self discharge.

(a) Environmental friendliness

Because ecologically-friendly power generation can reduce the amount of commercial power used - power that since the Great East Japan Earthquake is increasingly reliant on fossil fuels for generation - these systems can contribute to a reduction in environmental load.

(b) Reliability during disasters

Even if commercial power supplies to mobile telephone base stations stop during a disaster, the mobile telephone base station can operate on power generated by solar panels alone, ensuring mobile telephone communications during the day. Furthermore, this system is designed with large capacity cycle-type batteries to supply backup power for a long time to the mobile telephone base station when solar panels cannot supply power such as night-time.

3. Green Base Station Field Tests

Photographs and facility specifications for the three mobile telephone base stations fitted with the green base station facilities for the field tests (Kanagawa, Tokyo, Yamanashi) are shown in **Photo 1** and **Table 1** respectively. In all three field test sites, the amount of electricity generated by the solar panels installed surpassed the amount of electricity consumed by the base station. Hours of backup entailed design values determined by the base station power consumption at each site, and the battery capacity that could fit into the installation space. Below are descriptions of each field test site. (1) Kanagawa field test site

Because this was a relatively spacious site, it was well suited for solar panel installation. This site has the highest solar power generation capac-



(1) Kanagawa

(2) Tokyo

(3) Yamanashi

Photo 1 Green base station field test sites

Table 1 Specifications for Green base stations installed at	it field	test site	es
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	Kanagawa	Tokyo	Yamanashi	
Base station power consumption	Approx. 2.0 kW	Approx. 0.7 kW	Approx. 1.0 kW	
Solar power capability	4.2 kW	1.7 kW	1.4 kW	
Battery type	Lithium ion	Nickel hydride	Lithium ion	
Battery capacity	32 kWh	9.8 kWh	16 kWh	
Hours of backup	Approx. 16 hours	Approx. 14 hours	Approx. 16 hours	



ity of the three sites. Solar panels at this site have the capacity to generate more than twice the amount of power consumed by the base station, making it possible to charge batteries with the excess power while the base station is operating in fine weather. The facility was designed for about 16 hours of backup power using 32 kWh of lithium iron battery capacity.

(2) Tokyo field test site

Because this was an urban site, solar panels had to be installed in an almost completely flat position in consideration of adjacent environments (the solar panels were also given antiglare treatment). Nickel hydride batteries provide about 14 hours of backup power for the 0.7 kW facility power load.

(3) Yamanashi field test site

This site is in a mountainous area that has had solar panel facilities since 2001. In this test, the solar panels were updated for direct current connection, and large capacity batteries and a green power controller were included in the facility to create a green base station. With 16 kWh capacity lithium batteries, this station is designed to have the same amount of backup time as the facility in Kanagawa.

Each field test site is remote-monitored from the NTT DOCOMO R&D Center via a mobile data terminal installed at each facility. **Figure 2** shows field

test results for the Tokyo site as an example. The figure shows how much power was independently secured (self supplied) by solar power generation in fine, cloudy and rainy weather conditions over one day during September 2013 (for a 24 hour period including night time). The self-supplied power does not involve the use of commercial power. Therefore, the portion of self supply is the same as the portion of commercial power reduction (reduction in electricity charges). Being autumn, there were about 12 hours of daylight from sunrise to sunset, thus, these portions would be twice the values noted in Figure 2 during the 12 daylight hours under each of the weather conditions. In other words, during the daytime in fine weather, about 60 to 70% of electricity can be self supplied by solar power generation.

As a result of these tests, we were able to raise daily self supplied capacity in fine weather by about 1/3 at the test site by including control mechanisms to preferentially use solar panel generation.

4. Conclusion

By the end of November 2013, NTT DOCOMO had built a total of 10 stations under different climatic conditions along the Pacific Coast, along the Sea of Japan Coast and inland in the Kanto-Koshinetsu region. We plan to continue to collect data from the green base station field test sites, and use it to further advance designed for power control optimization.



Figure 2 Example of data gathered from Tokyo field test site

Moreover in future, we intend to diversify our lineup of green base station power sources with wind generation and fuel cells^{*6} etc, and strengthen our approaches to creating mobile telephone base stations that are environmentally friendly and disaster resistant, by continuing to study optimized power source operations through the green power controller, and at the same time finding ways to lower costs associated with installing and operating additional green base station facilities.

REFERENCES

- K. Komiya et al.: "Environmentally-Friendly, Disaster-Resistant Green Base Station Test Systems," NTT DOCOMO Technical Journal, Vol. 15, No.1, pp. 35-41, Jul. 2013.
- *6 **Fuel cells**: Cells that generate electricity through a chemical reaction between hydrogen and oxygen.