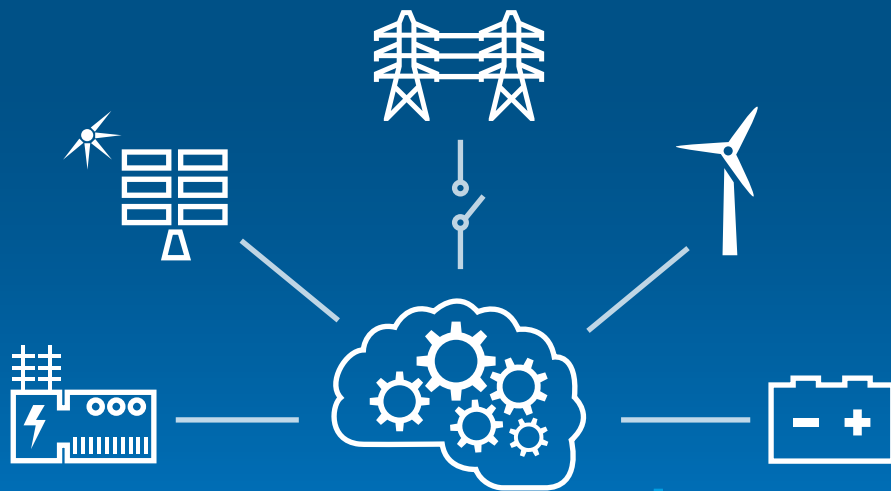


Microgrid Energy System



A challenging environment



Continuous availability of electricity

Today's facilities and communities are under extreme pressure to improve performance, operational efficiencies and reduce costs.

Continuous availability of electricity is critical to meet these goals.

The microgrid energy system concept

Local "Grid"

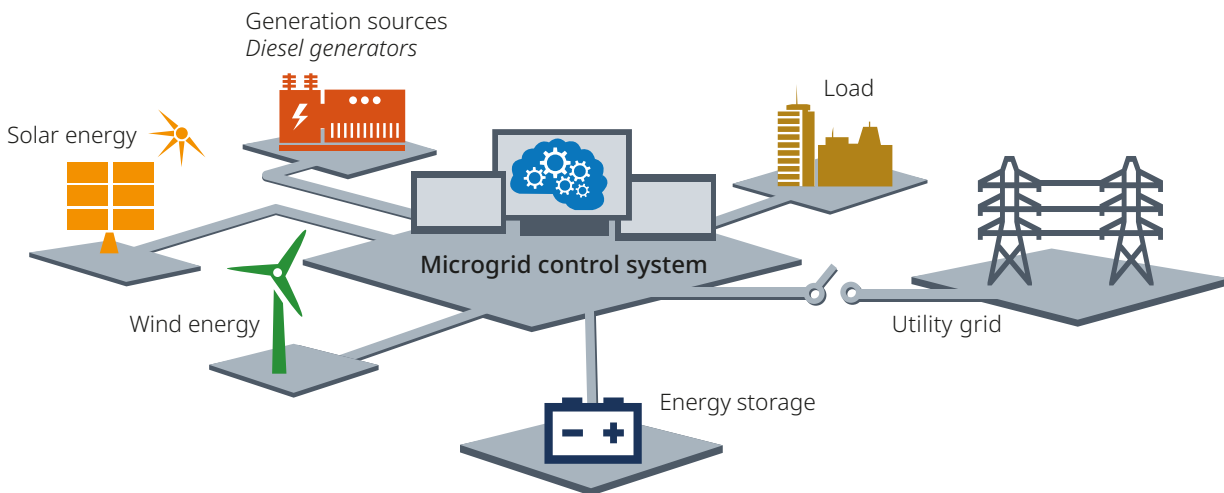
- Self-sufficient stand alone power generation and supply

Distributed energy sources

- Diesel engine generation
- Solar system generation
- Energy storage (Batteries)

Microgrid applications

- Islanding operation
- Black start
- Generation/load balance control



A microgrid is a stand-alone power grid that can be self-sufficient stand alone power system in a small area.

It is a power system that combines various energy production devices such as diesel generators, solar and wind power and energy storage devices. Unlike large-scale power generation facilities, it does not require a separate power transmission facility due to its proximity to supply area.

Values from microgrid energy system

Separate electricity transmission line free



- Unlike large-scale power production facilities, there is no need to have power transmission facility because the production facility and the supply area are close to each other

Renewable farming



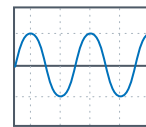
- Reduces generation cost by renewable energy
- Maximization of utilization of renewable energy

Islanding



- Independent operation of power source without grid connection
- Self-sufficient stand alone power generation and supply

Frequency & voltage regulation



- Stable frequency and voltage Grid forming control for load variation
- Automated generation source control to match demand

What Unbro can bring to you

Benefits are significant

- 1 Modularized and containerized system
- 2 Shorter project cycles
- 3 Improved overall cost effectiveness
- 4 Easier to troubleshoot
- 5 Easy reconfiguration of equipments
- 6 Turnkey and full lifecycle support
- 7 Single point of responsibility



Consistent power supply
Consistent supply of reliable, efficient and high-quality power



Adaptable infrastructure
An adaptable, secure and responsive infrastructure



Enhanced safety
Enhanced safety to protect people, property and the environment



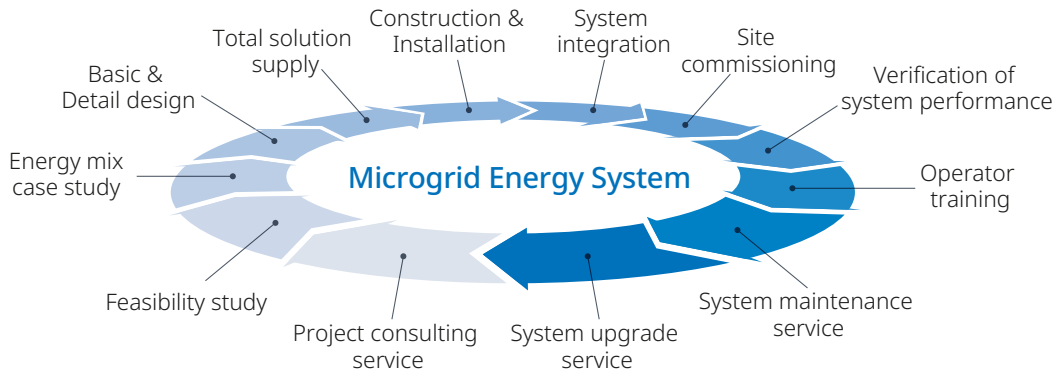
Expandable architecture
An architecture that can grow and modified without major reengineering

Total solution provider for microgrid energy system



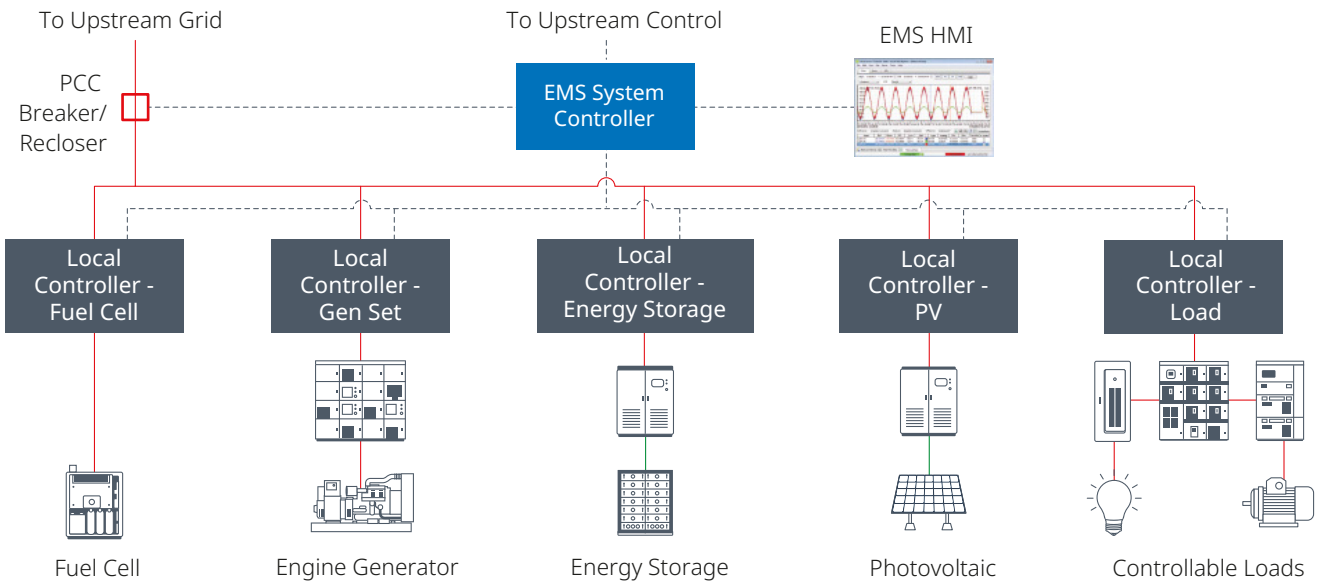
We are devoting ourselves to improving people’s lives and environment with power management technologies that are more reliable, efficient, safe and sustainable. Because that is what really matters. And we are here to make sure it works.

Unbro has been incorporating our all existing and on going technologies of development into our microgrid energy system.



Microgrid EMS system

System architecture

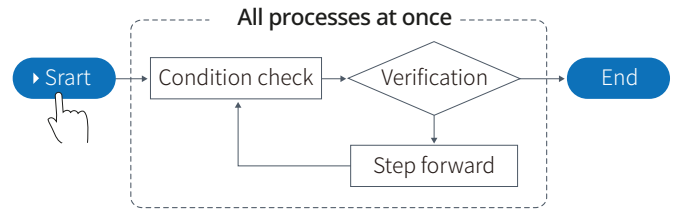


- Utilizes modular systems design
- Standard set of displays/reports
- Repeatabe gen modules (templates)
- Scale templates to match application
- Pre-format load options
- Build on open standards
- Suit of pre-engineered optimization strategies

EMS software for microgrid system

Automated microgrid system startup

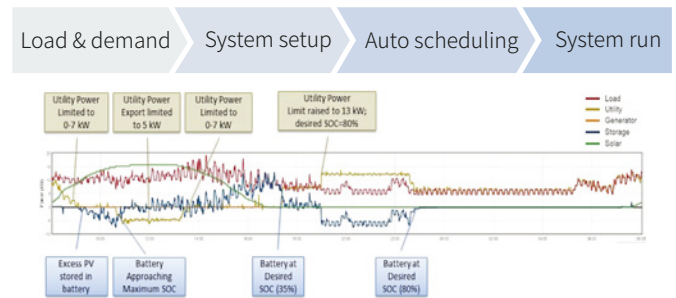
This function greatly simplifies the execution of complex black start process. It verifies the status of each step and automatically performs all processes moving to the next step. With just one button operation, the user can perform all processes at once.



Automatic scheduling and system operation

This function uses intelligent load & generation forecasting algorithm.

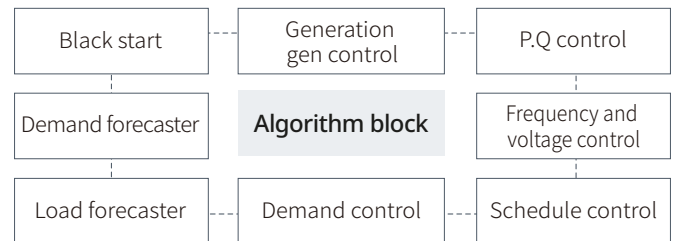
This function creates operation schedule automatically. With this automated scheduling function operator can run entire plant without burden of creating complex schedule.



Modularized control block

Our control system adopted modularized algorithm block architecture. Each algorithm block is built with the function of most frequently used. In most cases we do not need extra customization work.

We just need to combine each block for operation.



Type of microgrid EMS software & function

Function	Basic version	Standard version	Enhanced version
Grid forming & control (Microgrid function)	-	✓	✓
Black start (Automatic start and shutdown of microgrid system)	-	-	✓
Demand forecasting (Demand forecasting function based on history data)	-	-	✓
P.Q control (Active & Reactive power control)	✓	✓	✓
Frequency & Voltage control	-	✓	✓
P.F control (Power factor control)	-	✓	✓

Microgrid GUI design



Microgrid EMS software GUI

- Black Start Control
- Control of Operation Mode
- Load Forecaster Control
- Economic Generation Control
- Output Vs Frequency
- Voltage and Reactive Power Output

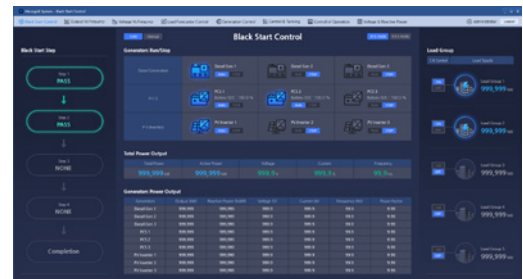
Black Start Control

The automated blackstart function of microgrid enables operators to recover microgrid system with minimum human intervention.

With few key strokes to microgrid control system, it automatically monitors each individual equipment's status and make entire generation system to be ready to execute automated blackstart function.

The automated black start function involves starting up the microgrid's generation sources such as diesel generators, renewable energy and energy storage systems. Microgrid control system monitors each generation source's status and system capacity. If microgrid control system decides to start to execute

automated blackstart function, it controls and monitors every step of blackstart procedure until microgrid system recovers to perform it's normal microgrid function based on pre-programmed scenario and sequence. It does not need manual or human intervention. Overall, an automated black start function is a crucial component of microgrid resiliency, ensuring that the microgrid can quickly recover from a power outage and continue to provide power to critical loads.



Control of Operation Mode

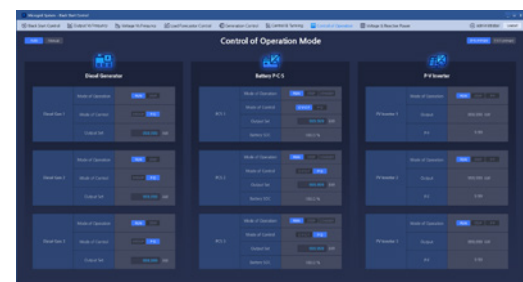
The control of the mode of operation of equipment in a microgrid, such as a generator, PV inverter, and battery PCS, involves managing the mode of output of each device to meet the electricity demand (frequency and voltage). The mode of operation consist of different operating modes to ensure to achieve this target.

Generator Control: In a microgrid, the generator may be used as the primary source of electricity or as a backup power source. Generators can be based on Droop control or P.Q control.

PV Inverter Control: A PV inverter may operate in modes such as maximum power point tracking (MPPT) mode, where it adjusts the output voltage and current to extract the maximum power from the solar panels. Or the inverter may also operate in P.F control mode to regulate the voltage of the microgrid and maintain system stability.

Battery PCS Control: The battery PCS manages the charge and discharge of battery. Also one of P.C.Ss of battery system will operate on C.V.C.F (Constant voltage and constant frequency) mode while the others operate in P.Q mode.

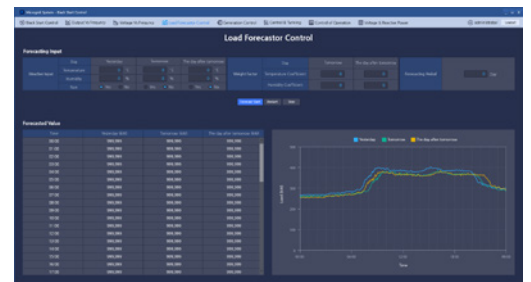
Mode of operation of each equipment will be defined automatically or manually by microgrid control software.



Load Forecaster Control

Load forecasting is done using the “similar day forecasting” prediction technique. The “similar day forecasting technique” is based on the theory that power consumption (load) shows a certain pattern under the influence of days of the week, seasons, time zones, and weather condition such as temperature, wind strength, and humidity. For forecasting, historic load data with weather information of past years are required, but if they are not available, the forecast is performed based on the data of the previous week or the previous day.

If there is usage data linked with past weather data, first input the weather factors such as temperature and humidity on the day to be predicted, and the system sets the characteristic conditions of the forecast day (Ex: Sunday, Saturday, Ordinary day, Christmas, Thanksgiving, First day of new year), etc. Based on this, 30 data with the most similar temperature and humidity are extracted by date type, season, and temperature and humidity, and the load is predicted by assigning weights for each temperature and humidity. Considering the natural increase in usage, software estimates the total demand.

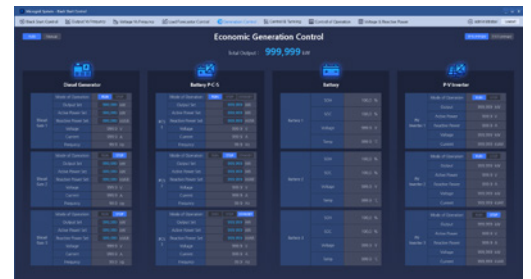


Economic Generation Control

Microgrid system typically includes multiple distributed energy resources such as solar photovoltaic (PV) panels, battery system, and generators. The economic generation and dispatch of electricity in a microgrid involves optimizing the use of diesel generators.

The economic dispatch of electricity of microgrid is focused on “How we can minimize running fuel engine based generators” and “How we can maximize the use of renewable energy”.

In order to achieve that objective, the future demand forecasting, optimal energy storage level, Optimal necessary running of fuel engine based system running should be considered and reflected in automated operation.



Output Vs Frequency

Frequency control function is needed to provide adequate amount of electricity and maintain reference frequency to microgrid system. The frequency of the electrical power system is measure of how enough or deficient the supplying amount of electricity to demand side. So frequency needs to be maintained at a constant level to ensure that the power supply is stable and reliable.

In a microgrid, the frequency control function of microgrid system continuously monitors the frequency of the electrical power system, amount of Active power and size of demand variation to adjusts the output of the generation sources to maintain a stable frequency. If the frequency deviates from the set point, the frequency control system triggers the necessary adjustments in generation sources to restore the frequency to the desired level.

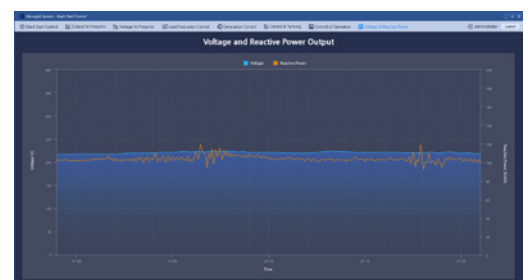


Voltage and Reactive Power Output

Voltage control function in microgrids is basically adding or subtracting reactive power to microgrid system.

If there is too much reactive power flow, then voltage may increase. Especially in microgrid system, if there is surplus power flow is made from renewable energy sources to microgrid, this voltage rise phenomenon may occur.

In a microgrid, the voltage control system continuously monitors the voltage of the electrical power system and controls the output of the reactive power generation to maintain target voltage.



Inverters for PCS (From Realtech)

- More than 20 years of experience and know-how in the PCS field
- Optimum cooling structure through heat flow analysis, optimum internal temperature increases the service life of the product
- Active FRT(Fault Ride Through) function
- High efficiency power conditioning at rated (more than 97.8%)
- Low output variation and low harmonic



Model		RTESS-30	RTESS-50	RTESS-75-OD	RTESS-95-OD	RTESS-250-OD	RTESS-500-OD	RTESS-1000-OD	RTESS-2000	
AC	Rated Power [kW]	30	50	75	95	250	500	1000	2000	
	Rated Voltage [V]	380	380	380	380	380	380	440	660	
	Frequency [Hz]	60	60	60	60	60	60	60	60	
	Power Factor(@Full load)	> 0.95	> 0.95	> 0.95	> 0.95	> 0.95	> 0.95	> 0.95	> 0.95	> 0.95
	Phase	3phase 3Wire, PE, Transformer			3phase 3Wire, PE, Transformer-less(Option : Transformer)					
	THD(@Full load)	< 5%	< 5%	< 5%	< 5%	< 5%	< 5%	< 5%	< 5%	< 5%
Max. Efficiency [%]	>97.0%	>97.0%	>97.0%	>97.0%	>97.0%	>97.0%	>97.0%	>97.0%	>97.0%	
DC	Nominal Voltage [V]	725	725	725	725	725	725	860	860	
	Voltage range [V]	600~950	600~950	600~950	570~840	600~950	600~1100	650~1100	650~1100	
Environment	Cooling Method	Forced Air Cooling								
	Op. Ambient temperature range [°C]	-20 ~ 40								
	Op. Humidity [%]	0 ~ 90, Non condensation								
	OP. Altitude [m]	0 ~ 2,000								
Touch panel	Display	TFT Color LCD								
	Size	10.2"			17.7cm (7")				10.2"	
	Back light	Auto On/Off								
Communication	MODBUS RTU RS-485									
Safety and EMC Standards	-	-	-	SGSF-025-04, KC62477-1	-	SGSF-025-04	SGSF-025-04	SGSF-025-04	SGSF-025-04	
IP Grade	IP20	IP20	IP44	IP44	IP44	IP44	IP44	IP44	IP20	
Dimension [WxDxH] [mm]	-	700x750x1,520	800x750x1,800	1,220x780x1,283	800x950x2,050	2,150x1,050x2,086	2,890x1,100x2,200	3,600x1,000x2,200	3,600x1,000x2,200	
Weight [kg]	-	550kg	450kg	480kg	500kg	1600kg	2500kg	3500kg	3500kg	
Safety	DC GFD(Ground Fault Detector), DC&AC SPD(Surge Protection Device), Option : FRT(Fault Ride Through)								-	

Microgrid controller



Microgrid controller

Microgrid controller uses the IEC 61131-3 Soft PLC

and logic functions to implement a stand-alone power generating, distribution and storage system that can isolate itself from the primary utility grid and provide a reliable and efficient solution to unexpected power loss.

The controller is one of the most advanced automation platforms in the industry and provides all the functions required by the modern automation system in a single highly reliable and powerful package.

In addition to data concentration, protocol translation and logic processing, it provides a built-in HMI and secure remote maintenance access to substation and field devices, reducing operating costs and increasing productivity for a large variety of applications.

Battery systems



Stability

- Considering C-rate, efficient and optimal charge/discharge control logic is applied to each battery brand

Types of battery applicable

- Li-ion battery
- LiFePO4 battery
- Vanadium Redox Flow Battery

Capacity

- Customized design for each application field and site

Safety

- Rack design with built-in self fire detector and fire extinguishing system
- Run at SOC 90% (outdoor)
- Operational data is backed up outside the ESS

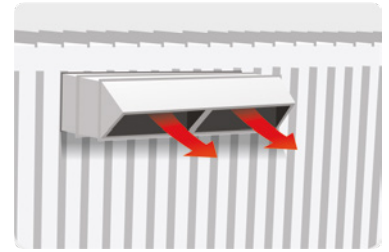
Battery brand

- SAMSUNG SDI
- LG Chem
- SK innovation

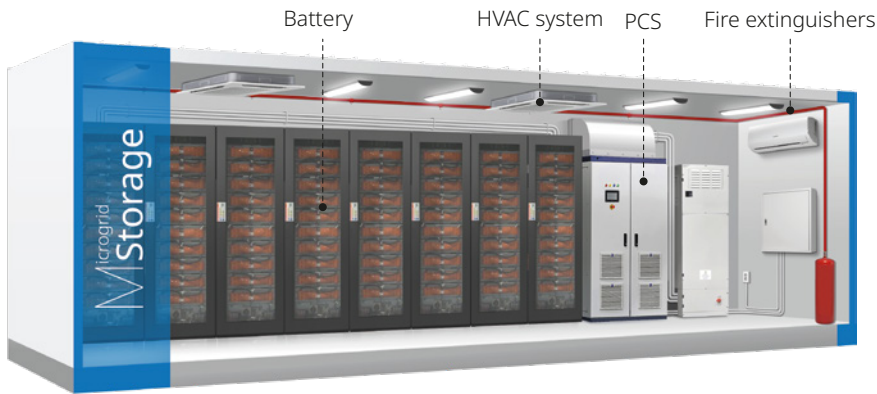
Containerized microgrid energy system



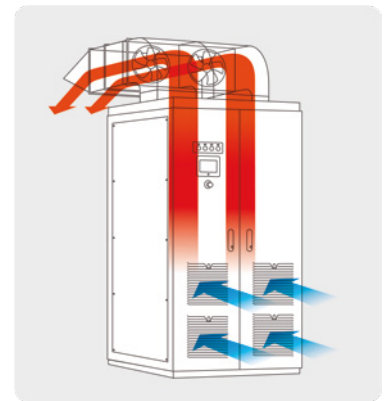
Exterior view 1



External ventilation



Interior view 1

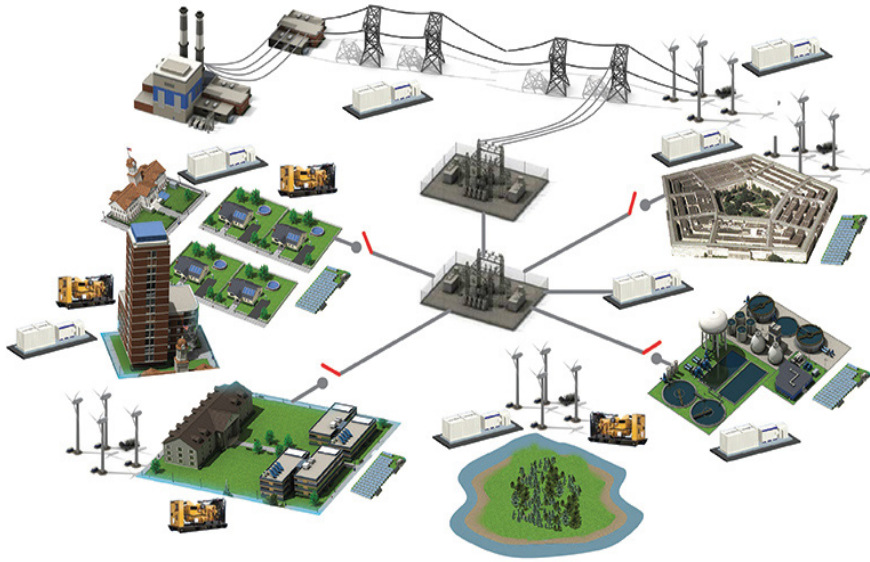


Airway for PCS

UNBRO's containerized microgrid energy system's special features

Hardware	Control and operation
<ul style="list-style-type: none"> • IP grade: IP55 • Inclusion: Batteries, Battery PCS, HVAC system, Fire extinguishers, Bus bars and cables, Cable connection interface panel, Transformer, E.M.S system • Size of container: 20ft ~ 40ft. • Standard capacity of batteries: 2MWH(expandable by need) • Capacity of PCS: 30kW ~ 2MW • Maintenance: Spacious room for maintenance • Specially designed airway for PCS • Precisely calculated heat discharging system • All equipments are fully tested and integrated into container • Specially hardened container with cross bar type H beam against deformation 	<ul style="list-style-type: none"> • Automated microgrid system startup • Automated schedule operation function • Specially designed and proven microgrid control function • Modularized microgrid algorithm block • Web connectivity allowing remote diagnosis • Minimized human intervention • Achieve a system architecture that's 75% Pre-engineered 15% App. configured 10% Custom • Offer customization as desired • Full system simulation testing

Megatrends, Microgrids



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