Distributed Control Strategy for Isolated Electrical Hybrid Power Systems

365

L.S. Azuara-Grande[1], S. Arnaltes[2], J. Alonso-Martinez[3] and J.L. Rodriguez-Amenedo[4]

Department of Electrical Engineering, Universidad Carlos III de Madrid (Spain)

[1] e-mail: lazuara@ing.uc3m.es, [2] e-mail: arnalte@ing.uc3m.es, [3] e-mail: jalonsom@ing.uc3m.es, [4] e-mail: amenedo@ing.uc3m.es

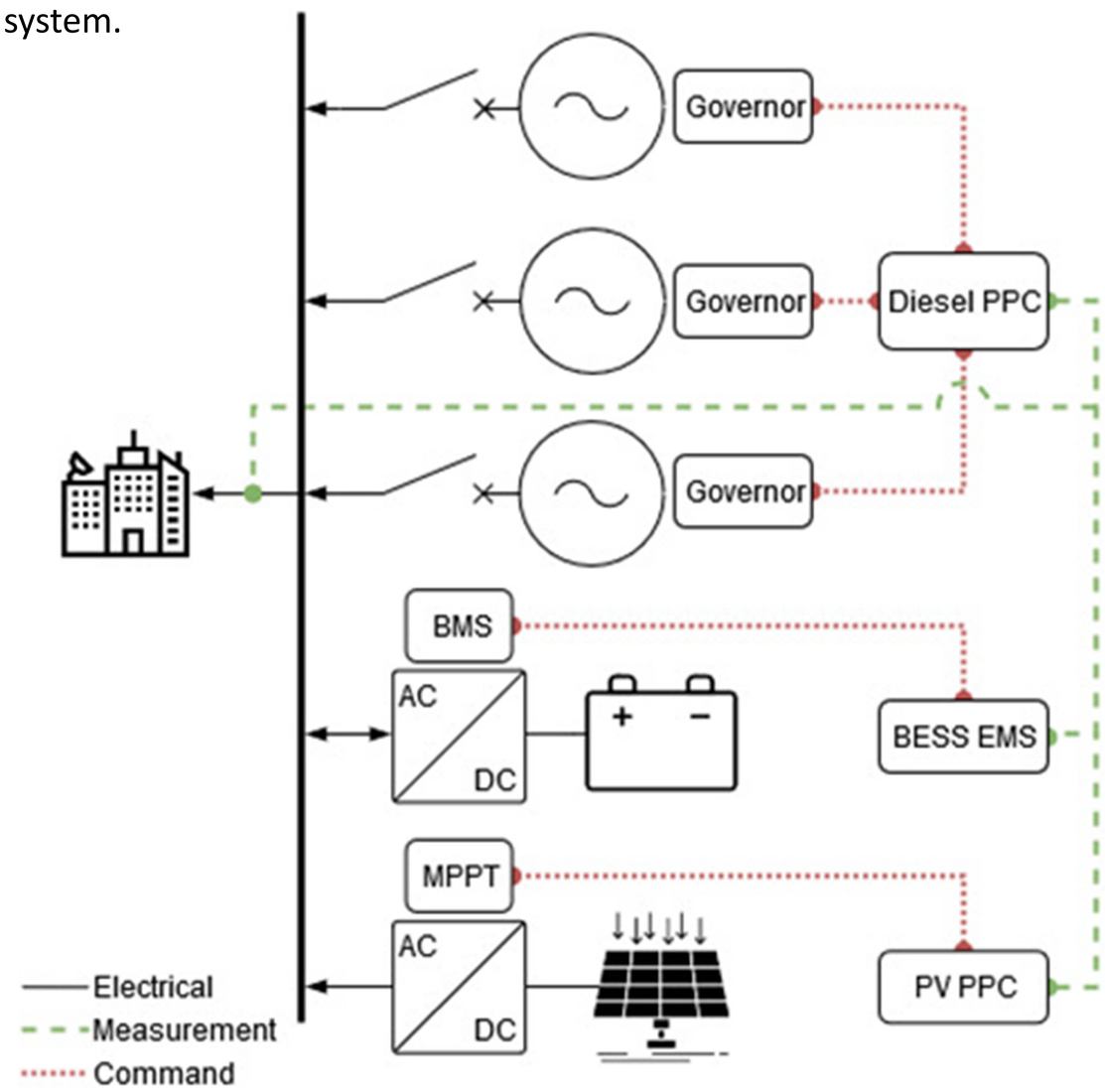
Introduction

The market for **off-grid solar** systems has **grown exponentially over the past decade**, with estimated sales reaching 23.5 million units in 2018, up from only 0.9 million in 2010 [1]. This growth is due to factors such as:

- The rapid decreases in photovoltaic (PV) **module costs**. Since 2009, for instance, the costs have fallen by more than 80% while, globally, the cost of solar PV power declined by 73% from 2010 to 2017 [2].
- The increase in the **cost of fossil fuels** for conventional generation and the reduction of dependence on fossil fuel imports [1].
- The emergence of **new energy storage technologies** such as electrochemical batteries [1].
- The urgent action to increase **mitigation of climate change** [1].

Isolated Microgrid Description and Modelling

The verification of the proposed control strategy has been done through the simulation of a **24-hour scenario in MATLAB/Simulink**. Therefore, it has been necessary to model an isolated microgrid with all its elements using the Simscape toolbox. The PV plant includes the **PV modules** and the **PV inverter** with a maximum power point tracker (MPPT), the BESS has a **lithium-ion battery pack** with a battery management system (BMS) and **diesel generators** which include a model of synchronous machine, a speed governor and an excitation system.



The **desired objectives** of the control strategy are:

1) Minimize Diesel Power Generation.
2) Maximize PV Power Generation.
3) Charge BESS with PV Surplus and Discharge it with lack of PV Power.

References

[1] REN 21 Renewables Now, *Renewables Global Status Report 2019*. 2019.

[2] IRENA, "Off-grid renewable energy solutions to expand electricity access : An opportunity not to be missed," p. 144, 2019.

Acknowledgement

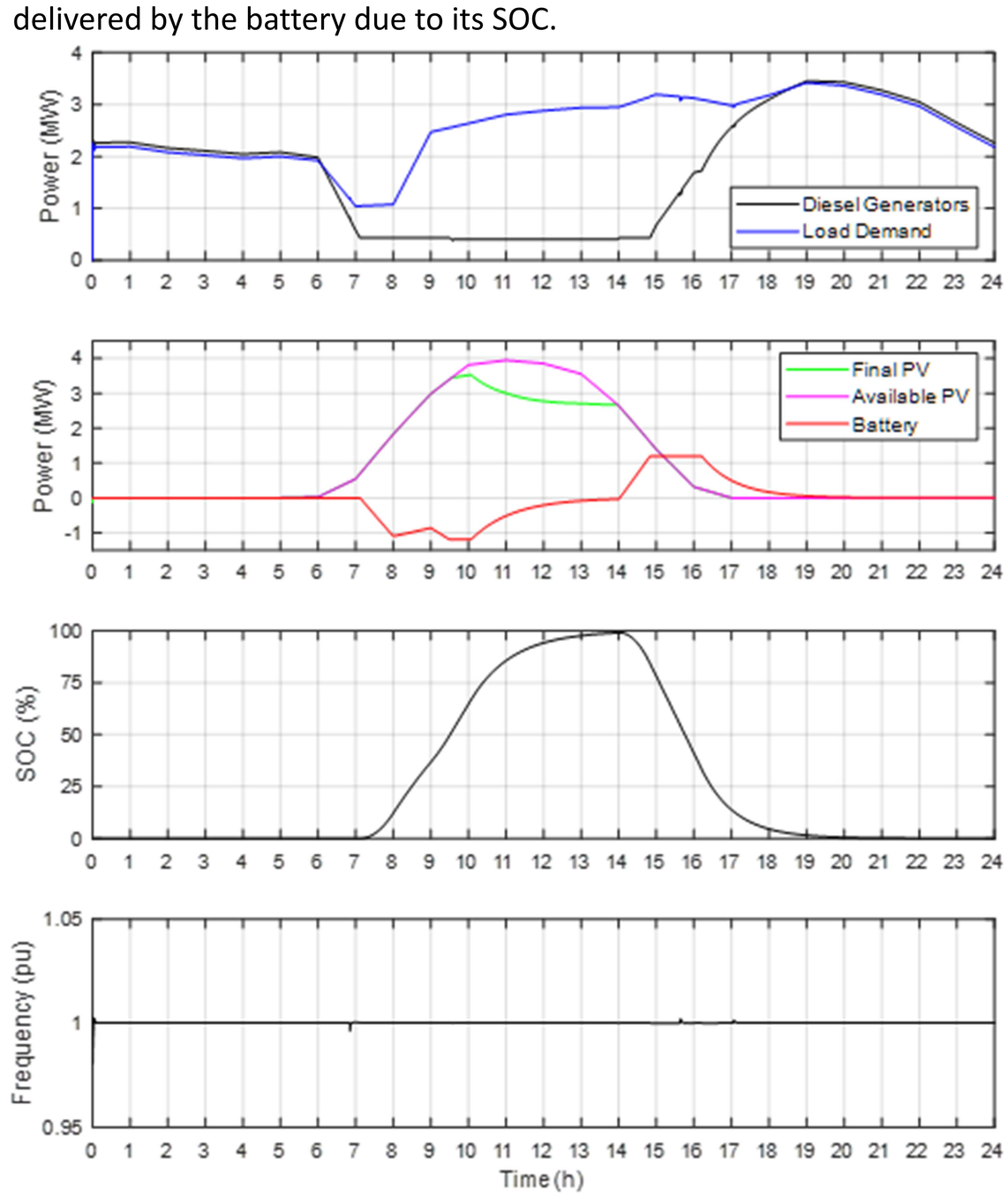
This work has been supported by the Autonomous Community of Madrid under the PROMINT-CM project (P2018/EMT-4366).

Isolated Microgrid Control Configuration

The **Diesel PPC** is responsible for controlling diesel generators and their governors have an Automatic Generation Control (AGC) to restore the frequency to the specified nominal value. This is accomplished by adding an integral control, which acts on the load reference settings of the units' governors. The integral control action ensures zero frequency error in the steady state. In case there are more than one synchronous generation unit, a droop control is used, which allows several synchronous generators to operate in parallel and share the load proportionally to their nominal power. The Diesel PPC oversees starting and stopping the units, depending on the available spinning reserve and the minimum rated capacity of the generators, respectively. In addition, due to the synchronous generators carry out the grid voltage and frequency control, a unit must always be on for the task of grid forming.

The **PV PPC** is responsible for controlling PV plant, since it adjusts the power of the PV plant to operate diesel generators to their minimum rated capacity. The PV inverter can restrict the power delivered by the PV plant due to its MPPT has less power available than required by the controller.

Finally, the **BESS EMS** is responsible for controlling the BESS, and its BMS calculates the State of Charge (SOC) and the available charge/discharge power. The BESS EMS strategy discharges the BESS to operate the diesel generators to their minimum rated capacity when the PV plant has not enough solar resource, while it charges the BESS to store the surpluses of the PV plant. The BMS can restrict the power delivered by the battery due to its SOC.



Conclusions

It provides greater **reliability** against communication failures between controllers, because the microgrid needs the minimum information shared sent by generation units to be operated and scheduled. Even if there is a total failure in communications, the isolated microgrid will continue to operate only with diesel generators, since the diesel generators are responsible for maintain the voltage and frequency of the isolated microgrid.