Enel Global Infrastructure and Networks MG activities and results

15/06/2018

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Italian islands power system

Italian minor islands MG enhancement

Microgrid Central Station (MCS) and grid

Goals: Enhance the island energy efficiency, increase the hosting capacity and improve the quality of supply and the power quality. All Enel group involved.

Control architecture: Two-layer hierarchy control, with strong or weak communication; innovative control and protection scheme.

Data exchange with regional SCADAs: Good measures and grid states exchange, but weak commands exchange; central controller does not need external intervention.

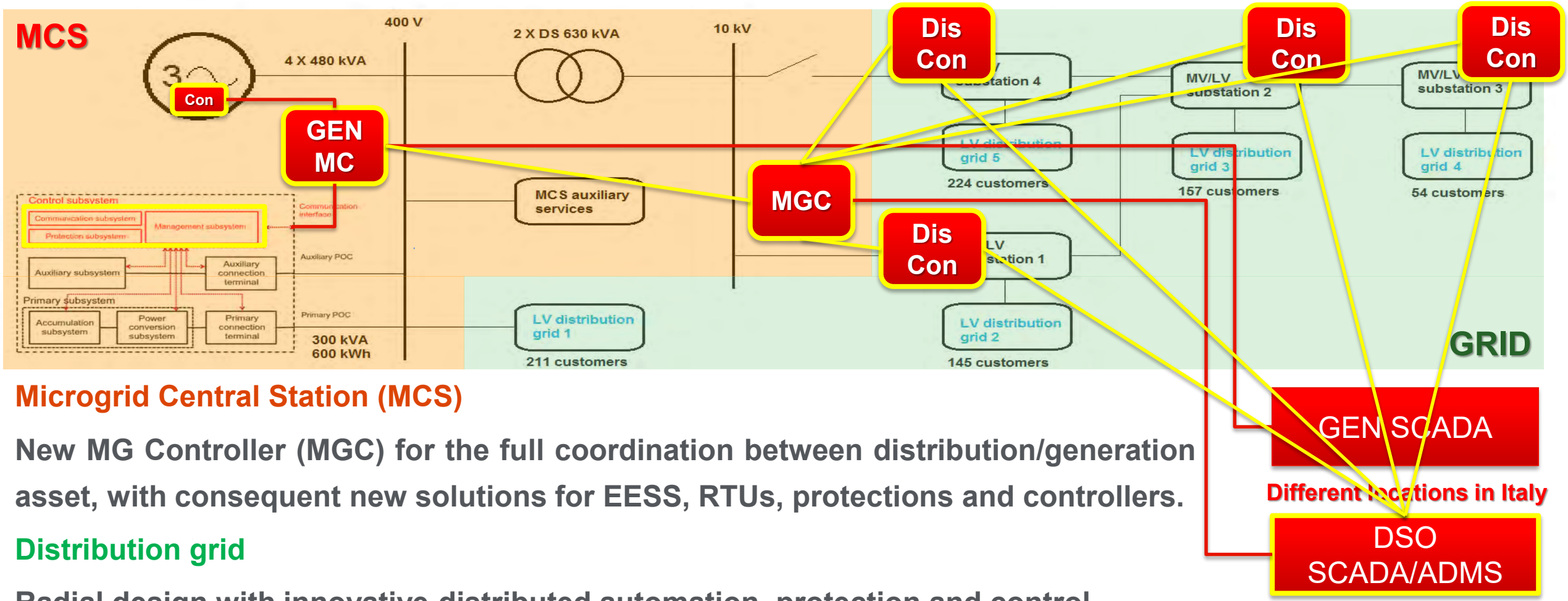
Central controller (MGC in the MCS): MG load/generation balance management (MG security management), MG operating modes management, MG voltage control, MG automation and protection management.

Main controller (MC in the MCS): MCS efficiency management, frequency control for entire MG and voltage control in the MCS by according to the setting received by the central controller.

Slave controllers (DSO SC or in customers SC): MG automation and protection management (DSO SC), customers can select to enable their flexibility by own SC or stay AS IS today receiving in any case the benefits of an enhanced MG.

Italian minor islands MG enhancement

Open MG control architecture



Microgrid Central Station (MCS)

New MG Controller (MGC) for the full coordination between distribution/generation asset, with consequent new solutions for EESS, RTUs, protections and controllers.

Distribution grid

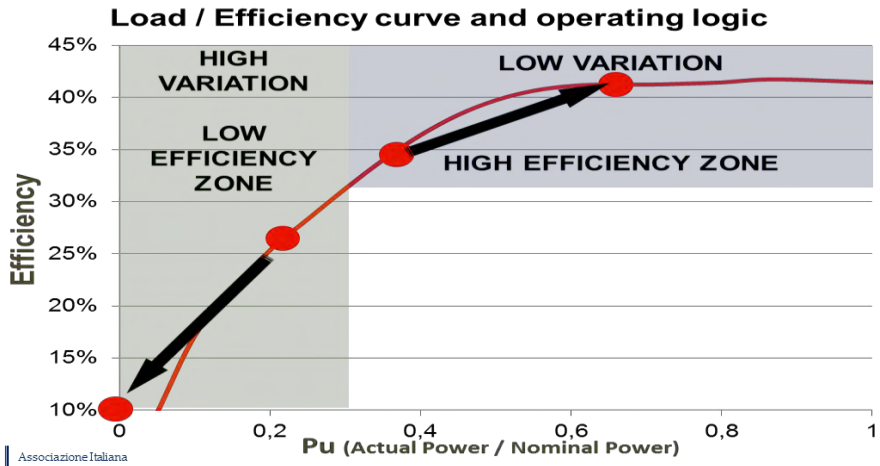
Radial design with innovative distributed automation, protection and control.

Italian minor islands MG enhancement
Efficiency improvement trough EESS integration

Solution

Integration of EESS (Electrical Energy Storage System) with the diesel power station to:

- **Guarantee a more efficient operation of diesel engines (fuel savings).**
- **Maintain reliability, prevent outages, increase power quality and hosting capacity.**
- **Minimize O&M costs and increase lifetime of conventional assets.**



Operation Mode developed by Enel Global Thermal Generation

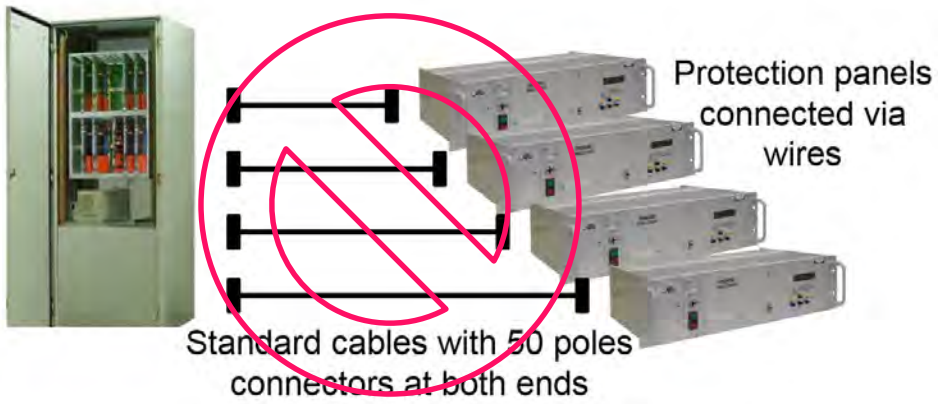
Concept similar to the hybrid vehicle operation:

1. **Use of Energy Storage System to switch off or "push" Diesel engines running toward higher efficiency points.**
2. **Smoothing load variations due to the high variability of the island load profile.**

Italian minor islands MG enhancement

Fully digitalized MG

Traditional MCS



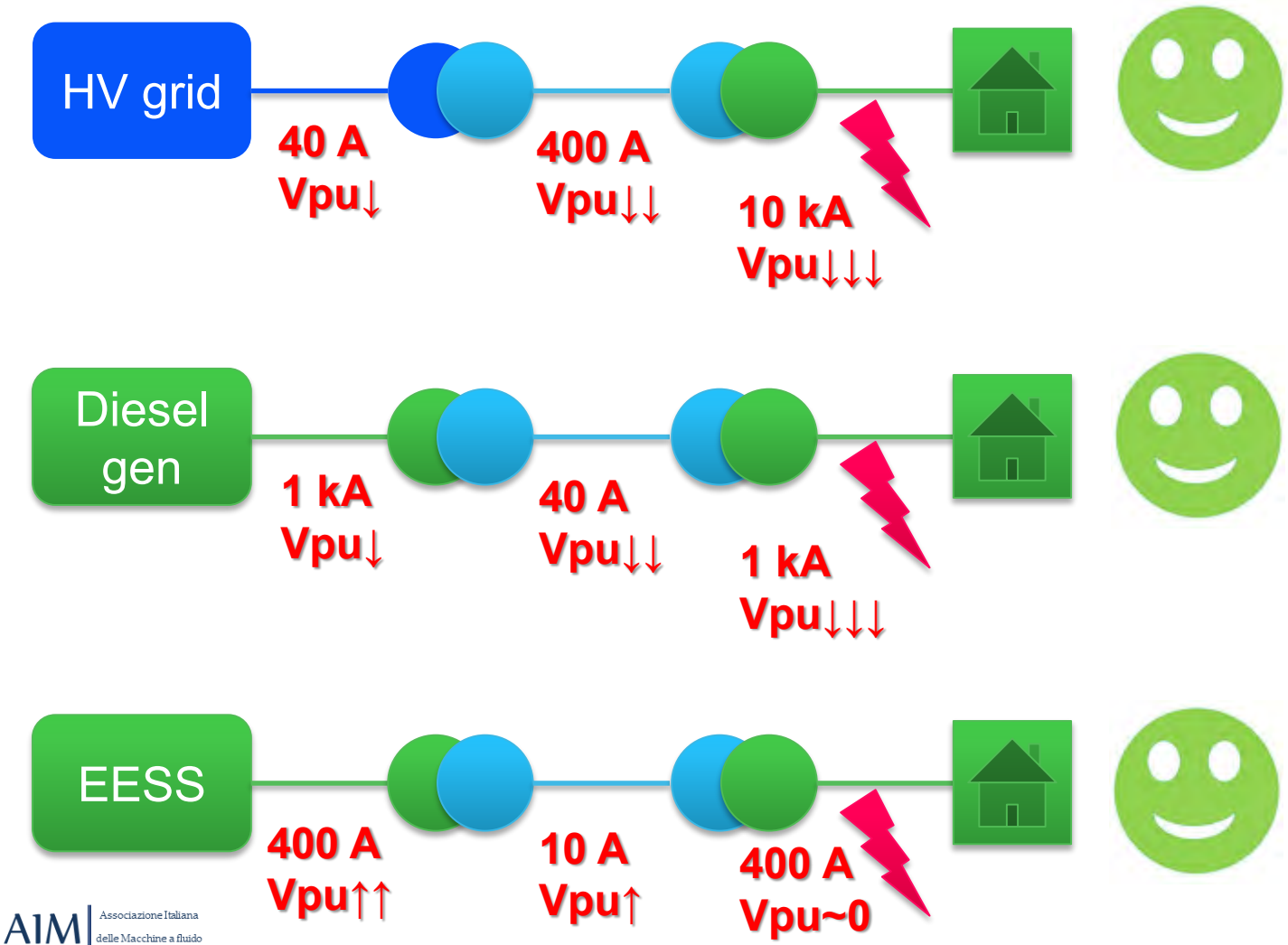
Digitalized MCS

Fully integrated modular smart control/protection devices trough fiber optic network.

- **The MCS will be fully digitalized with fully integrated modular smart control/protection devices trough fiber optic network that will be extended in the MV grid.**
- **Two-layer hierarchy control will be applied between central, master and slaves controllers; the control system will work also in case of weak communication.**
- **All the MV/LV substations will be also digitalized with a similar design of MCS.**
- **LV grid will be controlled with weak communication approach, to avoid expensive extension of the fiber optic network, but possible in the future, if needed.**
- **Also connection to the central SCADAs will be with weak communication approach; without any MG security reduction.**

Focus on MG protection

Innovative protection scheme in MGs



The innovative MG control architecture will enable an innovative protection scheme that will use the advanced fault ride through (aFRT) and an enhanced correlation between traditional protections and grid measures.

This innovative scheme will be effective in any situation:

- **grid-connected mode;**
- **islanded mode;**
- **both grid-connected and islanded mode.**

By assuring selectivity, sensitivity and speed.

Rural electrification

Rural electrification
Classification

Decentralized rural electrification (DRES) systems are designed to supply electric power for sites which are not connected to an electricity network.

They provide basic electricity access for household, community services (public lighting, pumping, health centres, administrative buildings, places of worship, cultural activities) and for economic activities in the form of micro-industry, workshops or agriculture.

DRES fall into three basic categories:

- **Process electrification systems (PES), for example for irrigation and the pumping of ground water.**
- **Individual electrification systems (IES) for sparsely populated regions or isolated individual households.**
- **Collective electrification systems (CES) for more densely populated areas, for example a village.**

Process and individual electrification systems comprise a relatively simple electricity generation system combined with a single electrical installation. Collective electrification systems also include a distribution system (MG) and interface equipment that links the individual electrical installation of each user to the MG.

Collective electrification system project
Pilot in Colombia

The non-interconnected areas (ZNI in Spanish), are defined in Colombia by the Article 11 of the Law 143 of 1994 and delimited and categorized by the resolution 18 2138 of CREG in 2007, as areas “where it is not provided the electric public service through the National Interconnected System (SIN – Sistema Interconectado Nacional)”

Characteristics

- Long distances till the main urbar areas
- Very low population density
- Rugged geography, climate diversity
- Complicated installations and connection to SIN

Data of interest

- Occupancy of **52% of the territory of Colombia**
- **1,8 million inhabitants** (3,7% of Colombian population)
- 90 municipalities (1448 towns (8% total municipalities)
- 20 special border territories and with high biodiversity
- 5 department capitals
- 39 municipality heads

Solutions

- Interconnection to SIN. High cost
- Electrification through micro-grids. Lower cost

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Collective electrification system project
Pilot in Colombia

ENEL objective

- Develop a first Microgrid pilot project that allow Enel demonstrate and gain experience for future massive implementation in the ZNI's:
  - ✓ Technical / technological issues
  - ✓ Planning and design
  - ✓ Operation & Maintenance
  - ✓ Cost-benefit analysis

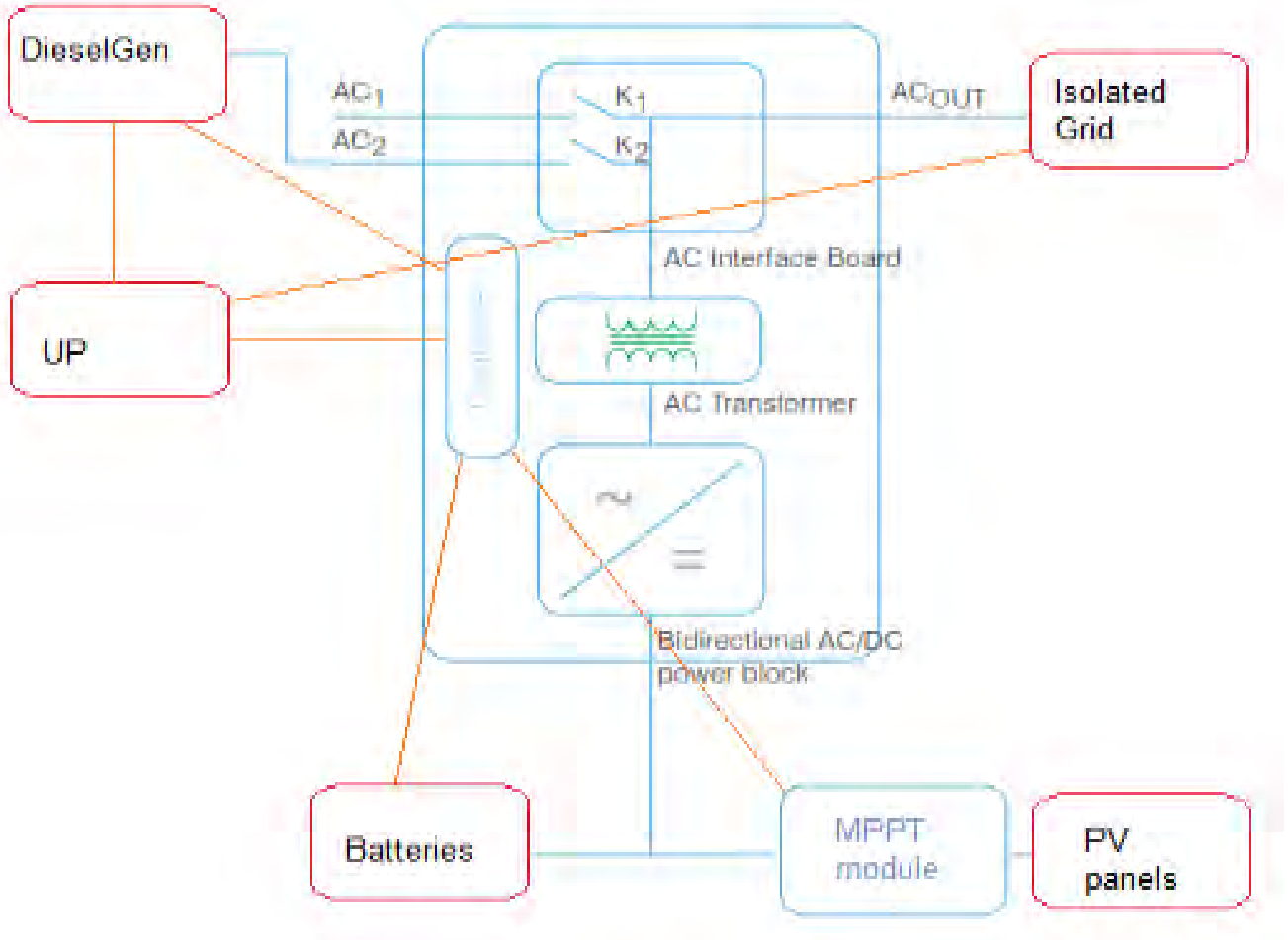
Scope

- Timeline: 2017 – 2018
- Number of users: 21 users
- Generation plant
  - ✓ PV plant
  - ✓ Battery storage
  - ✓ Back-up diesel set (for night hours, mainly)
- Partners:
  - ✓ Saufer (integrator)
  - ✓ Schneider (technology partner)

Rural electrification in Colombia
The result

Rural electrification in Colombia

Overall solution based on Hybrid power systems (HPS)



Hybrid power systems (HPS) combine two or more sources of renewable energy as one or more conventional energy sources. The renewable energy sources such as PV do not deliver a constant power, but due to their complementarities their combination provides a more continuous electrical output. HPS are generally independent of large interconnected networks and are often used in remote areas.

Rural electrification in Colombia

Overall solution based on Hybrid power systems (HPS)

The purpose of a hybrid power system is to produce as much energy from renewable energy sources to ensure the load demand.

The power delivered by HPS can vary from a few watts for domestic applications up to a few megawatts for systems used in the electrification of small villages. Thus, the hybrid systems used for applications with very low power (under 5 kW) generally feed DC loads. Larger systems, with power greater than 100 kW, connected to an AC bus, are designed to be connected to large interconnected networks. Hybrid systems are characterized by several different sources, several different loads, several storage elements and several forms of energy (electrical, thermal).

Advantages:

Not dependent on one source of energy.

Simple to use.

Lower needs for storage.

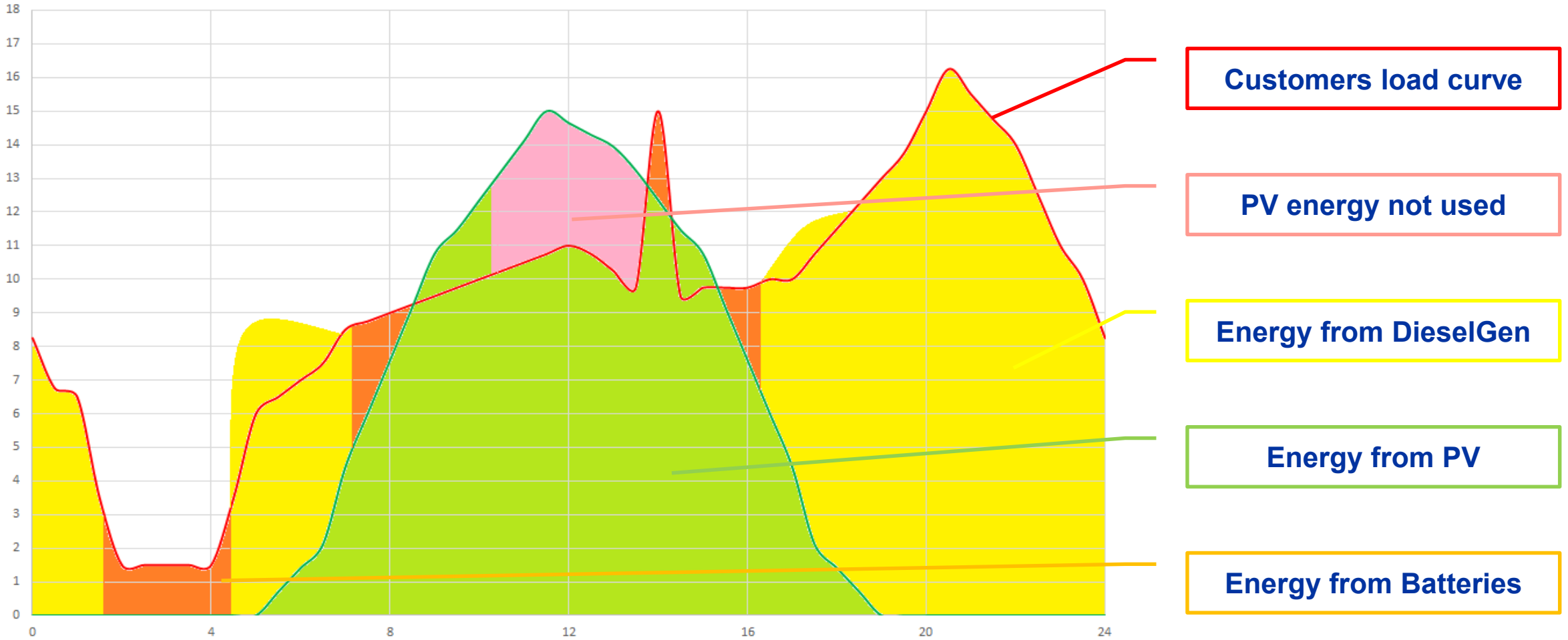
Disadvantages:

More complex than single-source systems.

High capital cost compared to diesel generators.

Rural electrification in Colombia

HPS energy management



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