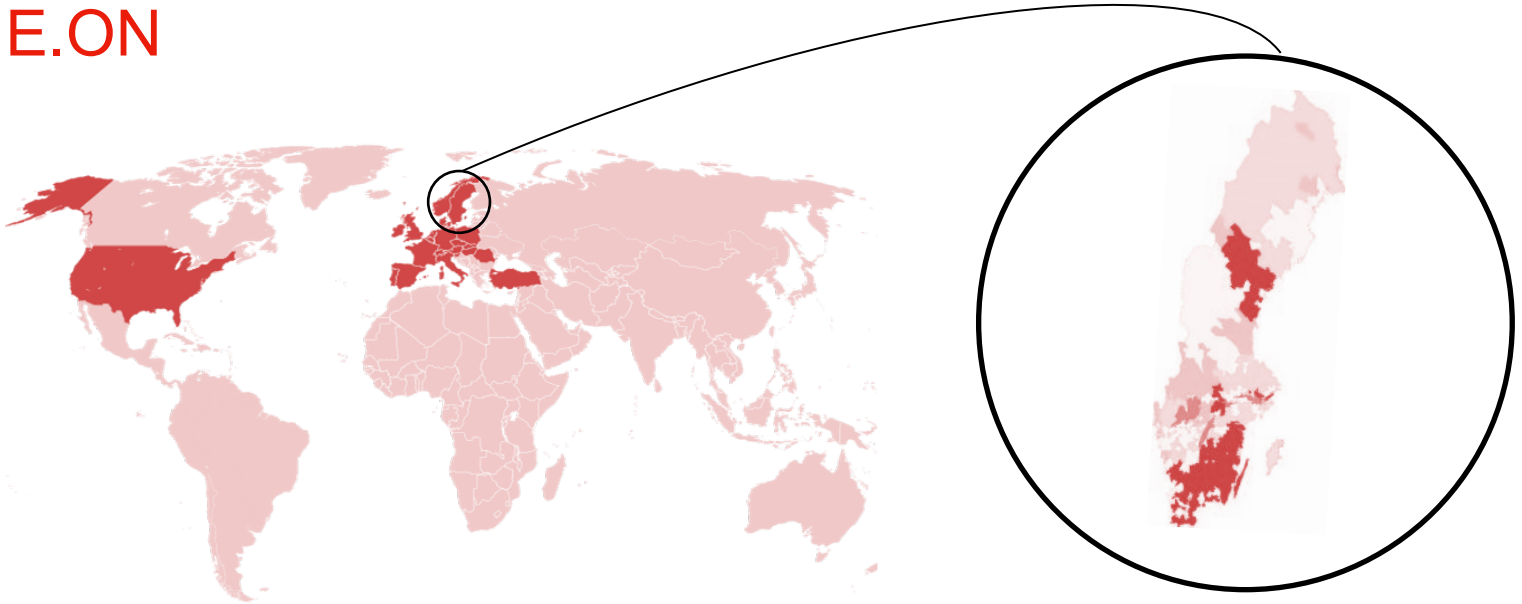
Mike Hirst
17.10.2018

E.ON Energy distribution Microgrid in southern Sweden

Control, operation, management and power quality within a 100% converter, zero-inertia microgrid

E.ON



Global

- **~38,2** BEuro in revenues
- **>22** M customers
- **~ 43.000** employees

E.ON Energidistribution (Sweden)

- **685** primary substations & **44.460** secondary substations
- **~ 8.656** km HV-grid & **~128.208** km MV-Grid
- **~ 1,2** BEuro in network investment

Background – changes to the grid structure in Europe/US

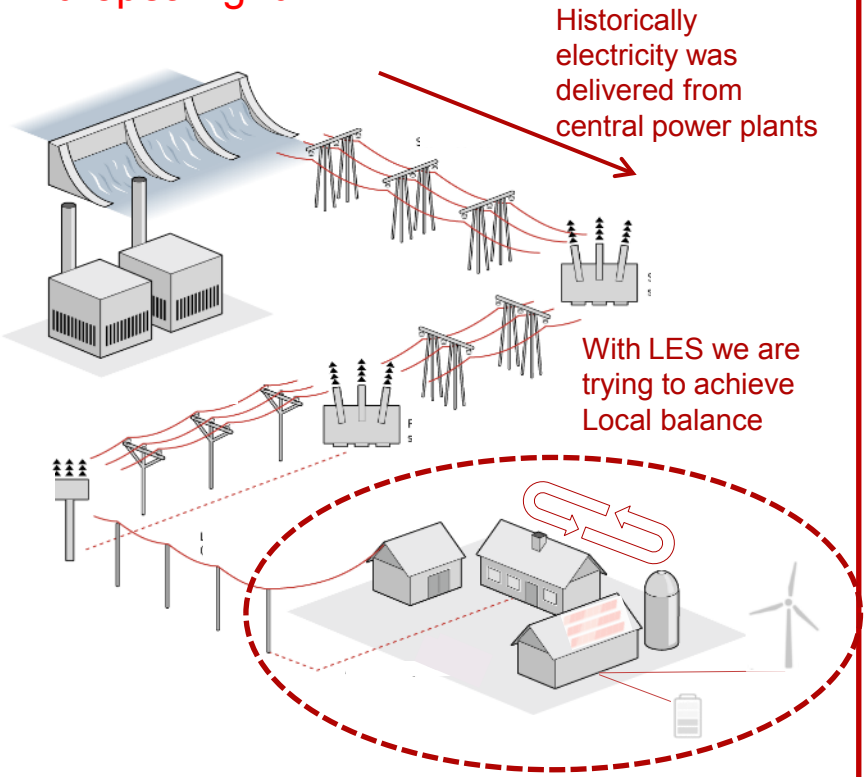
New challenges in the energy market

The Grid:
In rural areas grids can be over-dimensioned and are expensive to re-invest in.
In other parts with lots of renewables or growing demand there can be bottlenecks to deliver enough power

Production:
Renewables in general and small scale (PV) are growing and getting more competitive together with energy storage technologies

Customers:
Customers demand green electricity and are also interested in becoming self-sufficient

European grid



EU’s ”Winter package”

In the Winter package it is stated that:

1. Member States shall ensure that local energy communities:

(a) are entitled to own, establish, or lease community networks and to autonomously manage them;

where relevant, a local energy community may conclude an agreement with a distribution system operator to which their network is connected on the operation of the local energy community's network;

If this becomes reality, it would likely mean that Local Communities will be created to:

1. Maximize self consumption
2. Minimize the cost of energy

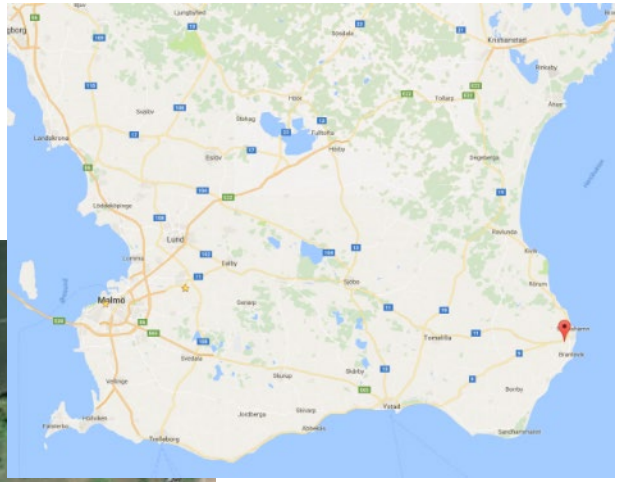
E.ON LES Project objectives

The objective of this LES Project is mainly:

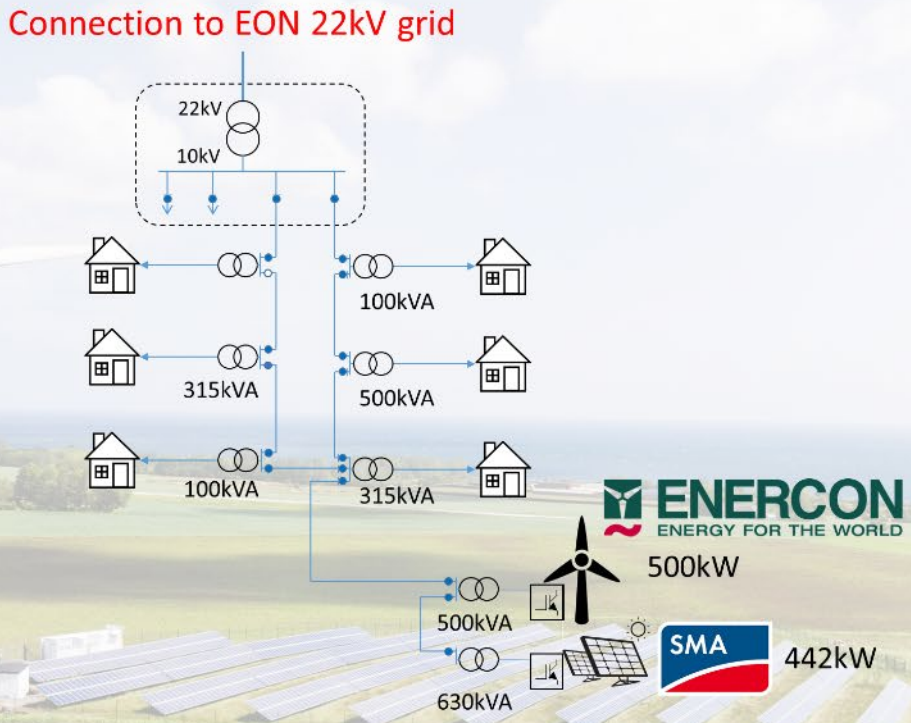
- To build and demonstrate capability (technical and commercial)
- Understand the business of LES, cost drivers, barriers, possibilities etc.
- Develop business cases and business models as well as identifying potential customers

The vision is to develop new, demanded solutions on the energy market and bring E.ON closer to the customer

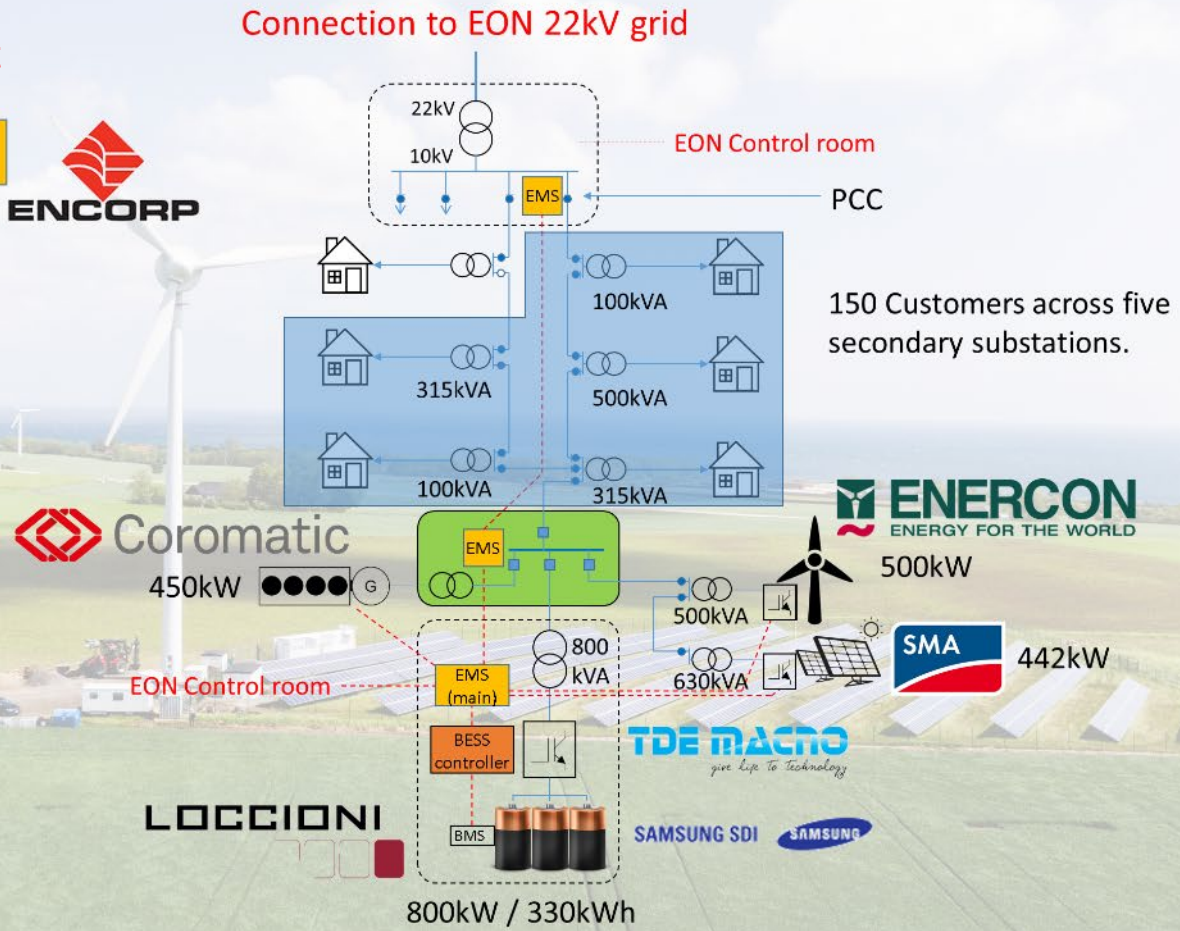
Simris – Simrishamn's Municipality



Existing circuit at Simris

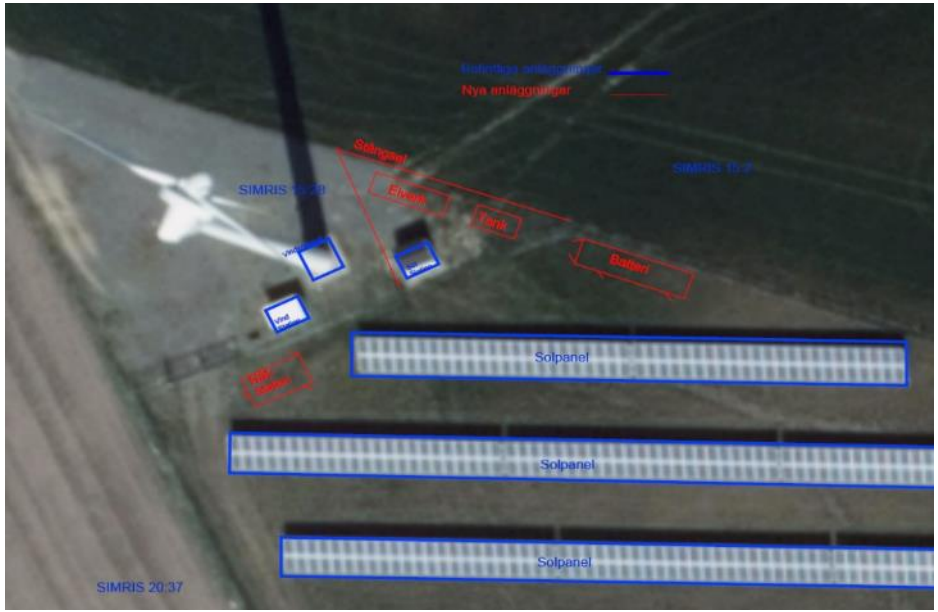


Development of microgrid system at Simris



LES Simris – Microgrid components

The microgrid was inaugurated in October 2017



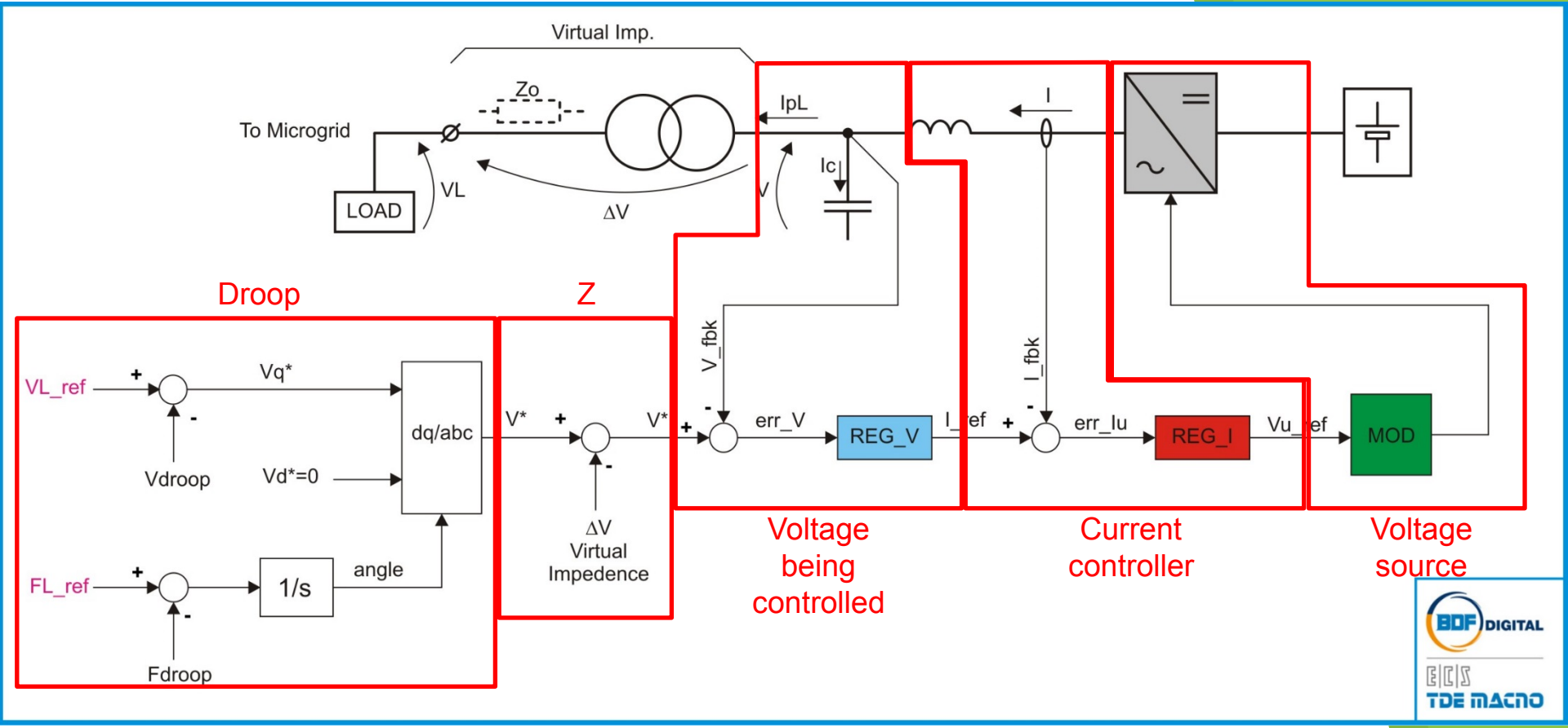
Red = New

Blue = existing

Battery system

Back-up generator

Control structure for battery PCS

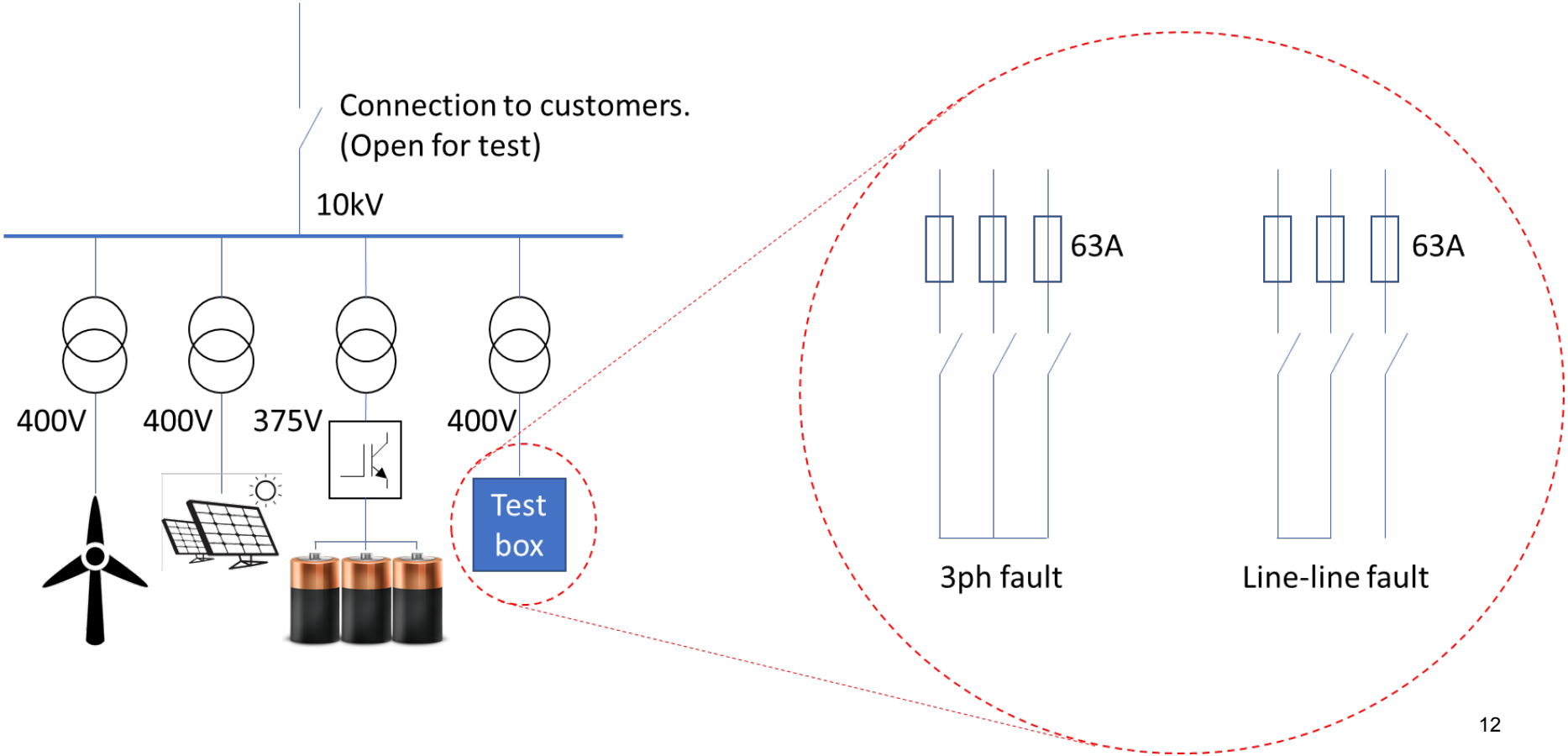


Courtesy of BDF Digital / TDE Macno

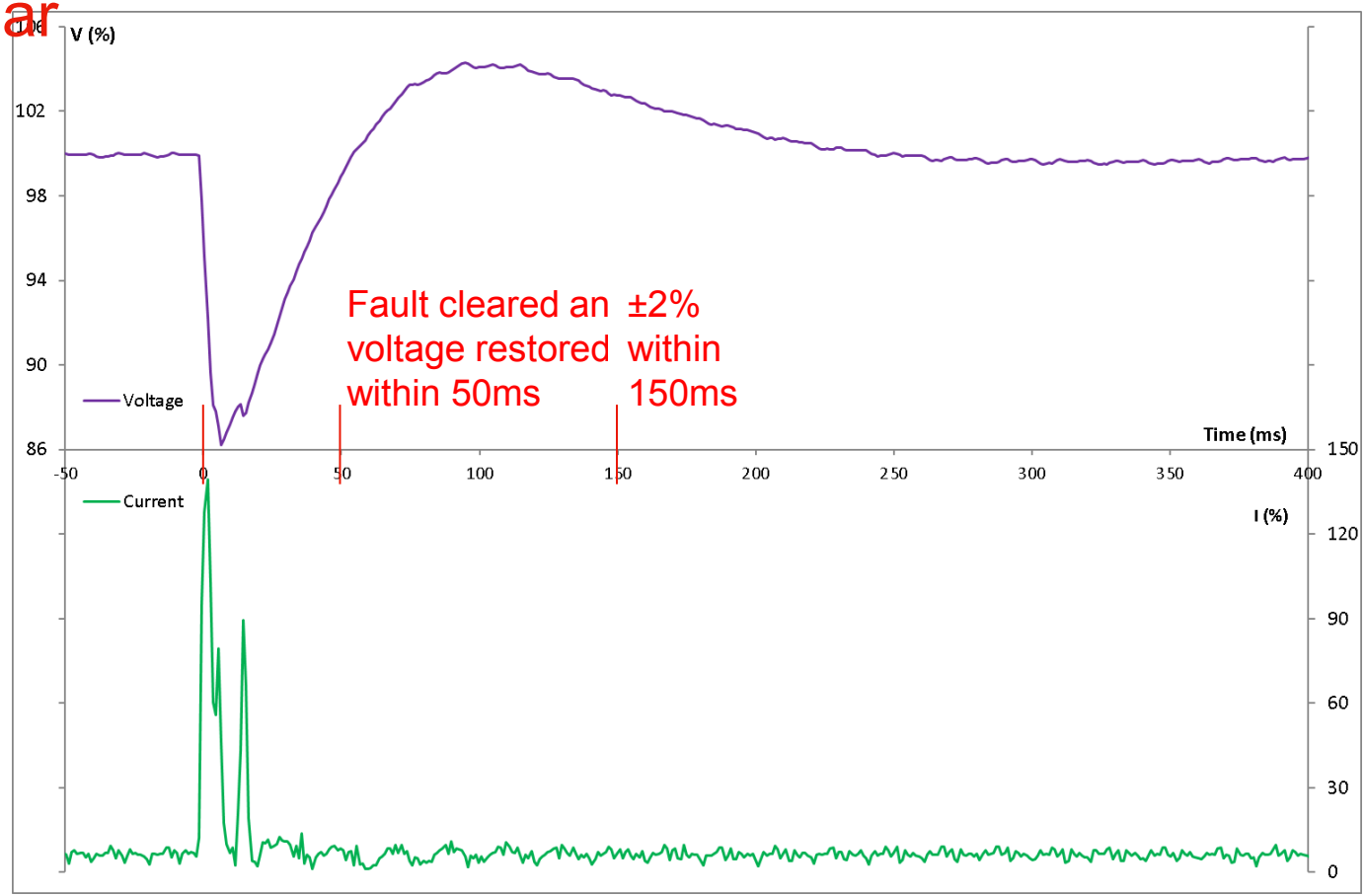
Battery PCS summary

- Standard 3-limb bridge hardware
- Control approach enables the functions that we require:
  - Operation in grid-connected and islanded mode
  - Power sharing with other power electronics and conventional synchronous generation
  - Seamless transition to between modes without high speed communication
  - Fault clearance and recovery
- Estimated 10% increase in cost compared to basic power electronicss interface
  - Partially attributable to low ac voltage to allow fully circular capability for all battery voltages
- Would not currently be compliant with all National Grid (UK TSO) draft requirements for Grid-Forming inverters
  - Parallel development activities
  - Meets all design intents, but in different way to that envisaged
- Additional tests planned to demonstrate transient power sharing

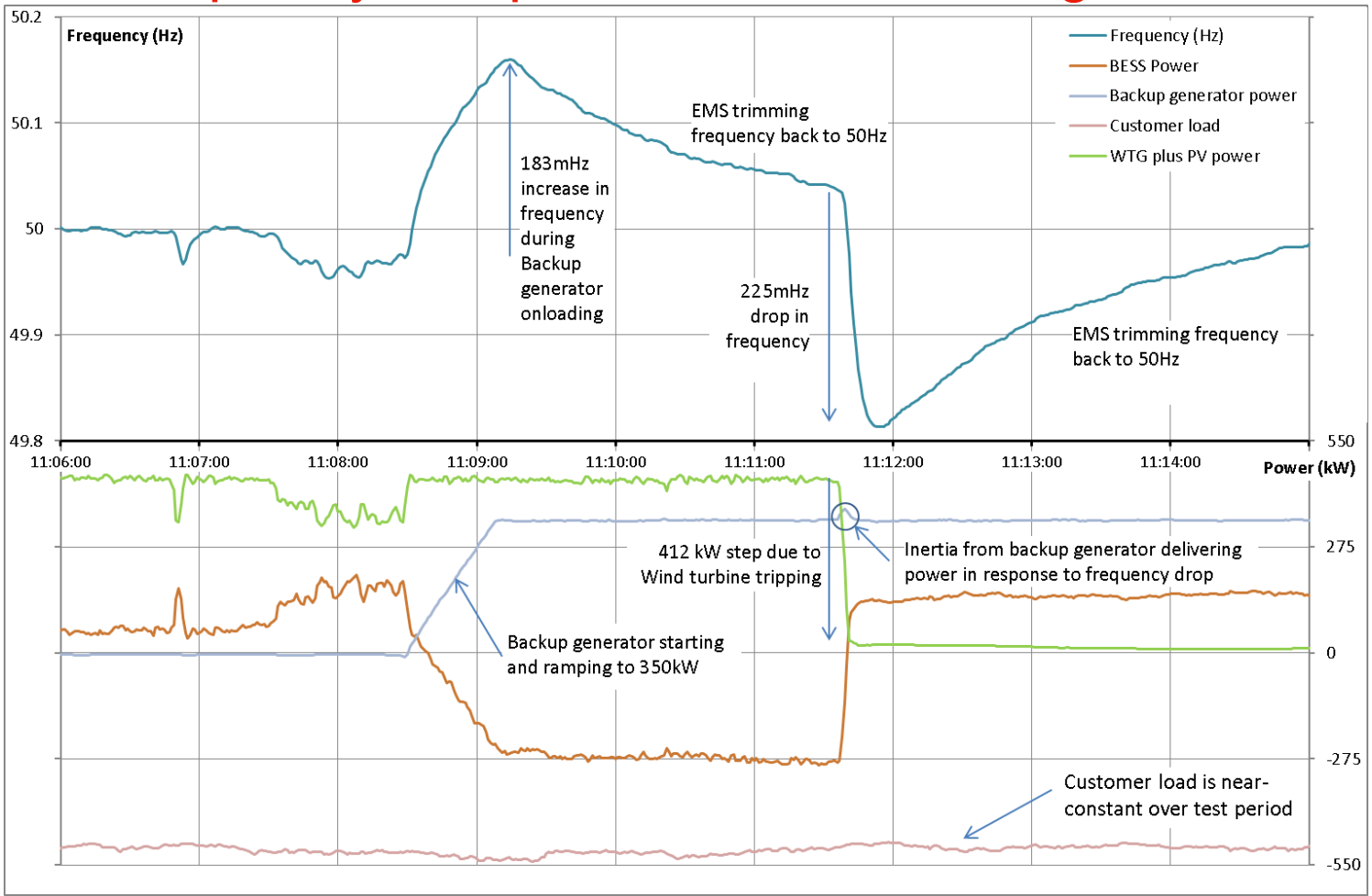
Fault testing setup (customers not connected for this test)



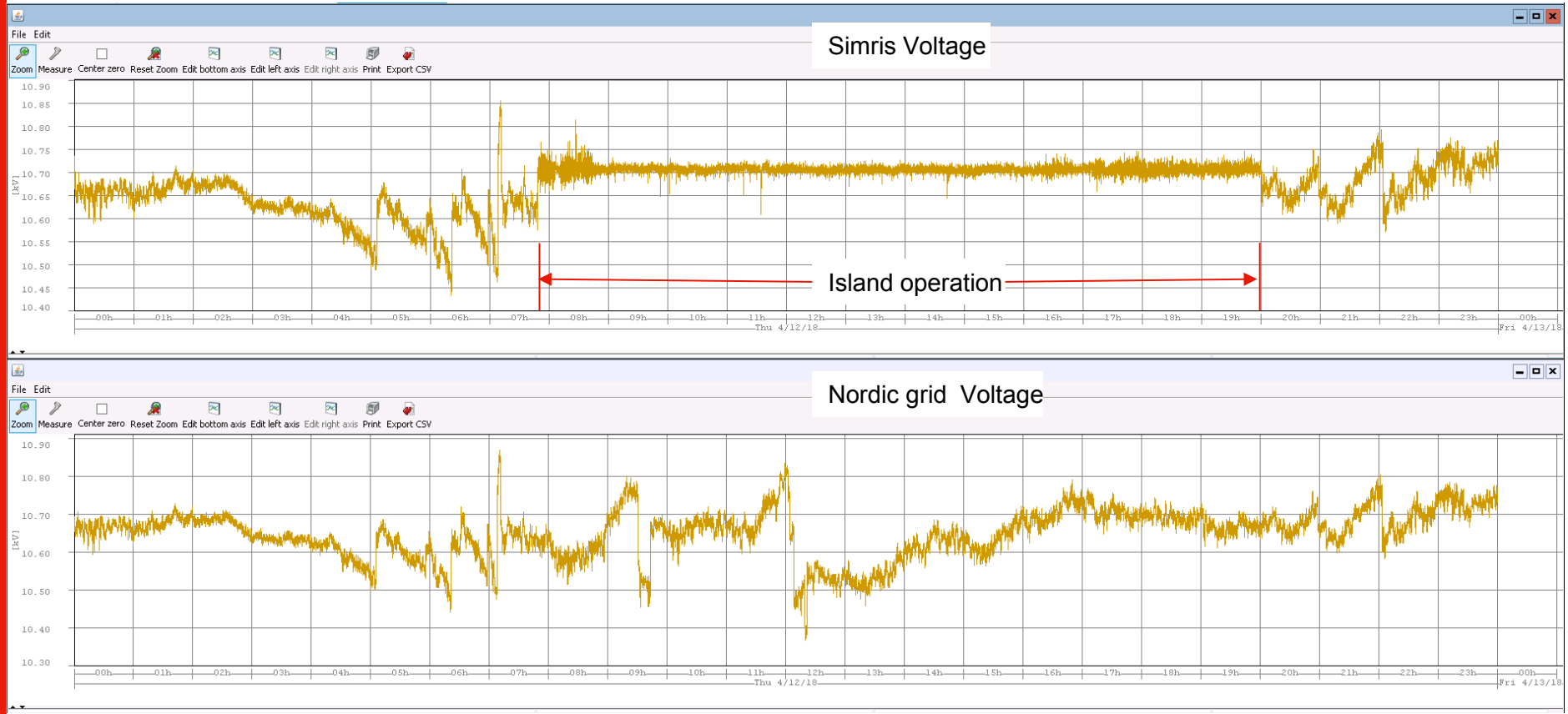
Voltage and current during 3ph fault, 63A fuse – Battery and solar



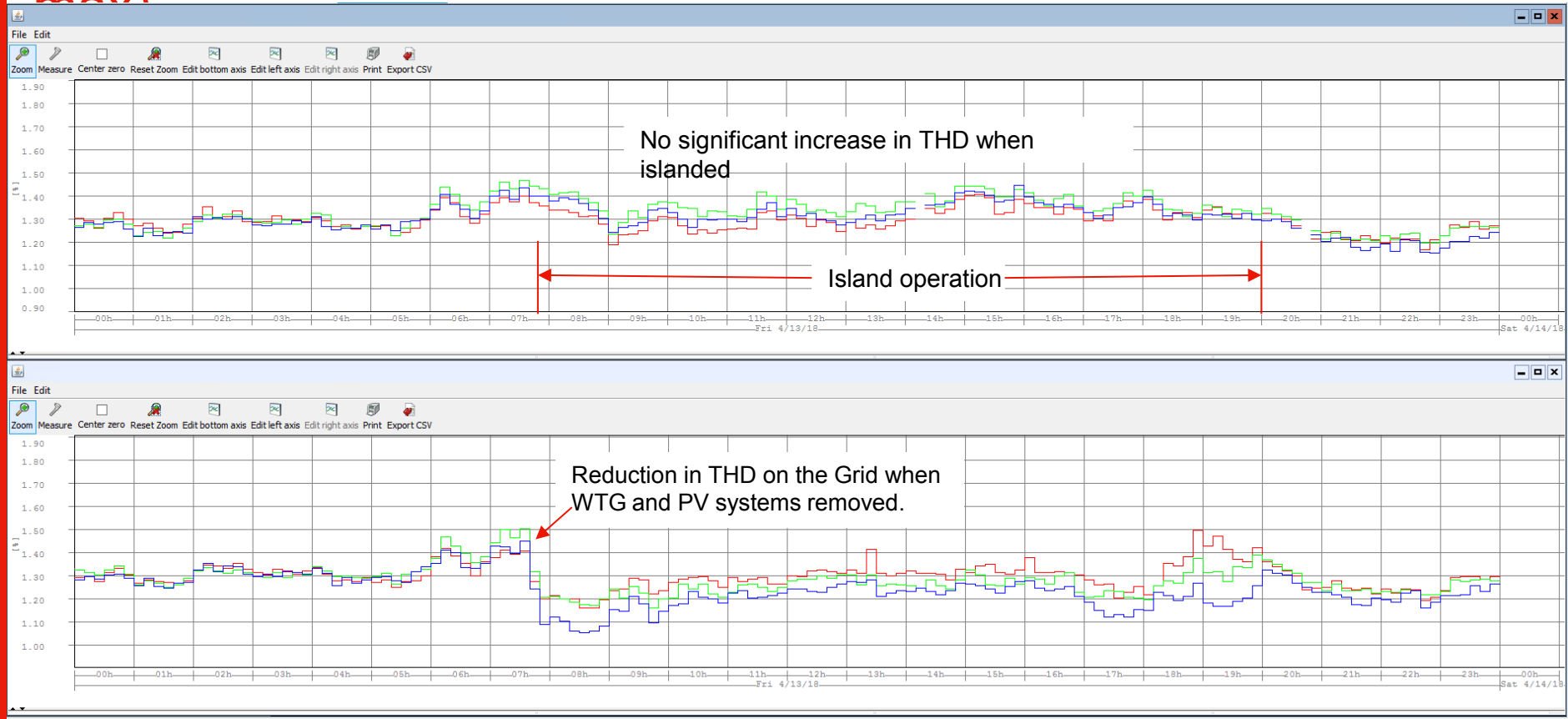
Results – Frequency and power of first islanding tests Dec 2017



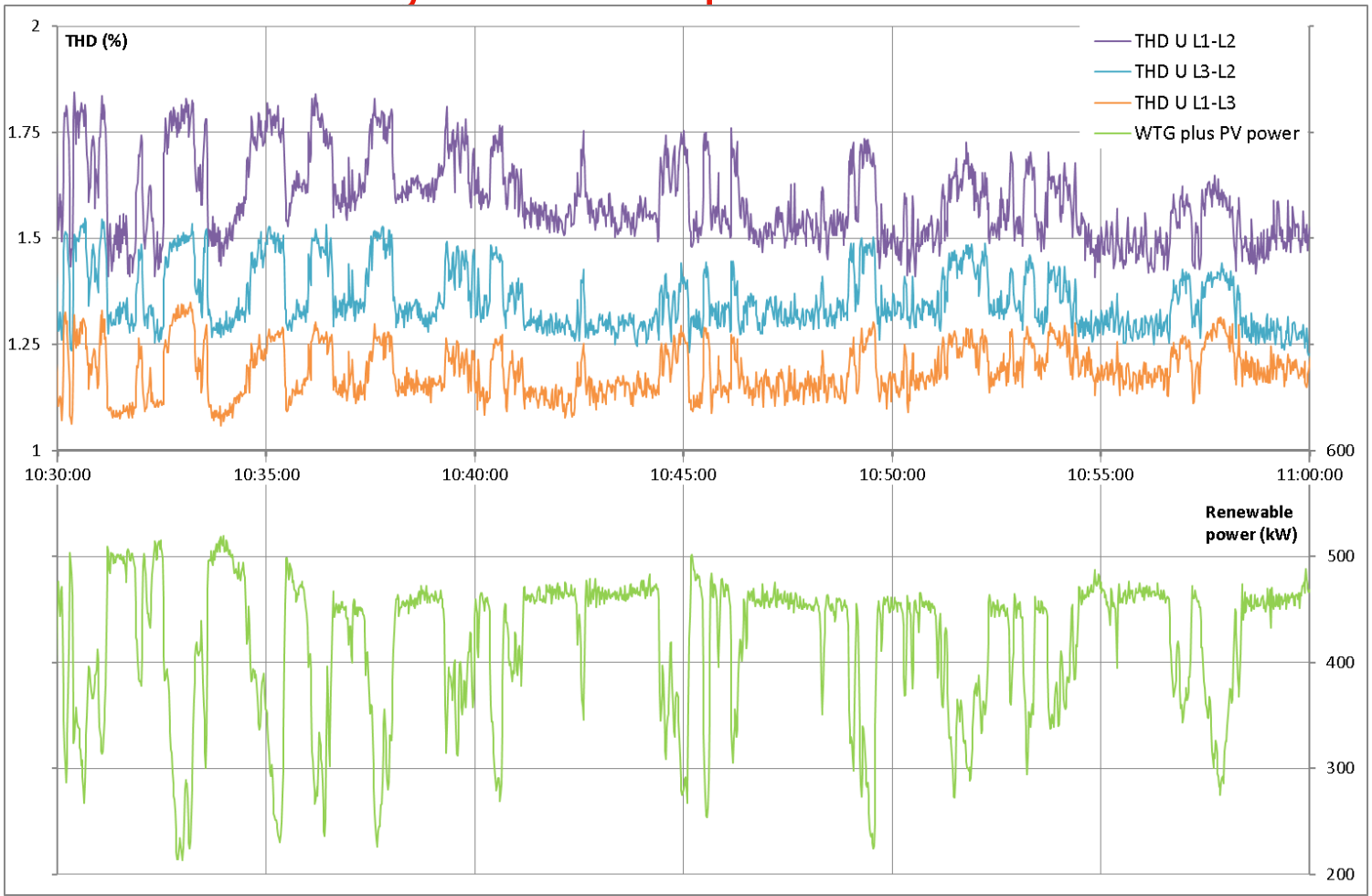
Island Voltage vs Nordic system 12 April



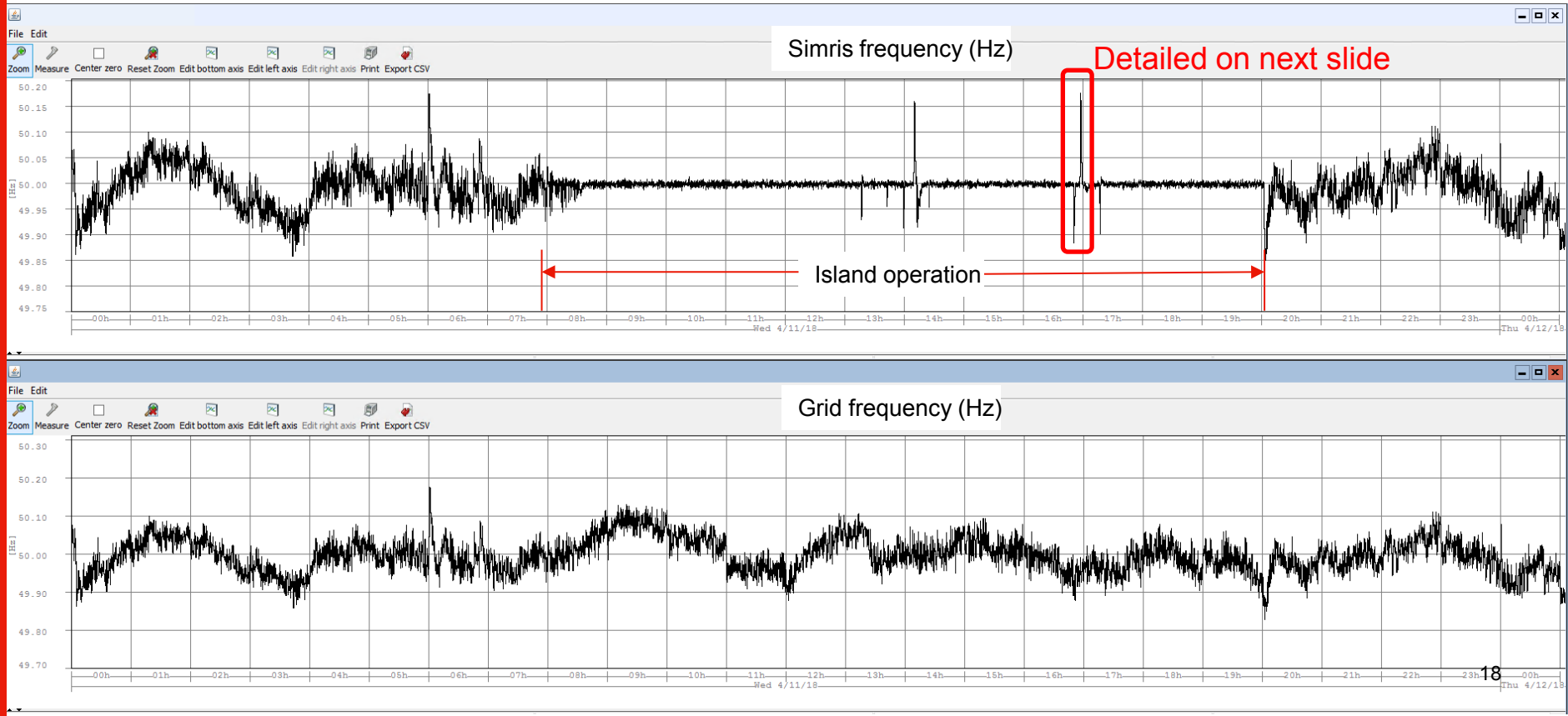
Total Harmonic Distorsion – THD 13th April (specification 8% max)



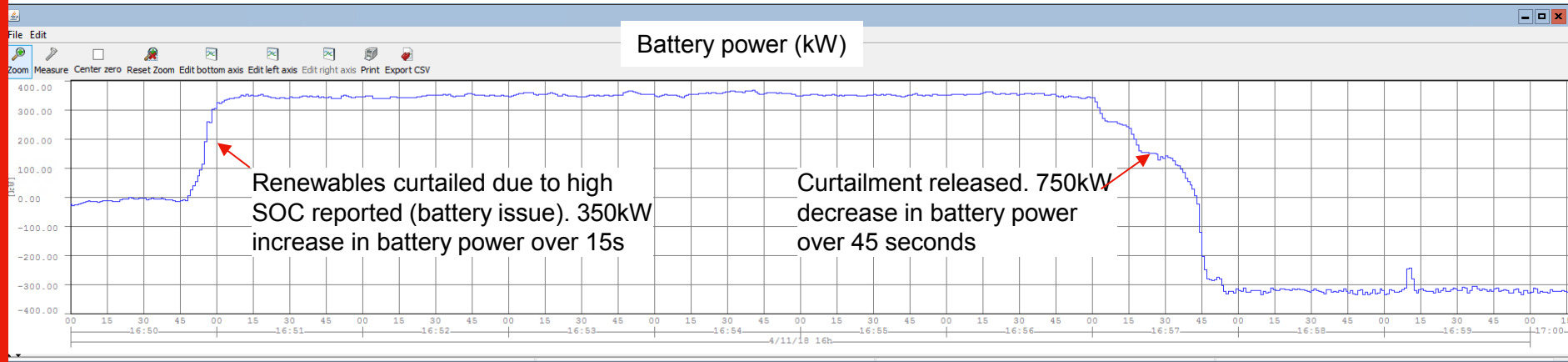
THD –varies inversely with wind power when islanded

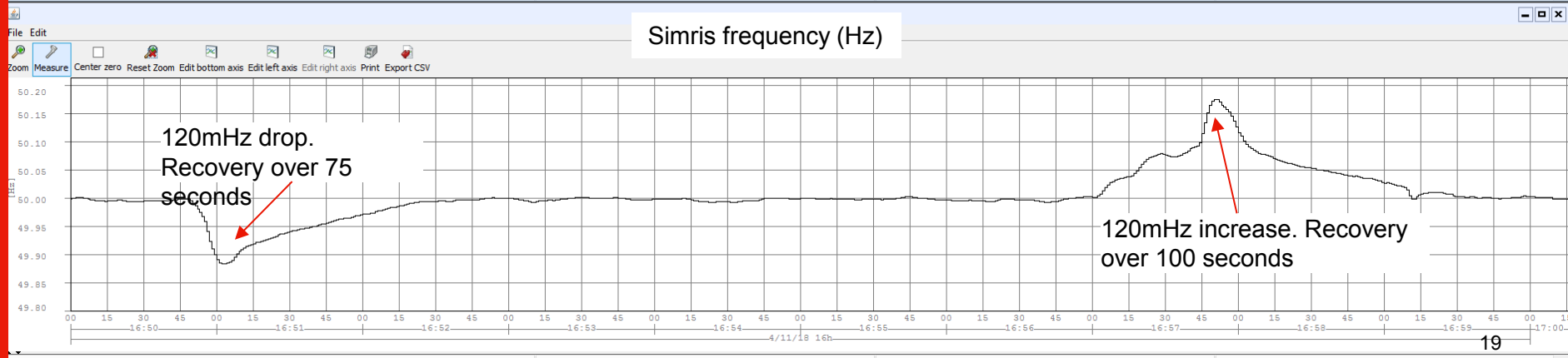


Frequency compared to Nordic system 11th April

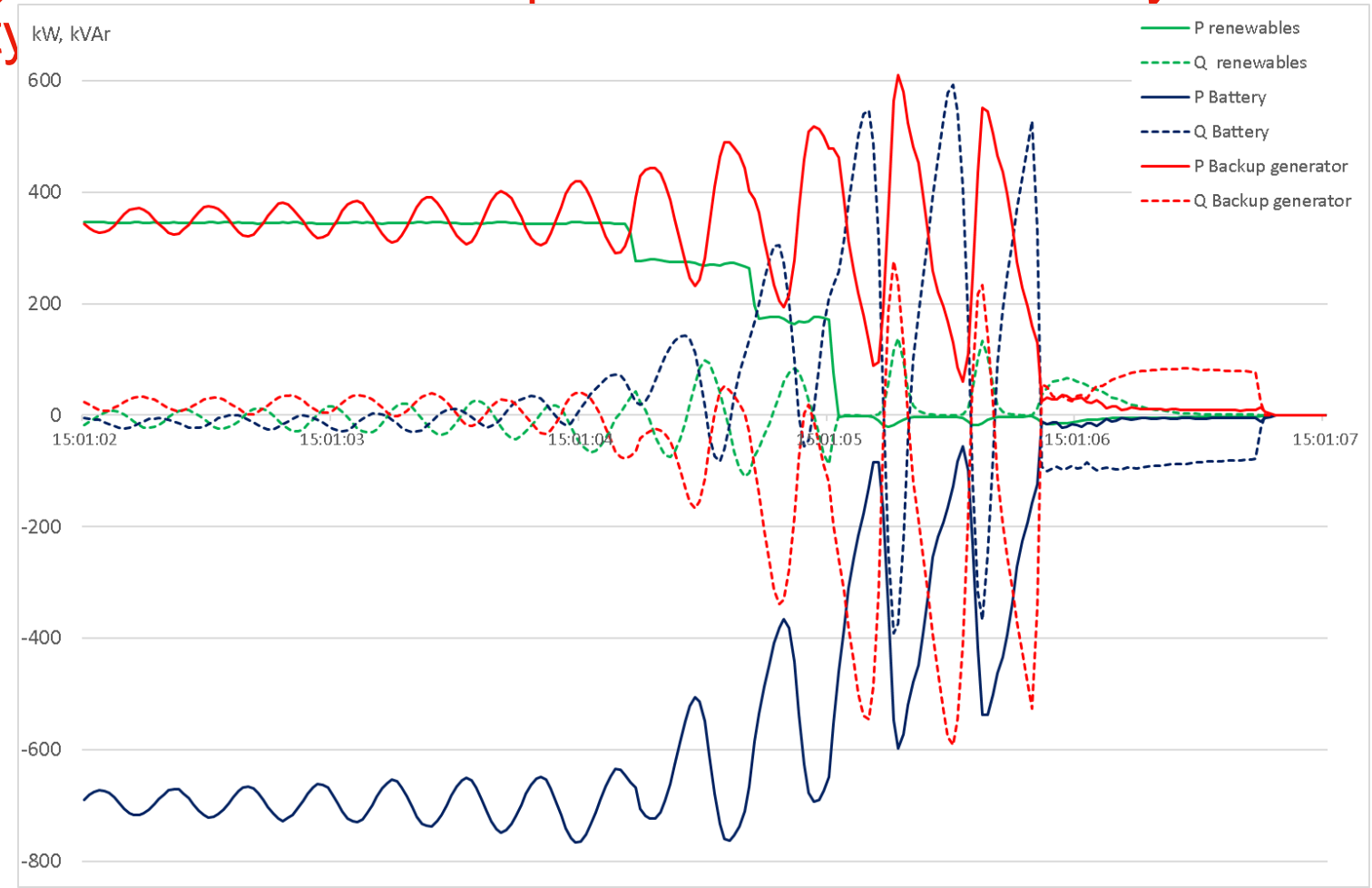


Frequency compared to Nordic system 11th April

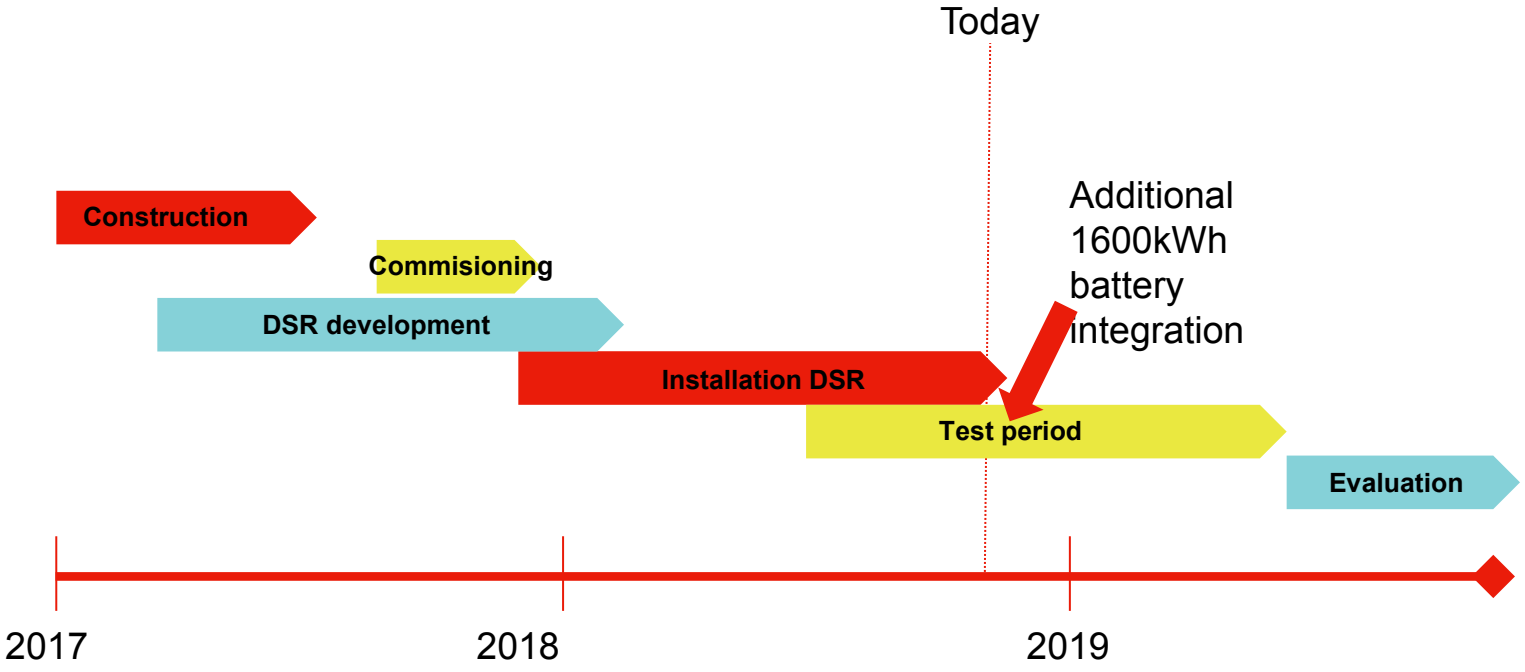




Changes to 1 or 2 inverter parameters can seriously affect stability



Timeline


Today
Construction
Commisioning
DSR development
Installation DSR
Test period
Evaluation
Additional 1600kWh battery integration
2017
2018
2019

Summary

- Novel battery and power electronics systems have allowed the integration of a microgrid system with operation on 100% converters (zero inertia):
  - 20yr old Enercon wind turbine
  - 6yr old Solar generation
- Power quality well within statutory limits (voltage, frequency, THD etc.)
- Security of supply maintained througout transitions and during island operation
- Fault current behaviour has been tested and is acceptable
- A zero-inertia (no classical inertia) system is capable of handling big load steps
- Additional battery with power electronics will be added by end 2018

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n°731289

Thank you for your attention

If you want to follow the system live: les.eon.se

For more information, please visit www.eon.se/simris

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