

# 2015 Aalborg Symposium on Microgrids

## Survey of Microgrid R&D in Latin America

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# Contents

- 1. Microgrids opportunities and potential**
- 2. Lessons learned from microgrid implementation**
- 3. Microgrids development and status**

# Microgrids opportunities in the region

Remote locations are the main microgrid development opportunity

**Remote (off-grid) microgrids are best hope for developing world, according to the United Nations**

- Solution for climate change and ending energy poverty

**Physical islands most attractive remote opportunity today**

- High fuel costs and supply vulnerability
- Single negotiating party entity for larger scale systems

# Microgrids opportunities in the region

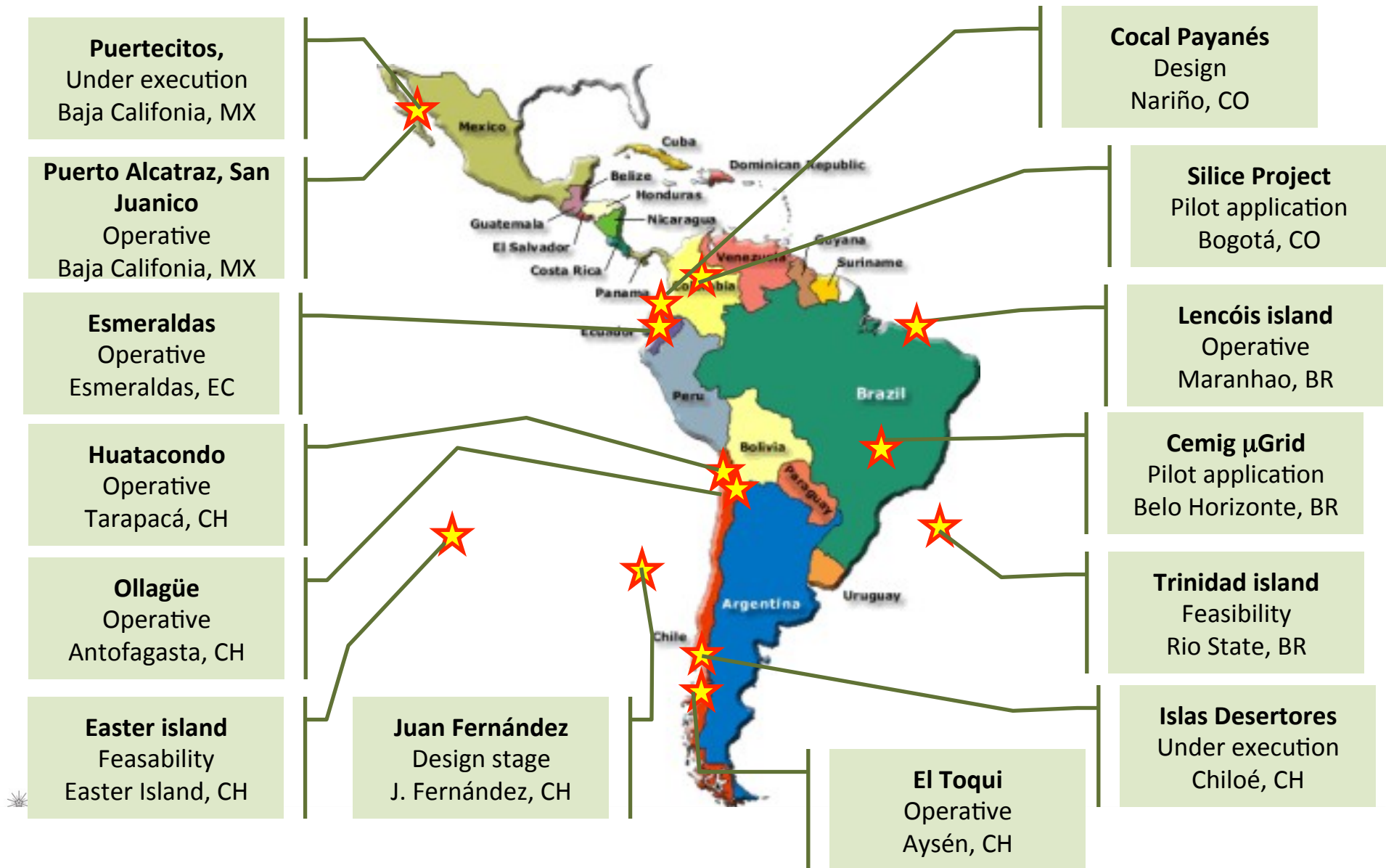
Remote locations are the main microgrid development opportunity

## Technology Drivers

- Declining cost of solar PV
- High cost of diesel
- Three primary segments
  - Commodity extraction systems
  - Physical islands
  - Village electrification



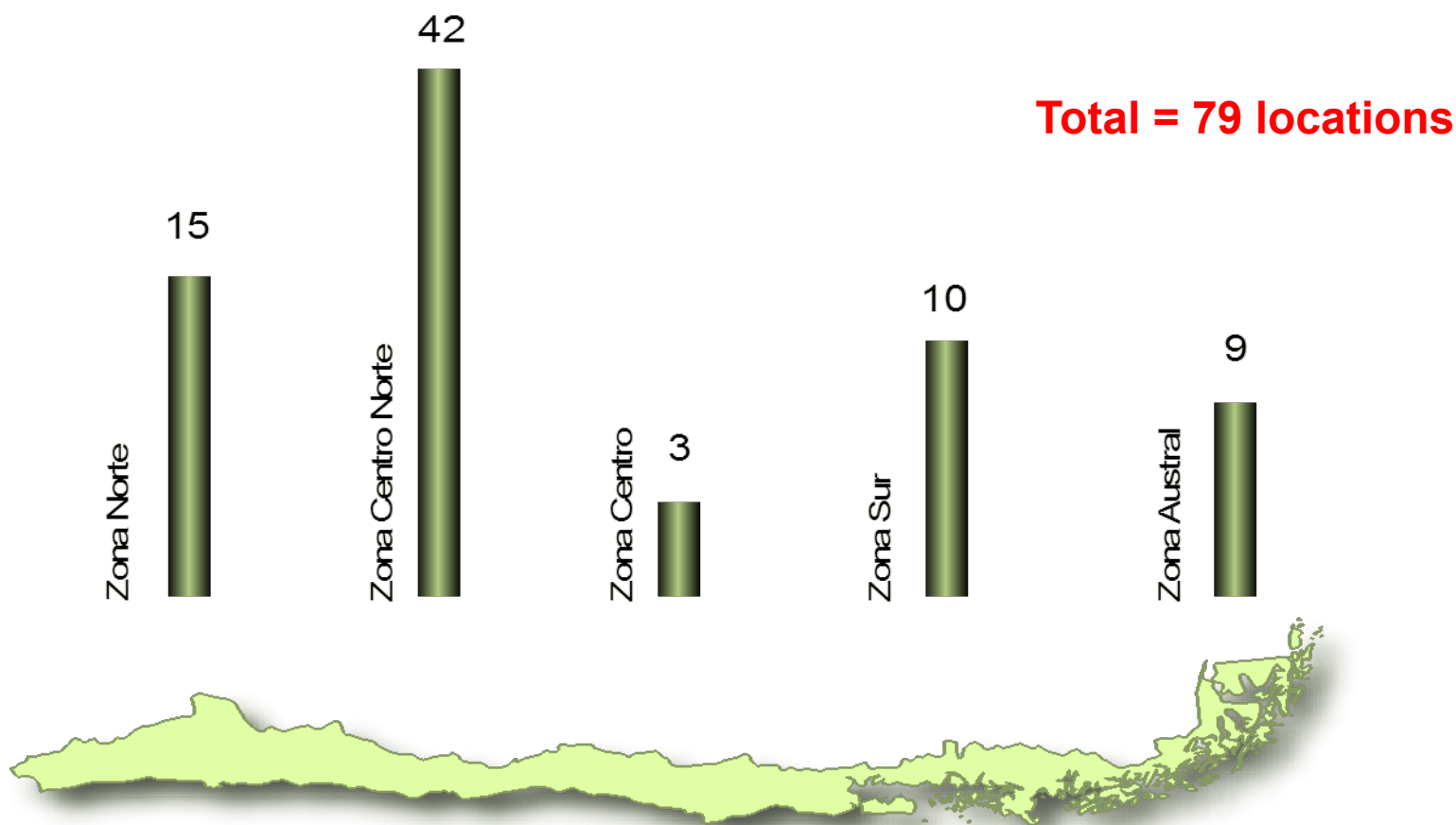
# Microgrids opportunities in the region



# Microgrids opportunities in the region



Chile: Number of feasible isolated MG opportunities



# Microgrids opportunities in the region

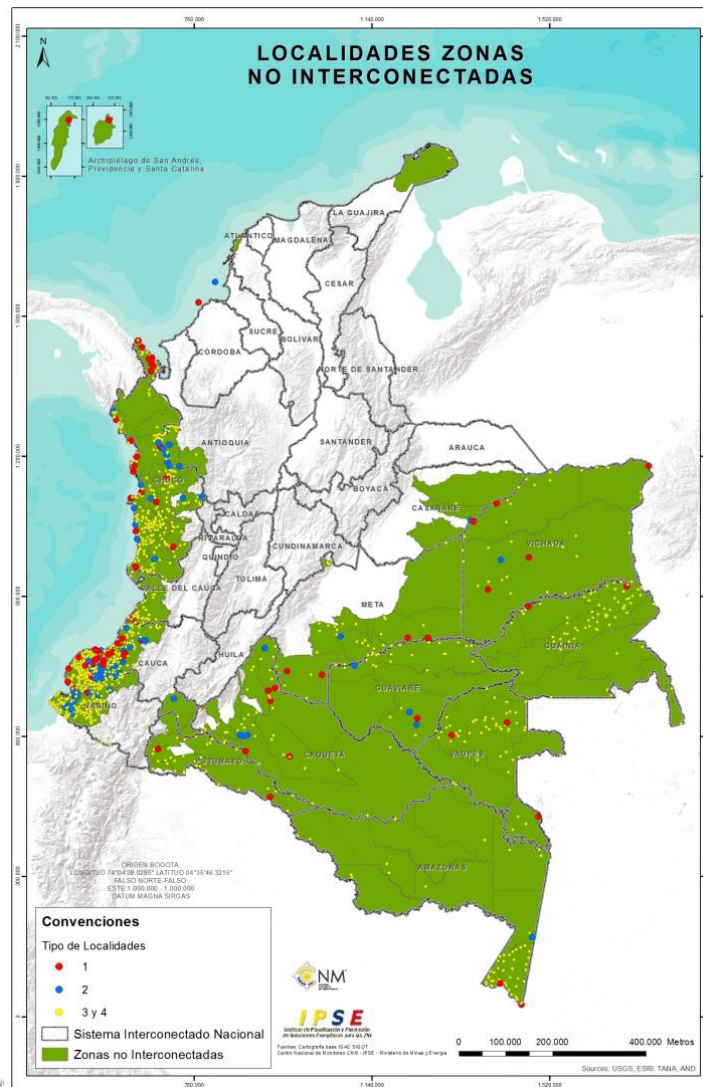


## Brazil: Isolated systems



# Microgrids opportunities in the region

## Colombia: Isolated systems



# Microgrids opportunities in the region

## Joint Research Groups

# MIGEDIR

Microgrids with Renewable Distributed Generation



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## Lessons learned

- A collection of coordination **control issues** in microgrids should be elaborated in order to avoid falling in the same problems (i.e transitions diesel / inverter, low/high SoC at battery bank).
- Incorporation of existing diesel engines requires determining parameters, so transitions between GenSet and BESS can be conducted in a proper way.
- Establish clear maintenance procedures → risk of missing control adjustments.
- Electricity is not a **unique energy source** → explore the potential of RE to provide heat in more efficient ways.

## Lessons Learned

- In the Latin American case, **funding** is mostly lead by private companies (**Social responsibility**). Academic institutions assume the role of developers. Promote strategic alliances among different actors. Local actors are key in terms of maintenance.
- Microgrid **funding** is associated to **CAPEX**, supporters are not interested on assuming OPEX → Develop business models that may ensure that OPEX can be covered in time.
- Even though **Energy Efficiency** can be promoted at community level, significative energy demand rise should be considered as a design and planning criterion.
- Definition with the community of a local **management structure** to ensure correct operation and maintenance practices.



- Microgrid developers are not “community planners”! Main contribution should be focused in the **generation of opportunities** for a local development (life quality, migration, productive projects).
- **Co-construction** schemes and a microgrid development methodology play a KEY role in the whole implementation process. If community is not incorporated from the beginning the project expected contribution present a high failure risk (Easter Island).

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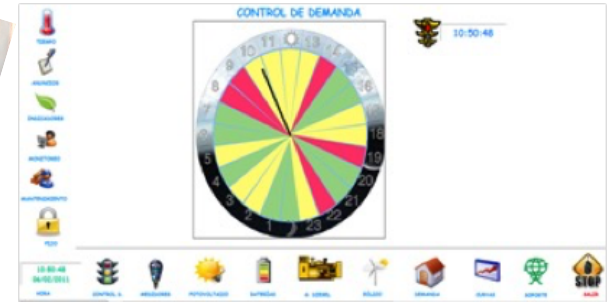
smart integration → innovation opportunities



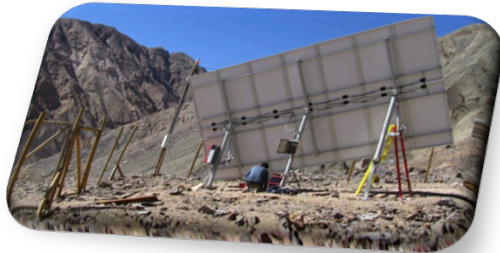
Bird protective device



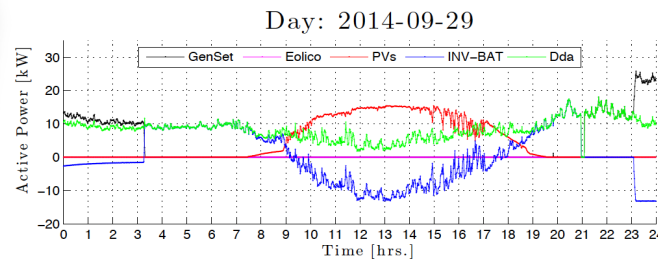
V2G solutions



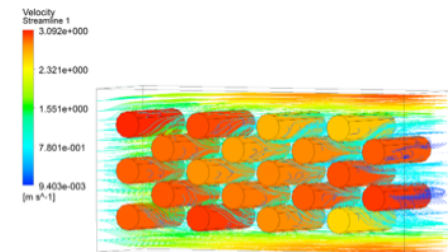
Demand response



Tracking system



Energy Management Systems



Battery pack design

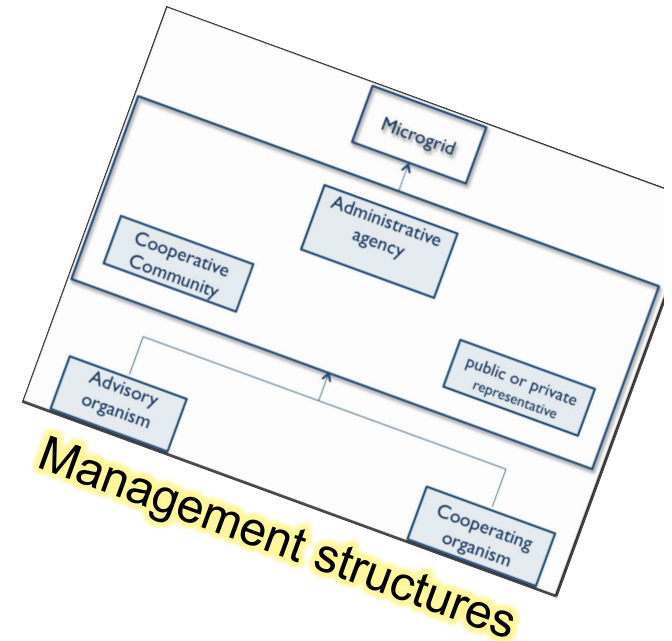
smart integration → innovation oportunities



Participative processes



Education, training

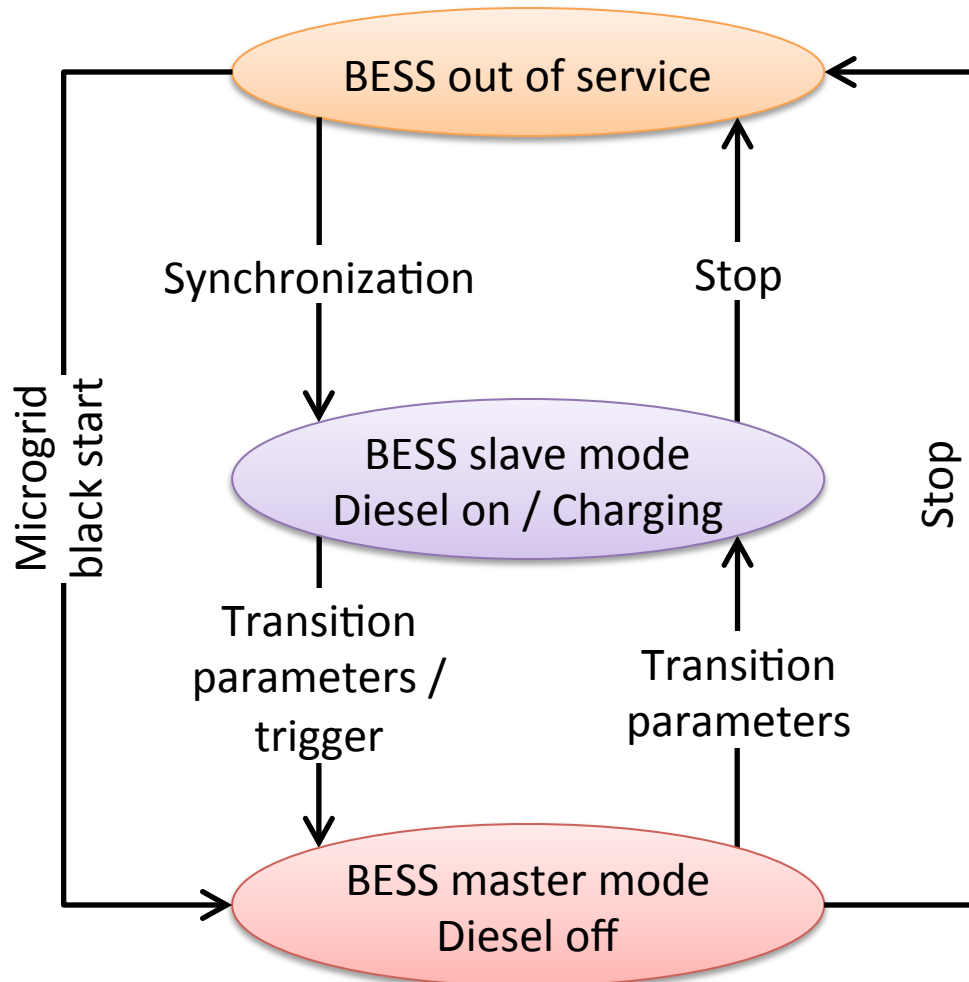


Social SCADA

**“Science questions  
comming from the  
community”**

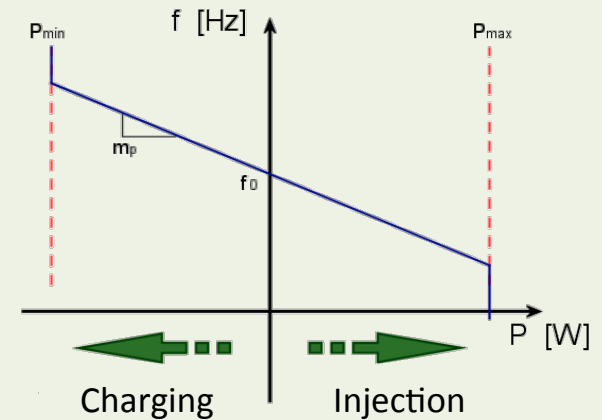
# Control Issues

**EMS set points → Droop control**



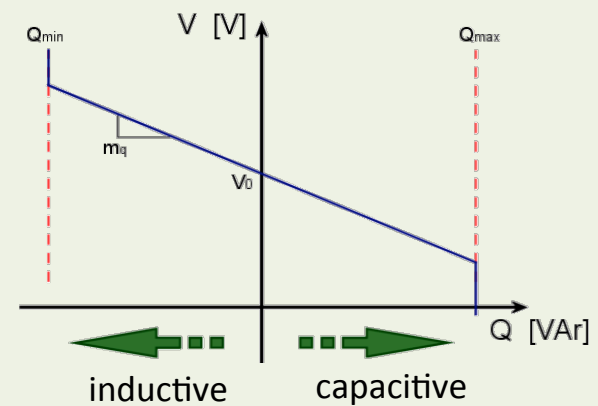
## Active power - Frequency

$$m_p \cdot P = f - f_0 \quad m_p < 0$$



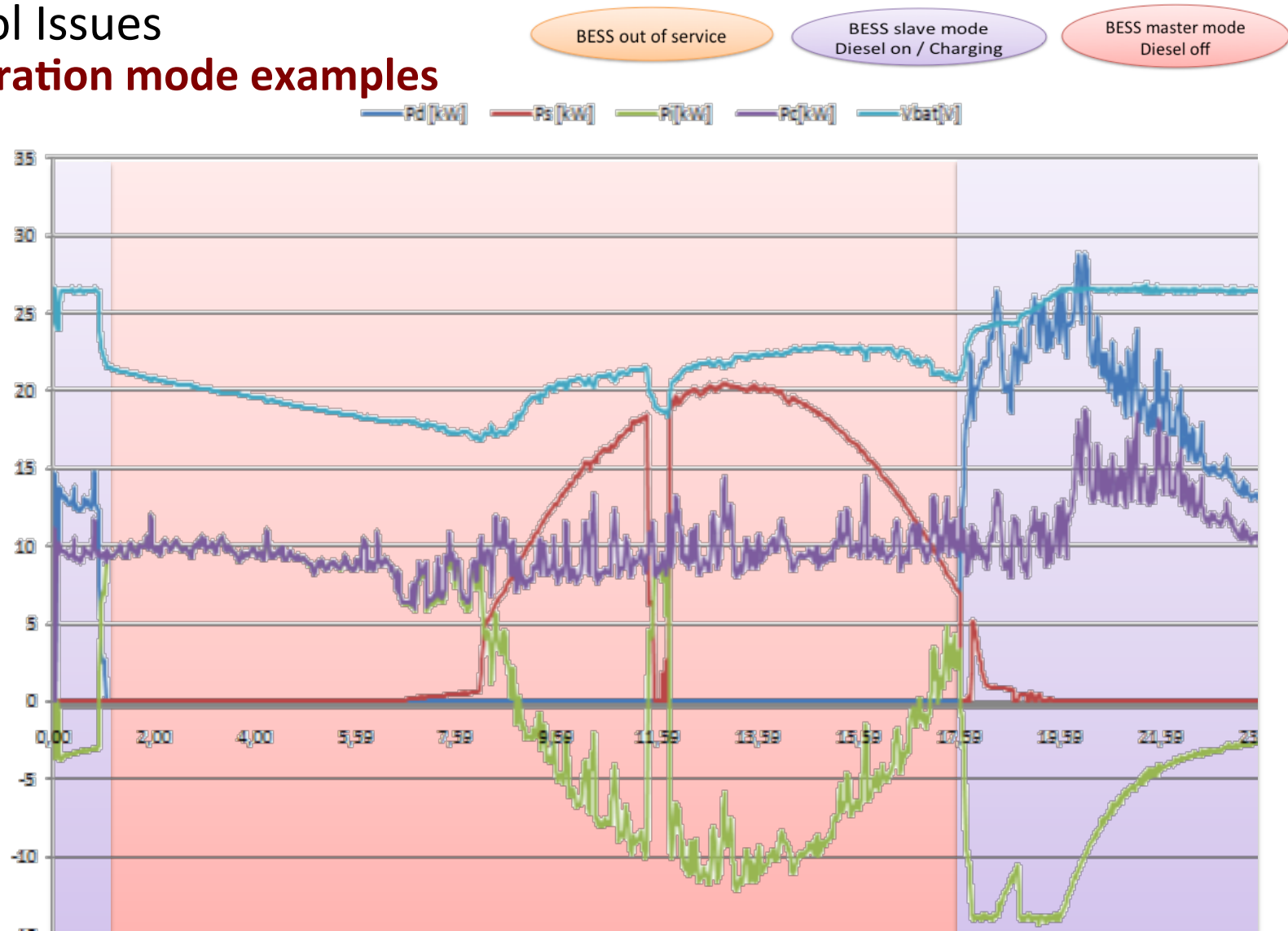
## Reactive power - Voltage

$$m_q \cdot Q = V - V_0 \quad m_q < 0$$



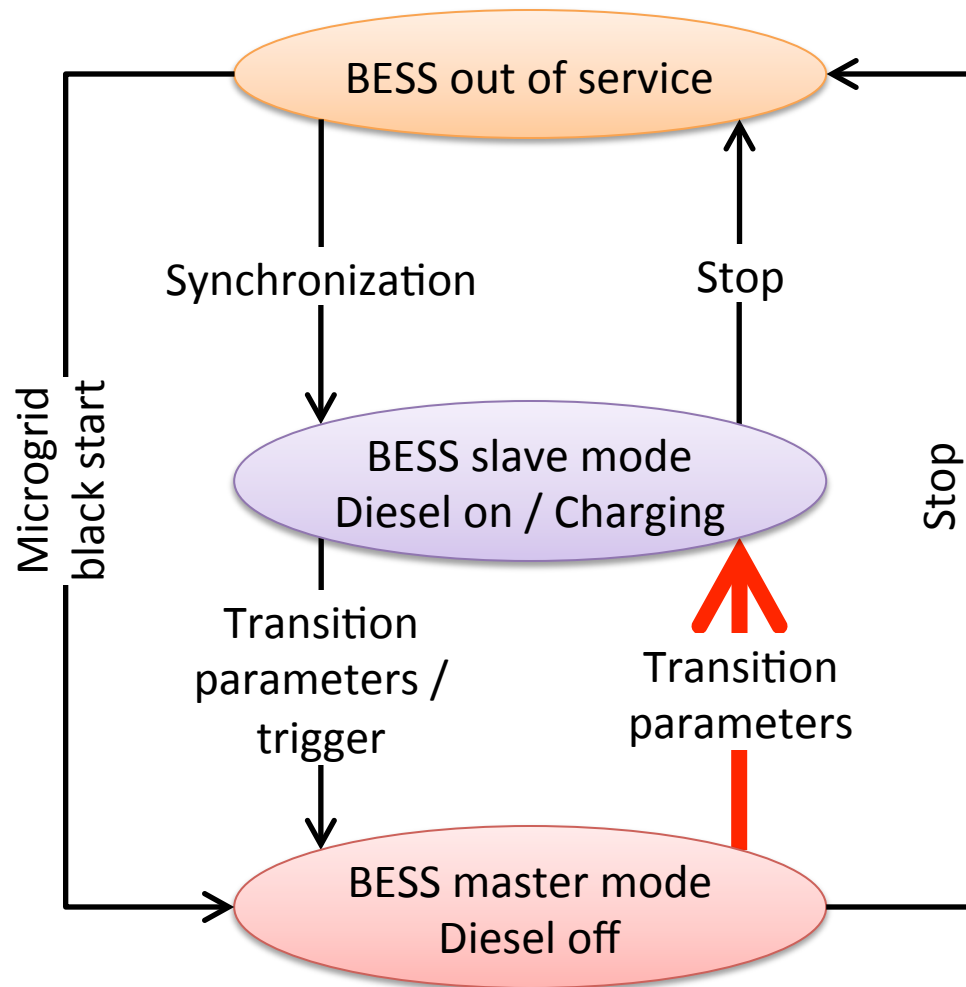
# Control Issues

## Operation mode examples



## Control issues

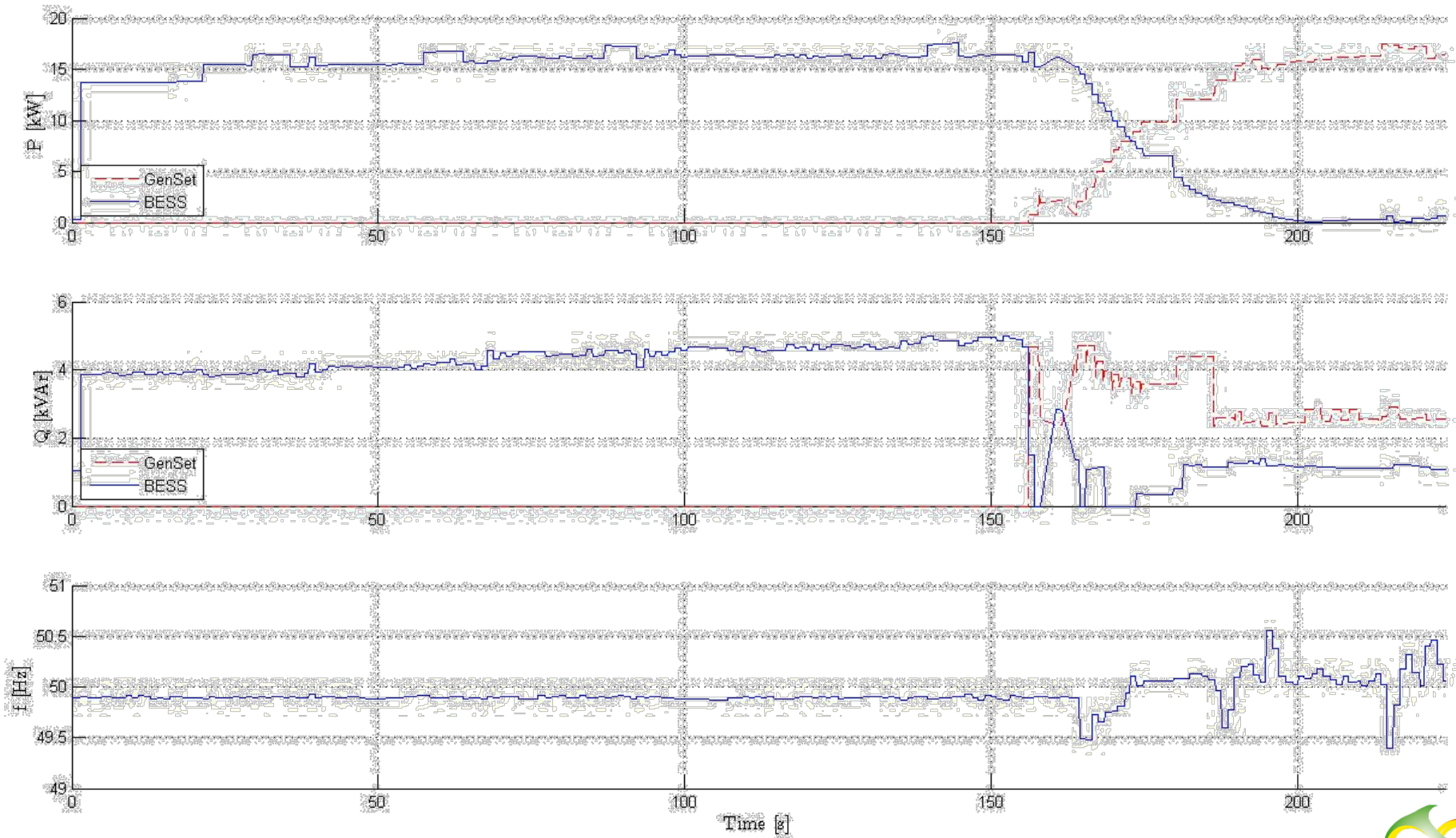
### I. Transition BEES master mode to Diesel generator + BESS slave





## Control issues

### I. Transition BEES master mode to Diesel generator + BESS slave





# Control issues

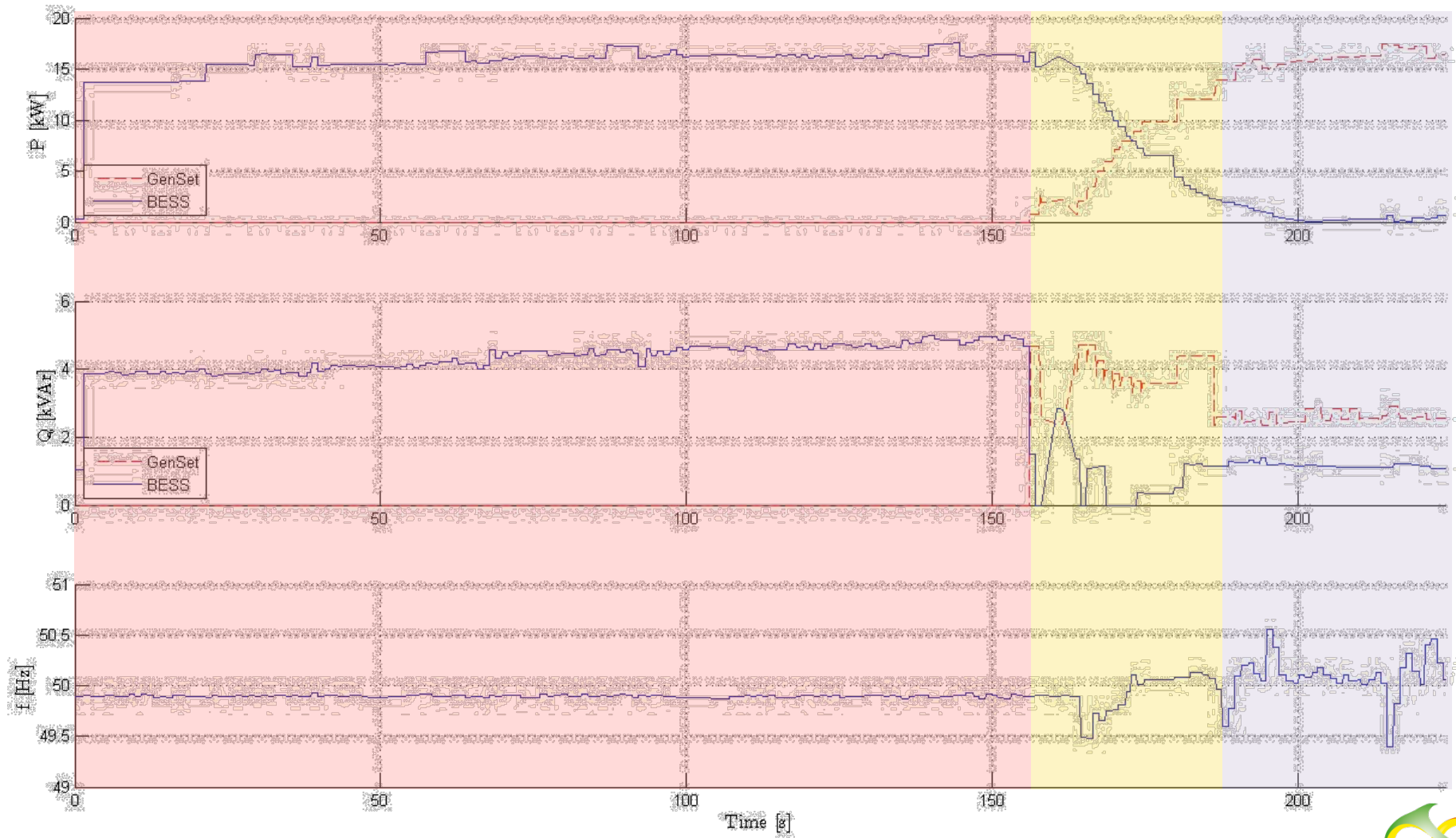
BESS out of service

BESS slave mode  
Diesel on / Charging

BESS master mode  
Diesel off

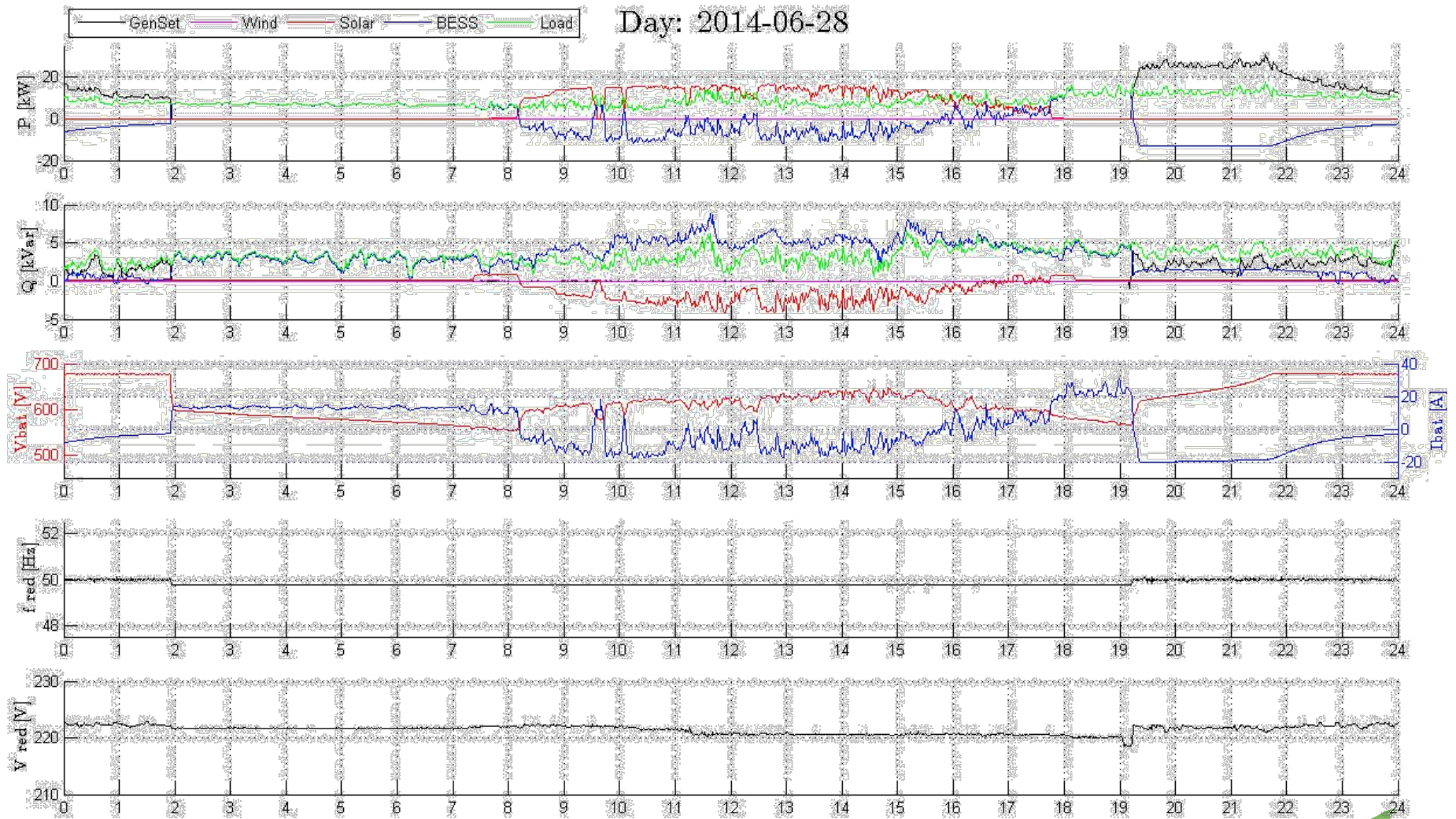
Transition

## I. Transition BEES master mode to Diesel generator + BESS slave



# Control issues

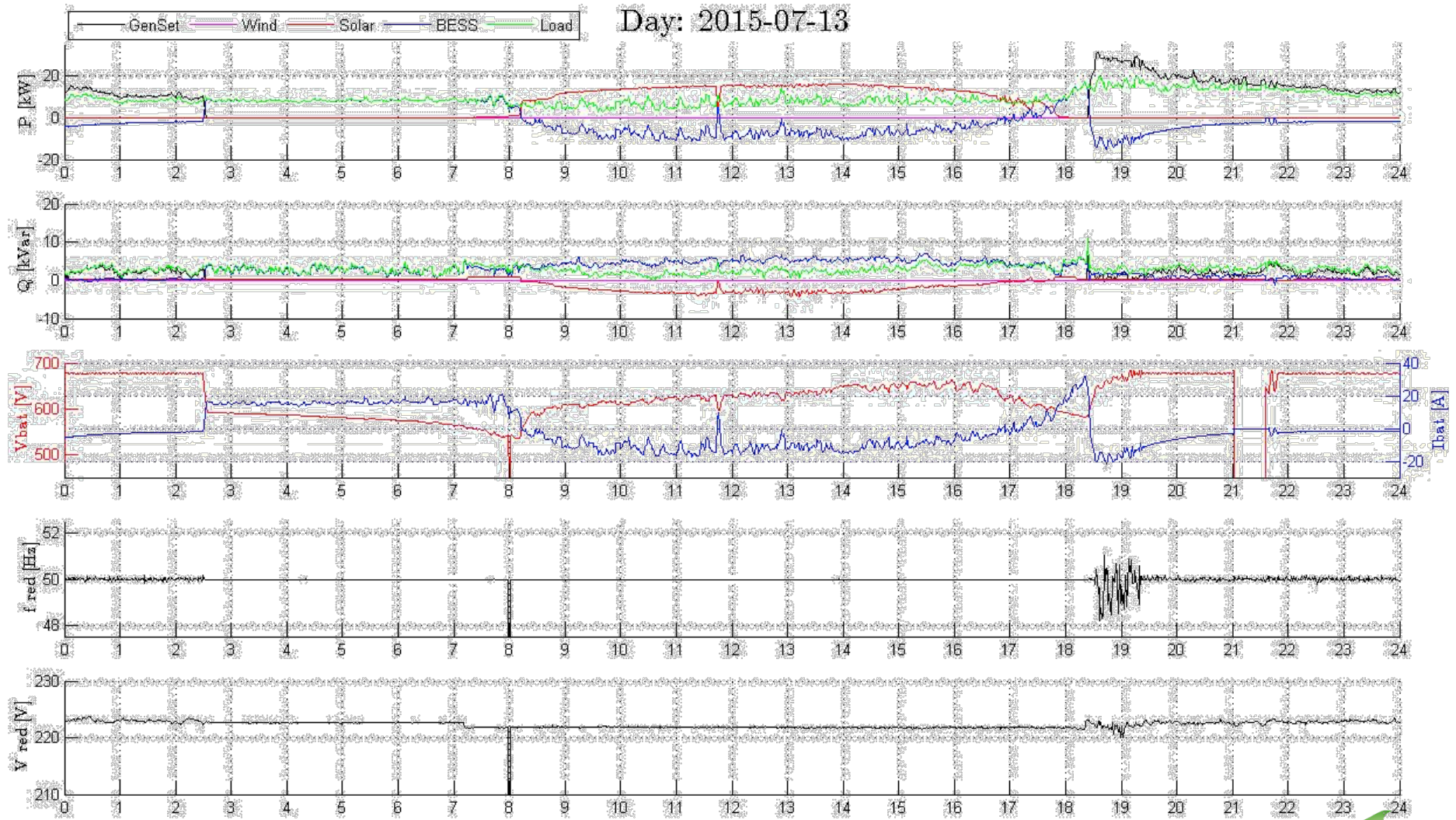
## II. External maintenance → change in parameters





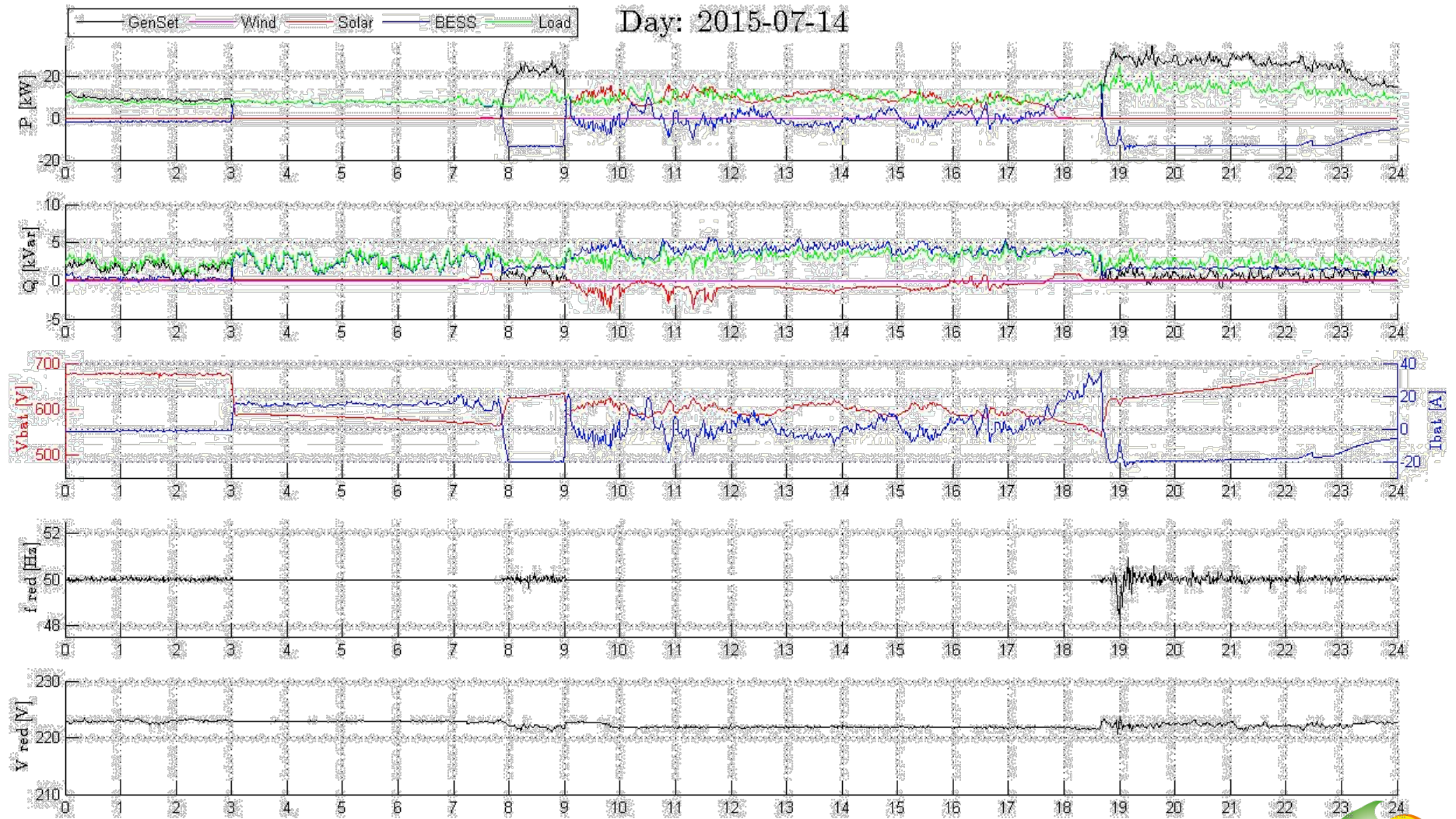
# Control issues

## II. External maintenance → change in parameter



# Control issues

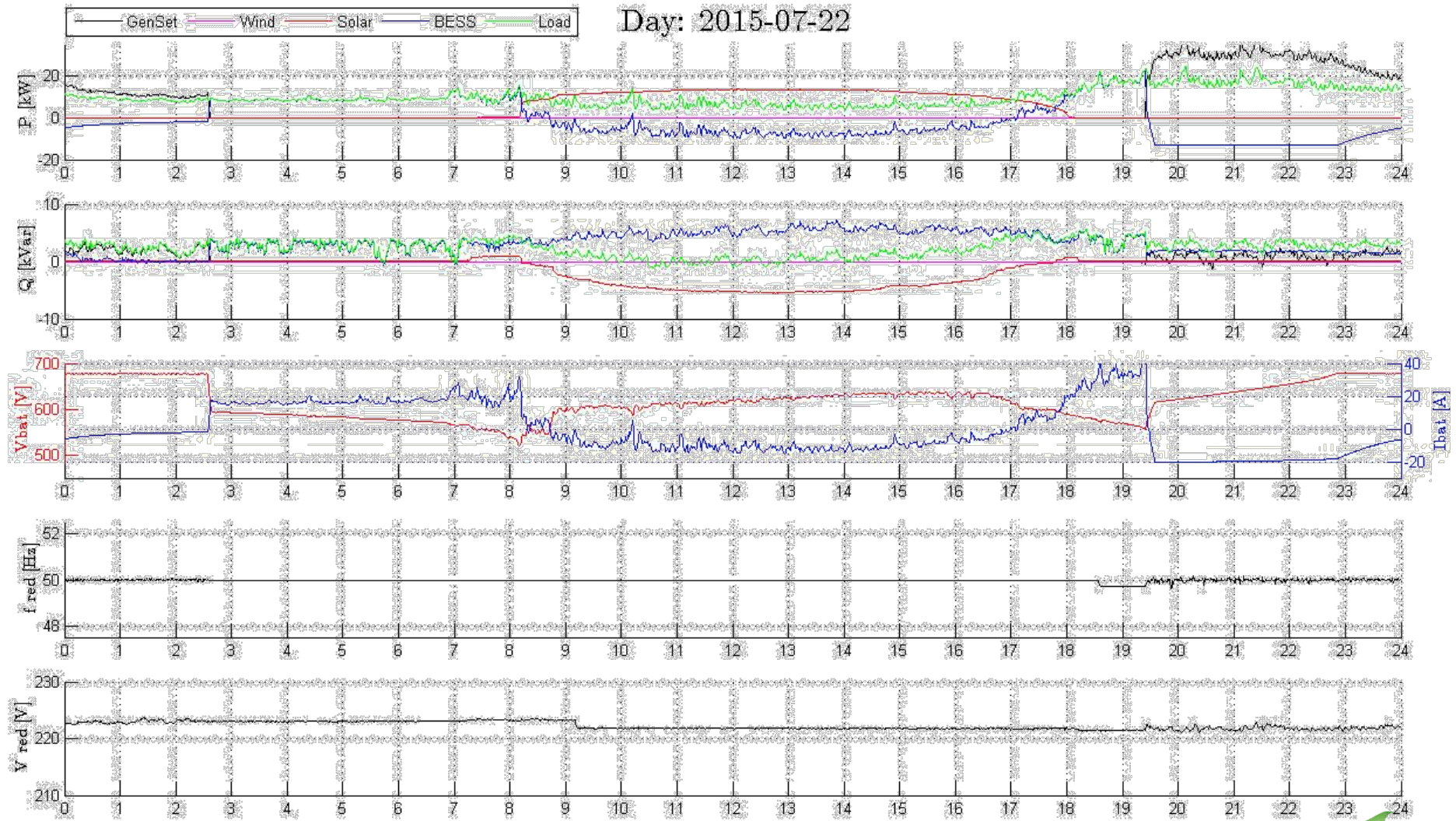
## II. External maintenance → change in parameter





# Control issues

## II. External maintenance → change in parameter



# Control issues

## III. Additional observed control issues

- Accuracy of UC to avoid coordination between set-points and feasible operation domain.
- System recovery after intentional/un-intentional black-outs → topology control strategy (switching).
- The use of non-linear loads such welding machines caused sudden disconnections of the solar panels.
- Battery equalization procedure is are neither automated in the SCADA nor included in the UC model.

# Final comments

- Based on a six year long experience in a rural isolated microgrid project, several control issues are presented and analyzed.
- New challenges were identified for both, a more detailed UC/EMS model able to avoid complex operational conditions and a framework for the analysis and design of control strategies and dynamic behavior.
- Test cases collection and structured description procedures can help to improve the penetration and effectiveness of this type of initiatives.
- Even though Huatacondo project is a specific pilot project, it is completely applicable to other Latin countries that face common challenges and characteristics like the Chilean ones.

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