Energy management system for islanded microgrids comprising PV systems, diesel generators, energy storage systems: Validation in a laboratory environment

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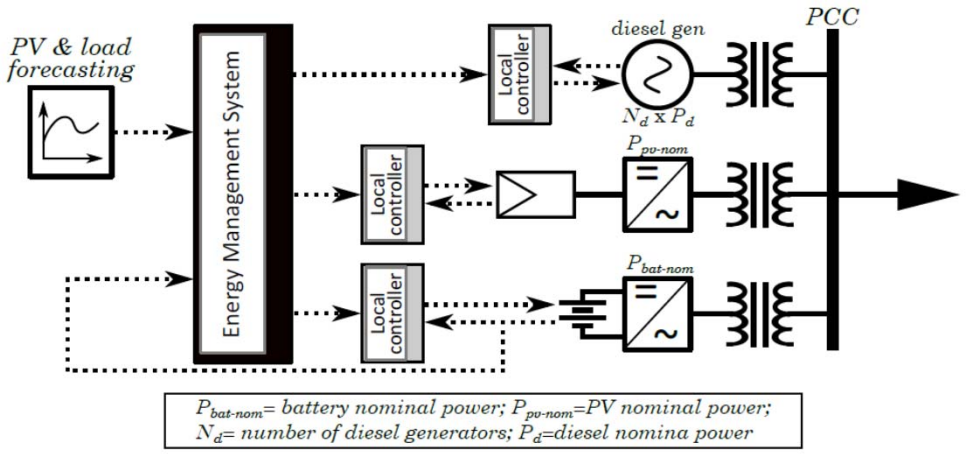
Islanded electric networks based on renewables

- Very dependent on renewable resource forecast –> need to deal with the deviations.
- Diesel generation efficiency is non-linear and can be optimized.
- Energy management systems are fundamental to ensure optimum operation.
- The limited inertia of the system can be a problem, risk of problems with the stability of the frequency.
- Power electronics converters can provide support to frequency with some limitations.
- It is proposed that Energy Management Systems include this aspects.

System under analysis
PV-Battery-Diesel-based microgrid scheme



$P_{bat\text{-}nom}$= battery nominal power; $P_{pv\text{-}nom}$=PV nominal power;
N_d= number of diesel generators; P_d=diesel nomina power

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System under study

- 9 diesel generators of 1.2 MVA
- 2 batteries of 560 kWh and converters of 2.2 MVA
- PV peak power of 10 MW
- Minimum allowed frequency 49 Hz

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Energy management system (EMS)

- The EMS minimizes the diesel consumption, while ensuring the load supply.
- The decision variables are the number of diesel generators connected, the maximum photovoltaic power set-point , and the battery set-point for the next hours.
- The system input parameters for each execution are the state of charge of the battery (SOC), load and the available PV forecast.
- Frequency excursions are taken into account, by including additional equations into the problem after conducting numerical simulations to determine the maximum deviation in a frequency excursion provoked by a sudden load change.
- In some cases, the EMS decides to connect diesel generators to use the inertia available for frequency control purposes.

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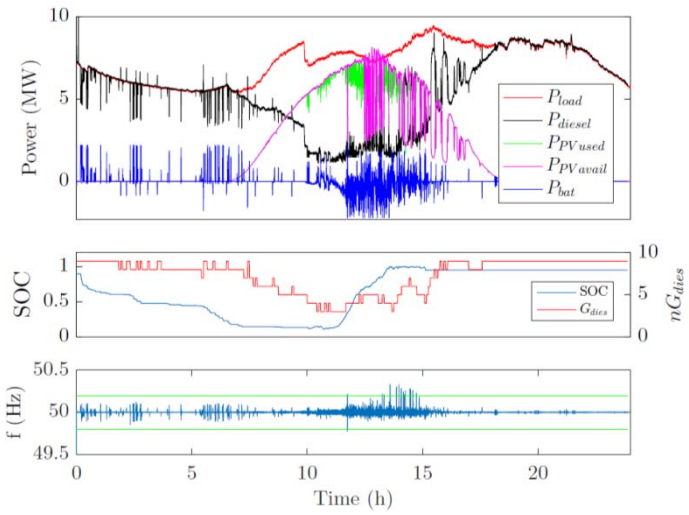
Simulation results for the scenario (high PV power variability after midday)



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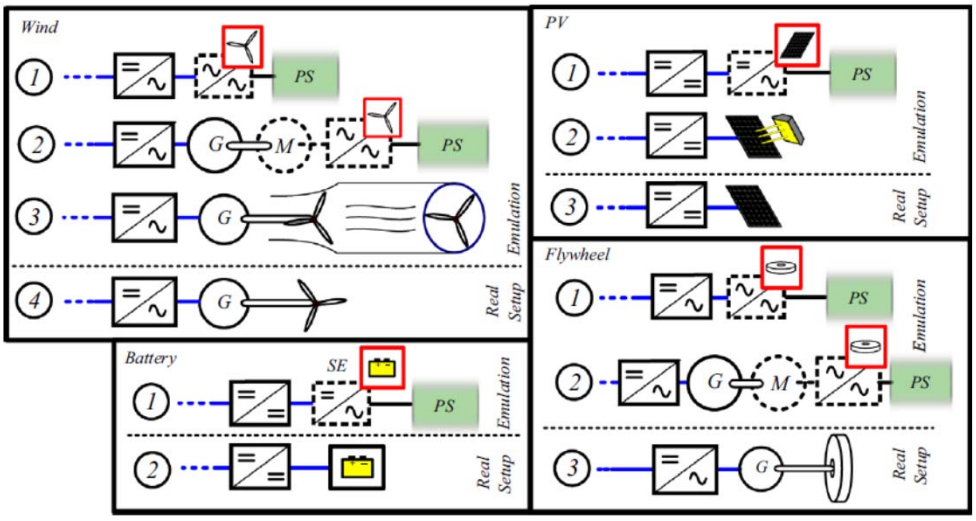
Emulation concepts



Renewable energy emulation concepts for microgrids, E Prieto et al, Renewable & Sustainable Energy Reviews 50 (2015)

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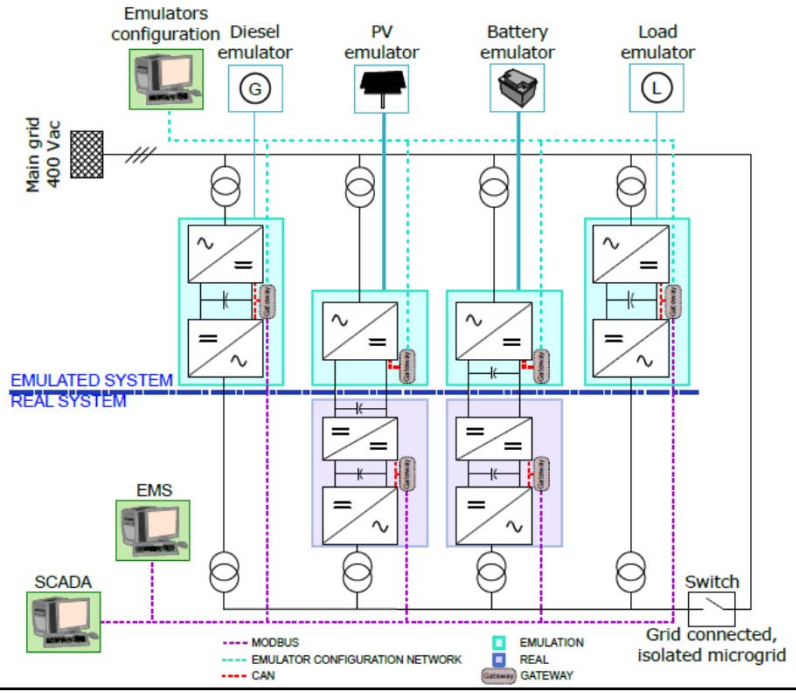
Microgrid scheme



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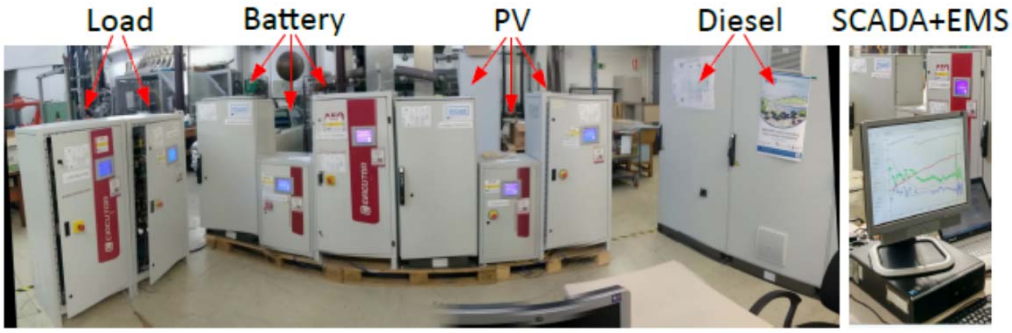
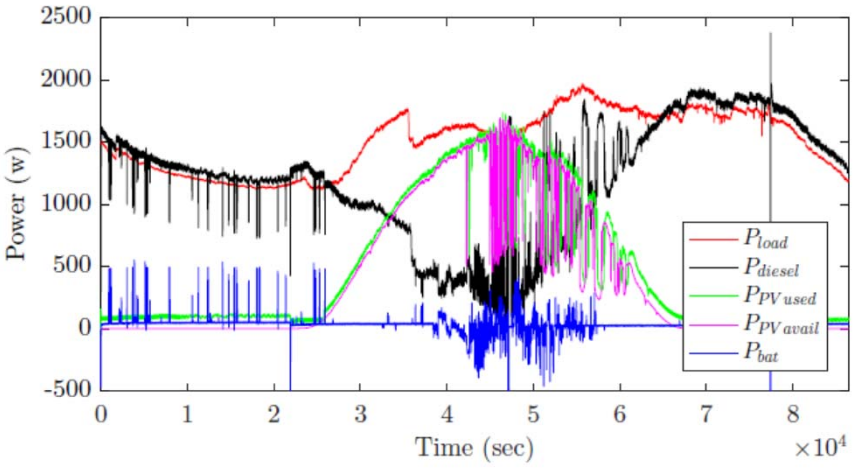
Microgrid



Experimental results



Conclusions

- The paper has presented the experimentally validation in an emulated platform of an algorithm for ensuring optimal operation of isolated microgrids.
- The experimental platform has shown that the developed algorithm can be implemented in practical applications and it has been shown that a normal computer can be used to implement the algorithm and to communicate efficiently with the relevant power converters.
- Next steps will be focused on the application of the algorithm in a real microgrid project.
- Further studies considering frequency support and grid-forming capability in the converters are being conducted.

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Thank you!

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