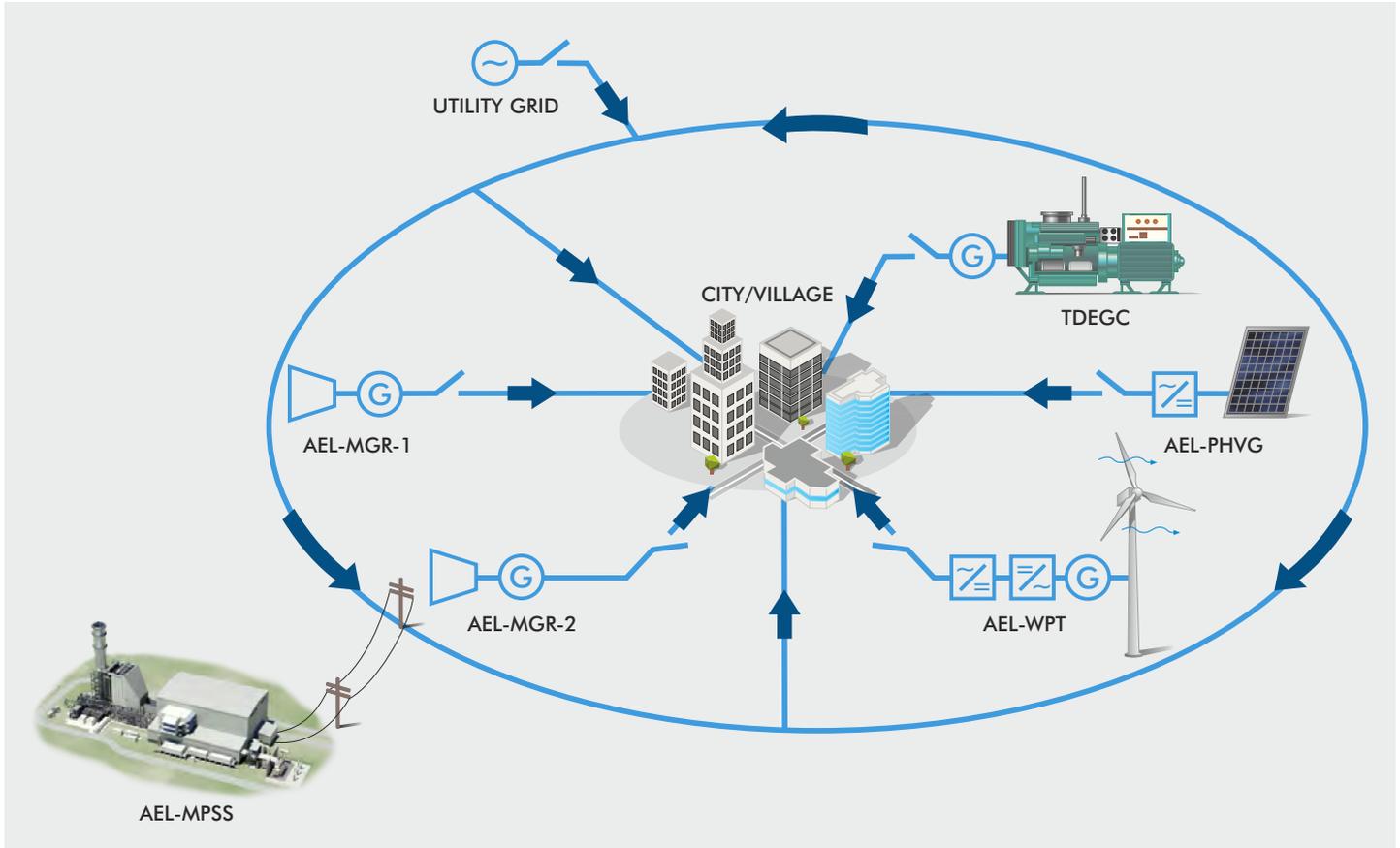


MICRO-GRIDS, A STEP TOWARD THE FUTURE



Key features:

- ▶ **Controlling of real micro grid devices.**
- ▶ **Studying of different renewable energy sources working in a micro-grid.**
- ▶ **Studying the behavior of a micro grid in stand-alone mode.**
- ▶ **Studying the behavior of a micro grid in isolated parallel or generator-to-generator operation.**
- ▶ **Controlling of multiple generators in a stand-alone grid.**
- ▶ **Controlling of multiple generators in parallel generation mode.**
- ▶ **Controlling the micro-grid connected to the utility grid (normal operation).**
- ▶ **Power factor, frequency and voltage control.**
- ▶ **Studying the behavior of a micro grid with wind turbines, photovoltaic panels and generators working in parallel.**
- ▶ **Power generation using renewable energy sources: Wind Energy, Photovoltaic Energy.**
- ▶ **Optional possibility of combining micro-grids with AEL-MPSS. Modular Smart Grid Power Systems.**

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 ↳ PRODUCTS  
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ISO 9001: Quality Management  
 (for Design, Manufacturing,  
 Commercialization and After-sales service)



European Union Certificate  
 (total safety)



Certificates ISO 14001 and  
 ECO-Management and Audit Scheme  
 (environmental management)



Worlddidac Quality Charter  
 Certificate and  
 Worlddidac Member

Imagine that all power that you require is close to you and the power flows do not need to travel hundreds and hundreds of kilometers up to the final consumer. Energy losses can be considerably reduced due to high voltage transmission lines and power transformers are less required.

Micro Grids play an important role for the progress of the world. Conventional energy sources are being depleted due to their overuse. It is very important to have in mind that renewable energies are the present and, especially, the future. They are of vital importance to reduce the pollution and the environment impact of non-renewable energy sources. Thus, there is a massive urgency to accelerate the utilization of distributed energy resources.

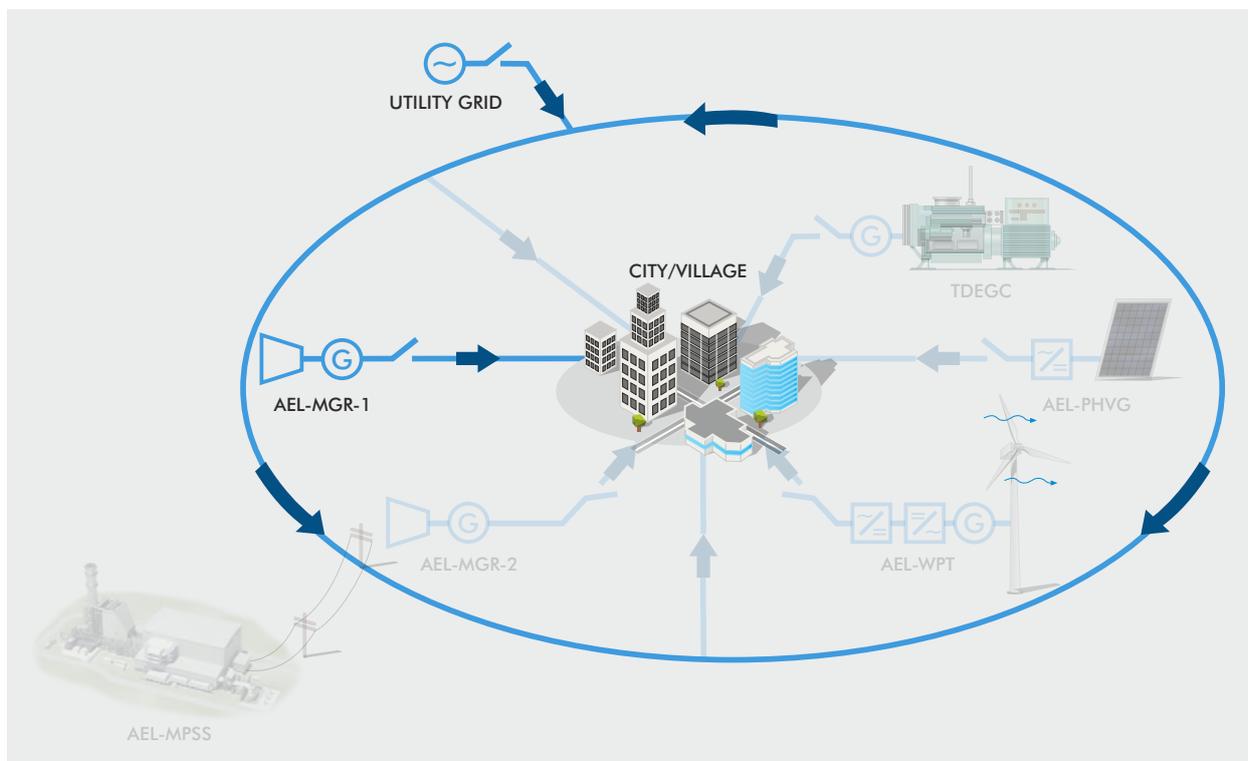
In the future great power plants that supply important amounts of energy to everywhere will not be necessary. A future without great transmission lines and power plants will be possible, with clean cities and countries without pollution. All these facts may come true if we reach a future where photovoltaic energy, wind energy, DC storage energy, etc. work together.

It is very important that everyone understand the importance of micro-grids and renewable energy sources for the world's sustainable future. For this purpose EDIBON International has designed a series of applications in order to demonstrate how micro grids work. Complete system AEL-MGR consists of the following applications which can work separately or together:

- AEL-MGR-1. **Stand-Alone and Parallel Generator Operations Application.**

Complementary micro-grids applications to AEL-MGR-1:

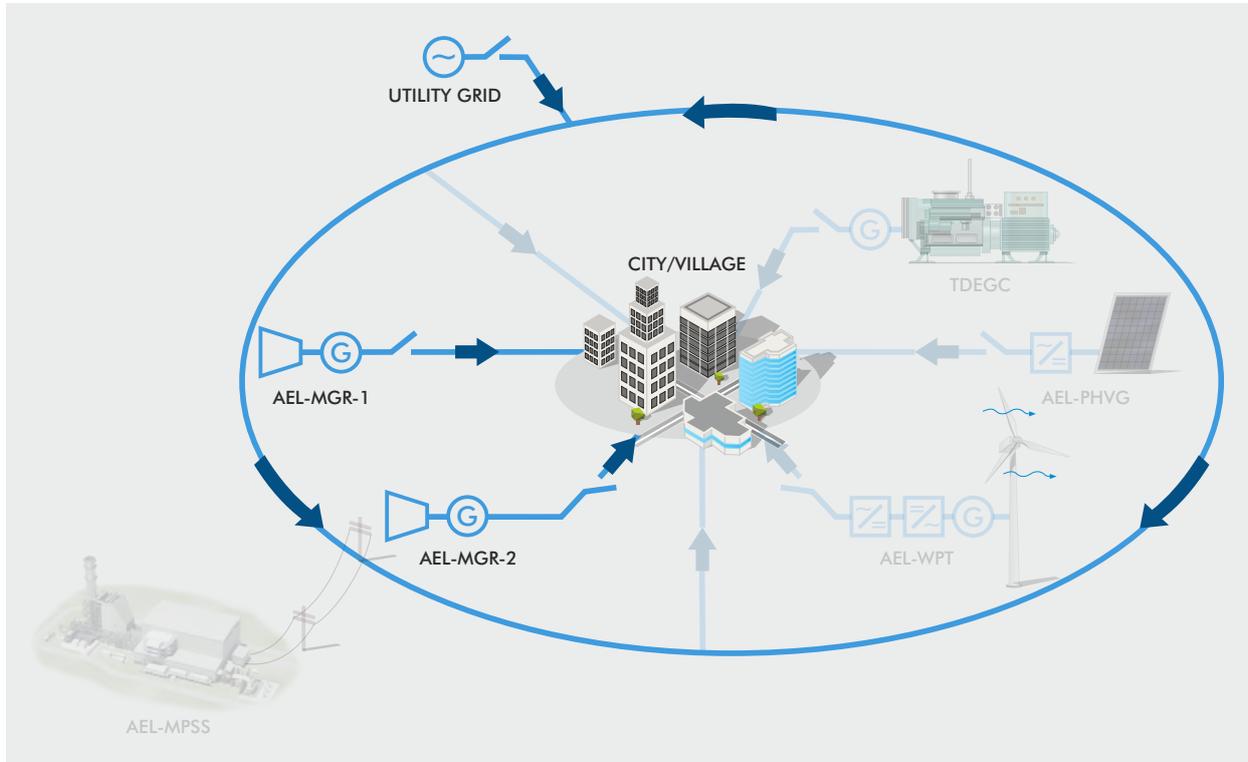
- AEL-MGR-2. **Isolated-Parallel Generator Operation Application.**
  - AEL-WPT. **Wind Power Trainer with Permanent Magnets Synchronous Generator.**
  - AEL-PHVG. **Photovoltaic Application with Connection to Grid.**
  - TDEGC. **Computer Controlled Diesel Engine Electrical Generator.**
- 
- AEL-MGR-1. **Stand-Alone and Parallel Generator Operations Application.**



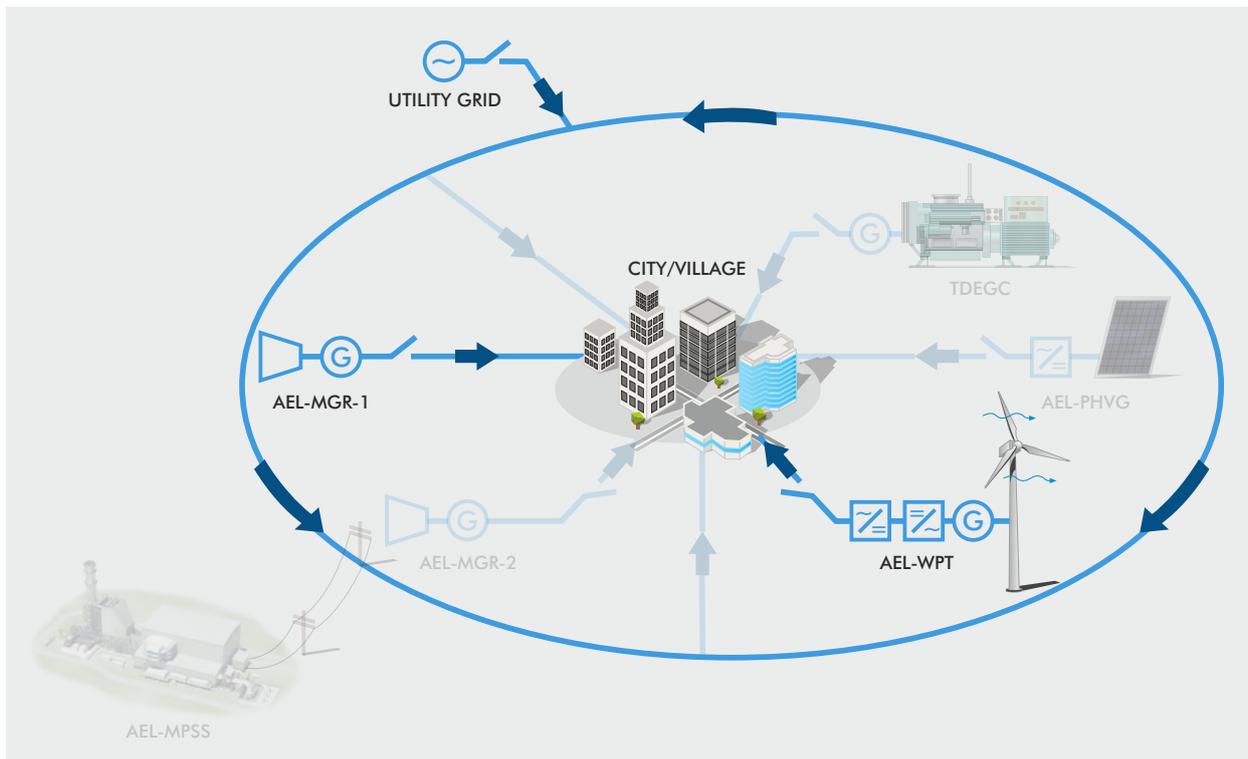
Complementary micro-grids applications to AEL-MGR-1:

The following applications have been designed to work together with the “AEL-MGR-1” application. According to the requirements, the user can assemble his own micro-grid adding any of the following applications.

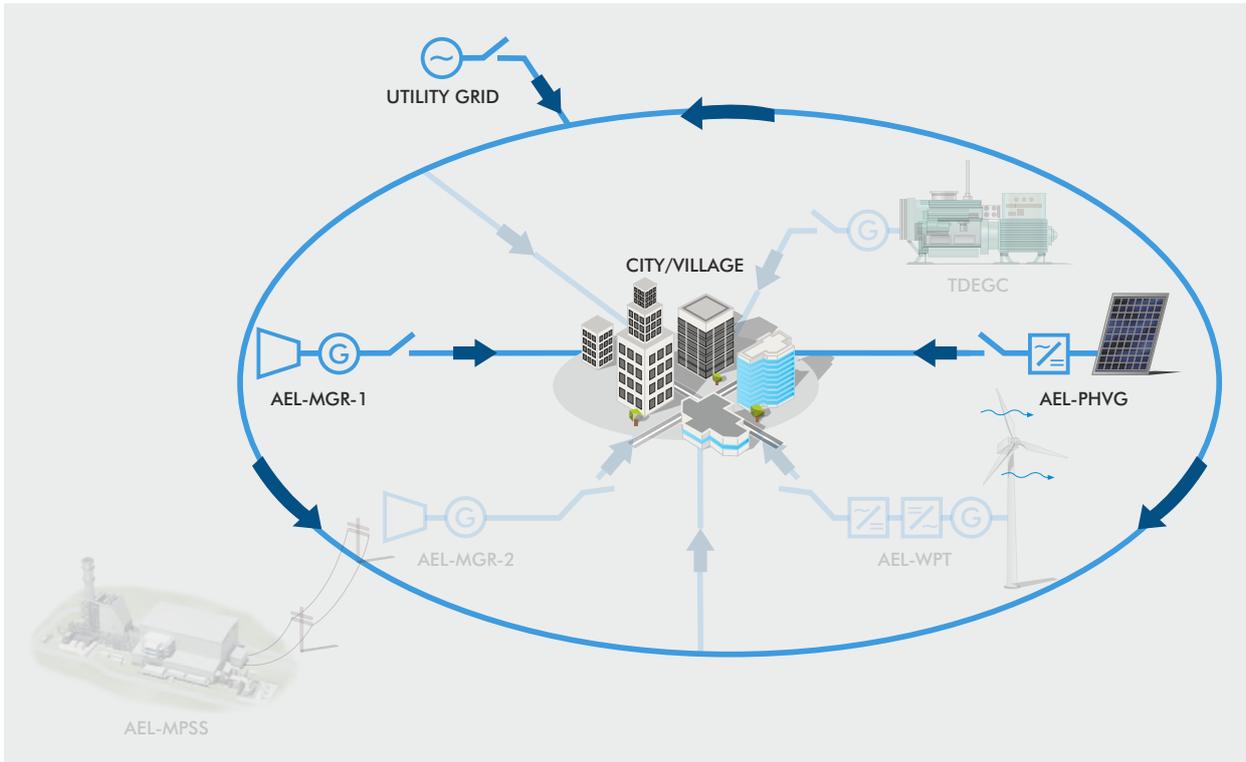
- AEL-MGR-2. **Isolated Parallel Operation Application.**



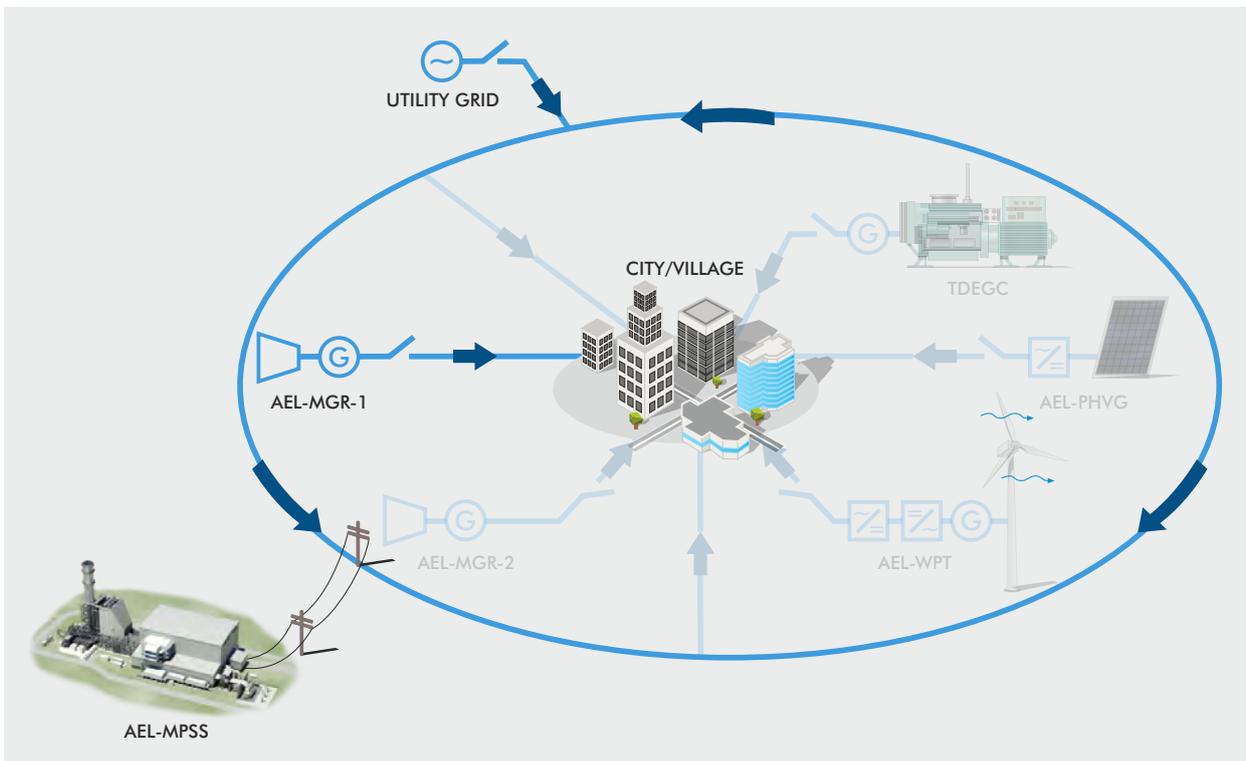
- AEL-WPT. **Wind Power Trainer with Permanent Magnets Synchronous Generator.**



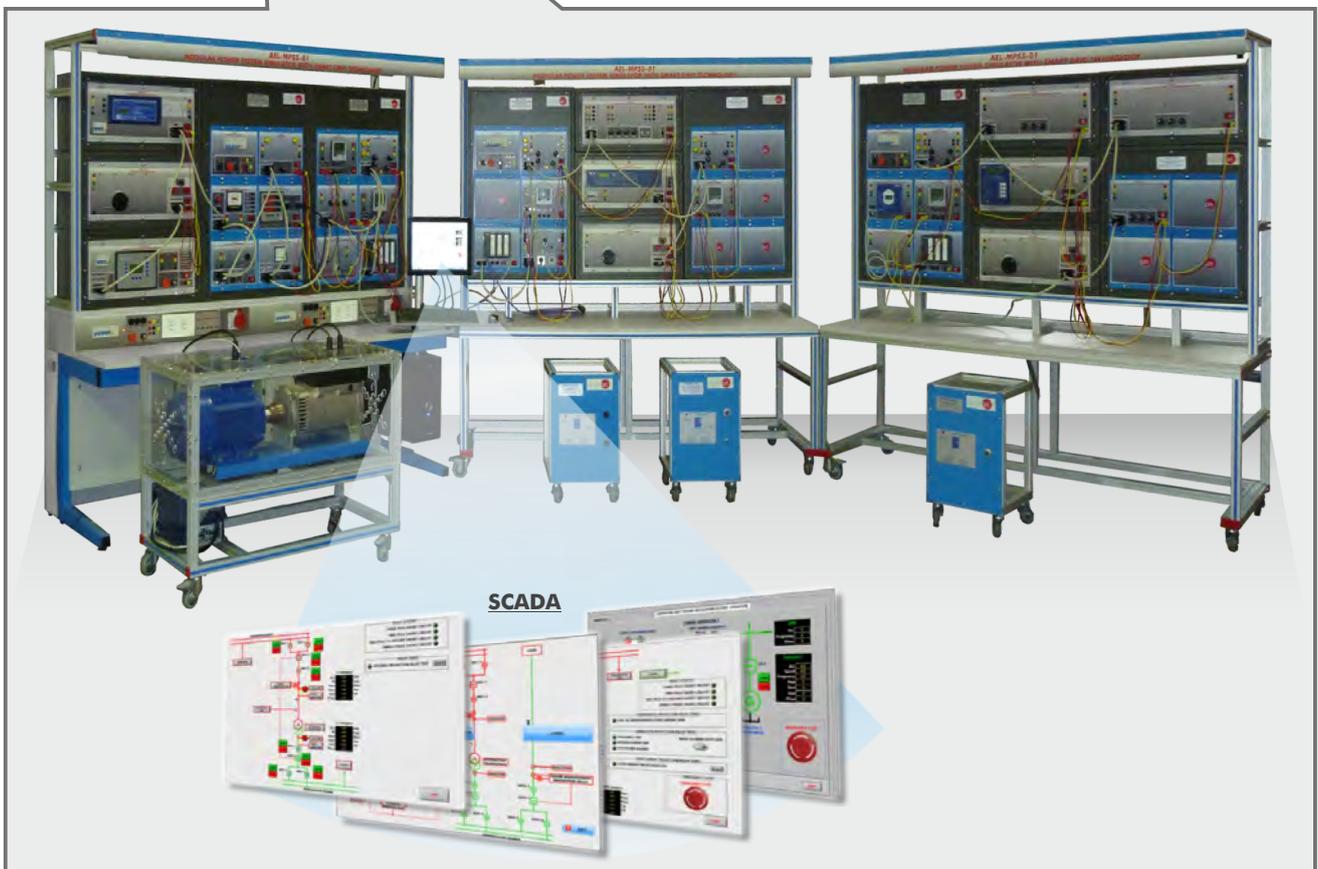
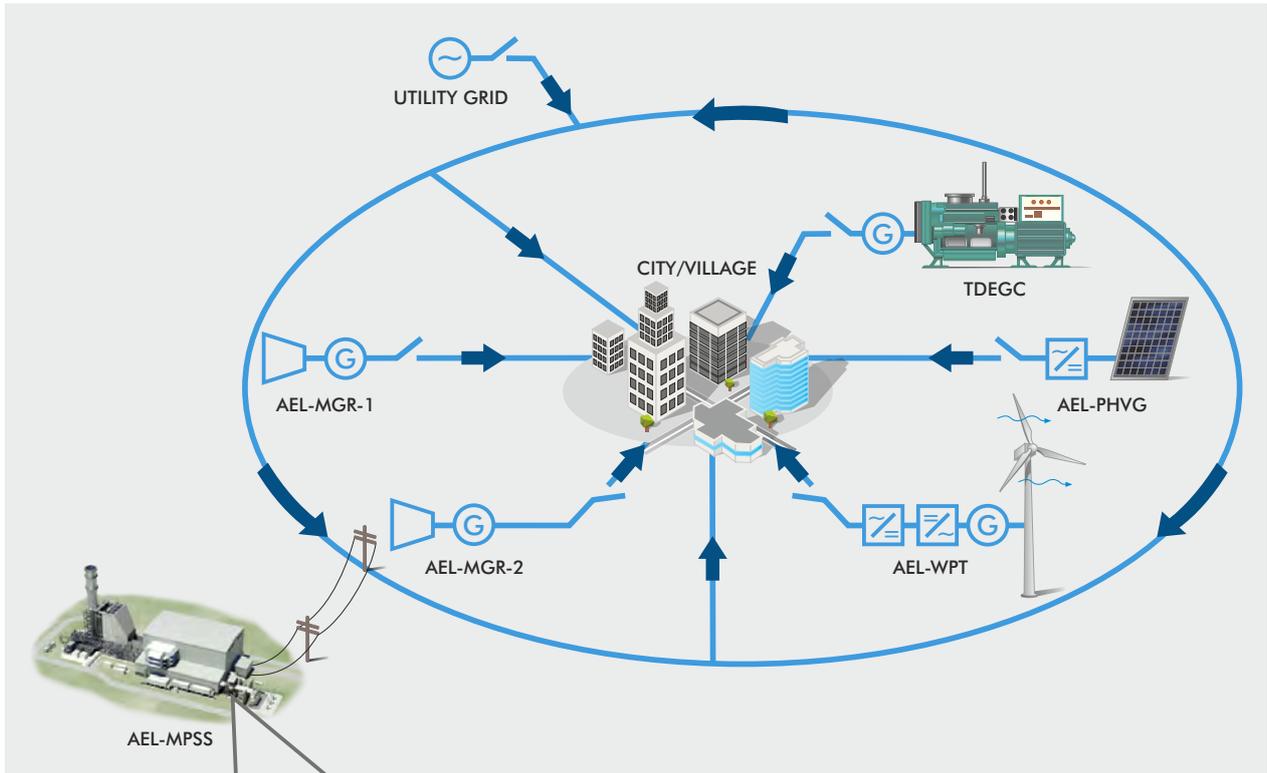
- AEL-PHVG. Photovoltaic Application with Connection to Grid.



- TDEGC. Computer Controlled Diesel Engine Electrical Generator.



### AEL-MPSS. Modular Smart Grid Power Systems



More information:

[www.edibon.com/products/catalogues/en/units/energy/smartgrid/AEL-MPSS.pdf](http://www.edibon.com/products/catalogues/en/units/energy/smartgrid/AEL-MPSS.pdf)

### AEL-MGR-1. Stand-Alone and Parallel Generator Operations Application

The "AEL-MGR-1" has been developed to show how carry out basic operations to control a generator which supplies power to a micro-grid: voltage stabilization, frequency control, synchronization both generator and the grid for load sharing, etc.

This application includes an advanced frequency and voltage controller that allows a perfect control over the synchronous generator. By changing a series of automatic switches the user can set between a manual or automatic frequency and voltage control of the synchronous generator. On this way, the user can be a simple supervisor of the electrical system, observing how current excitation and frequency change automatically, or he can take the whole control of the energy production.

Besides, this application includes an Advanced Network Analyzer module that allows smart metering of active, reactive and apparent power flows, currents, power factor and frequencies. According to the measured power values of the micro-grid the user can take decisions about the generator voltage and frequency parameters.

On the other hand, the application includes a series of resistive, inductive and capacitive loads in order to simulate different load consumptions. It is very important to consider that all devices used in this application are real and, for this reason, this application is a great opportunity for the students to learn how actual micro-grids work.

The application includes the following modules:

- Mobile Electrical Workbench (small).
- Three-Phase power supply: 400 VAC + GND.
- 1 kVA Synchronous Generator.
- 1.2 kVA Three-Phase Induction Motor of squirrel cage.
- Thermal protection for synchronous generator.
- Synchronoscope module.
- Frequency controller module.
- Variable DC power supply for synchronous generator current excitation with analog ammeter.
- Network Analyzer Module.
- Advanced Automatic Frequency and Voltage Controller (AVR).
- Three-Phase resistor load Module.
- Three-Phase inductive load Module.
- Three-Phase capacitive load Module.

Optional:

- SCADA system for remote control operations can be supplied as optional with the reference AEL-MGR-1S.

Some practical possibilities:

- 1.- Basic concepts of isolated, stand-alone grids.
- 2.- Manual control of voltage and frequency of the generator in a stand-alone grid.
- 3.- Automatic control of voltage and frequency of the generator in a stand-alone grid.
- 4.- Study of energy requirements and energy generation in stand-alone grids.
- 5.- Smart Metering of the generated energy.
- 6.- Studying of synchronous generator response when a load change is produced.
- 7.- Programming of synchronous generator controller working mode:

Some practical possibilities with AEL-MGR-1S (SCADA option):

- 9.- Remote manual control of voltage and frequency of the generator in a stand-alone grid.
- 10.- Remote automatic control of voltage and frequency of the generator in a stand-alone micro-grid.
- 11.- Real time measurement of generator electrical parameters.
- 12.- Remote control of open and close circuit breakers.
- 13.- Remote synchronization operation with synchronous generator and grid.



AEL-MGR-1. **Stand-Alone and Parallel Generator Operations Application** (continuation)

Technical specifications:

- Mobile Electrical Workbench (small).
- Three-Phase power supply: 400 VAC + GND.
- 1 kVA Synchronous Generator:
  - Three-Phase synchronous generator.
  - Synchronous speed: 3000 rpm.
  - 2 poles.
  - Nominal Power: 1 kVA.
  - Thermal protection for synchronous generator.
- 1.2 kVA Three-Phase Induction Motor of squirrel cage:
  - Three-Phase Induction Motor.
  - Nominal speed: 1870 rpm.
  - 2 poles.
  - Nominal Power: 1.2 kVA.
- Thermal protection for synchronous generator.
- Synchronoscope module:
  - Digital display for parameter setting and visualization.
  - Indicator lamps for visualization of phase angles degree.
  - 4 power connections for grid phases and neutral.
  - 4 power connections for synchronous generator phases.
  - 1 push-button to enable synchronization.
  - 1 push-button to disable synchronization.
- Frequency controller module.
- Variable DC power supply for synchronous generator current excitation with analog ammeter:
  - Power supply: 230 VAC.
  - Current range: 0-5 A.
  - Potentiometer for manual current excitation.
  - Enable/Disable control switch.
  - 7 pin power connector.
  - Analog ammeter: 0-10 A.
- Network Analyzer Module:
  - ON-OFF Switch.
  - 230 VAC supply voltage.
  - Input terminals: four input connections for voltage and current measurements.
  - Output terminals: four output connections to supply power.
  - Digital outputs: three digital outputs for pulses generation, alarms or combining both.
  - Fuses: 3x10A.
  - Network analyzer display:
    - Active, Reactive and Apparent Powers.
    - Active, Reactive and Apparent Energies.
    - Line and Phase Currents.
    - Lines and Phase Voltages.
    - Power Factor.
    - Harmonics.

AEL-MGR-1. **Stand-Alone and Parallel Generator Operations Application** (continuation)

Technical specifications: (continuation)

- Advanced Automatic Frequency and Voltage Controller (AVR):

Power supply: 230 VAC.

52G Circuit breaker for automatic synchronization.

Automatic current excitation controller.

Automatic frequency controller.

Switches control panel:

Parallel/island grid switch.

Local/Remote control switch.

Switch 1 for emergency stop.

Switch 2 for automatic starting.

Switch 3 for alarms reset.

Switch 4 to enable frequency control.

Switch 5 for synchronization permission.

Besides, this device includes the following protections:

Generator: maximum/minimum voltage (59/27), maximum/minimum frequency (81O/U), voltage asymmetry, detection of dead busbars, overvoltage (32), load unbalance (46), negative sequence power/reduced power (32R/F), overcurrent by defined curve (50/51), inverse time overcurrent (IEC255), measured ground fault (50N/51N), phases rotation phase rotation, fault of switches.

Motor: overspeed/subspeed (12).

Red: maximum/minimum voltage (59/27), maximum/minimum frequency (81O/U), vector jump, phase rotation.

- Three-Phase resistor load Module:

Three commutable resistive loads: 3x (3x150 Ohms).

- Three-Phase inductive load Module:

Three commutable inductive loads: 3x (3x1,4 H).

- Three-Phase capacitive load Module:

Three commutable capacitive loads: 3x (3x7 uF).

## AEL-MGR-2. Isolated Parallel Operation Application

The "AEL-MGR-2" has been developed as a complement to the "AEL-MGR-1" in order to show how carry out the control of multiple generators in parallel operation. With two parallel generators it is possible to supply power to a micro-grid as more realistic way, studying the voltage stabilization of the generators, frequency control, load sharing, etc.

Micro-grids can strengthen grid resilience and help mitigate grid disturbances because they are able to continue operating while the main grid is down, and they can function as a grid resource for faster system response and recovery.

This application includes an advanced frequency and voltage controller that allows a perfect control over the synchronous generator. By changing a series of automatic switches the user can set between a manual or automatic frequency and voltage control of the synchronous generator. On this way, the user can be a simple supervisor of the electrical system, observing how current excitation and frequency change automatically, or he can take the whole control of the energy production.

This application includes an Advanced Grid Analyzer module that allows smart metering of active, reactive and apparent power flows, currents, power factor and frequencies. According to the measured power values of the micro-grid the user can take decisions about the generator voltage and frequency control.

The application includes the following modules:

- Mobile Electrical Workbench (small).
- Three-Phase power supply: 400 VAC + GND.
- 1 kVA Synchronous Generator.
- 1.2 kVA Three Phase Induction Motor of squirrel cage.
- Thermal protection for synchronous generator.
- Synchronoscope module.
- Frequency controller module.
- Variable DC power supply for synchronous generator current excitation with analog ammeter.
- Network Analyzer Module.
- Advanced Automatic Frequency and Voltage Controller (AVR).

Optional:

- SCADA system for remote control operations can be supplied as optional with the reference AEL-MGR-2S.

Some practical possibilities:

- 1.- Control of multiple generators in a stand-alone grid.
- 2.- Control of multiple generators in parallel generation mode.
- 3.- Coordination of energy needs and generating capacity in stand-alone grids.
- 4.- Smart Metering of the generated energy by the generators.
- 5.- Manual control of voltage, frequency, power factor and torque.
- 6.- Manual control of voltage and frequency of the generator in a stand-alone and in parallel operation.
- 7.- Automatic control of voltage and frequency of the generator in a stand-alone and in parallel operation.
- 8.- Study of energy requirements and energy generation in stand-alone grids.
- 9.- Studying of synchronous generator response when a changing load is produced.
- 10.- Programming of synchronous generator controller working mode: base load and peak load coverage.
- 11.- Synchronization operations with two synchronous generators and grid.
- 12.- Synchronization operations with one synchronous generator and grid.
- 13.- Load sharing between two synchronous generators.

Some practical possibilities with AEL-MGR-2S (SCADA option):

- 14.- Remote control of multiple generators in a stand-alone grid.
- 15.- Remote control of multiple generators in parallel generation mode.
- 16.- Remote coordination of energy needs and generating capacity in stand-alone grids.
- 17.- Remote Smart Metering of the generated energy by the generators.
- 18.- Remote manual control of voltage, frequency, power factor and torque.
- 19.- Remote manual control of voltage and frequency of the generator in a stand-alone and in parallel operation.
- 20.- Remote automatic control of voltage and frequency of the generator in a stand-alone and in parallel operation.
- 21.- Remote synchronization operations with two synchronous generators and grid.
- 22.- Remote synchronization operations with one synchronous generator and grid.



AEL-MGR-2. **Isolated Parallel Operation Application** (continuation)

Technical specifications:

- Mobile Electrical Workbench (small).
- Three-Phase power supply: 400 VAC + GND.
- 1 kVA Synchronous Generator:
  - Three-Phase synchronous generator.
  - Synchronous speed: 3000 rpm.
  - 2 poles.
  - Nominal Power: 1 kVA.
  - Thermal protection for synchronous generator.
- 1.2 kVA Three-Phase Induction Motor of squirrel cage:
  - Three-Phase Induction Motor.
  - Nominal speed: 1870 rpm.
  - 2 poles.
  - Nominal Power: 1.2 kVA.
- Thermal protection for synchronous generator.
- Synchronoscope module:
  - Digital display for parameter setting and visualization.
  - Indicator lamps for visualization of phase angles degree.
  - 4 power connections for grid phases and neutral.
  - 4 power connections for synchronous generator phases.
  - 1 push-button to enable synchronization.
  - 1 push-button to disable synchronization.
- Frequency controller module.
- Variable DC power supply for synchronous generator current excitation with analog ammeter:
  - Power supply: 230 VAC.
  - Current range: 0-5 A.
  - Potentiometer for manual current excitation.
  - Enable/Disable control switch.
  - 7 pin power connector.
  - Analog ammeter: 0-10 A.
- Network Analyzer Module:
  - ON-OFF Switch.
  - 230 VAC supply voltage.
  - Input terminals: four input connections for voltage and current measurements.
  - Output terminals: four output connections to supply power.
  - Digital outputs: three digital outputs for pulses generation, alarms or combining both.
  - Fuses: 3x10A.
  - Network analyzer display:
    - Active, Reactive and Apparent Powers.
    - Active, Reactive and Apparent Energies.
    - Line and Phase Currents.
    - Lines and Phase Voltages.
    - Power Factor.
    - Harmonics.

AEL-MGR-2. **Isolated Parallel Operation Application** (continuation)

Technical specifications: (continuation)

- Advanced Automatic Frequency and Voltage Controller (AVR):

Power supply: 230 VAC.

52G Circuit breaker for automatic synchronization.

Automatic current excitation controller.

Automatic frequency controller.

Switches control panel:

Parallel/island grid switch.

Local/Remote control switch.

Switch 1 for emergency stop.

Switch 2 for automatic starting.

Switch 3 for alarms reset.

Switch 4 to enable frequency control.

Switch 5 for synchronization permission.

Besides, the device easYgen-2500 includes the following protections:

Generator: maximum/minimum voltage (59/27), maximum/minimum frequency (81O/U), voltage asymmetry, detection of dead busbars, overvoltage (32), load unbalance (46), negative sequence power/reduced power (32R/F), overcurrent by defined curve (50/51), inverse time overcurrent (IEC255), measured ground fault (50N/51N), phases rotation phase rotation, fault of switches.

Motor: overspeed/subspeed (12).

Red: maximum/minimum voltage (59/27), maximum/minimum frequency (81O/U), vector jump, phase rotation.

## AEL-WPT. **Wind Power Trainer with Permanent Magnets Synchronous Generator**

Renewable energies play an important role in the micro-grids field. For this reason, the "AEL-WPT" is a perfect complement to work together with the rest of micro-grid applications.

The Wind Power Trainer with Permanent Magnets Synchronous Generator (AEL-WPT) is an application designed to train the students in the main operations of wind turbines.

The wind speed is simulated through a three-phase squirrel cage of induction motor controlled through a frequency controller. This motor is coupled to a permanent magnet synchronous generator for energy production.

The energy produced by synchronous generator is converted to DC and managed through a grid inverter. The grid inverter supplies power to the micro-grid or directly to the grid.

This application includes an Advanced Grid Analyzer module that allows smart metering of active, reactive and apparent power flows, currents, power factor and frequencies. According to the measured power values of the micro-grid the user can take decisions about wind speed in order to produce/supply more or less power.

The application includes the following modules:

- Mobile Electrical Workbench (small).
- Industrial Main Power Supply.
- Three-Phase power supply: 400 VAC + GND.
- Permanent magnets synchronous three-phase generator.
- Asynchronous three-phase motor of squirrel cage.
- AC Motor Speed Controller.
- Network Analyzer Unit.
- Grid Inverter.

Optional:

- SCADA system for remote control operations can be supplied as optional with the reference AEL-WPTS.

Some practical possibilities:

- 1.- Voltage-Speed Characteristics of a Wind Turbine Generator.
- 2.- Power vs Wind Turbine Speed.
- 3.- Studying of active power production when the wind speed increases/decreases.
- 4.- Studying of grid inverter performances.

Some practical possibilities with AEL-WPTS (SCADA option):

- 5.- Monitoring and Data Acquisition wind turbine curves.
- 6.- Measurement of energy generation in function of the wind speed.
- 7.- Wind turbine response against wind speed changes.
- 8.- Studying of active power production when the wind speed increases/decreases.
- 9.- Studying of grid inverter performances.



AEL-WPT. **Wind Power Trainer with Permanent Magnets Synchronous Generator** (continuation)

Technical specifications:

- Mobile Electrical Workbench (small).
- Three-Phase power supply: 400 VAC + GND.
- Permanent magnets synchronous three-phase generator:
  - Three-Phase synchronous generator with permanent magnets.
  - Synchronous speed: 850 rpm.
  - 8 poles.
  - Nominal Power: 0.6 kVA.
- Asynchronous three-phase motor of squirrel cage:
  - Three-Phase asynchronous motor of squirrel cage.
  - Synchronous speed: 850 pm.
  - 8 poles.
  - Nominal Power: 0.75 kVA.
- AC Motor Speed Controller:
  - 230 VAC single phase power supply.
  - 0.75 kVA frequency controller.
  - Potentiometer for speed control.
  - Enable/Disable switch.
- Network Analyzer Unit:
  - ON-OFF Switch.
  - 230 VAC supply voltage.
  - Input terminals: four input connections for voltage and current measurements.
  - Output terminals: four output connections to supply power.
  - Digital outputs: three digital outputs for pulses generation, alarms or combining both.
  - Fuses: 3x10A.
  - Network analyzer display:
    - Active, Reactive and Apparent Powers.
    - Active, Reactive and Apparent Energies.
    - Line and Phase Currents.
    - Lines and Phase Voltages.
    - Power Factor.
    - Harmonics.
- Grid Inverter:
  - Automatic grid connection.
  - Internal protection against overvoltage and overcurrents.
  - Wide operating voltage.
  - Industrial-grade components with full power output.
  - Nominal power: 700 W.
  - Harmonics.

## AEL-PHVG. Photovoltaic Application with Connection to Grid

Renewable energies play an important role in the micro-grids field. For this reason, the "AEL-PHVG" is a perfect complement to work together with the rest of micro-grid applications.

The "AEL-PHVG" is an application designed to study the energy production by photovoltaic panels and how this energy is injected to the grid or to a micro-grid. This application can work together with other power generation sources to study the energy mix, their advantages and problems present when alternate sources are interconnected into a power system.

This application consists of the following elements:

- Mobile Electrical Workbench (small).
- Three-Phase power supply: 400 VAC + GND.
- 85W photovoltaic panel.
- Grid inverter.
- Panel with three halogen lamps: 3 x 250W.
- Current controller for halogen lamps intensity: 0-8 A.
- Circuit breaker to connect and disconnect the grid inverter to the grid.
- AC Network Analyzer to measure the energy produced for the photovoltaic panels.
- DC Network Analyzer to measure the energy produced for the photovoltaic panels.
- DC variable power supply to simulate the photovoltaic panel and to generate more power to the grid.

Optional:

- SCADA system for remote control operations can be supplied as optional with the reference AEL-PHVGs.

Some practical possibilities:

- 1.- Installation of photovoltaic systems.
- 2.- Configuring and testing of a photovoltaic system with feed to the electricity power grid.
- 3.- Measurement of energy generated by photovoltaic systems.
- 4.- Supplying of reactive power.
- 5.- Calculation of power grid inverter efficiency.
- 6.- Studying of the response of a photovoltaic system when there is a black-out on the grid.

Some practical possibilities with AEL-PHVGs (SCADA option):

- 7.- Maximum power point (MPP) tracking.
- 8.- Remote control of light intensity.
- 9.- Power output measurement according to the light intensity.



AEL-PHVG. **Photovoltaic Application with Connection to Grid** (continuation)

Technical specifications:

- Mobile Electrical Workbench (small).
- Three-Phase power supply: 400 VAC + GND.
- 85W photovoltaic panel:
  - Maximum power: 85 W.
  - Nominal voltage: 12 VDC.
- Grid inverter.
- Panel with three halogen lamps: 3 x 250W.
- Current controller for halogen lamps intensity: 0-8 A.
- Circuit breaker to connect and disconnect the grid inverter to the grid.
- AC Network Analyzer to measure the energy produced for the photovoltaic panels:
  - ON-OFF Switch.
  - 230 VAC supply voltage.
  - Input terminals: four input connections for voltage and current measurements.
  - Output terminals: four output connections to supply power.
  - Digital outputs: three digital outputs for pulses generation, alarms or combining both.
  - Fuses: 3x10A.
  - Network analyzer display:
    - Active, Reactive and Apparent Powers.
    - Active, Reactive and Apparent Energies.
    - Line and Phase Currents.
    - Lines and Phase Voltages.
    - Power Factor.
    - Harmonics.
- DC Network Analyzer to measure the energy produced for the photovoltaic panels:
  - ON-OFF switch.
  - 230 VAC power supply
  - Two input terminals for photovoltaic panels connection.
  - Two output terminals for grid inverter connection.
  - Digital display with push-buttons:
    - DC current measurement.
    - DC voltage measurement.
    - Power measurement.
    - Amperes per hour measurement (Ah).
    - Power energy measurement (Wh).
- DC variable power supply to simulate the photovoltaic panel and to generate more power to the grid:
  - Potentiometer to control the current output.
  - Output voltage range without load: 0-230 VDC.
  - Fuses: 1x5A.

## TDEGC. Computer Controlled Diesel Engine Electrical Generator

The TDEGC has been designed by EDIBON International to give teachers, students and researchers the most important knowledge about how works a real diesel engine-generator group. With the TDEGC unit the user can study the generator control in stand-alone mode and the synchronization with the grid for any power plant in general and the diesel generator group in particular.

The TDEGC unit can work together with many applications related to Smart Grids, Micro-Grids, Power Plants, Power Systems, etc.

- AEL-MPSS. Modular Smart Grid Power Systems Simulators (Utilities).
- AEL-CPSS. Compact Smart Grid Power Systems Application, with Automatic Control Generation, Transmission Line and Loads, with SCADA.
- APS12. Advanced Mechanical, Electrical and Smart Grid Power Systems.
- In general with several power systems units.

The TDEGC unit consists of the following elements and modules:

- Diesel Engine-Synchronous Generator Group.
- Control and Supervision Module.
- Instrumentation Module.
- Connection Diagram and SCADA Module.

Industrial load modules: Three-Phase Resistive Industrial Module, Three-Phase Inductive Industrial Module, Three-Phase Capacitive Industrial Module.

### Diesel Engine-Synchronous Generator Group:

Diesel engine has an electronic accelerator which is controlled by an Automatic Speed Controller to keep the speed constant independently of the load. On the other hand, diesel engine is coupled to a three-phase synchronous generator in order to transform chemical energy from a fuel to electrical energy. Synchronous generator has an Automatic Voltage Regulator to generate a constant voltage independently of the load consumption.

Automatic Speed Controller and Automatic Voltage Regulator work as primary control when the diesel engine and synchronous generator are working in stand-alone operation mode (without grid). The goal of these two controllers is to ensure that engine/generator always rotate at 1500 rpm/50 Hz or 1800 rpm/ 60 Hz (depending of the country frequency) and generate 400 VAC. However these two controllers are not enough when diesel engine – generator work in parallel with the grid. In this circumstance the TDEGC unit includes a secondary controller with four programmed PIDs: speed, voltage, power factor and active power PIDs. These PIDs allow the users to stabilize the machine in synchronism with the grid.

In addition secondary controller is very important for a complete protection of diesel engine electrical generator to avoid damages in the unit. The most important alarms are listed subsequently: over/undervoltage protection, overcurrent protection, reverse power protection, over/underfrequency protection, low level

fuel protection, low oil pressure protection, coolant high temperature protection, dirty filter alarm, etc.

### Control and Supervision Module:

This module is the brain of the TDEGC unit and consists of four important parts:

- Speed and voltage controller. It works as secondary controller. When the diesel engine electrical generator works in parallel operation with the grid four PIDs are working at the same time in order to establish the machine in synchronism with the National Grid. These PIDs are the following: speed, voltage, power factor and active power PIDs. The first two (speed and voltage PIDs) can be monitored from the SCADA in order to understand how the controller works.
- Alarms and operating conditions of the TDEGC unit. The speed and voltage controller works as protection relay too. On this way the unit is completely protected and safe. The following are some alarms/protections included in the unit: overvoltage, undervoltage, overfrequency, underfrequency, overcurrent, reverse power protections.

In addition, this module shows a series of operating conditions allowing the user to know the operating state of the machine. The following are the operating conditions shown in the control panel: ready for operation, start request, GCB synchronization conditions, remote closing signal for GCB synchronization, mains parallel operation, isolated operation, emergency stop, auxiliary services and starter signals.

- Maintenance operation panel. From this one the user can carry out a basic starting test disabling the secondary controller and working with the primary control alone. This function is very important when users work for the first time with the unit and it has to be checked.
- Back-Up protections panel. This panel consists of a differential protection relay and an overcurrent three-phase protection relay. These two protections give the unit a complete safety and reliability.

### Instrumentation Module:

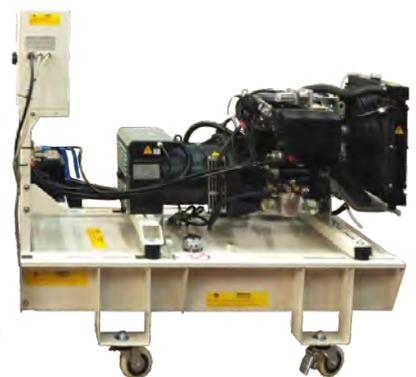
This module consist of a field dc power analyzer, an analog ammeter, a three phase generator power analyzer and a three phase grid power analyzer.

- Field DC Power Analyzer: field voltage, current and power measurements.
- Analog ammeter for field current excitation measurements.
- Synchronous generator power analyzer: three-phase output voltage, line currents, power factors, active power, reactive power, apparent powers, frequency, harmonics measurements.
- Grid power analyzer: three-phase output voltage, line currents, power factors, active powers, reactive powers, apparent powers, frequency, harmonics, measurements.



AEL-WBMP. Electrical Workbench (Mobile Small) including:

- Control and Supervision Module.
- Instrumentation Module.
- Connection Diagram and SCADA Module.
- Three-Phase Resistive Industrial Module.
- Three-Phase Inductive Industrial Module.
- Three-Phase Capacitive Industrial Module.



Diesel Engine-Electrical Generator Group.

TDEGC. Computer Controlled **Diesel Engine Electrical Generator** (continuation)**Connection Diagram and SCADA Module:**

This module includes all power and signal connectors, bus bars voltage indicator lamps, synchronization lamps and real diagram of generator, circuit breakers, grid and loads.

**Industrial load modules:**

Three-Phase Resistive Industrial Module, Three-Phase Inductive Industrial Module, Three-Phase Capacitive Industrial Module.

These modules allows user to simulate different industrial energy consumptions in order to study the generator and engine behavior in isolated operation mode.

**SCADA Control System:**

The TDEGC unit includes a SCADA Control System with which the user will manage and monitor a large amount of signals both manually and automatically. For example, start and stop diesel engine signals, fuel valve control signal, engine speed/frequency PID control signal, generator excitation PID control signal, opening and closing maneuvers of circuit breakers, etc.

Through the TDEGC's SCADA Control System the user can control and study the engine-generator group in stand-alone operation or in synchronism with the grid. For isolated operation the unit includes a series of commutable resistive, inductive and capacitive loads. On this way, the user can vary the active and reactive power to study the behavior of the engine and synchronous generator. For synchronization operation with the grid, the unit detects the presence of this; hence the speed and voltage secondary controller adjusts phase voltage angles and engine frequency in order to get synchronization conditions with the national grid. Other important characteristic is that the user can take the full control over the speed and excitation signals to manage the diesel engine-generator group manually.

On the other hand, through the TDEGC's SCADA System it is possible to acquire all electrical parameters such as generator output voltages, line currents, power factors, active powers, reactive powers, apparent powers, excitation voltage, excitation current, generator speed and frequency, PID speed and voltage signals, etc. Besides, the SCADA includes an oscilloscope that allows visualize generator voltage, current, active power and speed waves in order to carry out different analysis of the machine.

Some practical possibilities:

- 1.- Automatic speed control of the engine and generator in island.
- 2.- Manual speed control of the engine in island.
- 3.- Automatic excitation control of the three-phase synchronous generator.
- 4.- Manual excitation control of the three-phase synchronous generator.
- 5.- Automatic speed control of the engine in parallel with the grid.
- 6.- Manual speed control of the engine in parallel with the grid.
- 7.- Automatic excitation control of the synchronous generator in parallel with the grid.
- 8.- Manual excitation control of the synchronous generator in parallel with the grid.
- 9.- Control of the engine and generator in parallel generation mode (working with other generators).
- 10.-Coordination of energy needs and generating capacity in stand-alone grids.
- 11.-Active power waves measurement in real time and comparison with PID speed signal and engine.
- 12.-Smart Meter to measure the generated energy by the generator.
- 13.- Manual control of voltage, frequency, power factor and torque.
- 14.- Manual control of voltage and frequency of the generator in a stand-alone and in parallel operation (with any other generator).
- 15.- Automatic control of voltage and frequency of the generator/engine in a stand-alone or in parallel operation (with any other generator).
- 16.- Study of energy requirements and energy generation in stand-alone grid.
- 17.- Studying of synchronous generator/engine response when a change in load is produced.
- 18.- Synchronization operations of the one synchronous generator and the grid.

Other optional practical exercises:

- 19.- Synchronization operations with two synchronous generators and grid (with any other generator).
- 20.- Load sharing between two synchronous generators (with any other generator).

## TDEGC. Computer Controlled Diesel Engine Electrical Generator (continuation)

## Technical specifications:

- AEL-WBMP. Electrical Workbench (Mobile Small).

- Control and Supervision Module:

Enables to connect up to 16 diesel generators in parallel-island with distribution of active and reactive load and start/stop in function of the load demand.

Includes analogical outputs to control voltage and frequency regulators.

Three-phase measurements of the grid and generator voltage.

Three-phase measurements of the generator current and power.

Single-phase measurement of the grid current.

"island grid/parallel grid" sensor.

"local/remote control" digital signal.

Alarm indicators: over/undervoltage, reverse power, overcurrent, over/underfrequency, shutdown alarms and low level fuel.

Remote control signal states indicators: ready for operation, start request, GCB synchronization conditions, remote closing signal for GCB synchronization, mains parallel operation, isolated operation, emergency stop.

Maintenance panel: key of permission for maintenance, ignition switch, starter signal.

Back-Up protections: earth leakage relay, 3 phases overcurrent relay.

Generator protections: max/min-voltage (59/27), max/min-frequency (810/U), dead bus detection, reverse power/reduce (32R/F), overcurrent time defined curve (50/51), inverse time overcurrent (IEC255).

Motor: over/sub speed (12).

PID Power Factor Control.

PID Excitation Control.

PID Active Power Control.

PID Speed Control.

- Instrumentation Module:

- DC Power Analyzer:

Rated voltage range: 0-100 Vdc.

Rated current range: 0-10 A.

Communication port RS-485.

- DC Analog Ammeter:

Rated current range: 0-2.5A.

- AC Generator Power Analyzer:

Display for instantaneous variables: 3x3 digits.

Display for energies: 8+1 digits.

- Voltage:

VL-N = 185V to 460V.

VL-L = 320V to 800V.

- Current:

Phase Current : 0.03 to 10A.

Neutral Current : 0.09 to 10A.

Frequency: 48 to 62Hz 0.1Hz.

Power: Active, Reactive and Apparent.

Power Factor: Power factor for resistive, inductive and capacitive load types.



AEL-WBMP. Electrical Workbench (Mobile Small)

including:

- Control and Supervision Module.
- Instrumentation Module.
- Connection Diagram and SCADA Module.
- Three-Phase Resistive Industrial Module.
- Three-Phase Inductive Industrial Module.
- Three-Phase Capacitive Industrial Module.

TDEGC. **Computer Controlled Diesel Engine Electrical Generator** (continuation)

Technical specifications: (continuation)

AC Mains Power Analyzer:

Display for instantaneous variables:

3x3 digits.

Display for energies: 8+1 digits.

Voltage:

VL-N = 185V to 460V.

VL-L = 320V to 800V.

Current:

Phase Current : 0.03 to 10A.

Neutral Current : 0.09 to 10A

Frequency: 48 to 62Hz 0.1Hz.

Power: Active, Reactive and Apparent.

Power Factor: Power factor for resistive, inductive and capacitive load types.

- Connection Diagram and SCADA Module:

Panel with real diagram.

Emergency Stop Push-button.

3 Voltage indicators for three bus bar parts: generation indicator lamp, loads indicator lamp and mains indicator lamp.

3 synchronization lamps indicator.

GCB (generator circuit breaker) and MCB (mains circuit breaker) circuit breaker lamps.

P1 power connector for diesel engine-generator.

MAINS connector for synchronization operation.

USB 1 communication connector for maintenance operations.

ON-OFF switch.

230 VAC Power supply cable with single-phase plug.

230 VAC, 30mA differential protection.

- Three-Phase Resistive Industrial Module:

3 x 1kW three-phase resistor loads  
3x(3x150) ohms.

3 x manual commutators to change the resistive load.

3 x load indicator lamps.

- Three-Phase Inductive Industrial Module:

3 x 1kVar three-phase inductive loads.

3 x manual commutators to change the inductive load.

3 x load indicator lamps.

- Three-Phase Capacitive Industrial Module:

3 x 1kVar three-phase capacitive loads.

3 x manual commutators to change the capacitive load.

3 x load indicator lamps.

TDEGC. **Computer Controlled Diesel Engine Electrical Generator** (continuation)

Technical specifications: (continuation)

• Diesel Engine-Synchronous Generator

Group:

Diesel Engine:

4 stroke diesel engine with cylinders in line.

Liquid cooled with axial fan.

Forced lubrication with vane pump on the crankshaft.

Full flow external oil filter.

Water pump in the engine block.

Cylinder: 3.

Engine displ (cm<sup>3</sup>): 1028.

Injection system: IDI.

Compression ratio 22.8:1.

Nominal Power (kW/HP): 20 kW/26,8 HP.

Max torque (Nm/rpm): 67.0 / 2000.

Diesel Fuel.

Oil sump capacity (l): 2.4.

Physical characteristics:

H × L × W (mm): 519 × 516 × 412.

Dry weight (kg): 85.

Air filter.

Fuel tank: 160 l.

Synchronous generator:

Synchronous speed: 1500 rpm.

Nominal frequency: 50 Hz. (60 Hz on request).

Apparent power: 8 kVA.

Nominal voltage: 400 VAC.

Nominal current: 11 A

Power factor: 0,8.

Number of poles: 4.

Nominal current excitation: 1,5 A.

Nominal voltage excitation: 23,7 A.



Diesel Engine-Electrical Generator Group.

\*Specifications subject to change without previous notice, due to the convenience of improvements of the product.



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