

Increasing the accuracy of PV plants and power system dynamic models: a comparison of benefits for battery capacity sizing

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Supported by:
TOTAL R&D

- 1. Introduction**
- 2. Methodology**
- 3. PV transients analysis**
- 4. Comparison of battery capacity sizing methods**
- 5. Conclusion**

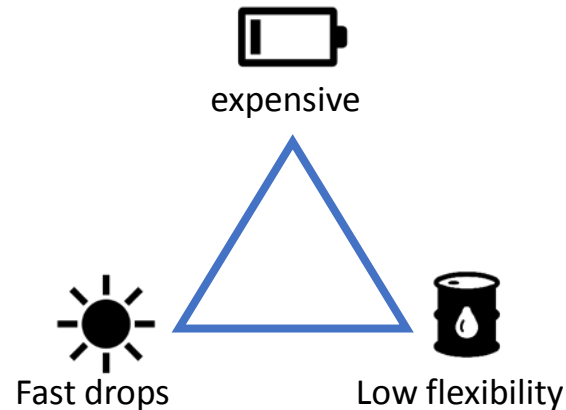
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Renewable energy integration into isolated industrial grids is becoming a key lever to reduce CO2 emissions

Characteristics of industrial microgrids

- Grid integration of Solar PV in large scale system poses a problem of reliability and power quality
- Strong relationship between solar drops and battery capacity



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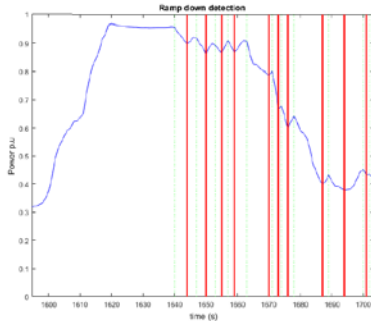
- Battery sizing methodologies mostly rely on:
 1. A description of the electrical system
 - Large bench of modeling solution from coarse energy level to fine electrical description
 - Global trend in increasing the complexity of the electrical system model in battery sizing studies
 2. Solar intermittency scenarios
 - Assumption on the rate of power change in a time interval
 - Less covered in the literature involves complex phenomenon and is subject to high uncertainties
- Research questions :
 - **Where should we investigate ?**
- Methodology :
 - Identification of solar-power intermittency scenario
 - Improving solar-power dynamic models
 - Compare the gain in battery requirements

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Improving intermittency scenarios

1 Worst case scenario identification

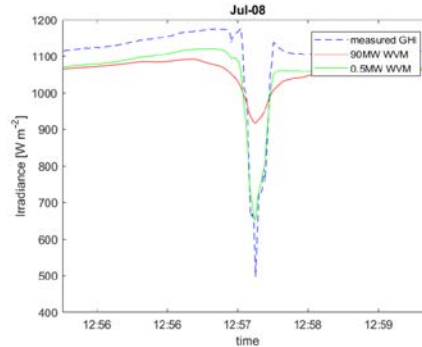
Statistical analysis of 1sec irradiance data @Hawaiï using ramp detection algorithm



2011/07/08 identified as the most variable day

2 Modeling the impact of power-plant scale

Apply Wavelet-Variability Model to simulate a 90MW plant output (smooth-out 1sec profile)



3 Identify the worst PV drop

Clear impact of the smoothing effect:

Single sensor:

- Worst RR : 13,5 %/s

90MW (Smoothed data) :

- Worst RR : 1,85%/s

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Comparison of battery capacity sizing methods

Battery capacity is evaluated thanks to:

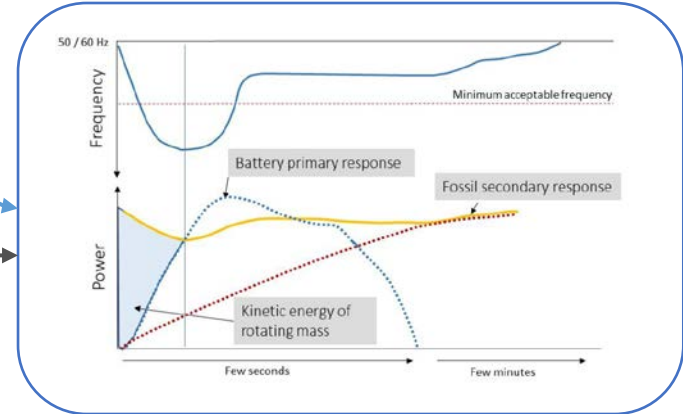
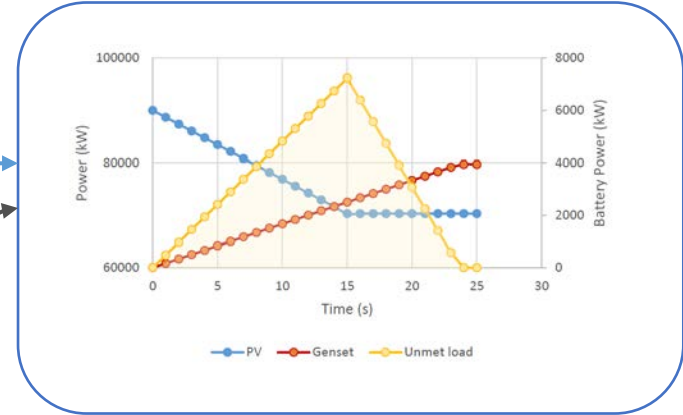
- 2 PV drop scenarios
- 2 system description

Case study :

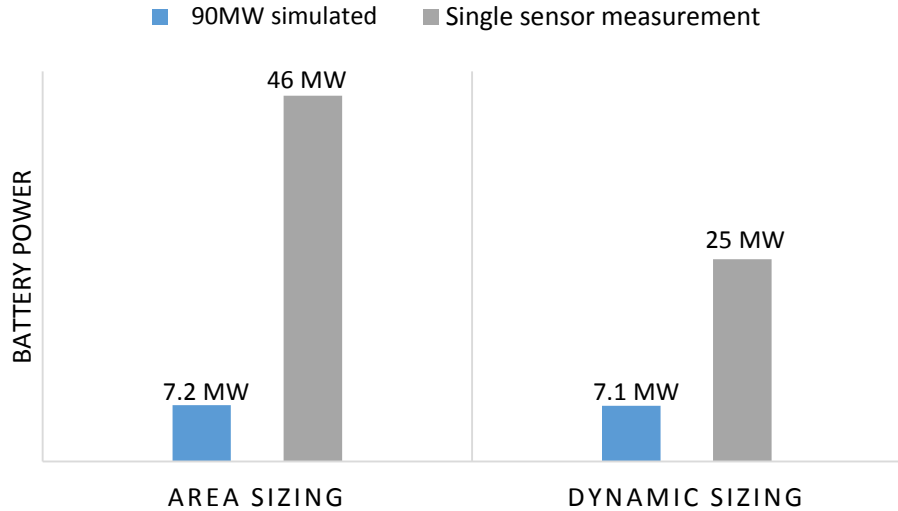
- 90MW PV
- 4 gas turbines (54MW)
- 150 MW load

Scenario 1
13,5 %/s

Scenario 2
1,85 %/s



Summary



Results

- The maximum PV penetration without battery varies from 9MW up to 44MW
- Battery capacity varies from 7MW to 60 MW...
- ...meaning from 4,4M\$ to 37M\$ of battery capex

There is more benefits to model PV variability smoothing than increasing the complexity of sizing procedure

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- **Work summary :**

- Methodology to identify a reliable scenario for PV intermittency is proposed
 - The Wavelet Variability Model is applied to simulated the real power output of a 90MW plant
 - A microgrid battery energy system is sized using both scenario and two sizing methodology with varying levels of complexity
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- Results show that refining the variability scenario has more potential than increasing the complexity of electrical system model



Take away : Accurate modelling of PV intermittency should be a focus in isolated microgrid studies.

Thank you for your attention

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Back-up slides

Addressing solar power intermittency

The overall solar dynamics is a combination of 2 effects :

Factor impacting solar variability (GHI)

Cloud movements are dependent of :

- Climate zone
- Orography
- Seasons

Variability indicators are independant from a site to another.

Pushes to use a worst-case dataset or carry a measurement campaign @ site



Factor impacting power plant variability

The aggregated solar energy received depends on :

- The power plant size
- Power plant shape
- Scattering of the plant

The plant's topology has a smoothing effect on the variability. This results in lower ramps at the output of the central inverter

Single sensor irradiance
 $GHI_{plane\ of\ array}$



Power plant aggregated irradiance
 $\phi(GHI)$