

# Wide Area Monitoring

Enabling Wide Area Monitoring, Protection, and Control (WAMPAC) systems with IEC 61850 to improve grid operation and stability

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LANDSNET

# Agenda

- Icelandic transmission system and the operational challenges
- Development of Wide Area Control Methodology
- Testing and Implementation of WACS
- Examples of how WACS have improved system response during disturbances
- What's next for WACS in Iceland?

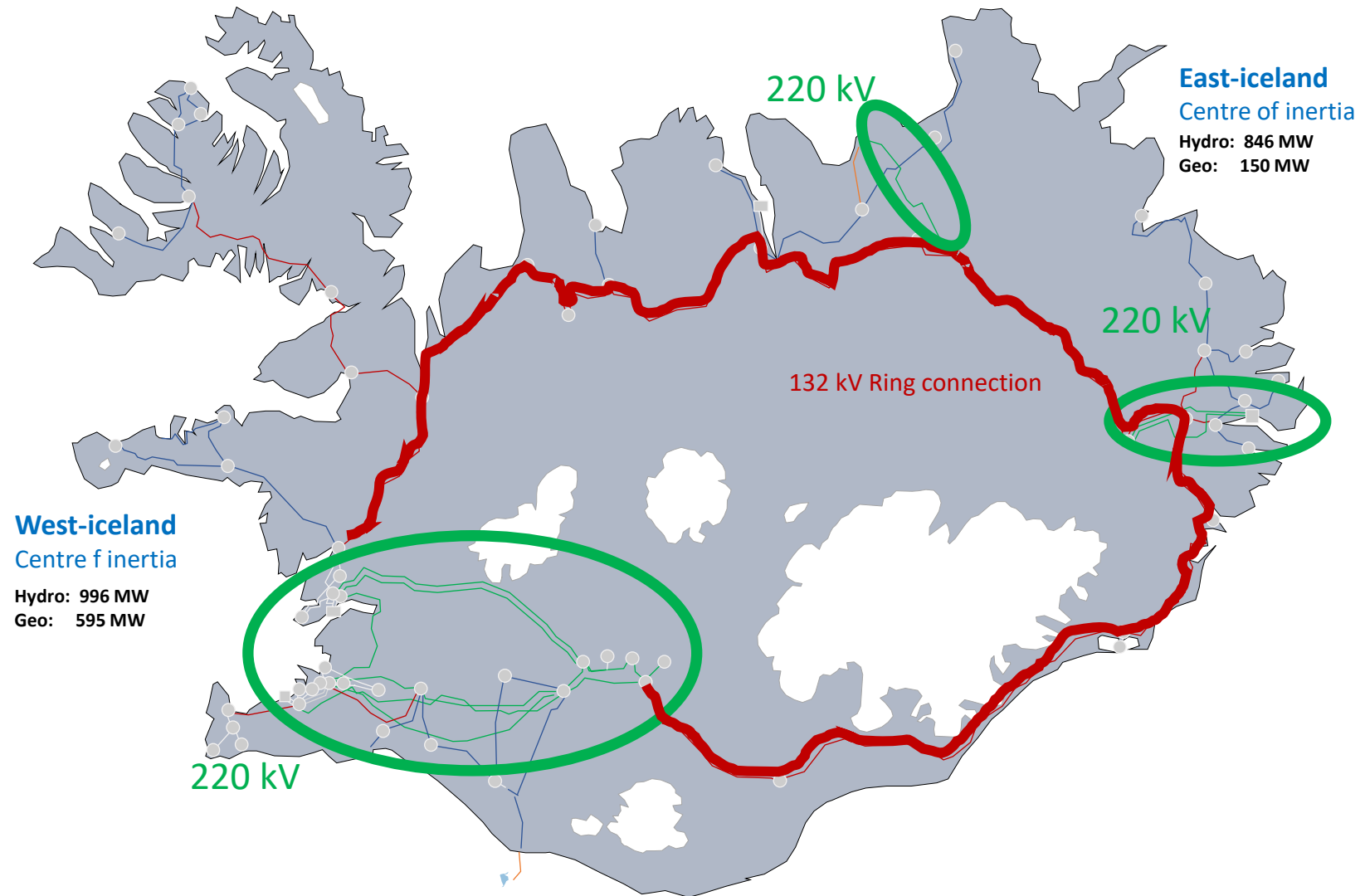
# Icelandic Transmission System

Load peak: 2400 MW

Total Energy: 17.7 GWh/year

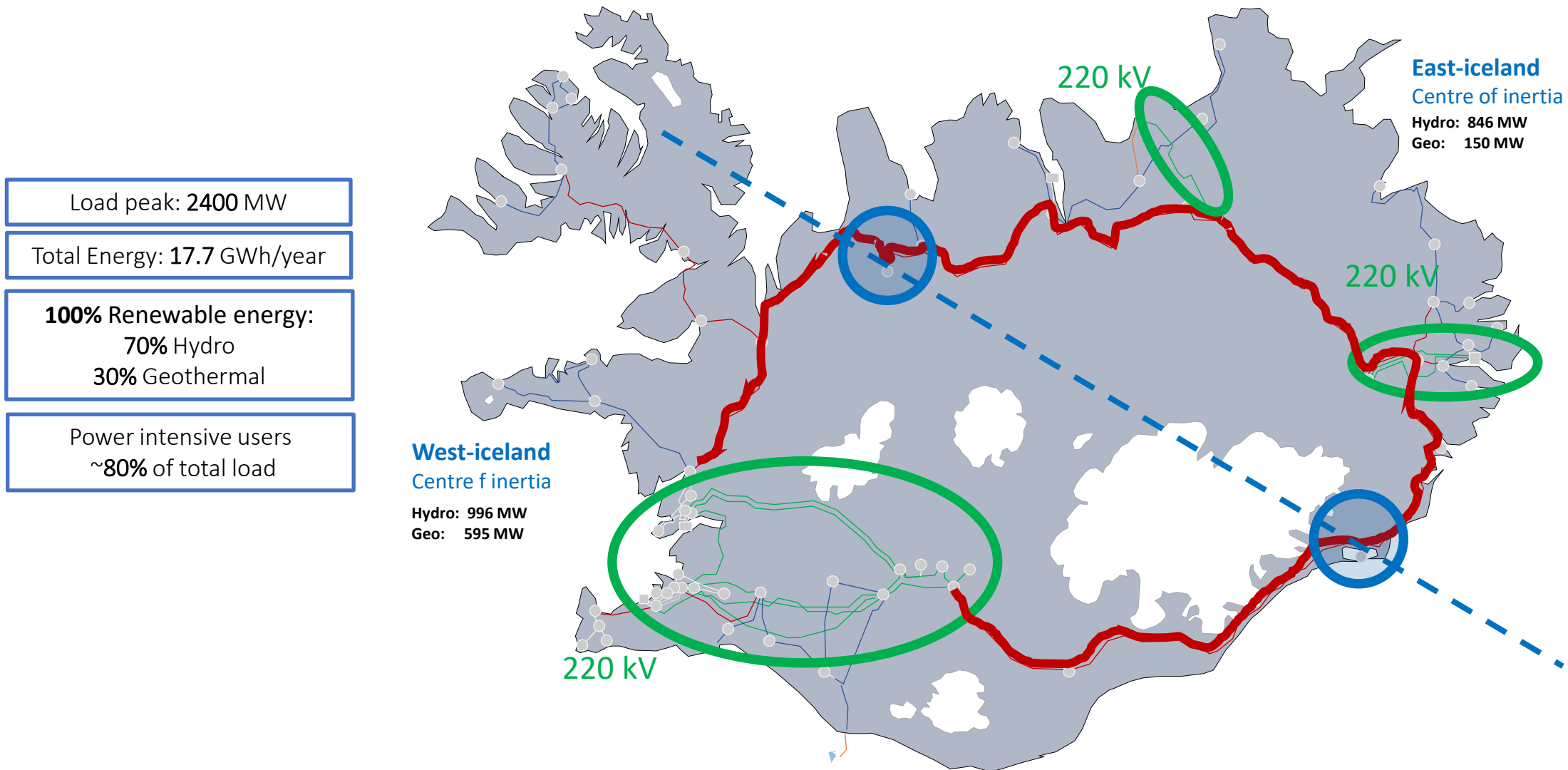
**100% Renewable energy:**  
70% Hydro  
30% Geothermal

Power intensive users  
~80% of total load



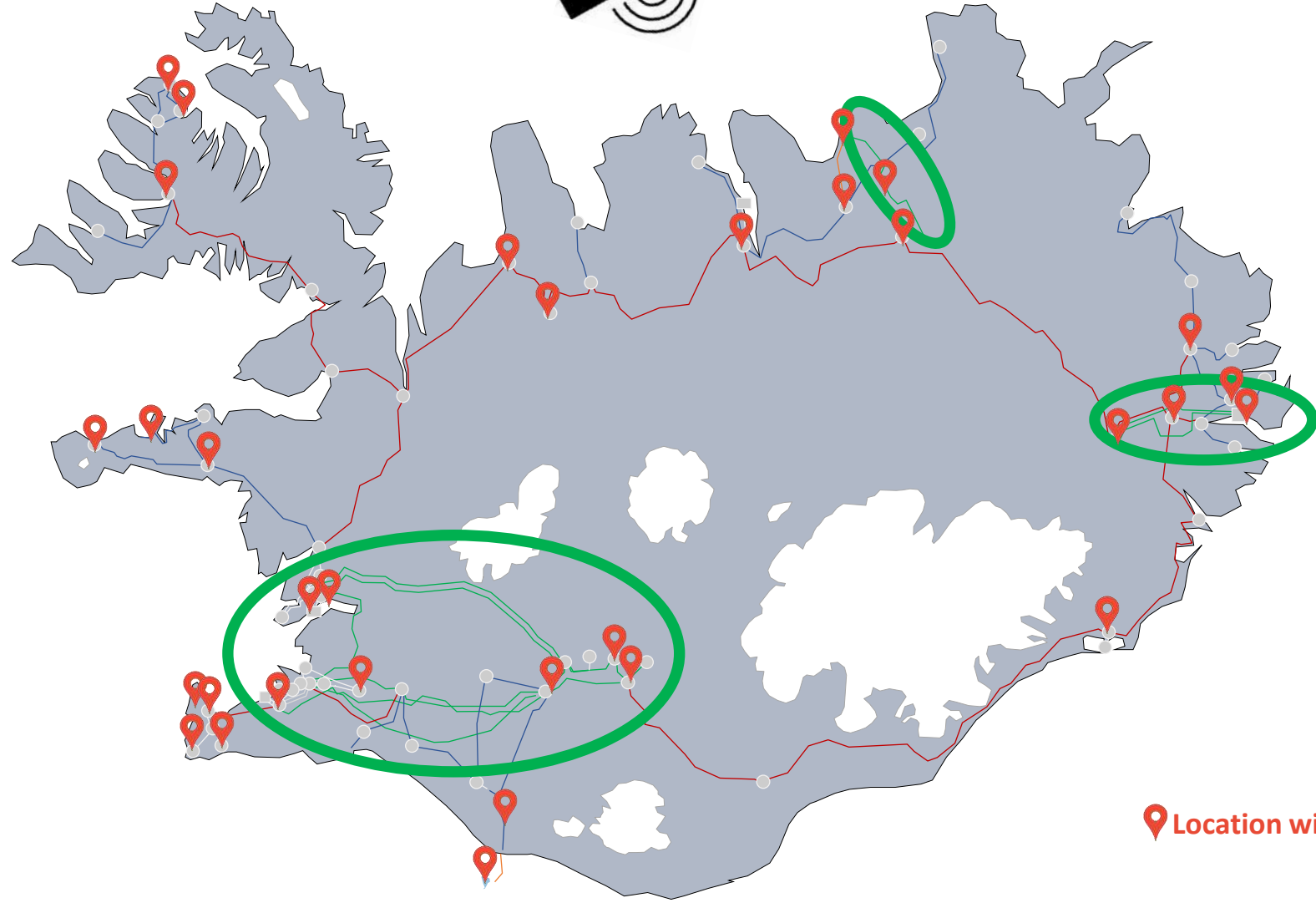
The grid includes more than 3,000km of transmission lines and about 70 substations

# Icelandic Transmission System



The grid includes more than 3,000km of transmission lines and about 70 substations

# Wide-Area-Monitoring-System



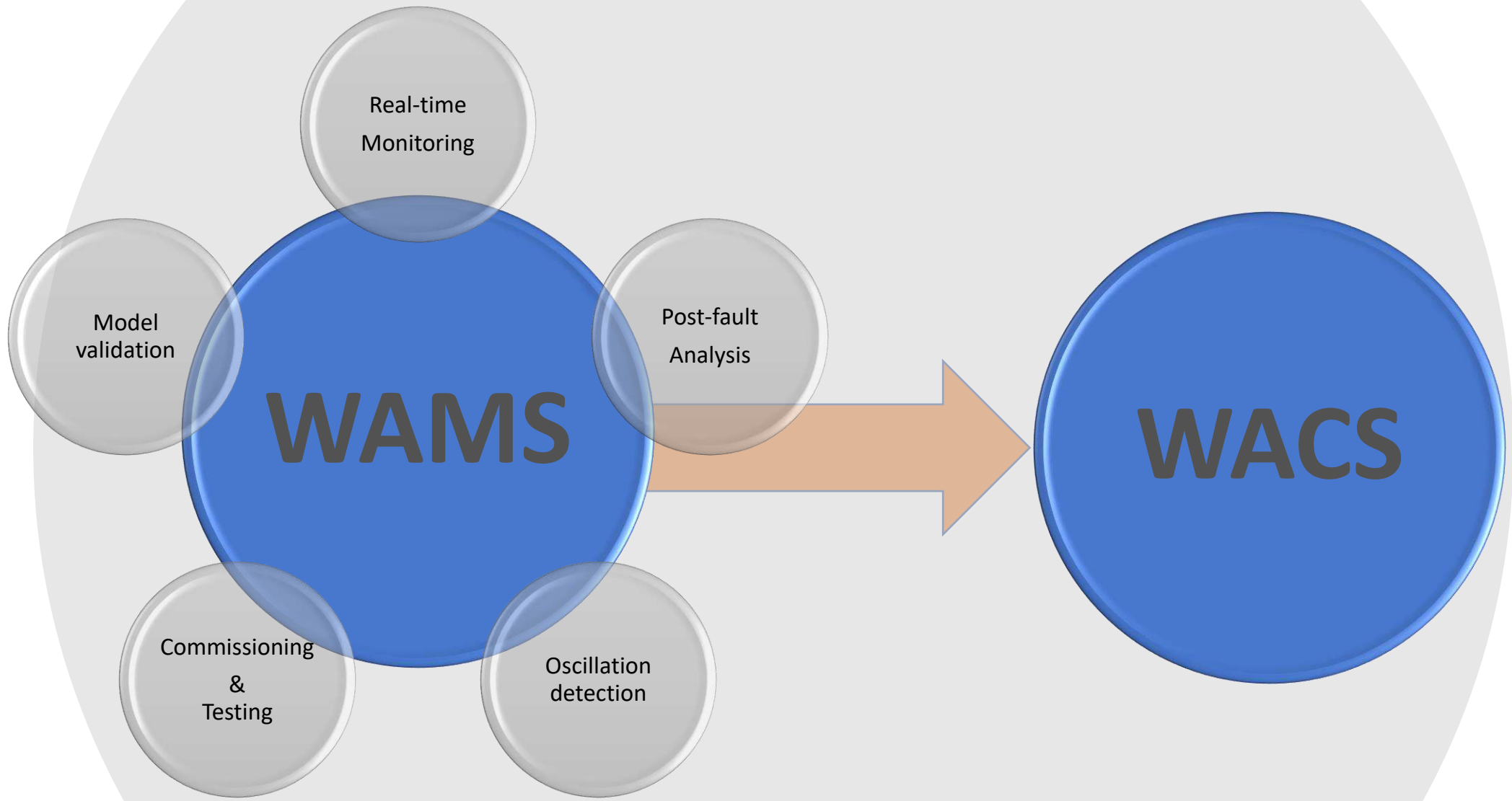
Extensive WAMS monitoring & records (~60 PMUs)

Good quality communications network

Landsnet & grid-stakeholders willing to trial innovation

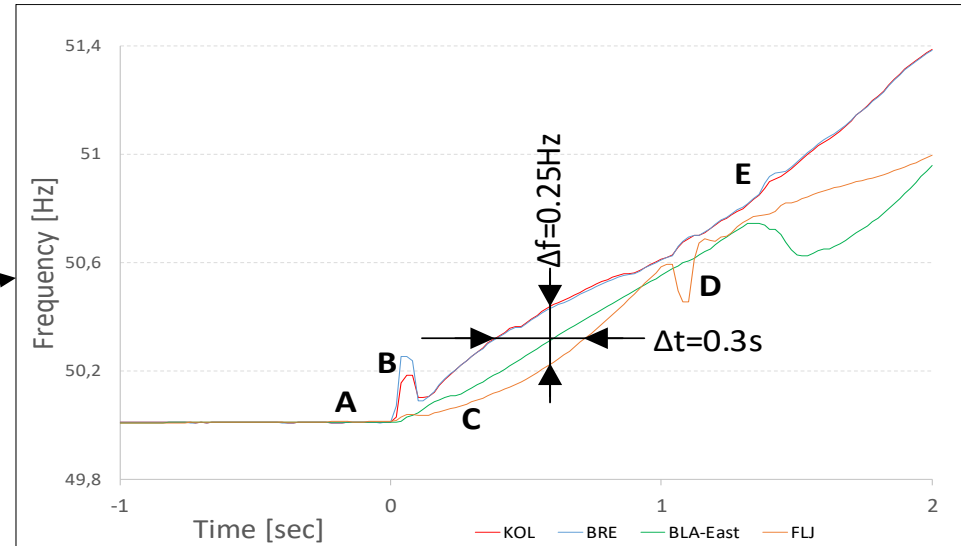
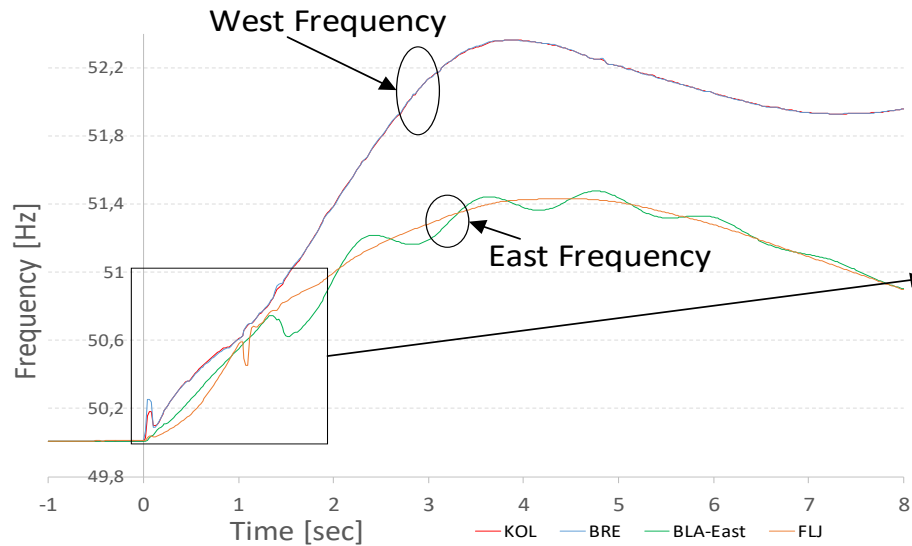
New control is measurable on small system

 Location with PMU



# Effect of Sparse Centres of Inertia

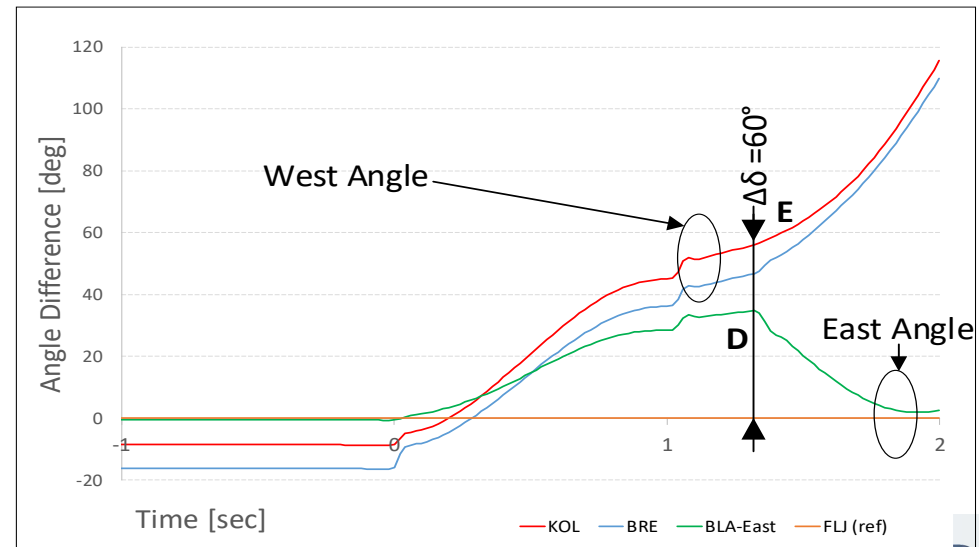
- Iceland shows frequency & angle divergence between centres of inertia



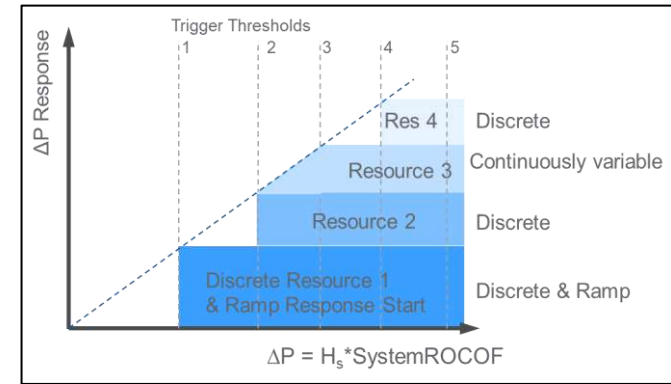
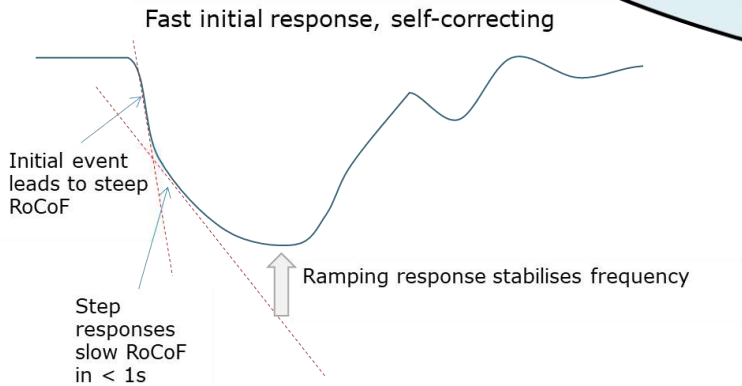
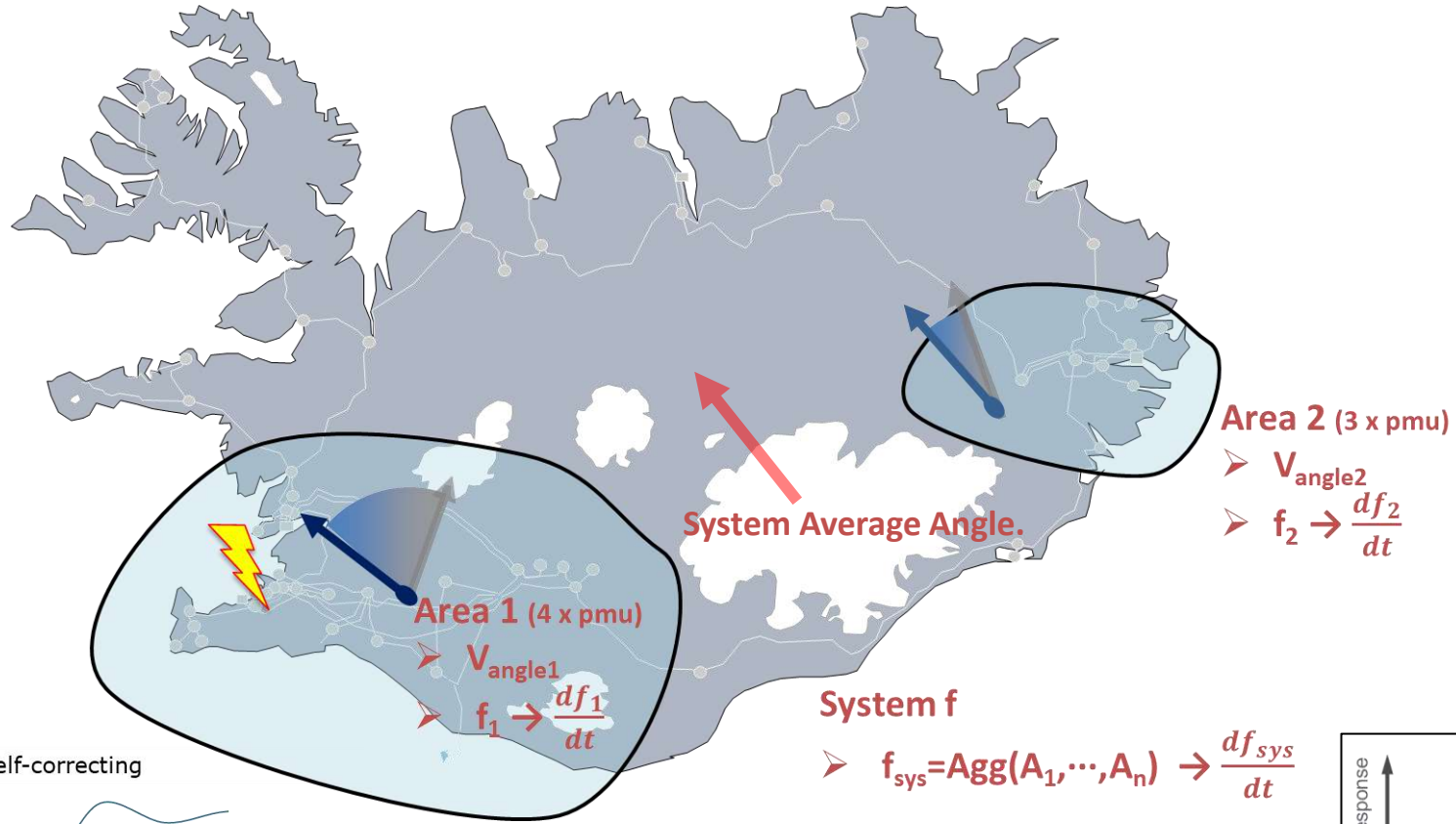
➔ 1.2s to Islanding

➔ 4s to Frequency Peak

- A** T=0s Industrial load #1 reduction (first stage)
- B** T=0.2s Industrial load #1 reduction (second stage)
- C** T=0.36s Industrial load #1 trip
- D** T=1.1s Area angles separated by 60°, result in high E-W power. One route opens by special protection
- E** T=1.2s Areas accelerate away from each other; synchronism is lost and system islands

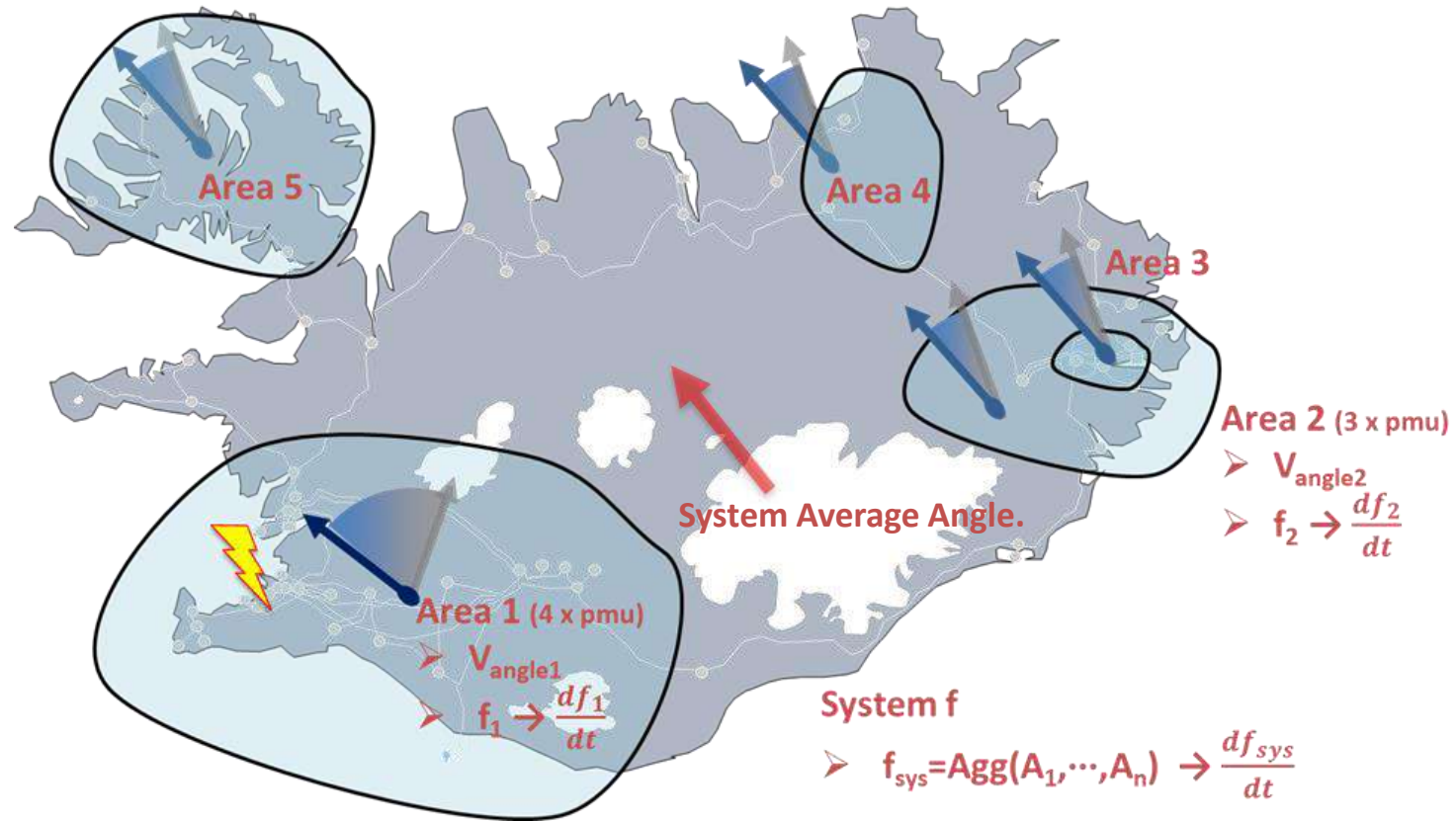


# General Method for Locational Fast Response

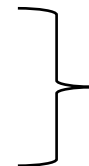




# General Method for Locational Fast Response



- Fast
- Locational
- Proportional to disturbance

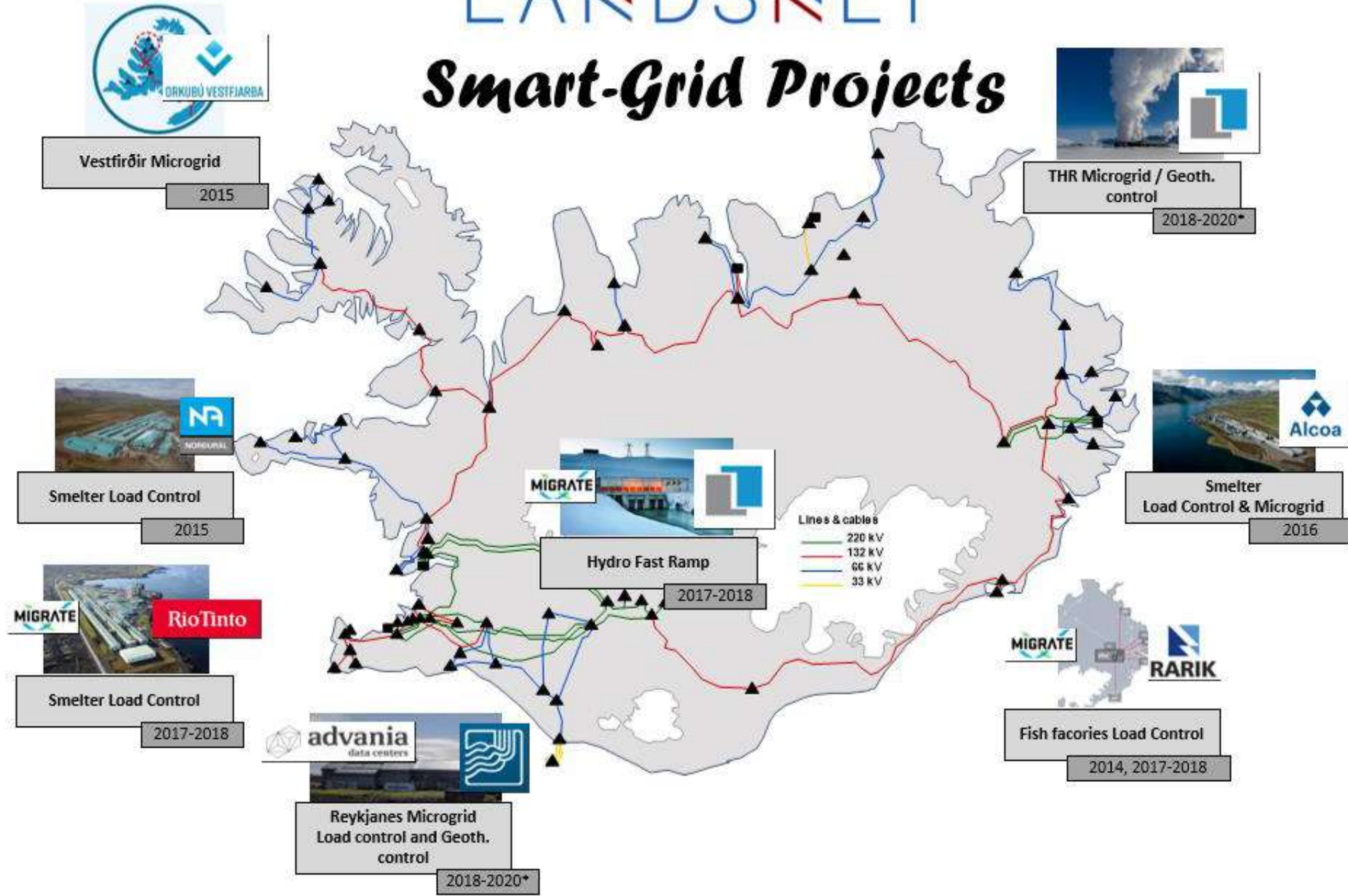


- Response Driven
- Event Driven



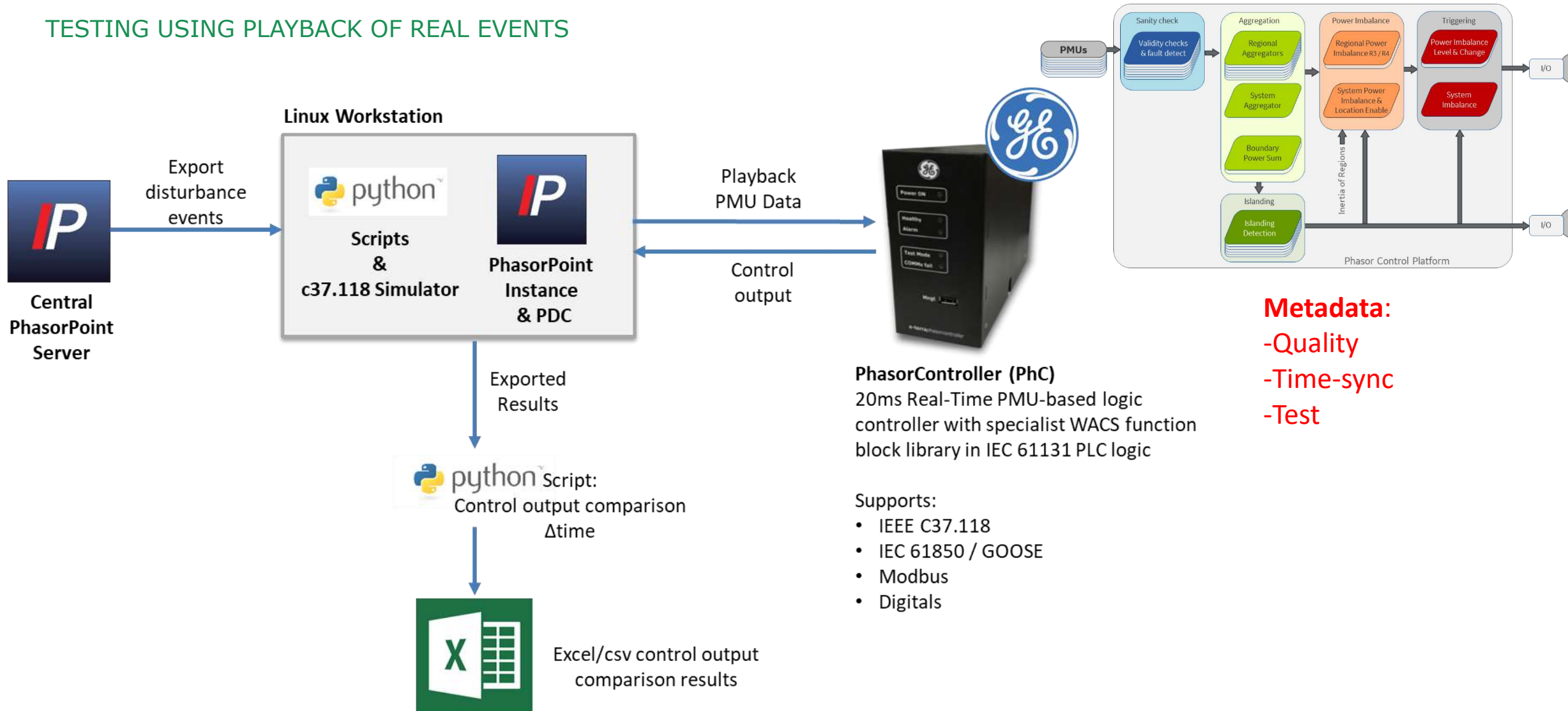
# LANDSNET

## Smart-Grid Projects

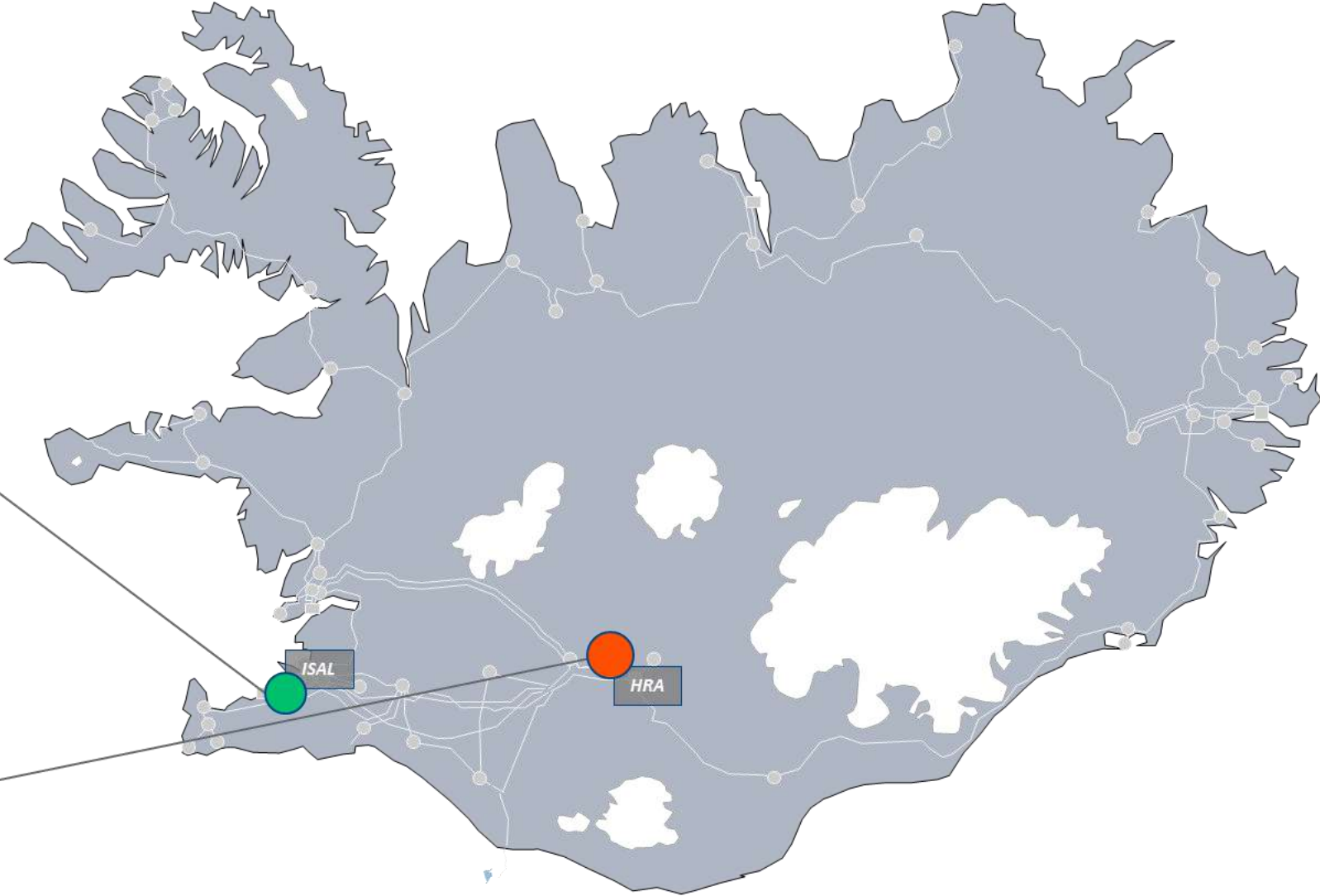
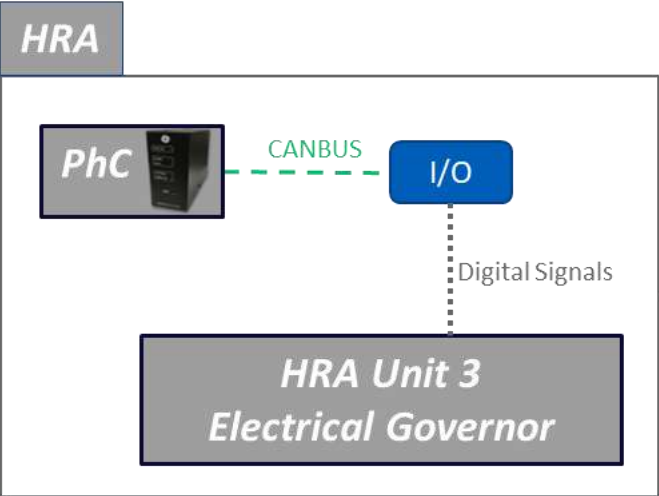
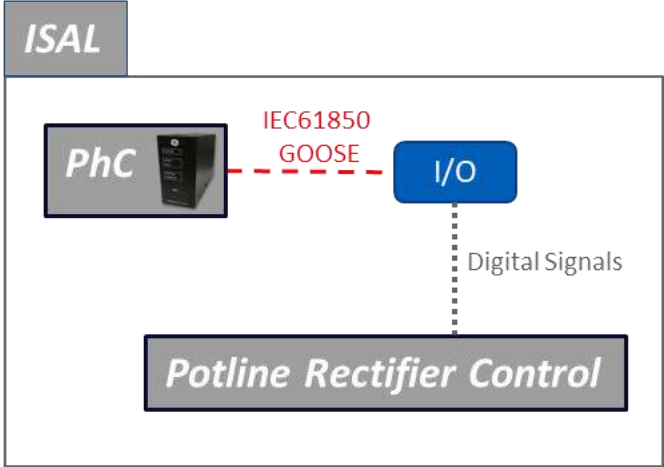


# Test Environment

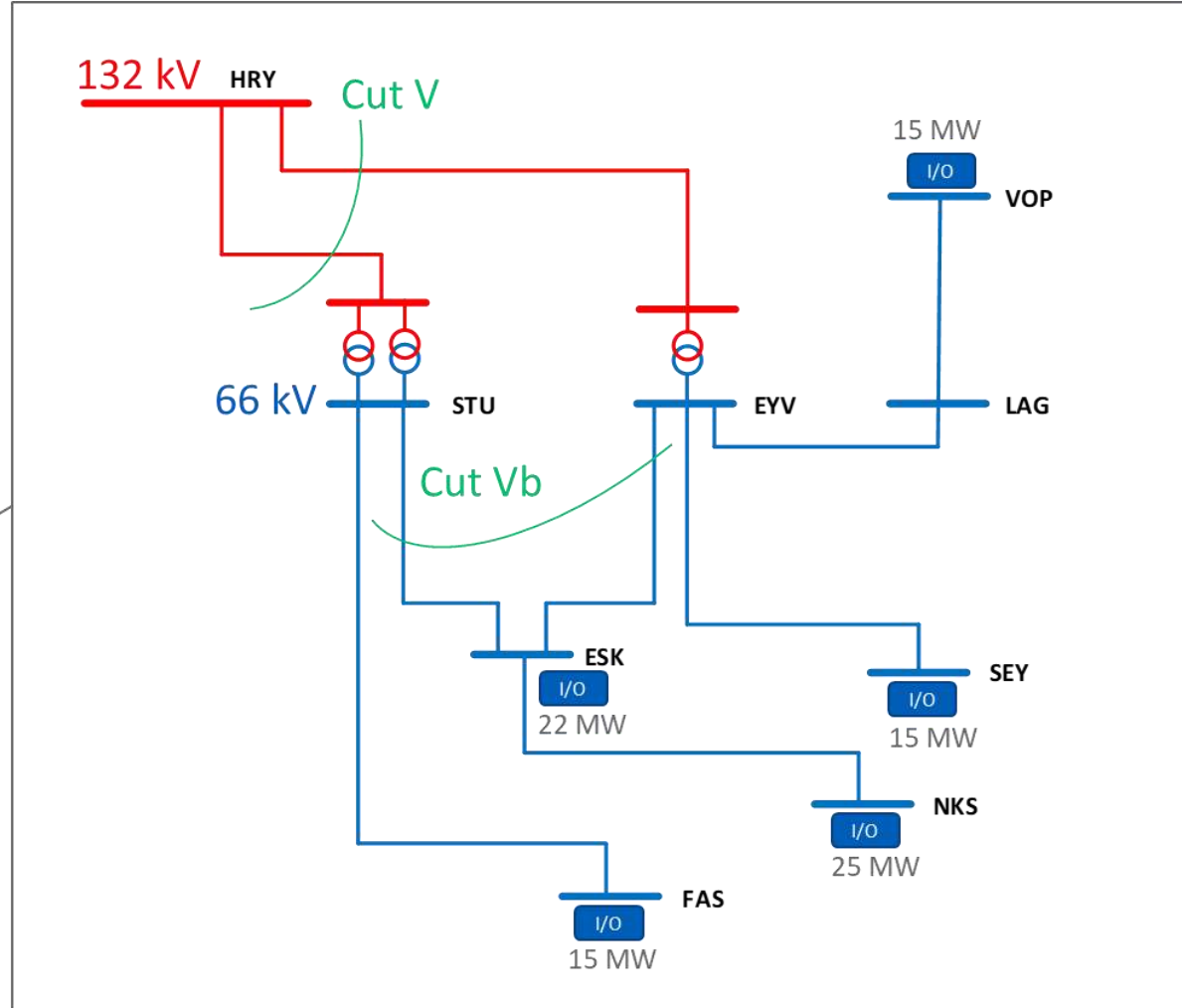
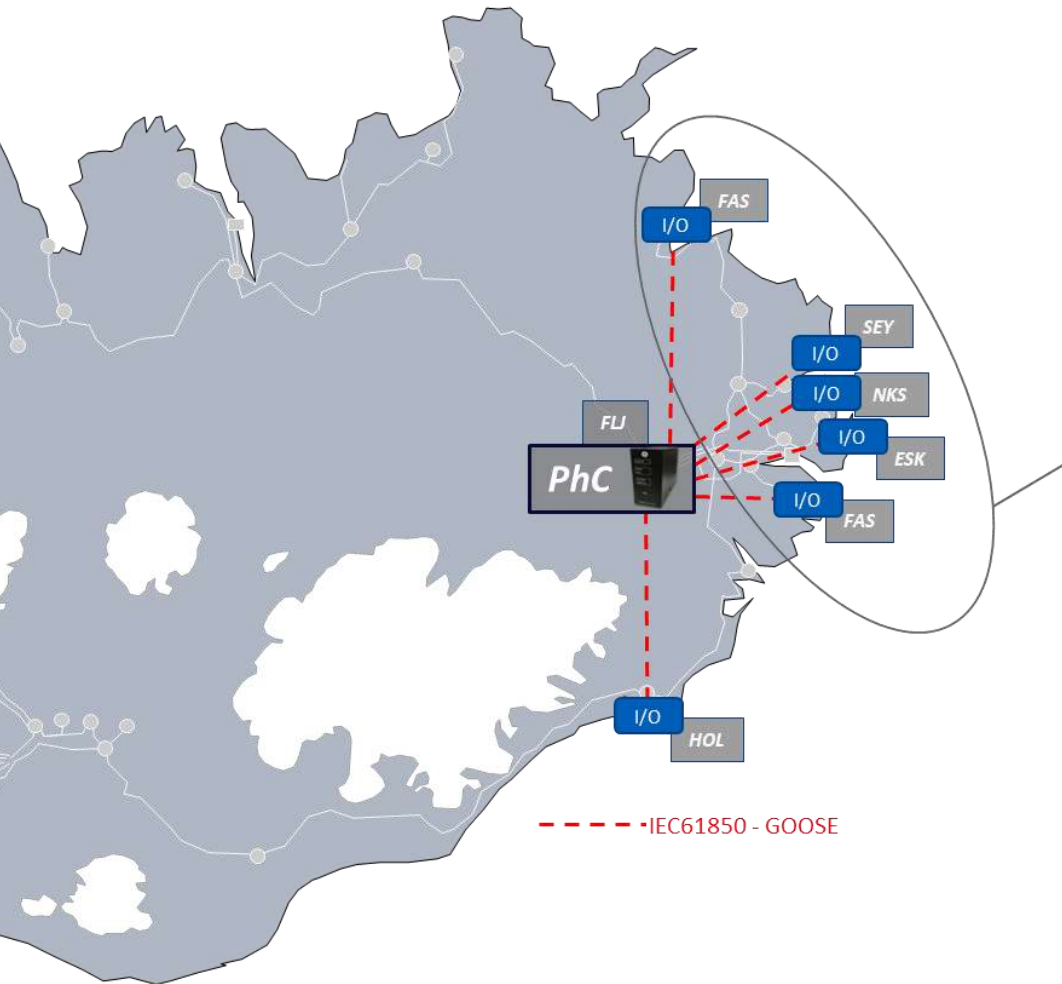
TESTING USING PLAYBACK OF REAL EVENTS



# Implementation

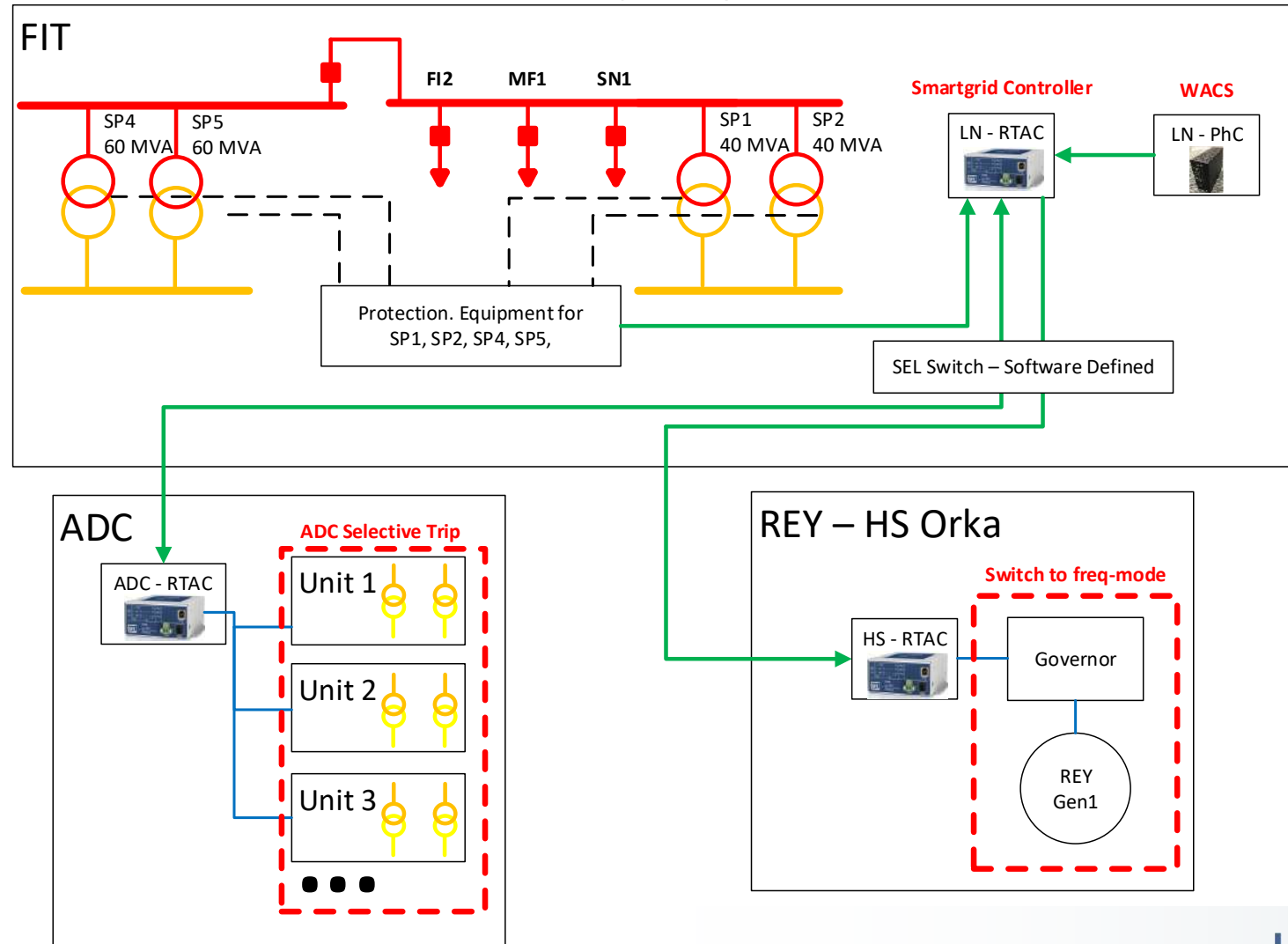


# Implementation



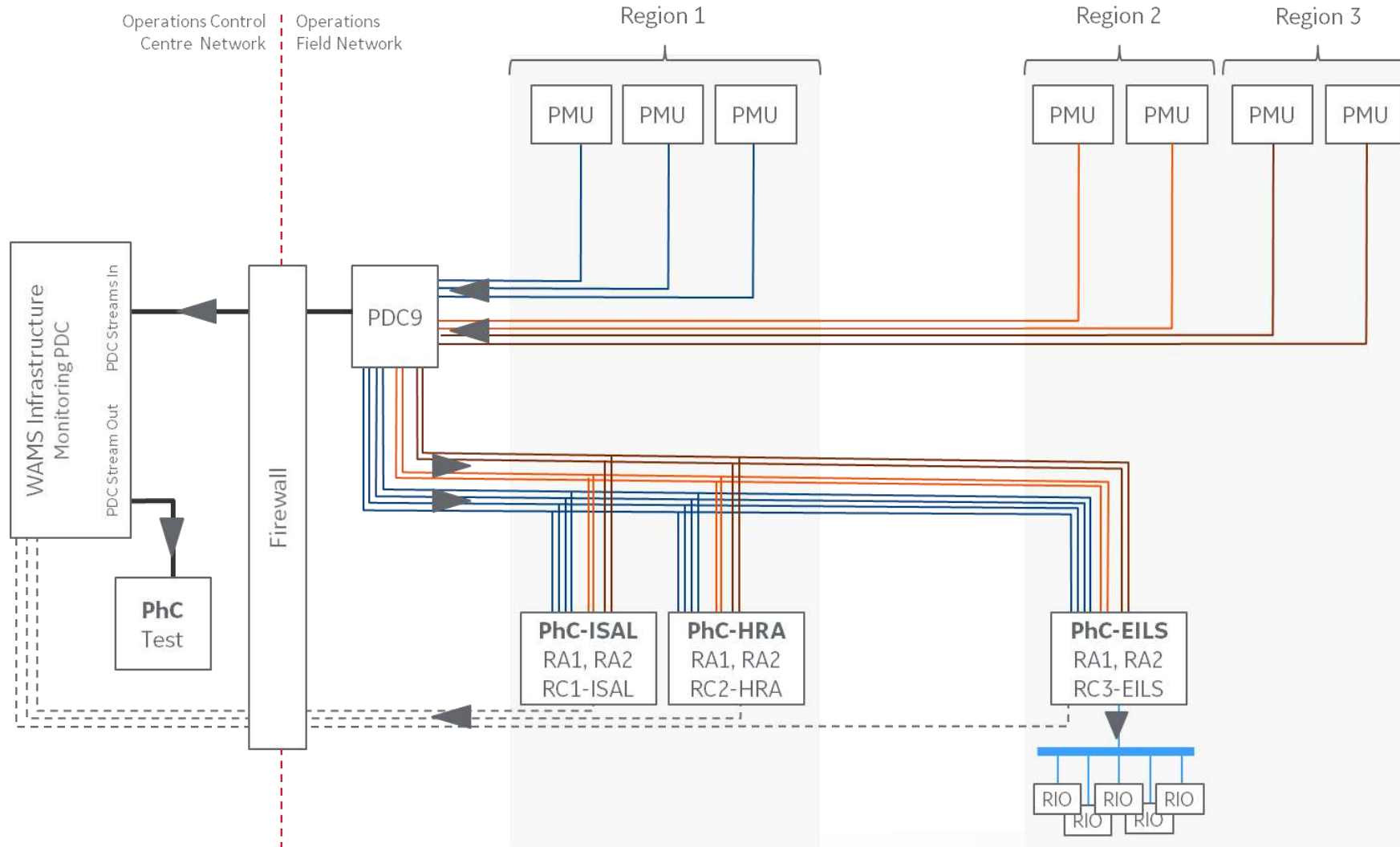
# Implementation

## Smartgrid Project in Reykjanes – Load Shed Control and Generator Governor Mode by using GOOSE [IEC 61850]



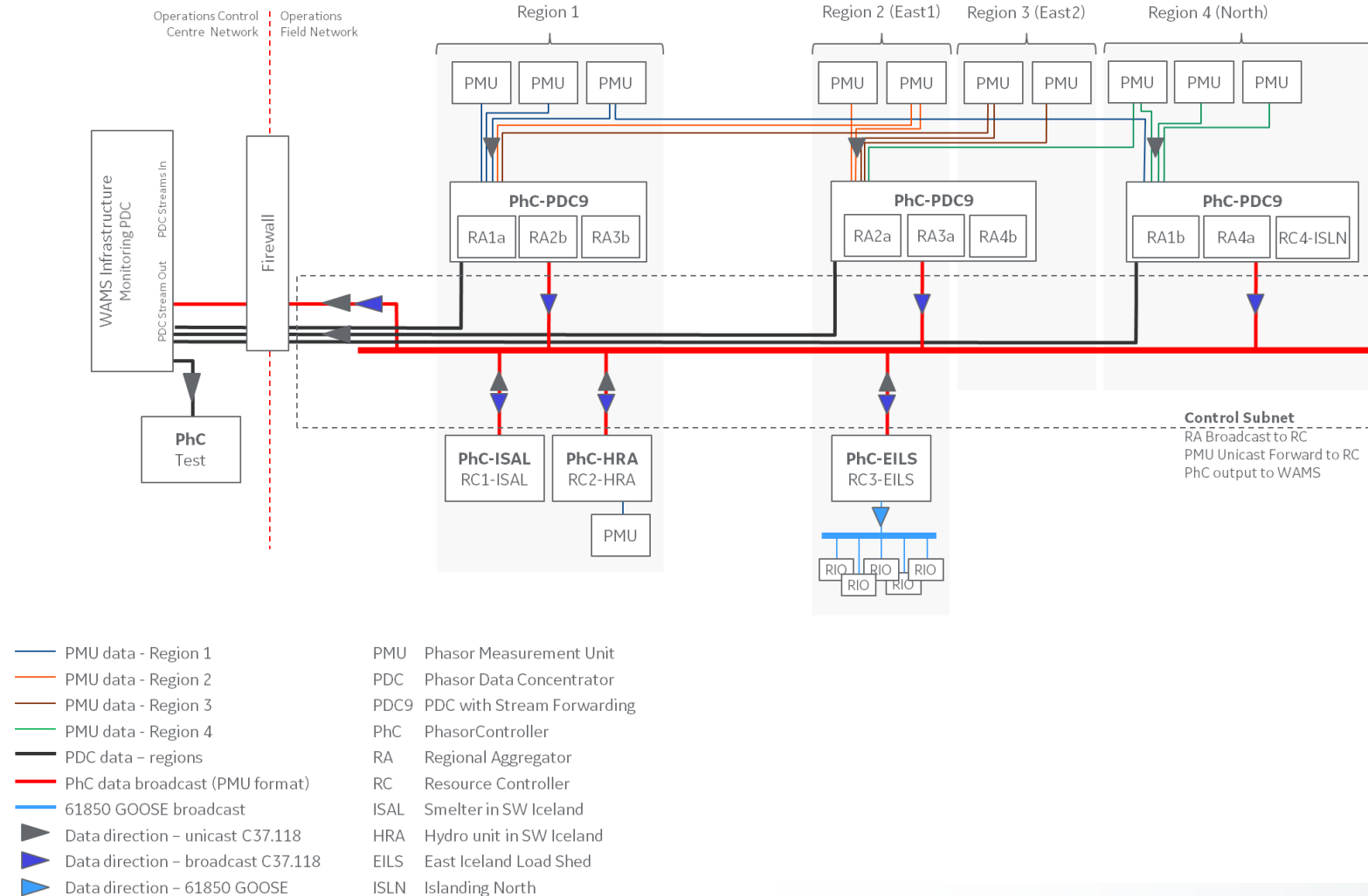
# NETWORK INFRASTRUCTURE

PMU+Communication latency <100ms; Overall trigger time <0.5s



# NETWORK INFRASTRUCTURE

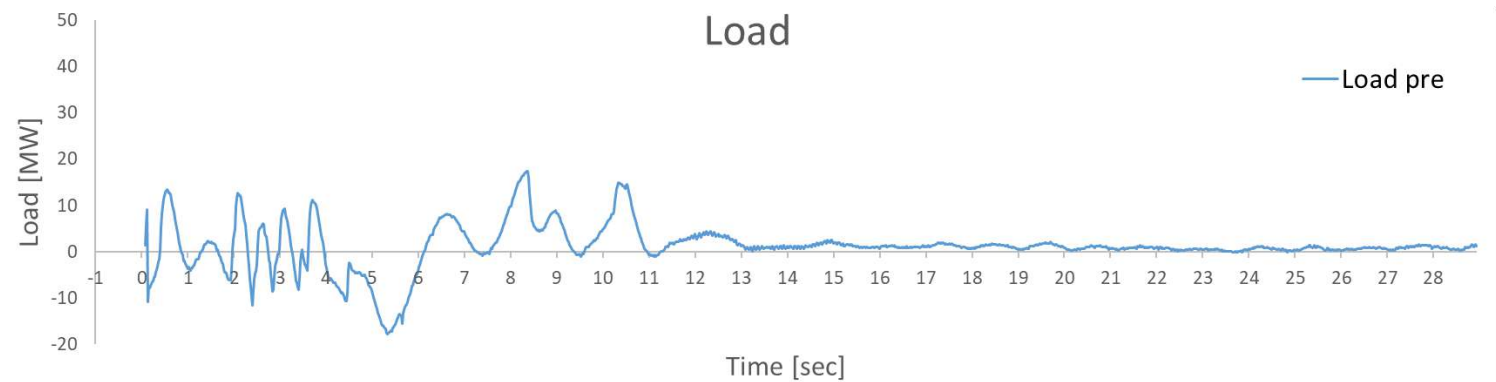
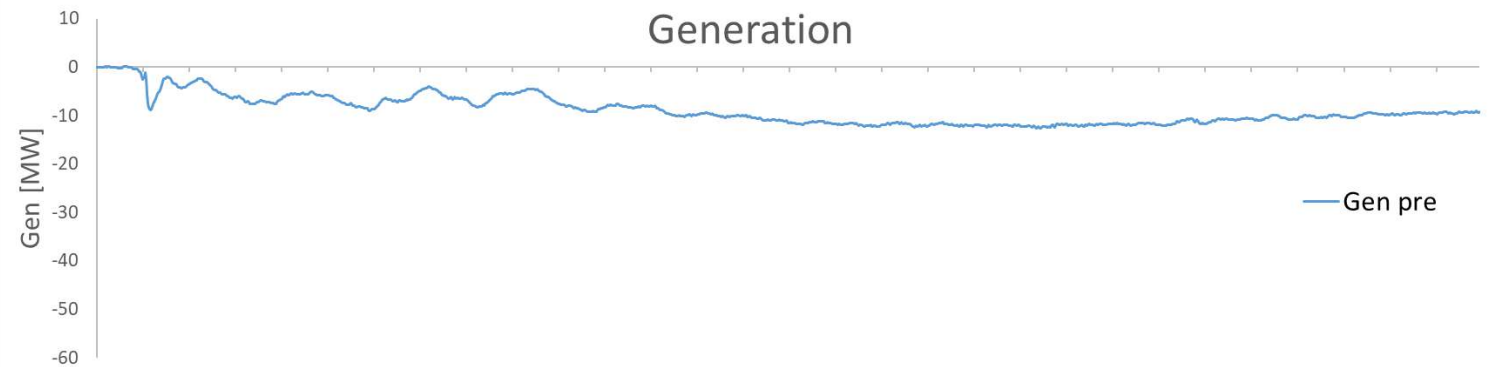
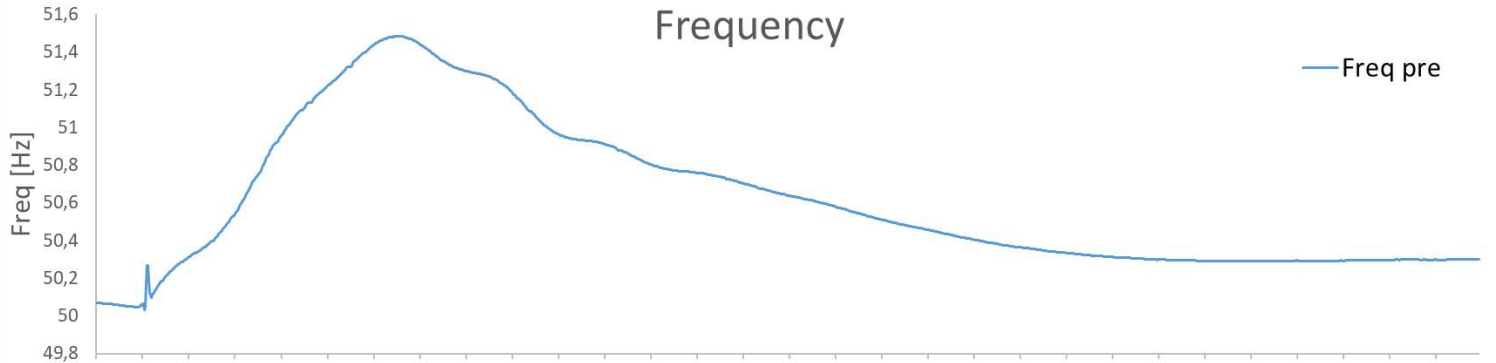
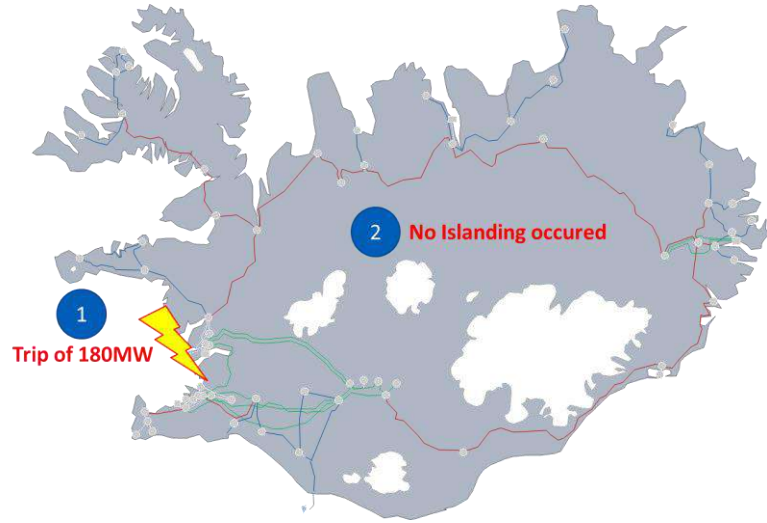
## Improved network architecture for WAMS/WACS Scalability & robustness with decentralization & redundancy





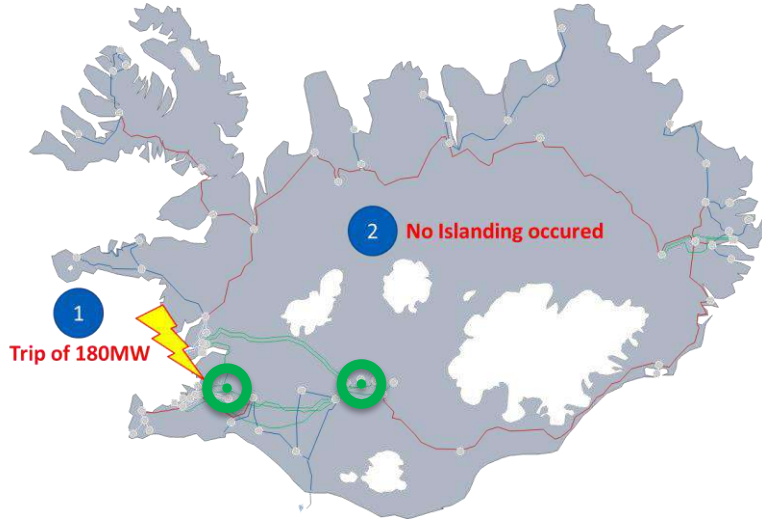
# REAL SYSTEM RESPONSES

LOAD LOSS EVENT **BEFORE** WACS IMPLEMENTATION

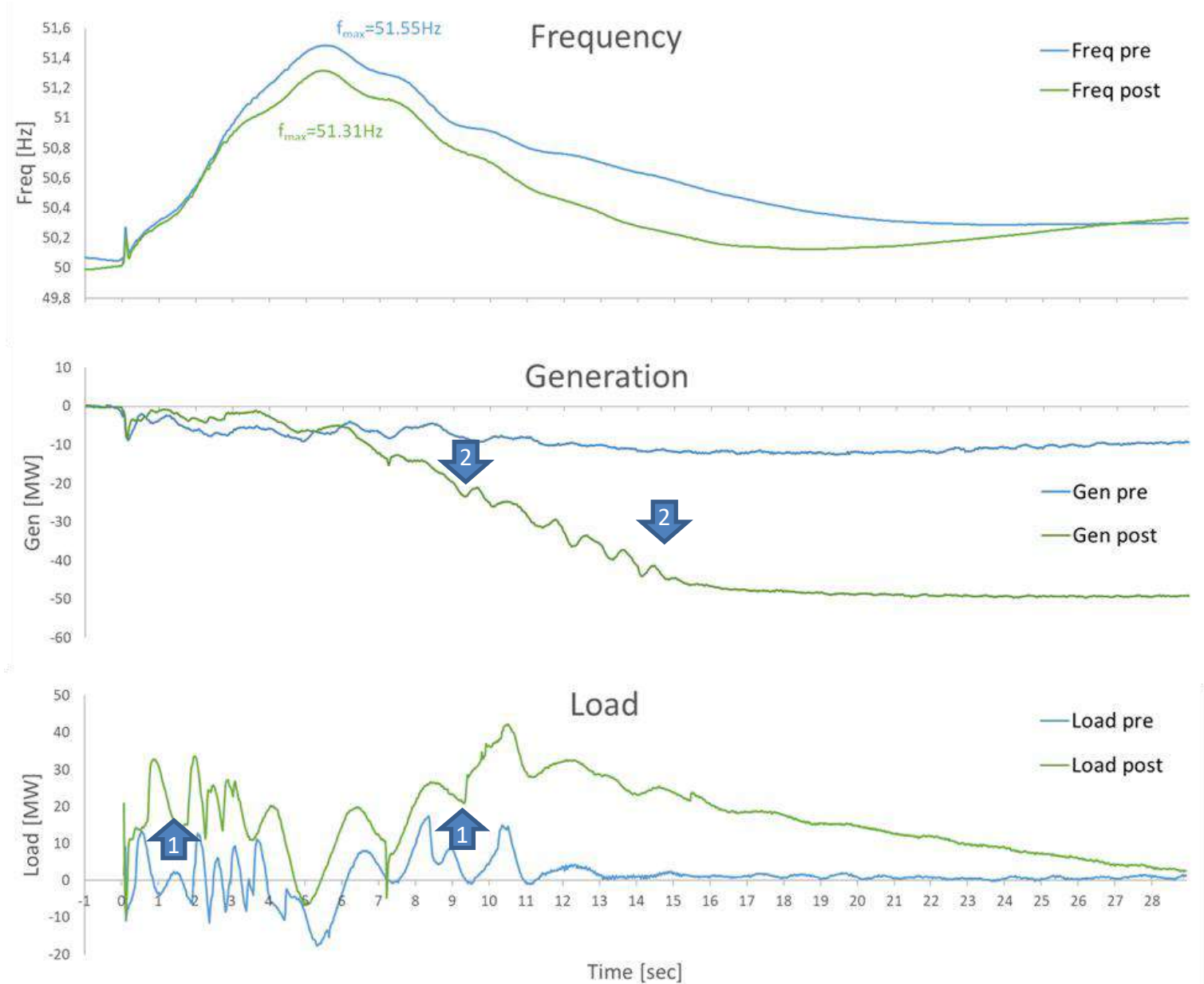


# REAL SYSTEM RESPONSES

LOAD LOSS EVENT **AFTER** WACS IMPLEMENTATION



- 1 Load response in  $<0.5s$ , reduces frequency peak.
- 2 Hydro fast ramp start at 3.5s, replaces fast temporary load response. Rate & volume greater than primary control

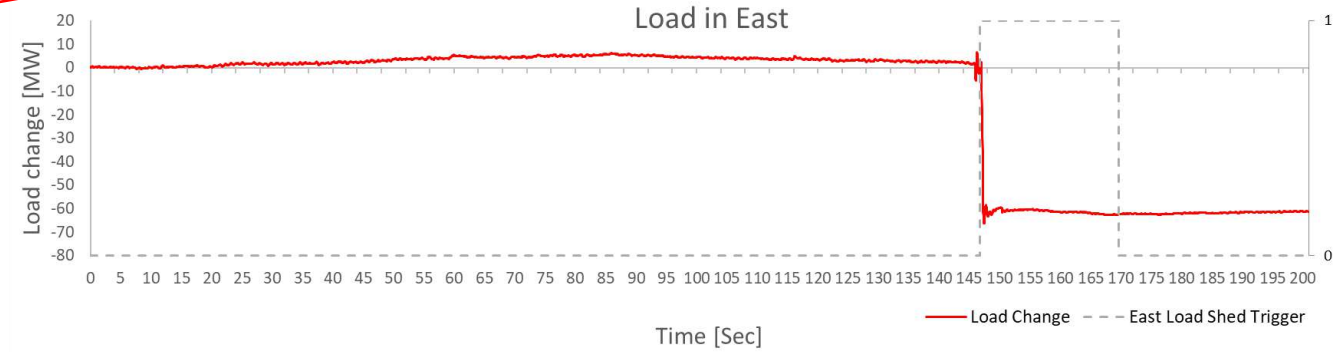
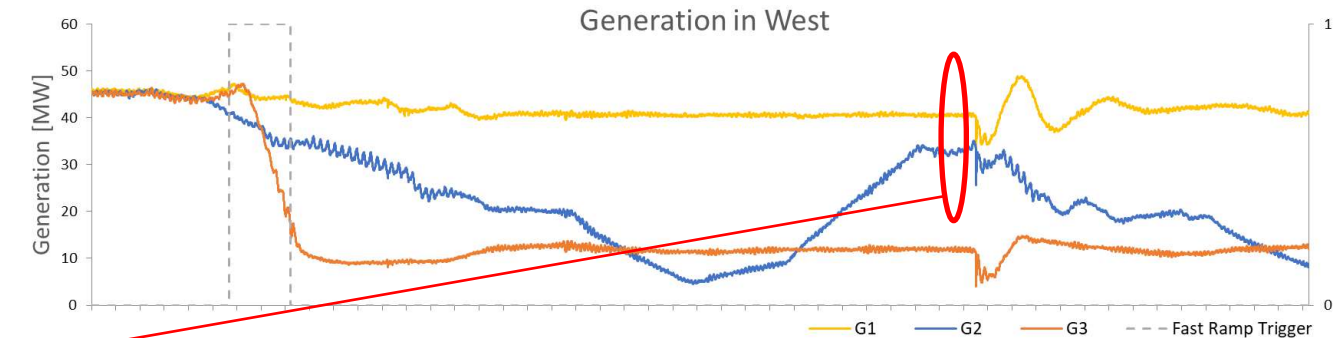
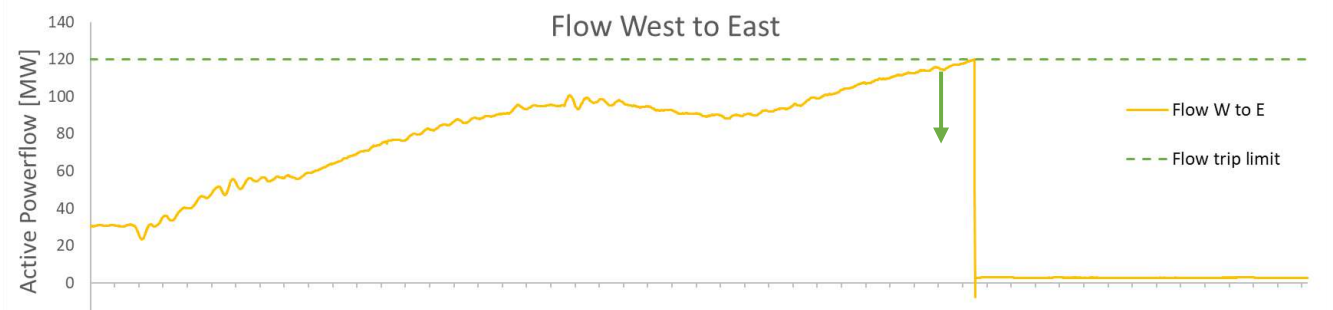
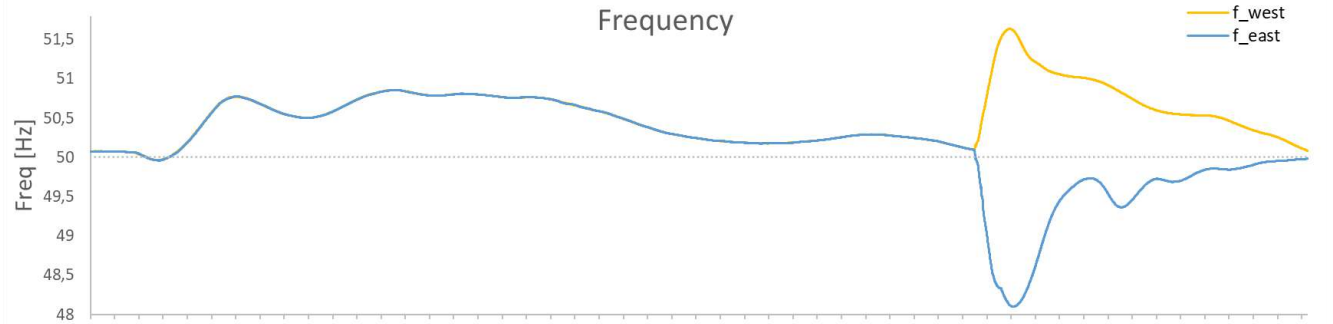


# REAL SYSTEM RESPONSES

OVER FREQUENCY AND ISLANDING EVENT

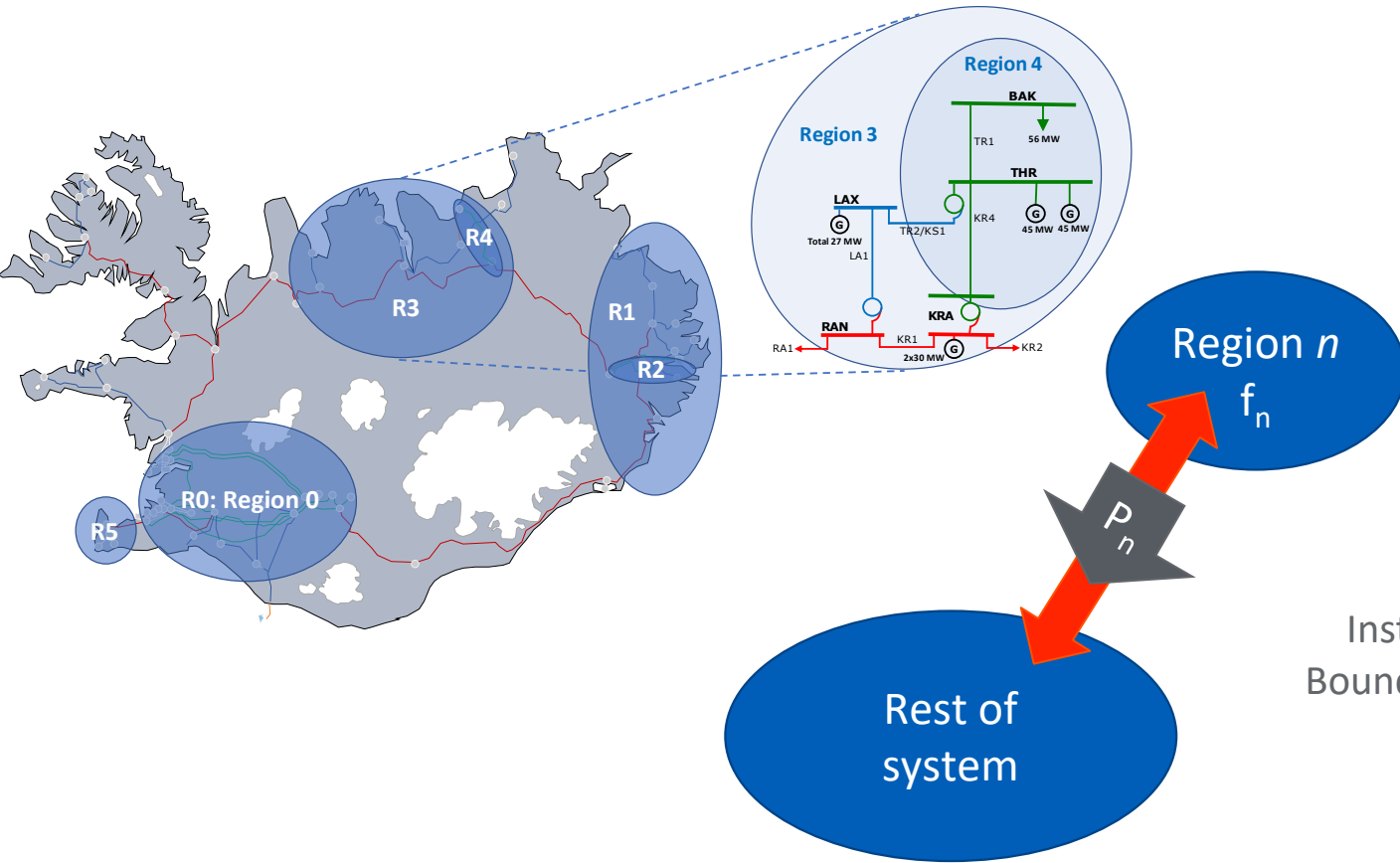


**MW div to min**  
G1: 30 MW  
G2: 22 MW



# Latest Development in Wide Area Control

for locational frequency response and regional re-balancing



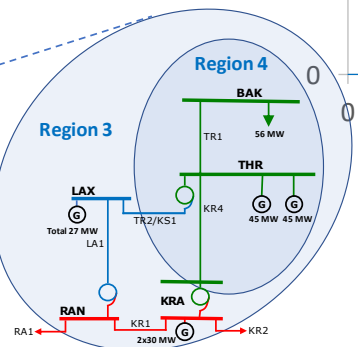
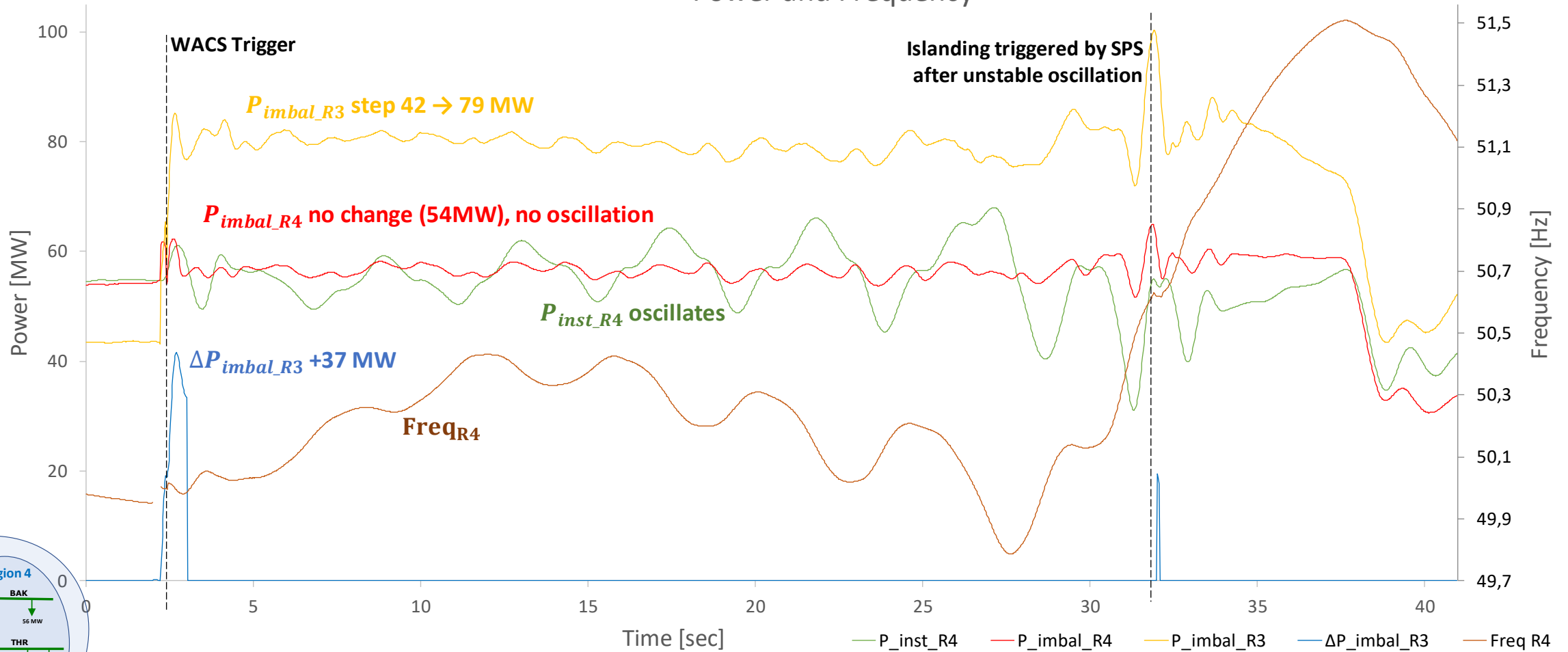
**Goal:** Quickly find the imbalance of load and generation for a region in the presence of dynamic power swings, so that we can re-balance the area.

$$P_n = P_{Imbal} - H_n \cdot ROCOF_n$$

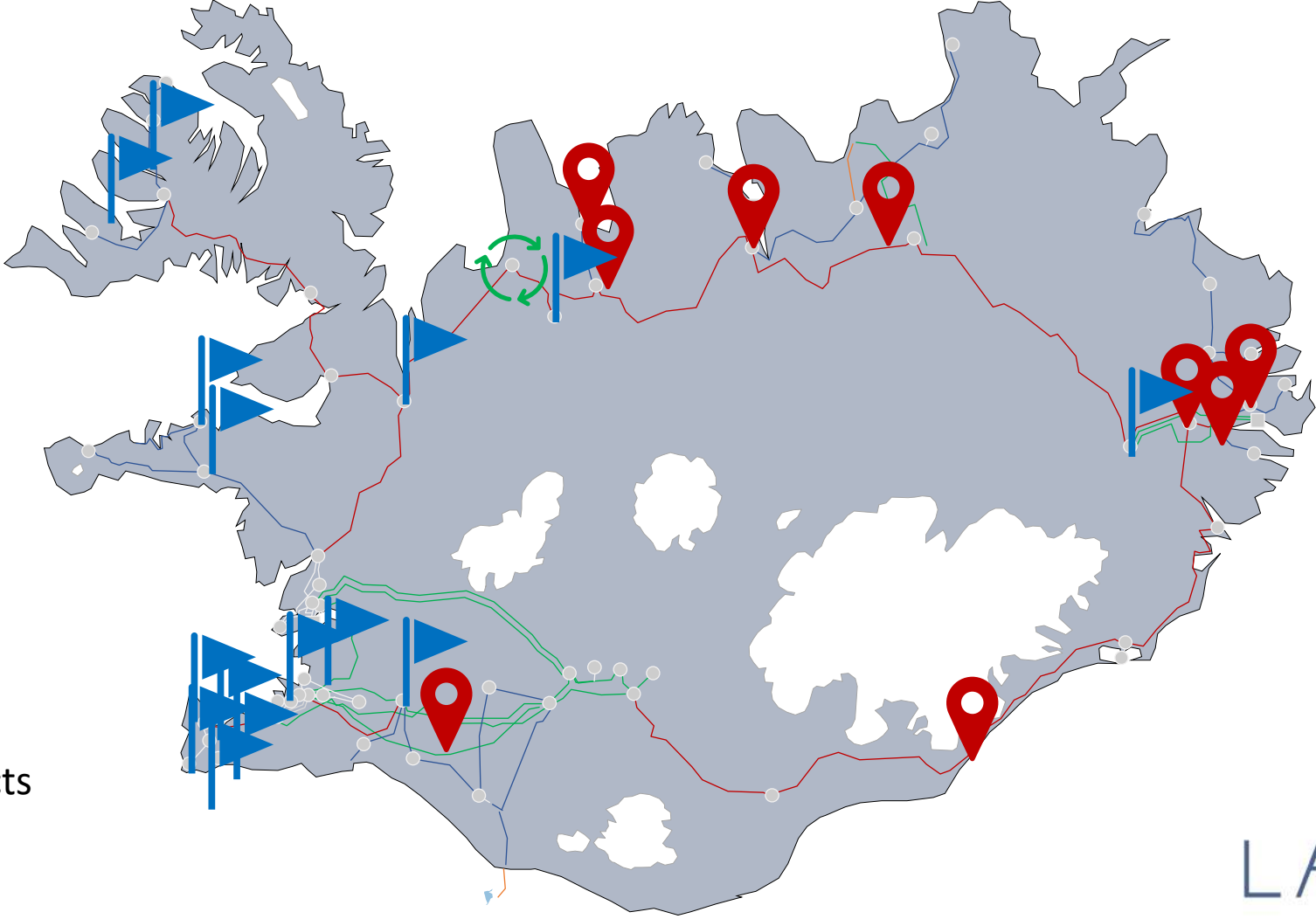
Instantaneous Boundary Power      Region  $n$  Power Imbalance not directly measurable      Effective Area Inertia      Region  $n$  Ctr of Inertia ROCOF

# Example of Region 3 load loss and oscillations

Power and Frequency




# Digital Substation Project Overview



-  Oct 2020
-  In operation  
One bay
-  On-going projects
-  2-3-years plan

# Conclusion

- WACS have improved the system performance during disturbances:
  - The system operators experience less severe disturbances, improving system security
  - The generator operator experiences fewer plant trips and large frequency excursions which extends the lifetime of the machines
  - The load customers in the region experience fewer and shorter interruptions and better power quality
- There are still many promising WACS project proposals, more capacity of regulating units in south west, harnessing the fast response of geothermal units, regulating options with datacenters and wide-area-damping.
- Fast Frequency Response (FFR) ancillary service is in development.
- Digital Substation projects increase the demand of fast and reliable communication between substations. Which opens the option for routable GOOSE, SV [IEC TR 61850-90-5] for enhanced protection and control.

A man with short brown hair and a beard, wearing a grey and white patterned sweater, is smiling and talking on a mobile phone. He is standing outdoors, with a blurred background of a beach and ocean. A white grid pattern is overlaid on the entire image. A vertical red line is positioned to the left of the text.

**Thank you for your attention**

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