Diesel-PV Solutions

Integration of photovoltaics into diesel grids

Ingeteam

Evolution of the price of Diesel and Solar systems

Diesel-PV Solutions

Integration of photovoltaics into diesel grids

The power generation from diesel gensets plays a key role for industrial companies and rural communities all over the world, especially in remote regions without a good grid infrastructure. They permit to create simple off-grid networks with a moderate initial investment.

However these applications have some disadvantages. First, the grid they create is totally dependent on diesel, which is a non-renewable and scarce energy source. On the other hand, the energy generated is expensive due to high prices of fuel and the difficulty of supplying and storing it. Furthermore, diesel-based systems have to face constant price increases and high OPEX -Operational Expenditures- directly related to the use of fuel.

Apart from that, CO_2 emissions increase with the use of gensets. This fact has to be taken into account, not only as a moral exigence towards global warming, but also because it could entail governmental fines, affecting operational expenditures.

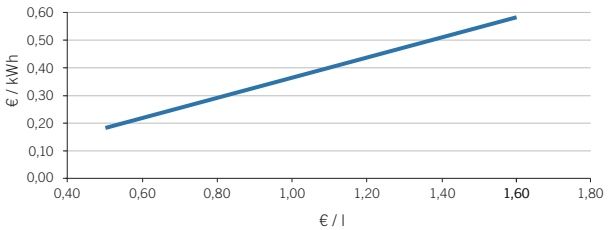
PV system prices have fallen in the last years, allowing nowadays generating energy to a more competitive cost compared to fuel. In regions with high solar irradiation levels and expensive fuel prices, PV systems can be amortized in less than four years. Furthermore, PV plants require little maintenance and they can be configured according to specific energy demands. Moreover, photovoltaics do not produce CO_2 emissions.

The integration of PV systems into diesel grids offers large industries and rural communities a way of saving fuel with a natural and renewable resource. This can be achieved by adding INGECON® SUN PV inverters and Ingeteam's Diesel-PV controllers to the diesel grid. The use of photovoltaics reduces the energy generated by the gensets and, therefore, the fuel consumption.

Challenges of Diesel-PV integration:

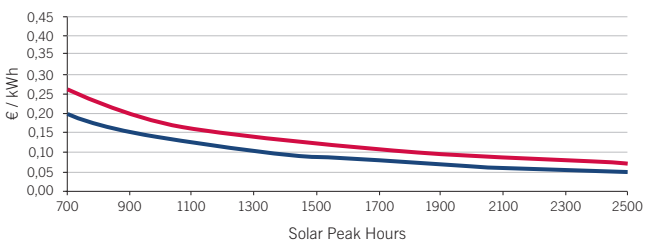
- To guarantee a minimum load for the generators, to ensure longer engine life.
- To protect against reverse power, in case of a total load disconnection.
- To ensure stability against irradiance variations due to cloud shading.

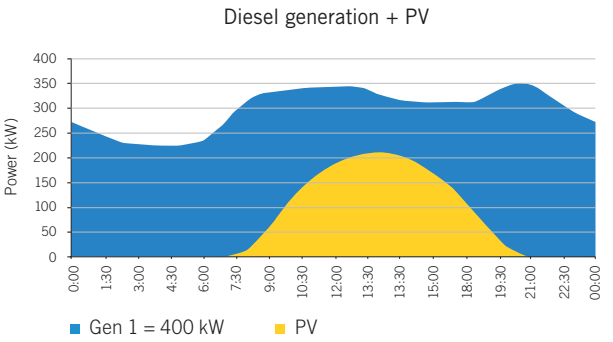
Levelized cost of energy on genset systems

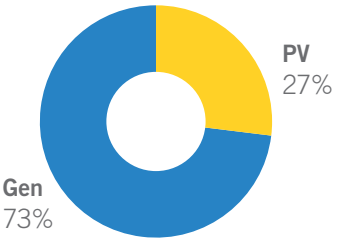


PV_{CapEX}= 2 - 1,5 €/Wp (> 1 MW); PV_{OpEx}:1,5% annual; Degradation: 0,4 annual; PR=0,85;
Diesel CapEX=0,3 €/W (> 1 MW); O&M=3% annual; Diesel cost: actual price + 3% annual
Interest loan= 6,4%; 12 years
Time: 20 years

Levelized cost of energy on PV based systems







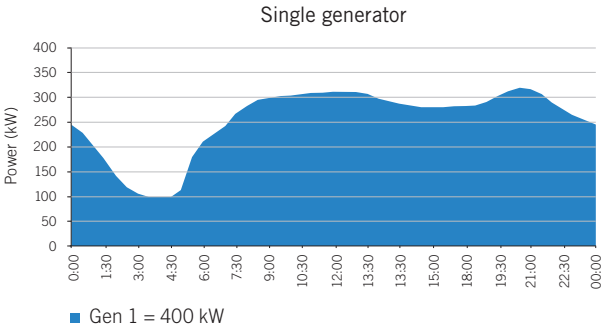
A scalable system to satisfy every project needs

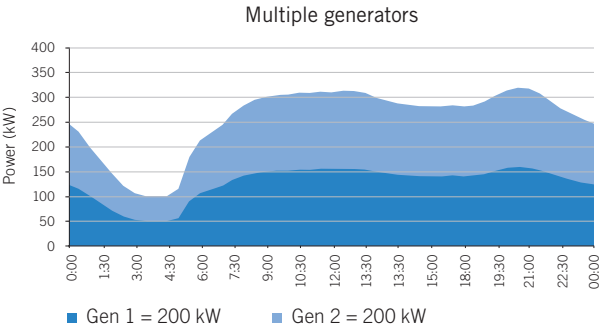
Ingeteam's Diesel-PV controllers monitor the power flows of the system and manage the PV injected to the diesel grid in order to guarantee the system stability, allowing achieving up to a 70 percent of PV penetration compared to the total diesel capacity.

Diesel systems can be classified in two main types depending on the generators operation: continuous operation diesel systems or on-demand diesel systems. Continuous operation diesel systems are based on one or more gensets operating permanently, no matter the load level. On-demand diesel systems feature an external controller that selects the number of gensets that will operate depending on the load requirement.

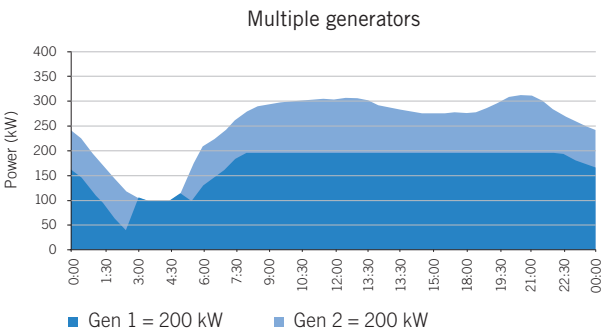
Ingeteam has developed different solutions for each system type that can be easily implemented in both new and already existing diesel systems.

Continuous operation diesel systems



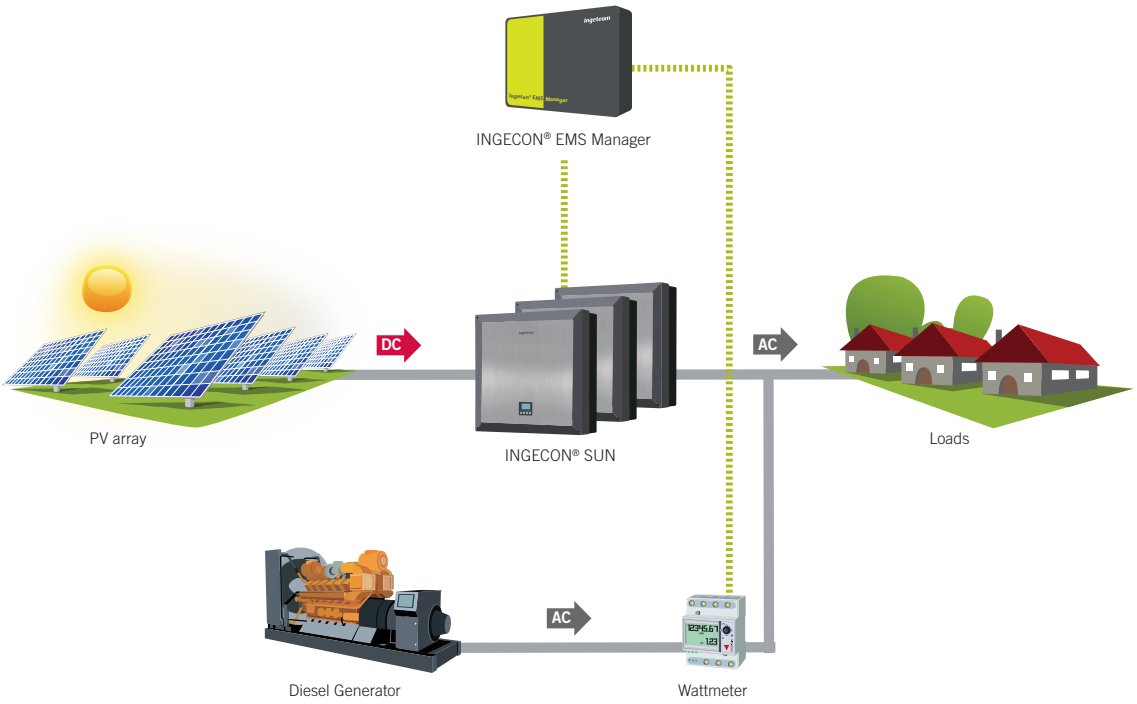


On-demand diesel systems



Continuous operation diesel systems

Schema with INGECON® EMS Manager



Operating mode
In those cases in which one or more gensets are operating permanently to satisfy the energy demand, the INGECON® EMS Manager can be used to control the PV inverters.

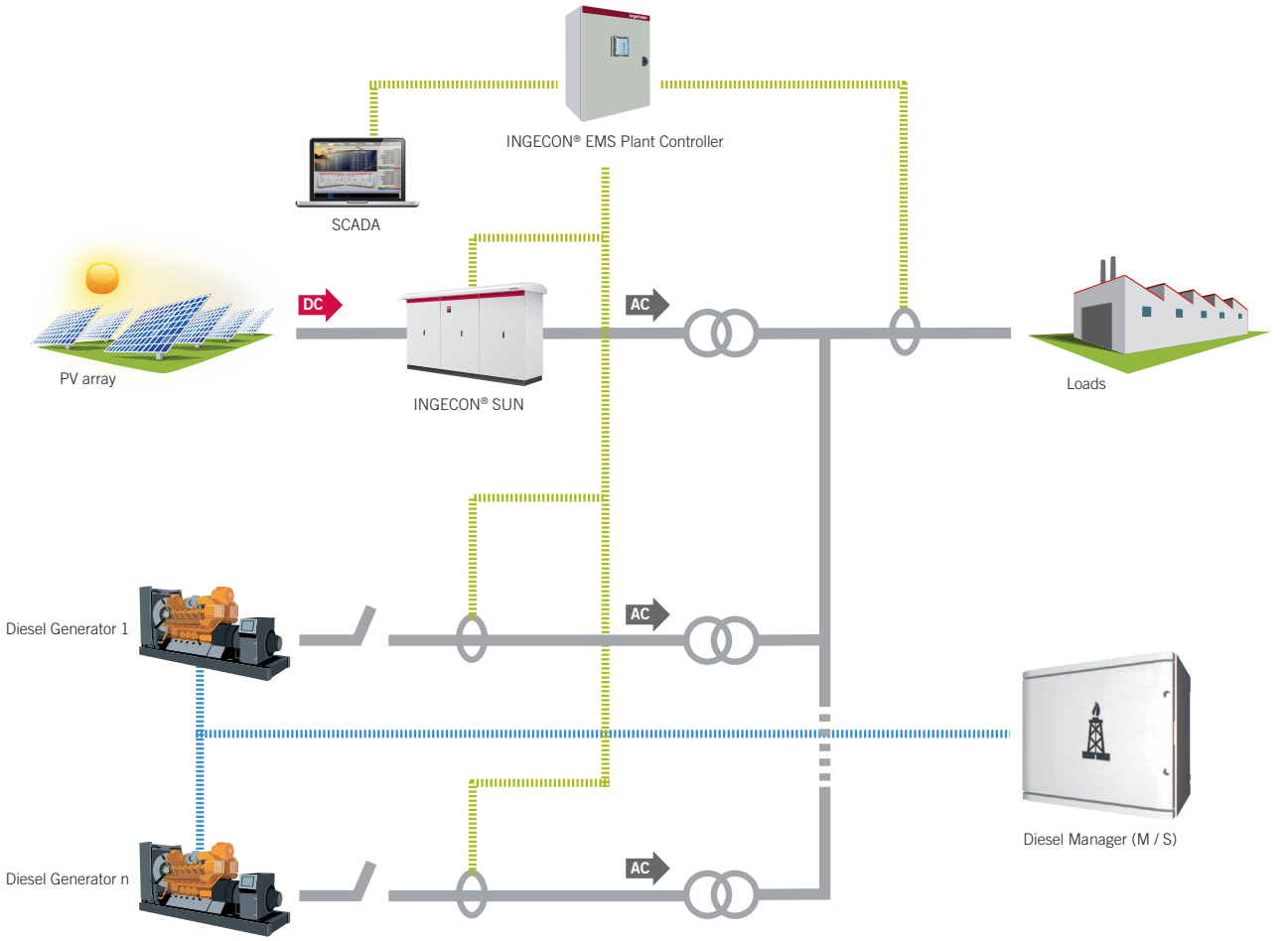
Photovoltaic inverters inject current to the diesel grid, being detected by the genset as a load reduction. INGECON® EMS Manager will control the energy production of the PV inverters depending on the energy required by the loads. Moreover, it will also act as a communications center, as it enables to remotely access all the system's relevant data.

Elements of the Diesel-PV Solution:
- INGECON® SUN PV inverters
- INGECON® EMS Manager
- Wattmeter

System features:
- Minimum diesel load
  It guarantees that the diesel generator does not operate under a minimum load level, in order to ensure a longer engine life.
- Reverse power protection
  It avoids a power flow from the inverter to the genset, for example, in the event of a total load disconnection.
- Stability against irradiance variations
  In continuous operation diesel systems, stability against irradiance variation it is guaranteed by the spinning reserve of the genset, previously sized for the maximum possible load.
- Monitoring
  The installation can be monitored by using the software INGECON® EMS Tools. Also, an internal datalogger allows to store more than 30 days historical data.
- Load control
  The INGECON® EMS Manager allows switching loads on when the genset load level is low and there is a PV generation surplus.

On-demand diesel systems

Schema with INGECON® EMS Plant Controller



Operating mode

In those cases in which an external diesel controller determines the number of operating gensets, the INGECON® EMS Plant Controller is used to guarantee a proper PV integration in the diesel grid.

Photovoltaic inverters inject current to the diesel grid, being detected by the genset as a load reduction. INGECON® EMS Plant Controller monitors the genset units, obtaining which ones are operating as well as their load level. This information is used to determine the maximum power that the solar inverters can supply in order to guarantee the system stability, i.e. in a cloud shading event.

The monitoring process of the genset units can be made by a Power Meter device or by an Ethernet Modbus / TCP straight from the genset (if available). The general system can be monitored via SCADA or dedicated software.

Elements of the Diesel-PV Solution:

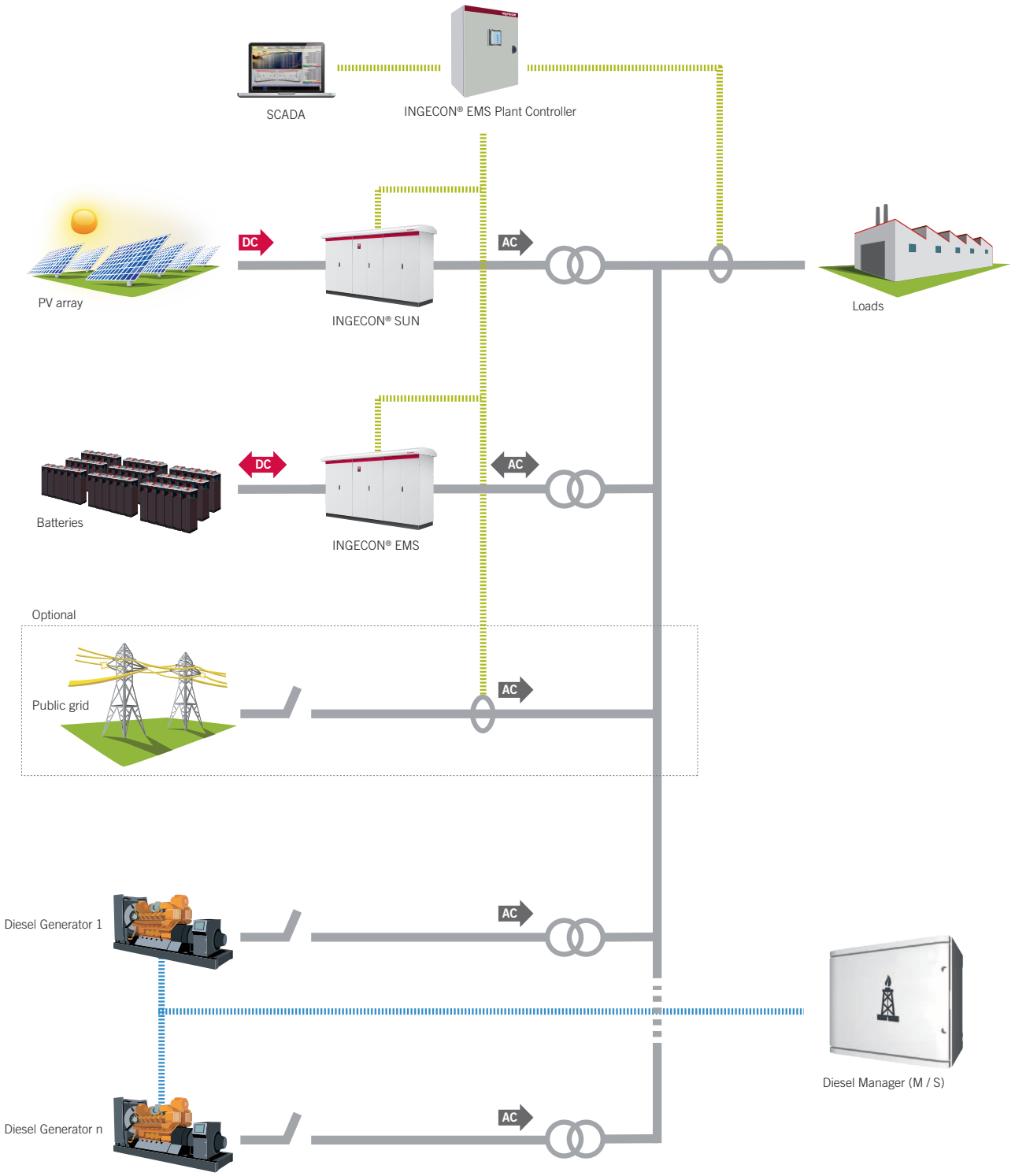
- INGECON® SUN PV inverters
- INGECON® EMS Plant Controller (PLC, communication switch, power supply and protections)
- Power Meter Unit (wattmeter, communication switch, power supply and protections)

System features:

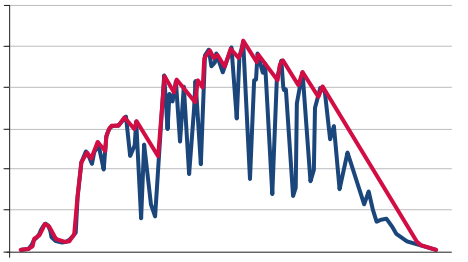
- Minimum diesel load
  It guarantees that the diesel generators do not operate under a minimum load level, in order to ensure a longer engine life.
- Reverse power protection
  It avoids a power flow from the inverter to the genset, for example, in the event of a total load disconnection.
- Stability against irradiance variations
  INGECON® EMS Plant Controller limits the PV output power to guarantee that the available spinning reserve is enough to meet the energy demand in a cloud shading event.
- Monitoring
  The installation can be monitored by using a SCADA.
- Reactive Power Support
  from the PV inverters, for those installations with high reactive power consumption.

On-demand diesel systems

Schema with INGECON® EMS Plant Controller and energy storage



A battery bank adds many advantages
The addition of an energy storage system allows increasing the PV penetration. In this case, the spinning reserve is not needed to absorb the irradiance variations in the plant, because the batteries supply the necessary power when PV generation decreases due to passing clouds.



Operating mode
Photovoltaic inverters inject current to the diesel grid, being detected by the genset as a load reduction. INGECON® EMS Plant Controller monitors the loads and determines the maximum PV power that can be injected into the diesel grid. Furthermore, in a cloud shading event, the INGECON® EMS Plant Controller together with the battery inverters INGECON® EMS Plants, reduce the output power with a established ramp rate, that will allow to the diesel controller to switch-on the required generators.

In these installations, the storage system has to provide the energy needed for the genset start-up.

The system can be monitored via SCADA or dedicated software.

Elements of the Diesel-PV Solution:
- INGECON® SUN PV inverters
- INGECON® EMS Plant Controller (PLC, communication switch, power supply and protections)
- INGECON® EMS Plants battery inverters
- Power Meter Unit (wattmeter, communication switch, power supply and protections)

System features:
- Minimum diesel generation. It guarantees that the diesel generators provide a minimum energy level, in order to guarantee the grid stability when load steps happen, or the loads are unbalanced or they present current harmonics.
- Reverse power protection. It avoids a power flow from the inverter to the genset, for example, in the event of a total load disconnection.
- Stability against irradiance variations. INGECON® EMS Plant Controller together with the battery inverters INGECON® EMS Plants, guarantee system stability in a cloud shading event.
- Monitoring. The installation can be monitored by using a SCADA.
- Reactive Power Support from the PV inverters, for those installations with high reactive power consumption.

OPTIONAL

- Public grid power flow management (if available).

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