Environmental and Energy Solutions: NTT Facilities Expands Its Energy Business

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Abstract

Capitalizing on its extensive experience and comprehensive know-how gained through supporting energy- and cost-savings programs developed within the NTT Group, NTT Facilities is expanding its energy business and promoting various environmental and energy solutions. These include stand-alone solar and wind power-generation systems, valve regulated lead-acid (VRLA) battery energy storage systems, DC power systems to reduce energy costs and decrease environmental loads such as CO_2 emissions, and systems for monitoring and controlling distributed power supplies.

1. Expansion of environmental and energy solutions

The environmental and energy business in Japan is entering a genuine expansion phase amid major efforts on the international, national, and local levels and in corporations and organizations to deal with global warming. The NTT Group began promoting energy-saving activities as far back as the 1980s, leading to the creation of thorough energy-saving and cost-saving mechanisms through the "Save Power" and "TPR" (total power revolution) movements that were later supported by NTT Facilities. Now, NTT Facilities is expanding its solutions to a broader range of customers, utilizing its comprehensive technical abilities and know-how including ten years of experience in constructing systems using solar and wind power. This article introduces these solutions, which promote, in particular, lower energy costs and smaller environmental loads with a focus on CO_2 emissions.

2. Stand-alone power supply systems using solar cells and wind turbines

Clean energy systems can be broadly divided into two types: an "interconnected system" that supplies power to a load in conjunction with a commercial power supply and a "stand-alone power supply system" that supplies power to a specific load without using a commercial power supply. Solar power and wind power are the best examples of clean energy. They reduce our dependence on fossil fuels and reduce damage to the environment. Moreover, because they are essentially on-site power supplies[*1], they can be used as emergency power supply facilities. For these reasons, solar cells and wind turbines have been attracting a lot of attention as ways of achieving stand-alone power supply systems.

NTT Facilities inherited power supply technology for telecommunications originally developed by the NTT Group and has been expanding and improving it. The company is developing optimal storage batteries and power supply equipment for stand-alone power supply systems as well as highly accurate power-generation simulation techniques while creating highly reliable designs.

The power generated by solar cells or wind turbines varies greatly according to meteorological conditions, so the load must be provided with a stable supply of power from a storage battery when power cannot be generated, such as during the night or at times of inclement weather. The storage battery is charged while the load is being supplied with power generated by the solar cells or wind turbines during the day

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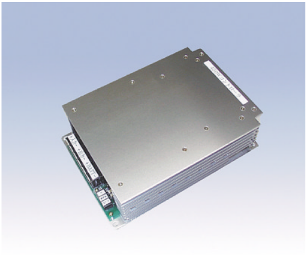
*1 On-site power supply: A relatively small power generator installed close to the demand.

when weather conditions are favorable. However, the system must not generate more power than can be consumed by the load and storage battery. Therefore, functions for repeatedly charging the storage battery and suppressing excess power generation are important elements of a stand-alone power supply system. They can be achieved using a storage battery designed for cyclic use and power-supply equipment capable of suppressing excess power and controlling battery charging. From the viewpoints of reliability and economy, NTT Facilities has been designing systems using solar power generation as the main power supply and wind power generation (which has a mechanical drive section) as a supplementary power supply.

At NTT Facilities, a commercial "2-V valve regulated lead-acid (VRLA) battery for cyclic use" has been applied to stand-alone power supply systems for use as an energy storage system that can provide sufficient reliability and economy. As of November 2003, such stand-alone power supply systems had been deployed together with associated converters at 13 wireless base stations in areas with no commercial power supplies. These base stations have been running continuously in a stable fashion 24 hours a day, 7 days a week. Based on this technology, NTT Facilities has expanded its product lineup by developing a small-capacity "12-V 50-Ah product" featuring a superior cyclic lifetime and charging characteristics that are not easily affected by ambient temperature.

NTT Facilities has also developed a DC-DC converter with up to four 5-kW converter units for stand-alone power supply systems and used it in a new addition to its product lineup: a 150–450-W "small-capacity charge/discharge controller" (**Fig. 1**). Conventional charge/discharge controllers for small-capacity stand-alone systems supply pulse current, which unfortunately make it easy for the battery to deteriorate. This new charge/discharge controller has been designed to give the storage battery optimal fixed-voltage charging characteristics to minimize battery deterioration.



Dimensions: 170 × 240 × 70 (mm)

Fig. 1. Small-capacity charge/discharge controller.

These technologies let us construct a system that optimally combines solar and wind power generation by i) considering load capacity, operation duration and times, and other requirements as well as customer needs, ii) investigating functions, costs, and designs, and iii) evaluating power-generation by simulation.

3. VRLA battery energy storage systems

NTT Facilities is also involved with VRLA battery energy storage systems that can make more efficient use of commercial power supplies. Peak power demand has been increasing year on year, and the difference between the maximum and minimum levels of power demand within one day has also been widening (**Fig. 2**). One way of achieving a stable supply of power in the face of such fluctuation is "load leveling". The development of energy storage systems has been progressing toward this end. For example, an energy storage system developed by NTT Facilities and first put on the market in 2001 charges storage batteries using nighttime power and discharges them during the day at times of peak power demand. Because storage batteries such as these undergo a daily cycle of nighttime charging and daytime discharging, there is a need for long-life low-cost batteries for cyclic use.

An energy storage system consists of power-conversion equipment for controlling the charging and discharging of power and cyclic VRLA batteries for storing electrical energy. There are two types of energy storage systems according to the configuration of the power-conversion equipment: a UPS (uninterruptible power supply) type and an interconnected type (**Table 1**).

A UPS type of energy storage system with an inverter feed in normal operating mode has essentially the same equipment configuration as an ordinary UPS. It uses cyclic VRLA batteries as storage cells but adds a dedicated charger for efficient and quick battery charging at nighttime (**Fig. 3**). During normal operation, the system converts commercial AC power to high-quality AC power with a constant voltage and

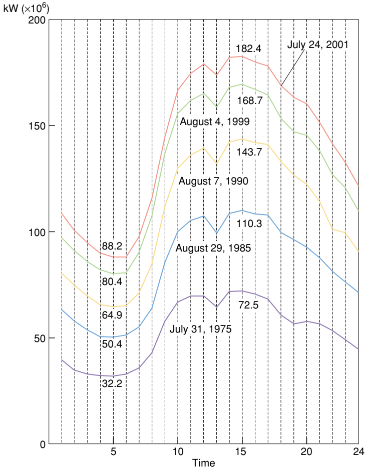


Fig. 2. Daily power-demand curves.

Table 1. Features of energy storage systems.

System	UPS type	Interconnected type
Features	• Highly accurate constant voltage and constant frequency output • In the event of inverter failure, power is supplied from commercial source without interruption • Capacity of rectifier increases • Load must be limited	• Interconnection with commercial source makes load limitation unnecessary • Output voltage and frequency accuracy about the same as commercial power • Load limited to facilities that tolerate a momentary power cut at the time of commercial power failure • Load must be divided into 50-kW units
Feed system	Inverter feeds in normal mode	Commercial-power feed in normal mode
Quality of output voltage and frequency	Constant voltage and constant frequency at all times	Higher quality than input commercial source
Switching time at peak cut-over	Uninterruptible	Uninterruptible
Switching time at power failure	Uninterruptible	5–20 s
Inverter operation efficiency	88%	93%
Cost ratio	1.25	1

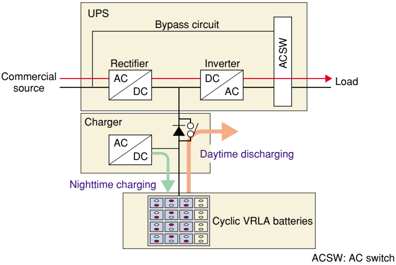


Fig. 3. UPS-type energy storage system.

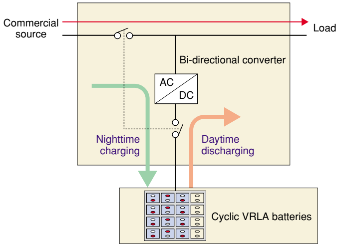


Fig. 4. Interconnected-type energy storage system.

constant frequency via the UPS and supplies this power to the load. During the daytime, the system can switch on the power from the cyclic VRLA batteries charged at night and continue supplying power in a smooth fashion. Finally, in the event of a commercial power failure, the system can switch over to discharge the storage batteries to continue providing power without interruption and achieve uninterrupted power supply.

An interconnected type of energy storage system uses a bi-directional converter that functions as a battery charger at night and as an inverter during the day (**Fig. 4**). This type of energy storage system interconnects with commercial power to supply power to a load. Whenever the commercial power supply fails, the power is cut off for at least five seconds in accordance with technical guidelines for interconnection.

The structure of the system's cyclic VRLA batteries is based on regulated cubicles*2, so the batteries do not necessarily have to be installed in a special battery room, which previously restricted the battery-installation location. In addition, a modular building-block system using fire-retardant materials eliminates the need for an earthquake-resistant case, which simplifies installation work and reduces installation costs.

Appropriate management of cyclic VRLA batteries is an important factor in achieving reliable operation in an energy storage system. Although VRLA batteries are known for their ease of installation and maintenance (e.g., supplementary water is not required during operation), they require voltage measurements and capacity checks to determine their internal state and ensure long-term use. NTT Facilities has enabled temperature management, defective-battery detection, and battery-voltage monitoring by equipping energy storage systems with battery management units developed for backup batteries in telecommunications power supply equipment. Functions for displaying faults in the UPS or charger and for displaying system operation status are also provided by various management units. Thus, the labor involved in managing system operation has been reduced and high reliability has been achieved. It is also possible to monitor and view diagnostic information remotely over the Internet.

4. DC power supply system (i-DC Power) project

The main form of input power supply for servers, routers, and other IT (information technology) devices is alternating current (AC), which is what UPS systems have generally been using. In the telecommunications field, however, high-reliability

*2 Regulated cubicle: A small box-shaped structure that conforms to fire prevention laws.

power supplies are provided by direct current (DC) typically of the DC48V type. In September 2000, NTT Facilities launched the i-DC Power project to promote the introduction of DC power systems.

Why is a DC power supply system more reliable? The main reason is its straightforward control method and simple circuit configuration compared with a UPS. It is at least ten times as reliable as an AC system, according to field data. Moreover, its simple configuration means that a DC system takes up about half the space of an AC system of similar capacity.

A DC power supply system also features fewer conversion steps than a UPS resulting, in general, in an overall conversion efficiency about 20% higher. This can lower the running cost associated with electricity costs and the initial cost of air conditioning facilities (**Fig. 5**). Another feature of DC power supply systems is that they enable additional power supply units to be installed without having to shut down the power feed. They also make it easy to exchange units in the event of a failure. In short, DC power supply systems excel in extendibility and maintainability. They can be thought of as optimal power supplies for IT facilities such as data centers, where the concentration of devices that dissipate a lot of heat like servers and routers leads to a lot of energy being required.

In the NTT Group, the establishment of power supply guidelines (prepared by NTT) in January 2002 is promoting DC power supply systems for IT devices. Likewise, the establishment of power supply requirements and guidelines at NTT DoCoMo in June 2002 is promoting DC power through guidelines prescribed for power supply procurement. In addition, meetings to “study the DC power supply systems in the IT age” are being held to gather the opinions of experts and business partners and to make extensive contributions to new solutions in IT society through the use of DC systems. These meetings are providing a forum for discussing the possibilities of promoting DC power and finding the direction that should be taken from here on.

As IT advances, however, the amount of energy consumed by IT systems is increasing. Using energy efficiently is becoming a matter of utmost importance for the global environment. For a data center with a total floor area of about 1000 m^2, the 20% greater efficiency of DC power supply systems compared with AC systems means that the use of DC systems can reduce annual electricity usage by about 2.5 million kWh, which is equivalent to that used by 710 ordinary households. This could save about 920 tons of CO_2 emissions and about 1730 barrels of crude oil per year. Thus, DC power supply systems could be very effective in suppressing the emission of global-warming gases like CO_2 and protecting the global environment.

Distributed power supplies like solar power systems and fuel cell systems, which are expected to find widespread use in the years to come, produce a DC output, as do energy storage systems that utilize

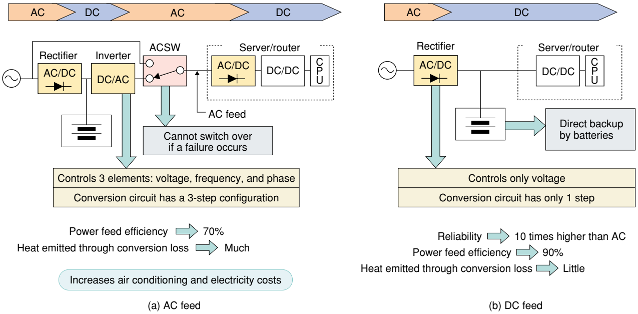


Fig. 5. Comparison of AC and DC power supply systems.

nighttime power and apply load leveling. These systems are highly compatible with DC power feeds. The interconnected use of these systems should also lead to further reductions in the emission of global warming gases.

5. Remote monitoring of micro gas turbines

The growing use of distributed power supplies has raised three important issues concerning their deployment and operation: inspections with regard to environmental protection and energy saving, facility operation and management, and improvements in maintenance services. The micro gas turbine (MGT) is one example of an excellent distributed power supply slated for introduction. An MGT uses a remote maintenance system to ensure reliability and economy. Making good use of monitoring technology for telecommunications facilities and other technology developed by the NTT Group, NTT Facilities has developed a remote monitoring system to support remote MGT maintenance and has offered a remote monitoring service to customers (MGT manufacturers).

In the event of an MGT failure, the MGT remote monitoring service automatically notifies the customer of that failure by e-mail via NTT Facilities' new remote facility-monitoring system (MARY II). The customer can access the failure history, daily reports, and other relevant data and obtain files from anywhere via the Internet (**Fig. 6**).

An MGT itself is managed remotely by MARY II, and if a failure should occur in equipment or if the equipment should recover, the MGT will send a message to an access server at the monitoring center via a router and public lines. On the access server side, the system performs authentication using the account name and password received from the message-sending side. Then, after sounding an alarm, the system notifies the customer of the failure or recovery by sending e-mail to his cellular phone or mobile terminal. In addition to MGT failure monitoring, other services can be offered making use of Web display functions, various MARY II functions, etc.

With the deregulation of high-voltage power starting in 2004, the need for small-scale distributed power supplies like MGTs and fuel cells is expected to rise, so remote monitoring services will become increasingly important.

6. Expansion into energy control and retail power business

As more and more distributed power supplies are deployed, individual municipalities and regions are investigating means of achieving comprehensive control and efficient operation of multiple distributed power supplies. NTT Facilities plans to conduct R&D in energy control and to participate in "Local Trials of New Energy Technologies at the 2005 World Expo

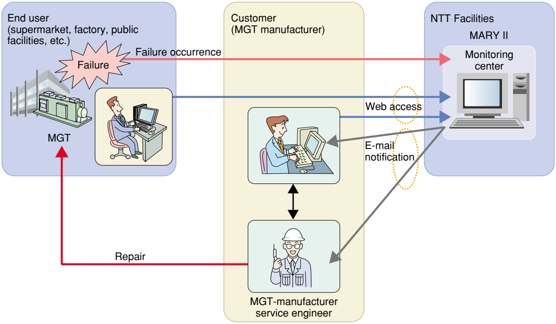


Fig. 6. MGT remote monitoring service.

and Central Japan Airport City" to be held as an entrusted research project of the New Energy and Industrial Technology Development Organization (NEDO) at the 2005 World Expo in Aichi prefecture. The company will be involved in various verification experiments including the world's first trial of a commercial system for supplying stable power and reducing the environmental load. It will be deployed on the premises of the 2005 World Expo (in pavilions, restaurants, etc.). The plan is to disseminate the results of these experiments and trials throughout the world.

Furthermore, on the basis of a business strategy that aims to reduce environmental load and energy costs, a joint enterprise called ENNET Corporation has been set up by NTT Facilities, Tokyo Gas Co., Ltd., and Osaka Gas Co., Ltd. as a retail power business. Since opening for business in 2001 in the Kanto and Kansai regions of Japan, this company had supplied more than 400,000 kW of electric power to 110 buildings as of August 2003. ENNET is supplying power and reducing power costs for many customers, besides those in the NTT Group. Its corporate philosophy is to "create new value in energy". In the years to come, NTT Facilities will work energetically with ENNET to create value-added products across all energy fields and develop a "total energy solution" business.

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He received the B.E. degree in electronic engineering from Kobe University, Kobe in 1976. Since joining NTT in 1976, he has been engaged in R&D of DC-DC converter technology, telecommunications power systems, and fuel cell systems. In 1999, he joined NTT Facilities. His current interests are clean energy systems and highly reliable power supply systems for IP equipment. He is a member of IEEE, the Institute of Electronics, Information and Communication Engineers , and the Institute of Electrical Engineers of Japan.