# EMS (Energy Management Systems) Technologies Optimizing Energy Consumption for Mobile phone Base Stations

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**Abstract**

Due to the sharp rise in the number of mobile phone subscribers in India and other emerging countries more and more base stations that support mobile phone networks are being built. They are now to be found not only in urban areas but also in rural areas. These base stations are expected to be operational year-round 24-7, so that telecom tower operators can ensure power in case of a power outage in the areas where stable grid power supplies cannot be expected. In such areas they use diesel powered generators, however, the use of diesel power generation poses some issues, including a negative influence on the earth environment due to $CO_2$ emissions and a high economic burden on the telecom tower operators due to a rise in fuel costs, etc. In order to resolve these issues, the replacement of lead storage batteries with lithium-ion batteries and the employment of a server-client model energy management system (EMS) is expected to improve the operational efficiency of the diesel power generators. In consequence the operational hours may decrease and a fuel combustion saving can be achieved.

Keywords

fuel consumption saving, $CO_2$ reduction, emerging country, mobile phone base station, energy management, power outage prediction

## 1. Introduction

The population of India now exceeds 1.2 billion 50 million, and mobile phones have become popular not only in urban areas but also in rural areas. Internet users in India have exceeded 86 million (as of 2013) and it is now ranked second in the world. More than 440,000 mobile phone base stations have already been built to support the networks by which over 86 million users are linked. Notwithstanding this trend, the power supply infrastructure in India is not as stable as it might be. Therefore, many diesel generators (DG) are employed in the event of power outage and over 2 billion liters of diesel oil are consumed per year in order to maintain year-round 24-7 mobile phone network operation.

NEC is conducting demonstration test of the EMS (energy management system) technology and aims to reduce both diesel oil consumption and $CO_2$ emissions. Our solution employs an EMS to control the power systems via use of LIB (lithium-ion batteries), PV (photovoltaic) and DG.

## 2. The Background of the Demonstration Test

Mobile phone base stations are expected to be operated to provide a year-round 24/7 service. In India, for example, the amount of electricity that power grid systems provide is only about 33% of the required amount. Therefore, many mobile phone base stations use DGs to generate power if the grid power is cut, which consumes over 2 billion liters of diesel oil per year and exhausts over 11 million tons of $CO_2$ per year.

In many cases, the mobile phone business in India is shared by several specialist companies. A tower company leases land from a landowner to build a mobile phone base station and a tower. It ensures the power supply and then rents the base station site to a mobile phone carrier company. In such a case, the tower company invoices the rental fee to the carrier company for the base station and the tower together with the power supply charge. Recently, it is becoming common to pay the power charge with a fixed-monthly fee. This means that any cost rise for the diesel fuel may adversely affect the management of the tower company.

The tower company provides power to the telecom carrier company. In order to provide DC power without any temporary outages the tower company rectifies the power received from the grid power system and uses it together with that supplied by the lead storage batteries. Moreover, the tower companies are usually able to operate DGs so that power is continuously provided, even in the case of a power outage. Some companies use lead storage batteries during certain hours to discharge power in order to reduce the operational hours of the DGs. Recently PVs are being employed as a countermeasure. However, only around 1% of mobile phone base stations employ such a strategy.

NEC expects that a system employing LIBs instead of lead storage batteries to reduce both the fuel consumption of the DGs and the $CO_2$ emissions. With lead storage batteries, when power charge/discharge is repeatedly operated with a high DOD (depth of discharge) setting, the performance of the power generation degrades rapidly. This means that the power generation of the lead storage batteries is not efficient, even if they are of a large capacity. On the other hand, an LIB is capable of a rapid charge that is several times faster compared to that of the lead storage battery with a charging current of 0.05C. By employing LIBs, it can be expected that the operational hours of the DGs will be reduced and also that the DG's power generation load will be increased. The power generation load of the DGs is generally low, which indicates inefficiency. However, the employment of LIBs will allow the DGs to be operated with high efficiency, and in consequence the fuel consumption will be reduced significantly. Additionally, the LIBs achieve almost 100% DOD and have a larger energy capability compared to that of the lead storage batteries. Such properties of the LIBs may allow the power source equipment installed at the base station to be reduced in both size and weight.

Moreover, the energy system that employs EMS to predict PV power generation, power outage duration time, etc., enables controlling the start/stop of the DG and in consequence of achieving further fuels savings. In order to examine the above effects, NEC has been conducting the "Demonstration Project of International Energy Consumption Efficiency Technologies and Systems - Project to Demonstrate Energy Management Systems for Mobile Phone Base Stations in India". This is a demonstration project of the New Energy and Industrial Technology Development Organization (NEDO). It is intended to perform the demonstration test for energy saving using high-solar reflectance photocatalytic paint supplied by the Pixela Corporation in order to curb temperature rises inside the mobile phone base station housing. At the same time, we will demonstrate possible solutions to counteract the energy issues that are being faced by the tower companies of the emerging countries.

## 3. Building Layout for the Demonstration Test

The buildings for the demonstration test are generally allocated according to the layout as shown in **Photo 1** and **Fig. 1**. There are two models of the mobile phone base stations; one is an indoor model where equipment is installed inside the shelter (Photo 1), and the other


Photo 1 Mobile phone base station (indoor model).

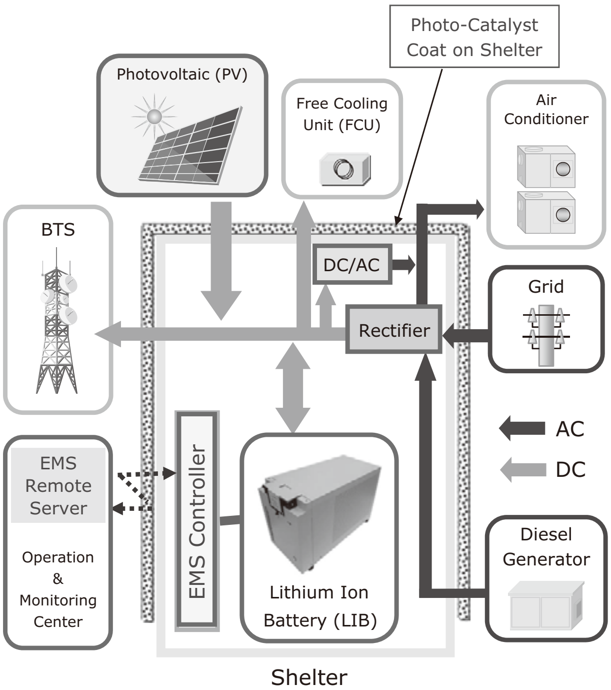


Fig. 1 Demonstration equipment configuration (indoor model).

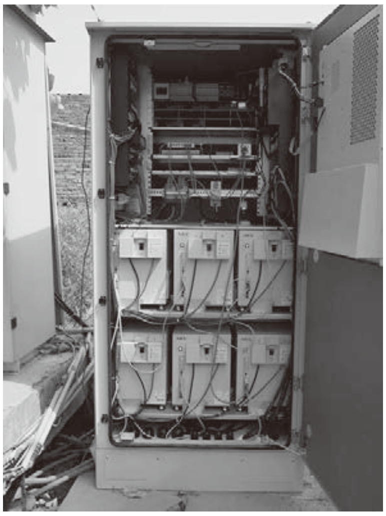

Photo 2 Demonstration test equipment housing (outdoor model. with the door left open)

is an outdoor model that uses a waterproofed cabinet with the equipment installed inside it (**Photo 2**). Fig. 1 shows details of the equipment layout used to conduct the demonstration in the indoor model base station. The temperature inside the shelter is controlled by an air conditioner.

With the conventional system, in the case of a power outage an air conditioner has to be operated by the power generated from a DG. However, our demonstration test proves that in the event of a power outage it is possible to convert the DC power generated by a storage battery into AC power and to be able to operate the air conditioner using the discharge from the storage battery. This facility may contribute to a further reduction in the operational hours of the DG.

Most base stations are equipped ideally with rectifiers to convert AC power into DC power. However, such a procedure does not fit in with our demonstration test, as it is necessary to connect the storage battery to the controller of the rectifier to achieve a fine control of the voltage. Therefore, when conducting the demonstration test, the present rectifier had to be replaced with a suitable one at the time that the lead storage battery was replaced by an LIB.

The existing equipment used for the demonstration test includes an air conditioner, a DG, a FCU (free cooling unit) and the wireless system of the power generation load base station. Newly introduced facilities are: a PV cell, an ESS (energy storage system, a LIB that is equipped with a battery management unit), an IPMS (integrated power management system) and an EMS. The EMS is configured with the client-server model (**Fig. 2**). The EMS controller communicates with an IPMS controller, an ESS and various sensors for temperature, fuel consumption, sunlight amount, etc. via CAN (controller area network) or LAN. It collects this measured data and sends it to the server. At the same time, it controls the start/stop operation of the DG and the charge/discharge of the ESS according to the operational plan that is downloaded from the server.

For our demonstration test, we have firstly selected 60 base stations after examining the meteorological conditions throughout India and have picked 20 base stations among them to be used in our test (**Fig. 3**). These 20 base stations are then grouped into five areas according to power supplied hours from a grid power system; Off Grid areas (no grid power is supplied), Poor Grid areas (three types of average power supplied at various hours per day, e.g. 3, 6 and 9 hours), and Average Grid areas

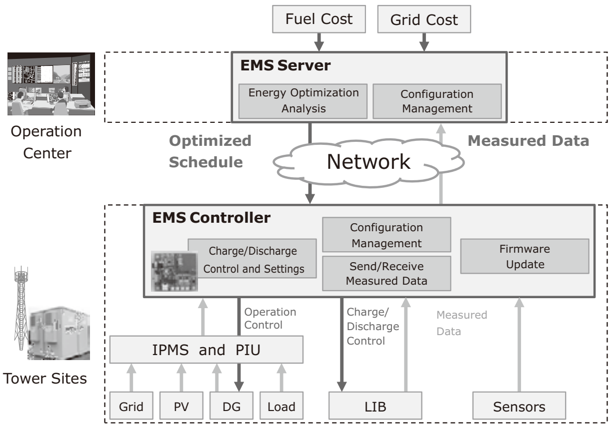


Fig. 2 EMS client-server configuration.

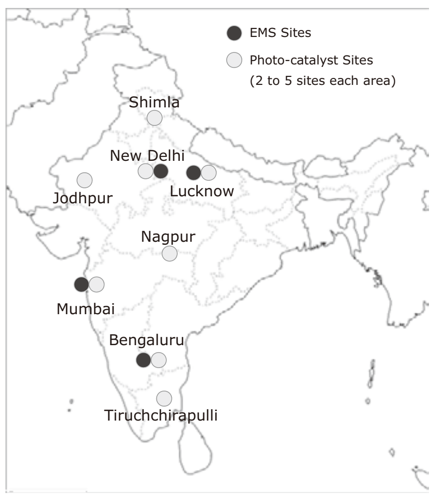


Fig. 3 Places where the demonstration tests are to be conducted.

(average power supplied for some hours per day, which is usually about 16 hours). Subsequently, they are again grouped into two models (10 stations per model): the outdoor station model and the indoor station model.

Two tower companies that are both partner companies of NEC provide the above 20 base stations for the demonstration test.

## 4. Goal of the Demonstration Test (Technology Aspect)

Features of the LIBs are; rapid charging with a large current compared to that of a lead storage battery, and an almost 100% capacity charge/discharge performance. These features enable large-volume charging within the limited hours during grid power supply periods, and also full capacity discharging power. In case a power outage continues after the LIB discharge finishes, the DGs start to supply power for the power generation, charging the LIBs at the same time. By applying a large charge to the LIBs, the power generation efficiency of the DGs can be much improved compared to when charging the lead storage batteries.

A significant fuel consumption reduction can be expected by replacing the lead storage batteries with LIBs and by controlling the power for charging. Beside this feature, the demonstration test aims at the goals as shown below.

(1) Predicting the PV generation power in order to consume it at the most efficient rate.

(2) Predicting the power outage end time in order to control the DGs efficiently.

Goal (2) aims to avoid unplanned operation of the DGs in the event of a power outage. It also aims at the most efficient power consumption of the DGs by discontinuing charging the LIBs by the DGs when a certain level is reached, and by starting to discharge power from the LIBs until satisfactory grid power is restored. This procedure could conserve DG power mainly if the grid power is restored when the LIBs have used up their power.

Moreover, the EMS may achieve further reduction of fuel consumption by predicting the PV's power generation amount, and also by predicting the power outage occurring time and its duration hours.

## 5. Goal of the Demonstration Test (Environmental Aspect)

We have already started to conduct a survey to find how the severe temperature condition in India could affect batteries and also how such a drastic temperature rise affects the charge/discharge schedule. However, once we started the installation construction there, we found many other issues before starting to provide energy service business for the mobile phone base stations of India.

These are; the land owner's interest in leasing out the land to the base station, religious matter such as not being permitted to cut down trees that obstruct the PV, inadequate grid power systems such as open phase, malfunction of facilities, etc. Besides these issues, most of the base stations need to be revamped in order to start automatic DG operations effectively.

Our demonstration tests aim to solve these issues from a technological aspect, and to demonstrate the possibility of efficient fuel consumption reduction by employing the EMSs. At the same time, we will detect issues in operating the system, so that we will be able to examine business issues in providing energy in the emerging countries.

## 6. Conclusion

The demonstration test is proceeding under the schedule as follows; an applicability survey in May, 2012, a feasibility study in July, 2013, a contractor agreement for the demonstration project between NEC and NEDO, and a memorandum of understanding (MOU) between the Indian Department of Economic Affairs and NEDO, both in October, 2013. This demonstration test is scheduled to be carried out until March, 2017, while implementing upgrading of the EMS functions and algorithms, etc.

## 7. Acknowledgement

The demonstration test is conducted under a contractual agreement with NEDO. The results described in this paper have all been acquired via the test.

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Vol.10 No.2
April 2016

Special Issue TOP