[Background Reasons Why Hybrid Power Generation is Required]

As the electrification rate is low in colored areas in the global map in Figure 1, where the population is dispersed across a vast tract of land, the conventional electrification by national grid is difficult in those areas.

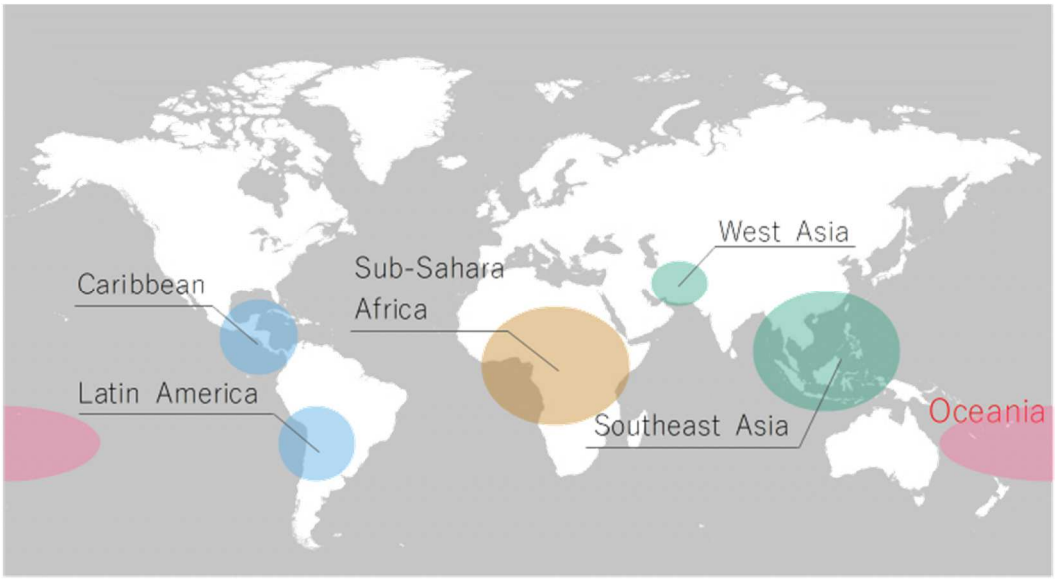


Figure 1. Areas where electrification is difficult

In those areas, people live without electricity or on a very fragile power infrastructure with solar lanterns and uncontrolled solar power generation, enabling them no more than to charge cell phones.

Against such a backdrop, governments of countries concerned have made attempts for electrification by using small diesel power generators, which is the easiest way, out of necessity, but it has become difficult to maintain them due to inability to finance high fuel and maintenance costs. Those governments are calling for technological and financial assistance for hybrid power generation using renewable energy from Japan and other countries with advanced energy infrastructure.
According to a document by JICA, 1.4 billion people live in those areas where electrification is difficult, and those people want energy infrastructure that suits actual local situations, such as hybrid power generation combining natural energy.

[Issues with Technological Assistance in the Area of Energy]

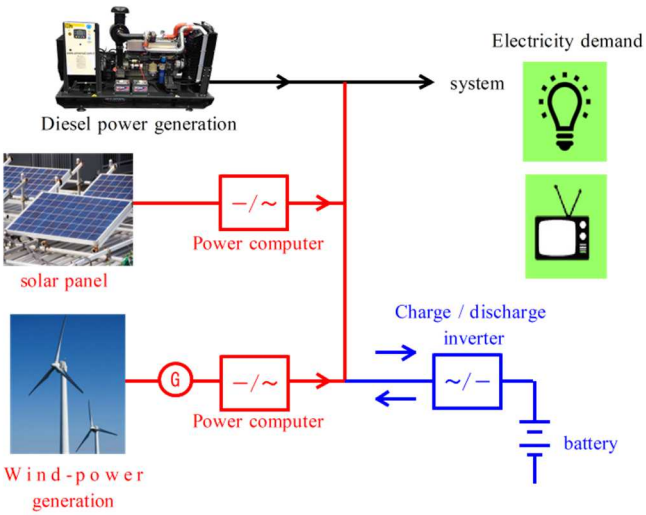


Figure 2. Conventional hybridization by a microgrid

Electrification of areas where national grid cannot be used including remote islands and areas starts with an easy microgrid whereby small diesel power generators are directly connected to the electricity grid, as shown by the black line in Figure 2.

This method, however, incurs high fuel and maintenance costs, making it difficult to maintain the system as resulting high electricity prices ranging from 50 to 100 yen/kWh, inconceivable in Japan, hinder economic activities.

If renewable energy is introduced, partly because of the needs of the times, under assistance from Japan and other countries, power from solar panel generation and wind power generation will be converted by power line conditioners (PLC) and transmitted to the grid in the form of alternating current, as shown by the red line in Figure 2. This is the same method normally used in introducing renewable energy in mainland Japan.

As power from renewable energy has recently been refused to be received even by the grid of a large electric power company in mainland Japan, a small grid powered by a single diesel generator in a remote island is easily overflown, forcing the disconnection of renewable power sources.

In response to this, numerous demonstration tests have been conducted in Japanese and Oceanian islands for shaving the peak of renewable energy power generation by adding a very expensive inverter with EMS and a battery, as shown by the blue line in Figure 2. A power line conditioner, which is a generation device ancillary to the main power supply device such as a diesel generator, cannot be the main power supply device, however. If the main power supply device halts, a power line conditioner will also halt.

Since, even if there is sufficient natural energy providing surplus power, under the conventional hybridization of a microgrid shown in Figure 2, a diesel power generator has to be kept operating to an extent that prevents low load operation, it is impossible to operate the microgrid 100% by natural energy.

[Mechanism of an Inverter]

While an inverter is normally used as a device to drive a motor, it is used as a power supply device in Tamaden Industry's hybrid power generation system.
How an inverter operates is illustrated by using the schematic diagram of a three phase inverter shown in Figure 3.

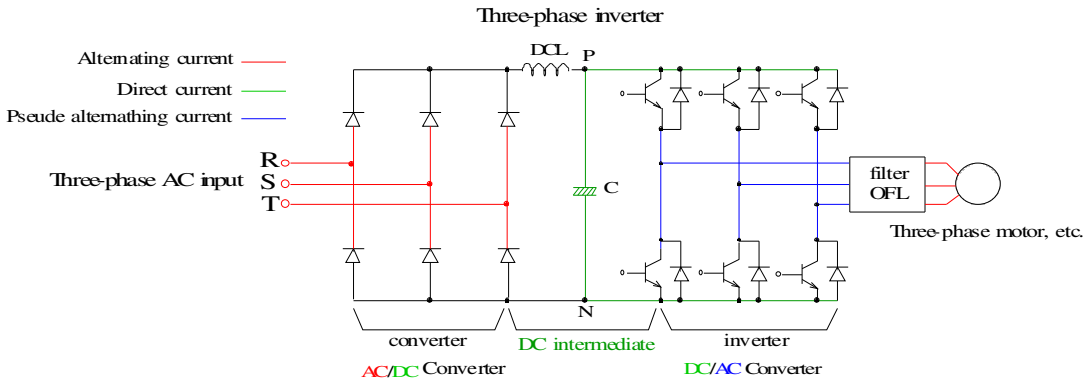


Figure 3. Schematic Diagram of a Three Phase Inverter

Converter circuit: A converter circuit rectifies three phase alternating current into direct current.

DC intermediate circuit: The DC part of an inverter is called DC intermediate circuit.

A DC intermediate circuit can be connected in parallel with that of another inverter just like a battery.
This enables the construction of a variety of power conversion devices.

Inverter circuit: An inverter circuit generates pseudo three phase alternating current by the PWM method using a three-phase H-bridge.

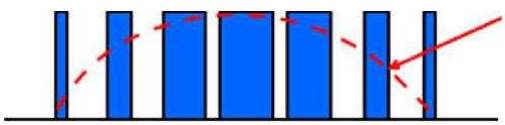
Switches are turned on and off in synchrony with the carrier frequency to modulate the pulse width of the output from the H-bridge to generate an AC waveform in accordance with effective output values.

Although the wave form of an inverter output is a PWM waveform (square waves with different pulse widths), an inverter output can drive a motor.

The addition of an output filter circuit to an inverter enables it to generate a clean sine wave, and the inverter can then be used as a power supply with frequency and voltage adjustment.

PWM: Pulse Width Modulation

It is a modulation method that produces a variable output by varying the pulse width (duty ratio).



An inverter controls the pulse width to generate a sine wave in accordance with effective values of its output.

An output is controlled by varying the pulse width (duty ratio).

Figure 4. PWM Control

[Tamaden Industry's Hybrid Power Generation]

The greatest challenge for hybrid power generation is to aim for zero fossil fuel consumption by optimizing the energy mix composed of multiple energy sources including solar power generation, wind power generation, and diesel power generators and by improving the proportion of natural energy.

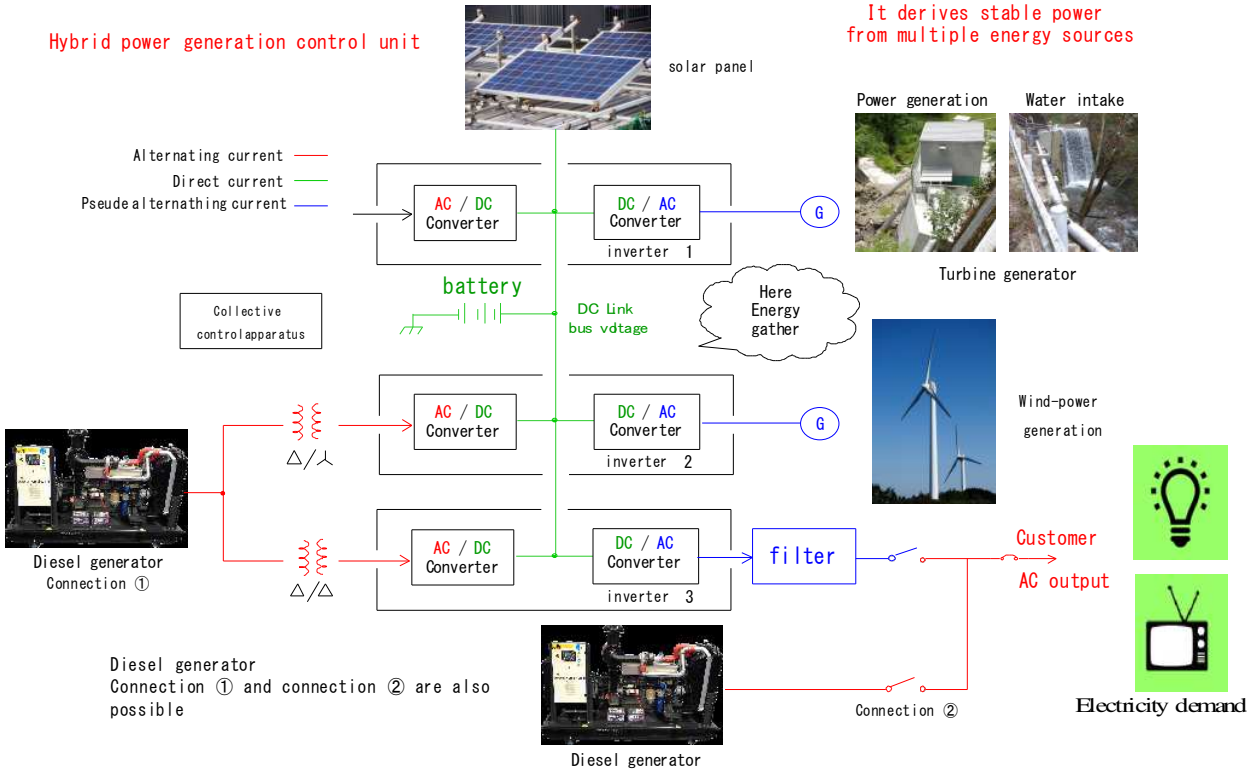


Figure 5. Schematic Diagram of Hybrid Power Generation Demonstration Unit

The schematic diagram of the hybrid power generation demonstration unit constructed by Tamaden Industry in Kojimayuga, Kurashiki-shi, Okayama prefecture, is shown in Figure 5.
It is an standalone power plant with the rated output of 75 kW which uses inverters as its main power supply devices and to which solar panels, wind turbine equivalents, batteries, diesel power generators, etc. are connected.
This hybrid power generation system using inverters can completely halt diesel power generators if there is a sufficient amount of power generated from renewable energy sources, and one of its advantages is its ability to reduce the fuel and maintenance costs of diesel engines significantly by operating 100% on renewable energy sources.
In addition, in connecting a diesel power generator, you can choose the connection method (1) via inverters or the connection method (2) for synchronous parallel operation.
Elements in green in the schematic diagram of the demonstration unit represent the DC intermediate circuit of an inverter.
Since the DC intermediate circuit is a DC circuit, an energy mix of multiple energy sources can be easily created by connecting multiple inverters, solar panels, and batteries in parallel just as dry batteries can be connected in parallel.

Since renewable energy sources from which to compose an energy mix can be chosen at will, a simple hybrid power generation system created by connecting solar panels to an existing diesel power generator, as shown in Figure 6, is possible depending on the conditions of the area in which the system is installed.

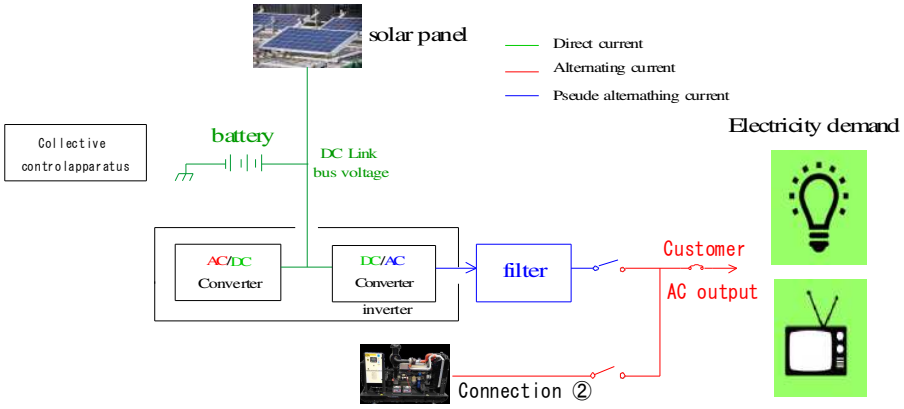


Figure 6 Example of a hybrid power generation system for a remote island

Besides the demonstration unit in Kojimayuga, Kurashiki-shi, our overseas hybrid power generation business is also underway (in Maldives) by utilizing the subsidy from the Ministry of Environment.

While solar power generation is in saturation in Japan, in areas where electrification is difficult described in the beginning, there is limitless demand for power infrastructure suiting real life such as a combination of solar panels and a diesel power generator illustrated in Figure 6.

Furthermore, even in Japan, hybrid power generation combining natural energy sources can contribute to energy saving and decarbonization in environments with a special power supply such as construction ships and construction sites in mountains where power is supplied by in-house power generation.

We have been promoting our hybrid power generation system based on the idea that it can be a pillar of power infrastructure in areas where electrification by national grid is difficult, including sparsely populated areas and remote islands, and create a new trend in solar power generation.