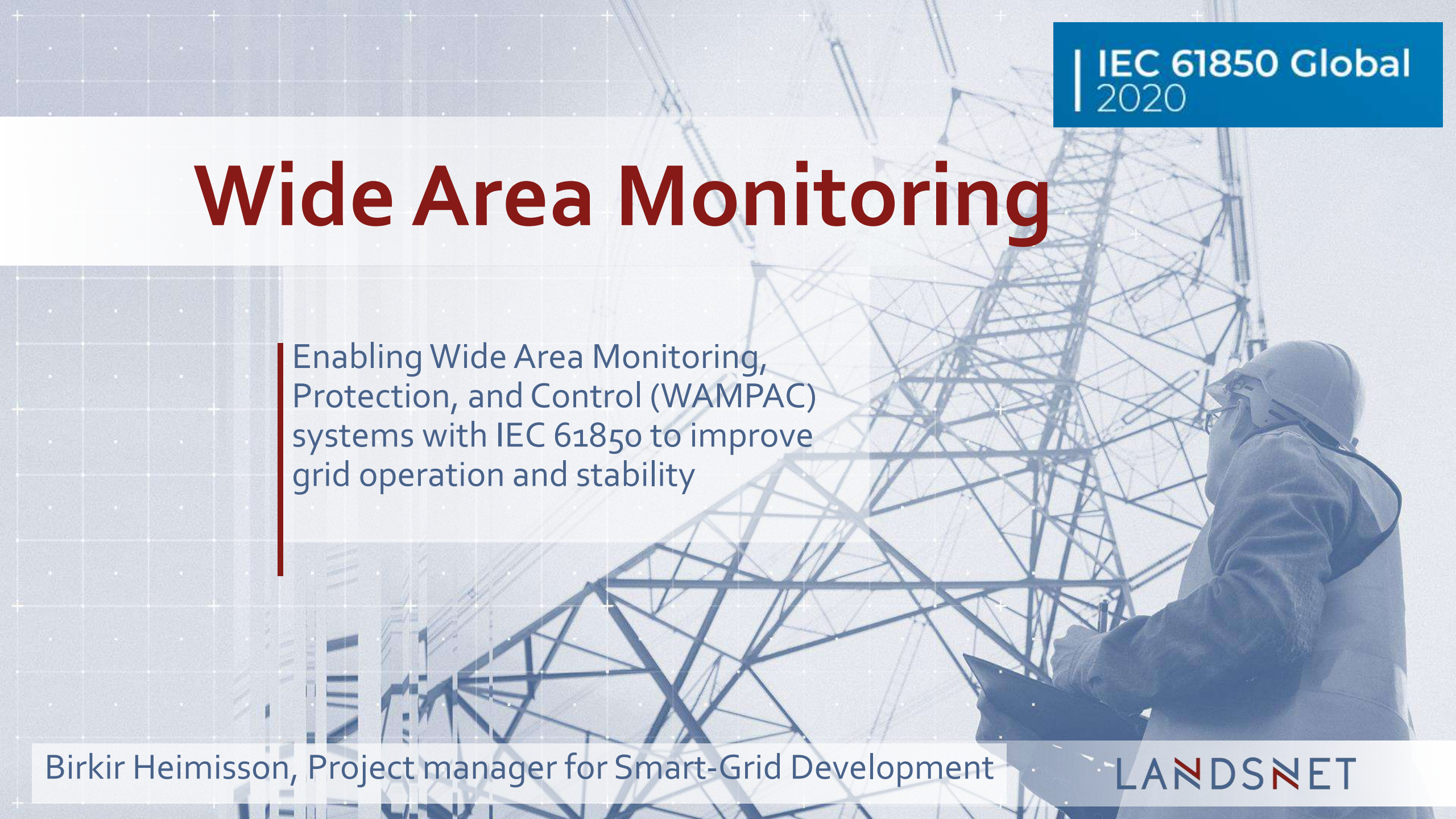
IEC 61850 Global 2020

Wide Area Monitoring

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



Birkir Heimisson, Project manager for Smart-Grid Development

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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?

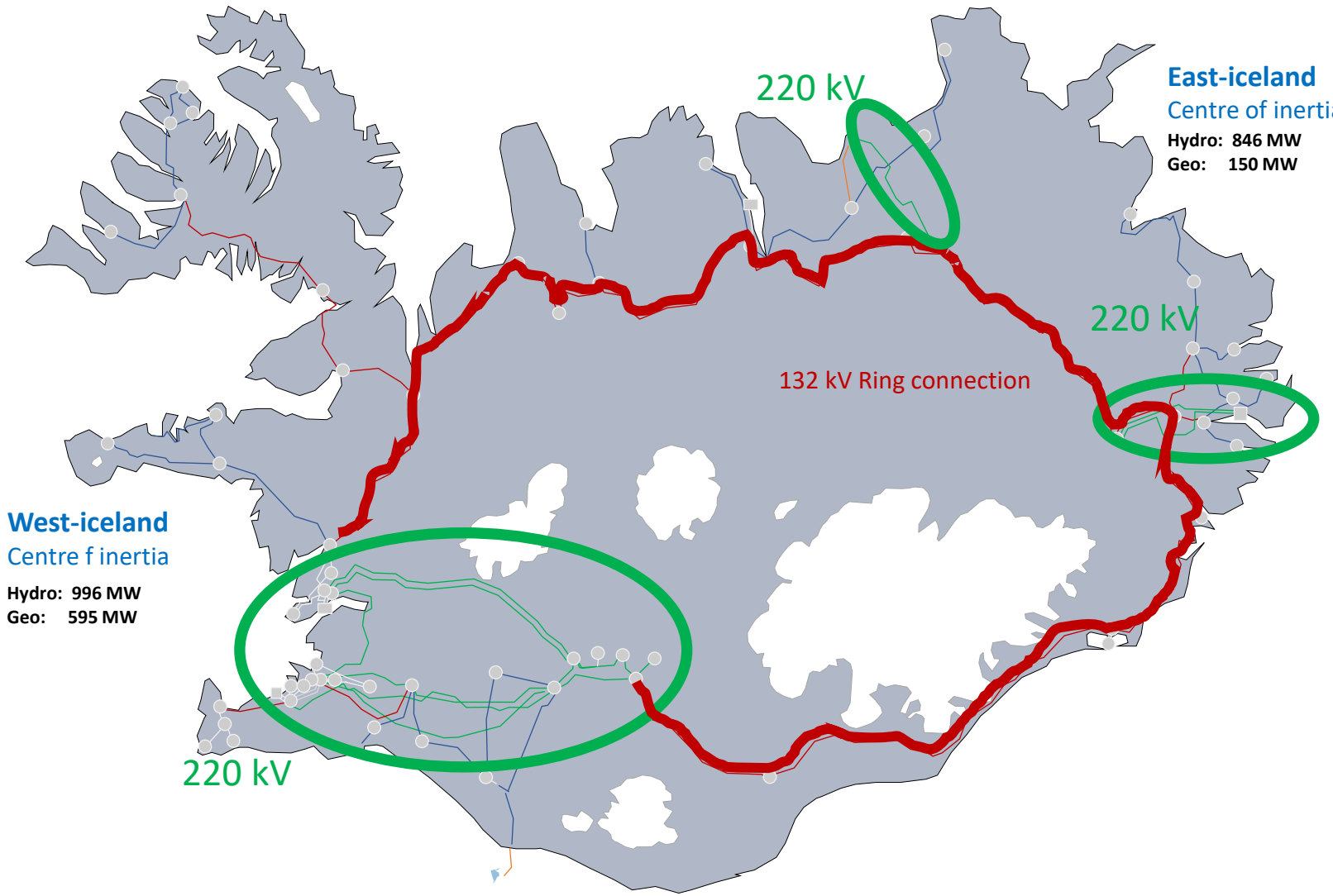
Icelandic Transmission System

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

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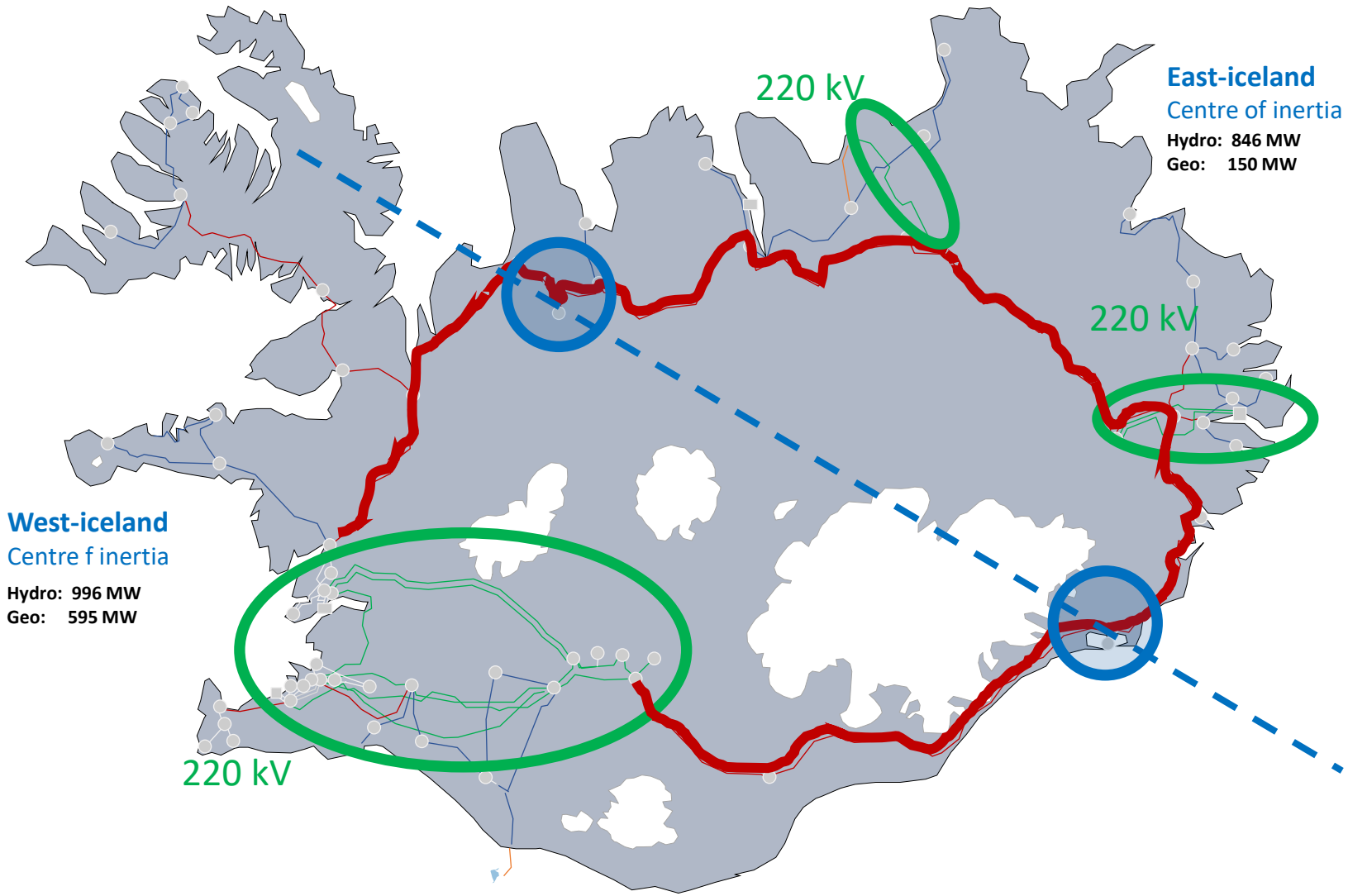

The grid includes more than 3,000km of transmission lines and about 70 substations

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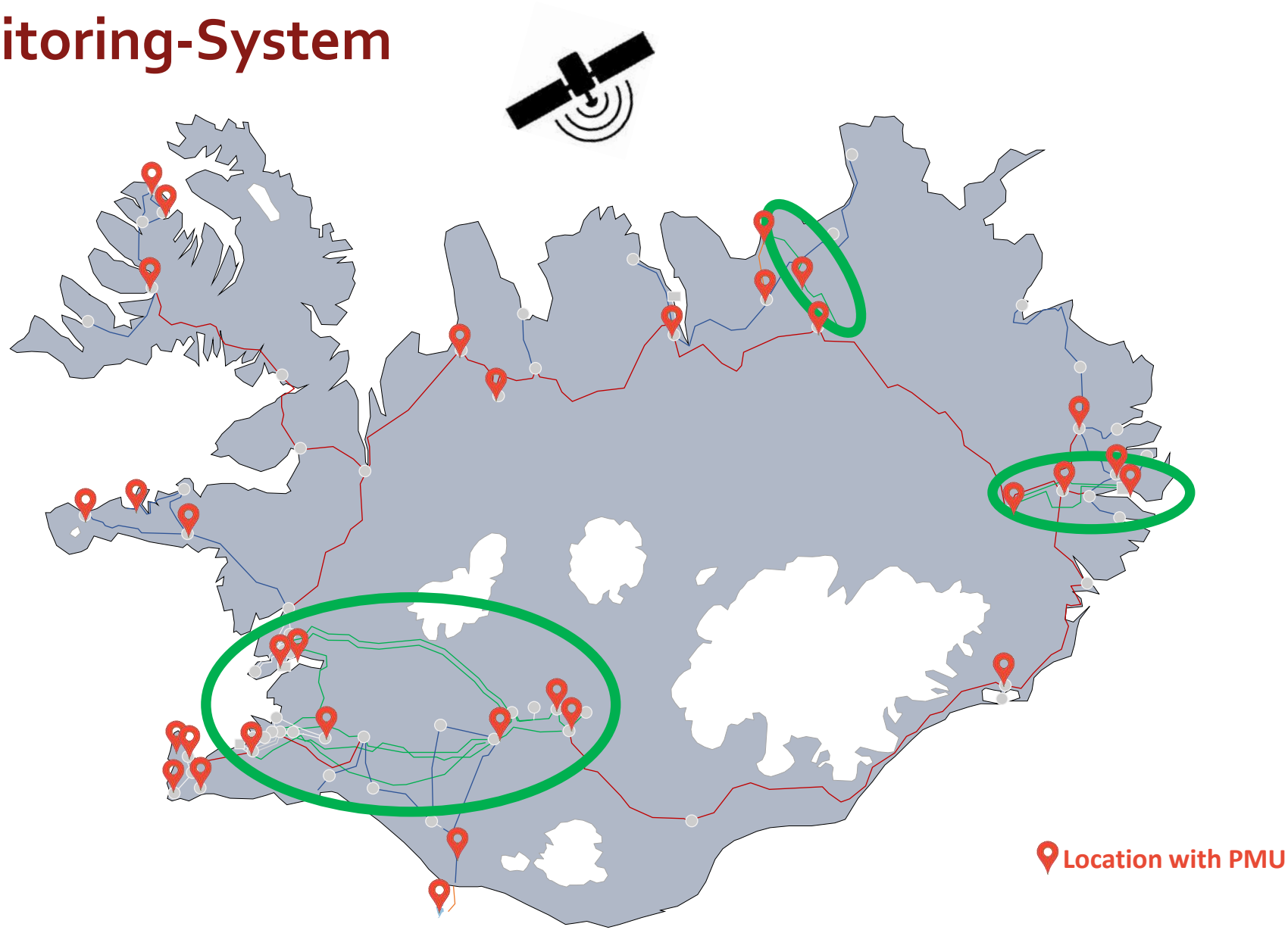
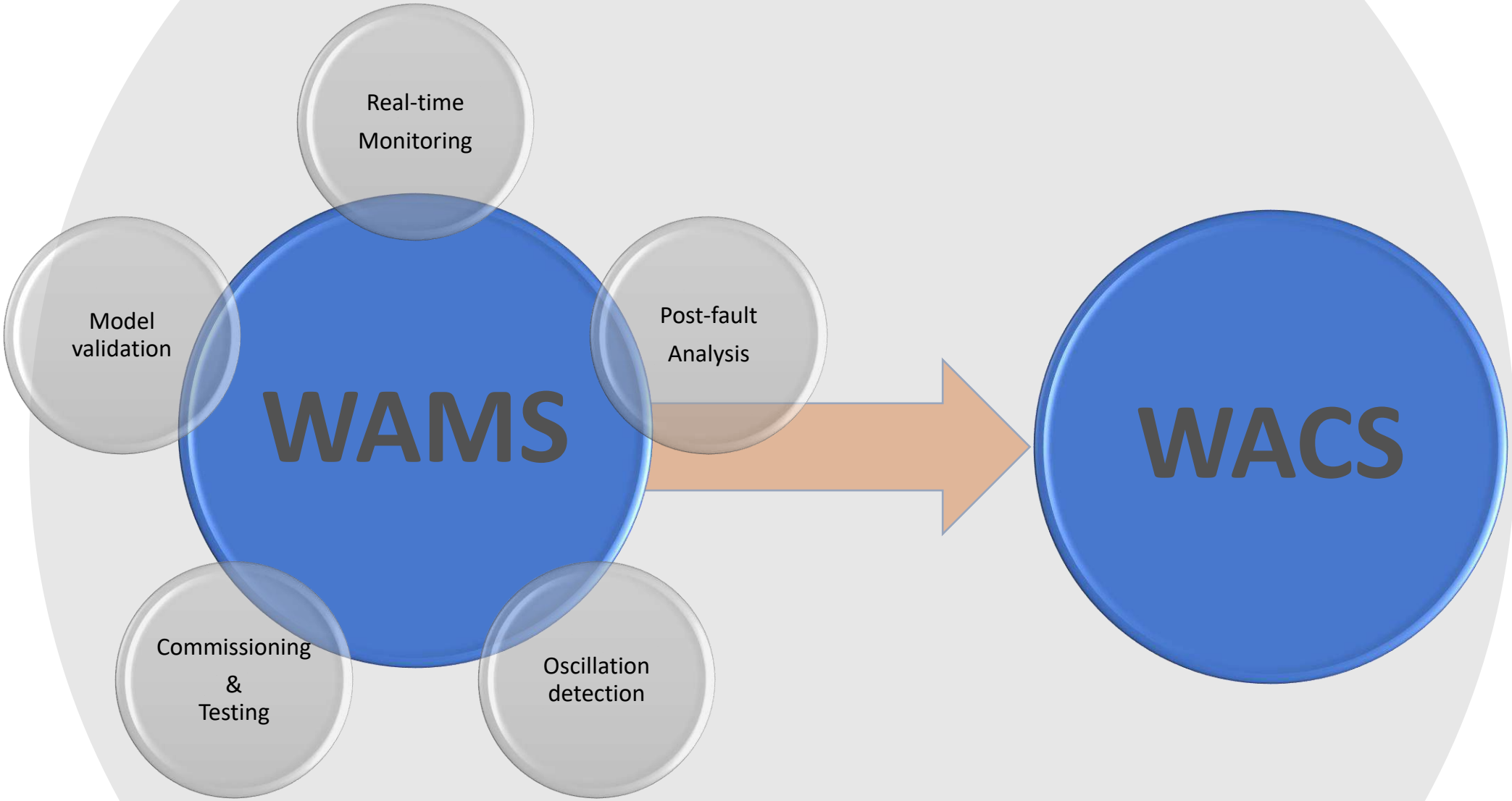
Wide-Area-Monitoring-System

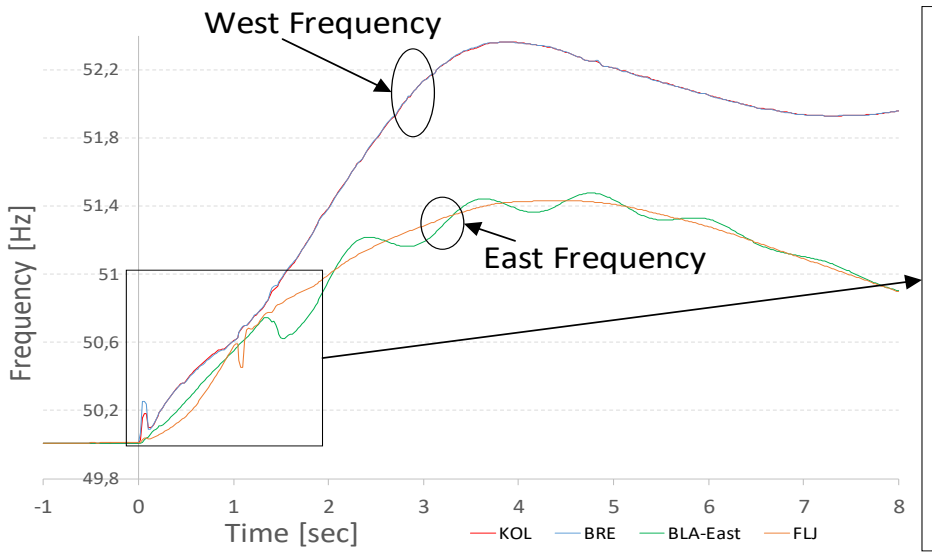
- Extensive WAMS monitoring & records (~60 PMUs)
- Good quality communications network
- Landsnet & grid-stakeholders willing to trial innovation
- New control is measurable on small system

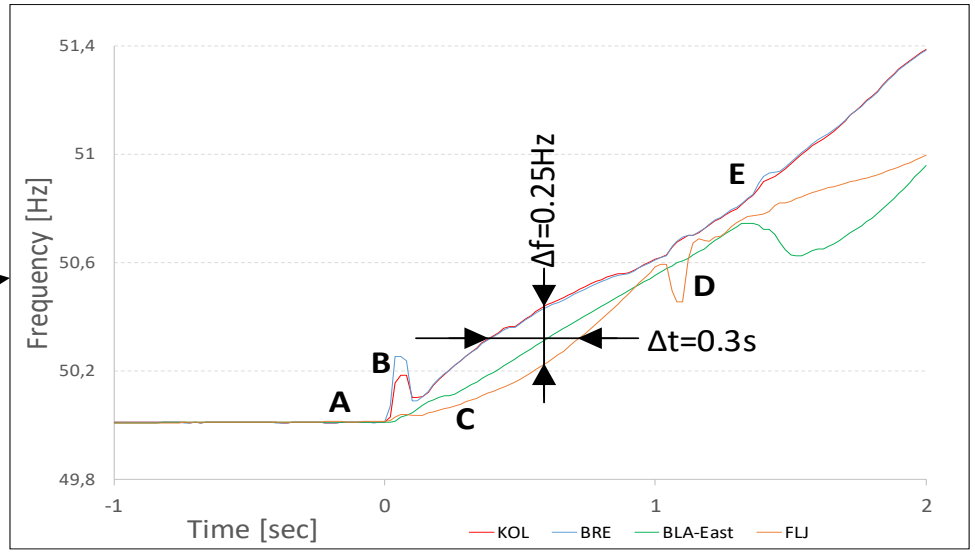


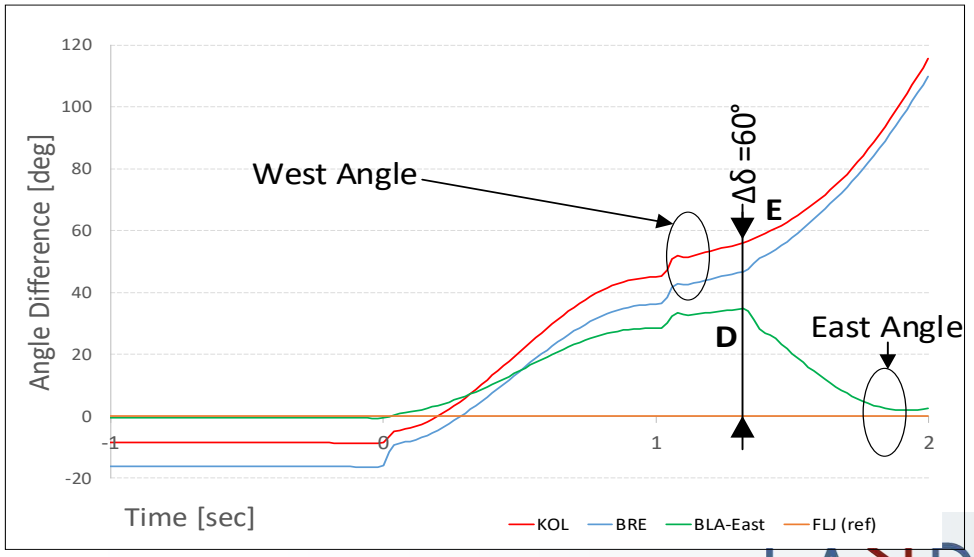

Real-time
Monitoring
Model
validation
WAMS
Post-fault
Analysis
Commissioning
&
Testing
Oscillation
detection
WACS

Effect of Sparse Centres of Inertia

- Iceland shows frequency & angle divergence between centres of inertia







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

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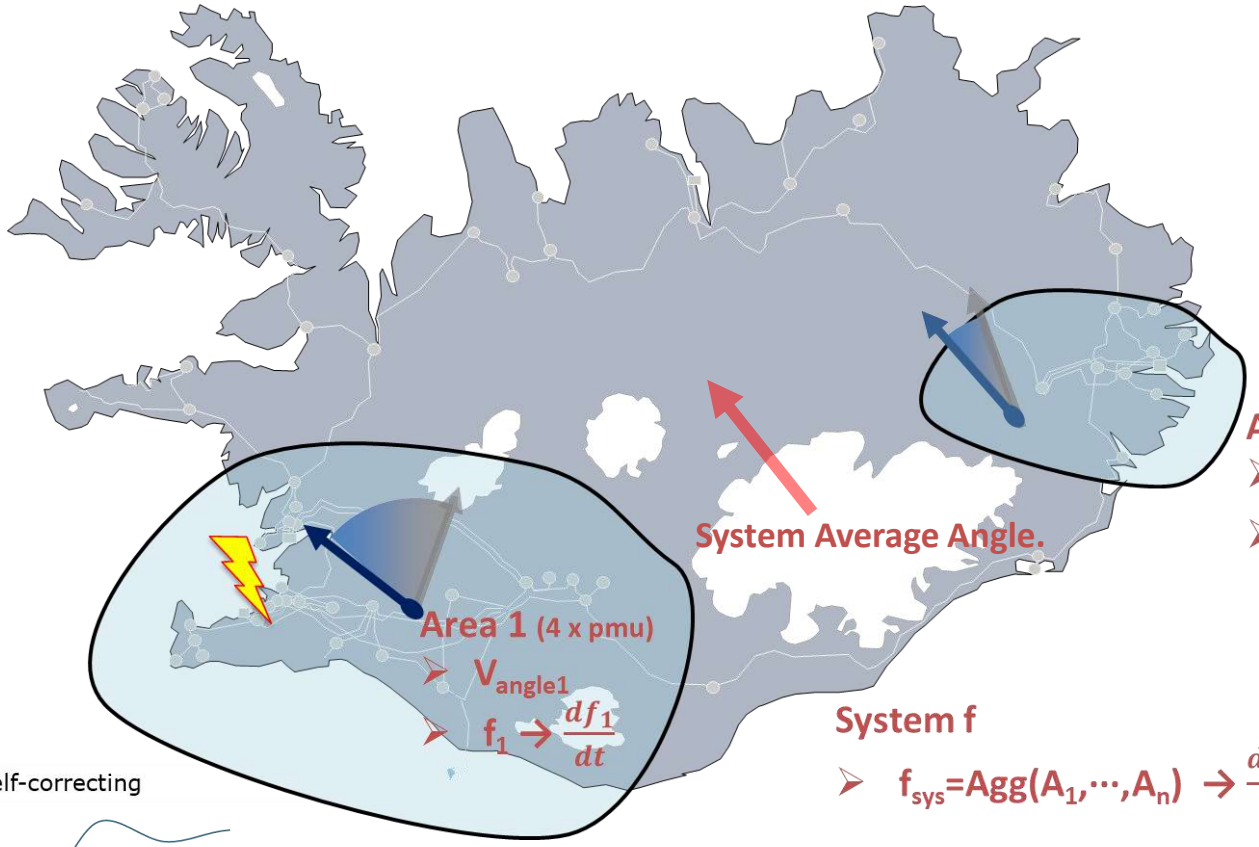
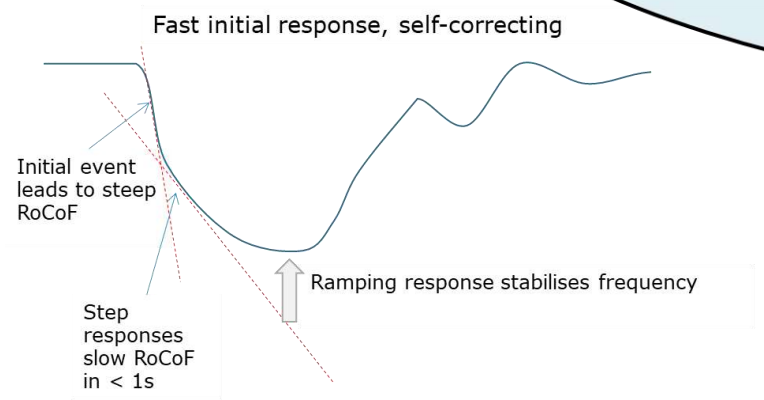
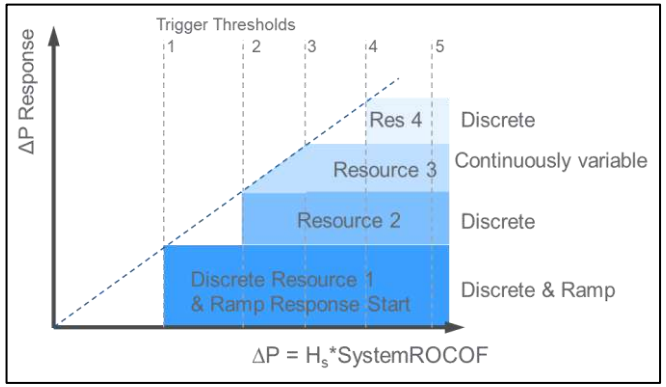
General Method for Locational Fast Response



System f

- $f_{sys}=Agg(A_1,\cdots,A_n) \rightarrow \frac{df_{sys}}{dt}$





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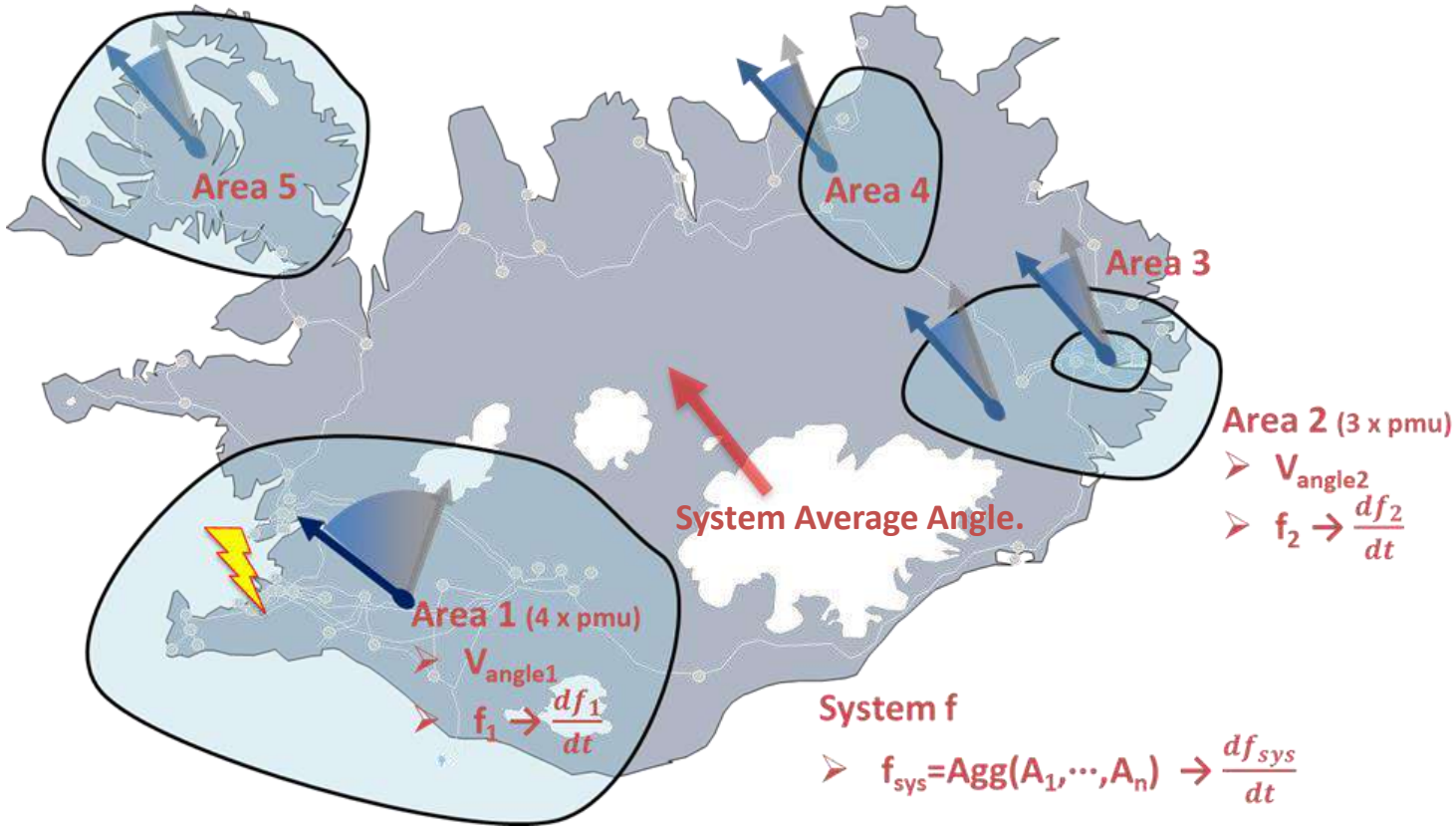
General Method for Locational Fast Response



- **Fast**
- **Locational**
- **Proportional to disturbance**

- **Response Driven**
- **Event Driven**

MIGRATE

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Smart-Grid Projects

Vestfirðir Microgrid

2015

THR Microgrid / Geoth. control

2018-2020*

Smelter Load Control

2015

Hydro Fast Ramp

2017-2018

Smelter Load Control & Microgrid

2016

Smelter Load Control

2017-2018

Fish facories Load Control

2014, 2017-2018

Reykjanes Microgrid Load control and Geoth. control

2018-2020*

Test Environment

TESTING USING PLAYBACK OF REAL EVENTS

Central PhasorPoint Server

Export disturbance events

Linux Workstation

Scripts & c37.118 Simulator

PhasorPoint Instance & PDC

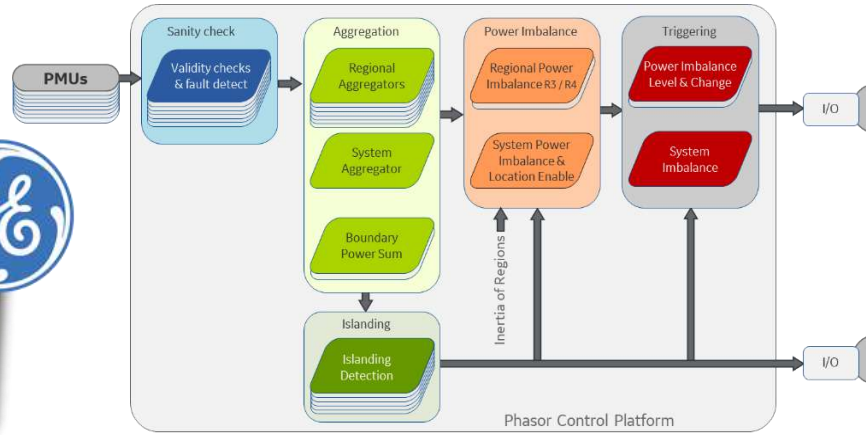
Playback PMU Data

Control output

Exported Results

Script: Control output comparison Δtime

Excel/csv control output comparison results



PhasorController (PhC)
20ms Real-Time PMU-based logic controller with specialist WACS function block library in IEC 61131 PLC logic

Supports:
- IEEE C37.118
- IEC 61850 / GOOSE
- Modbus
- Digitals

Metadata:
-Quality
-Time-sync
-Test

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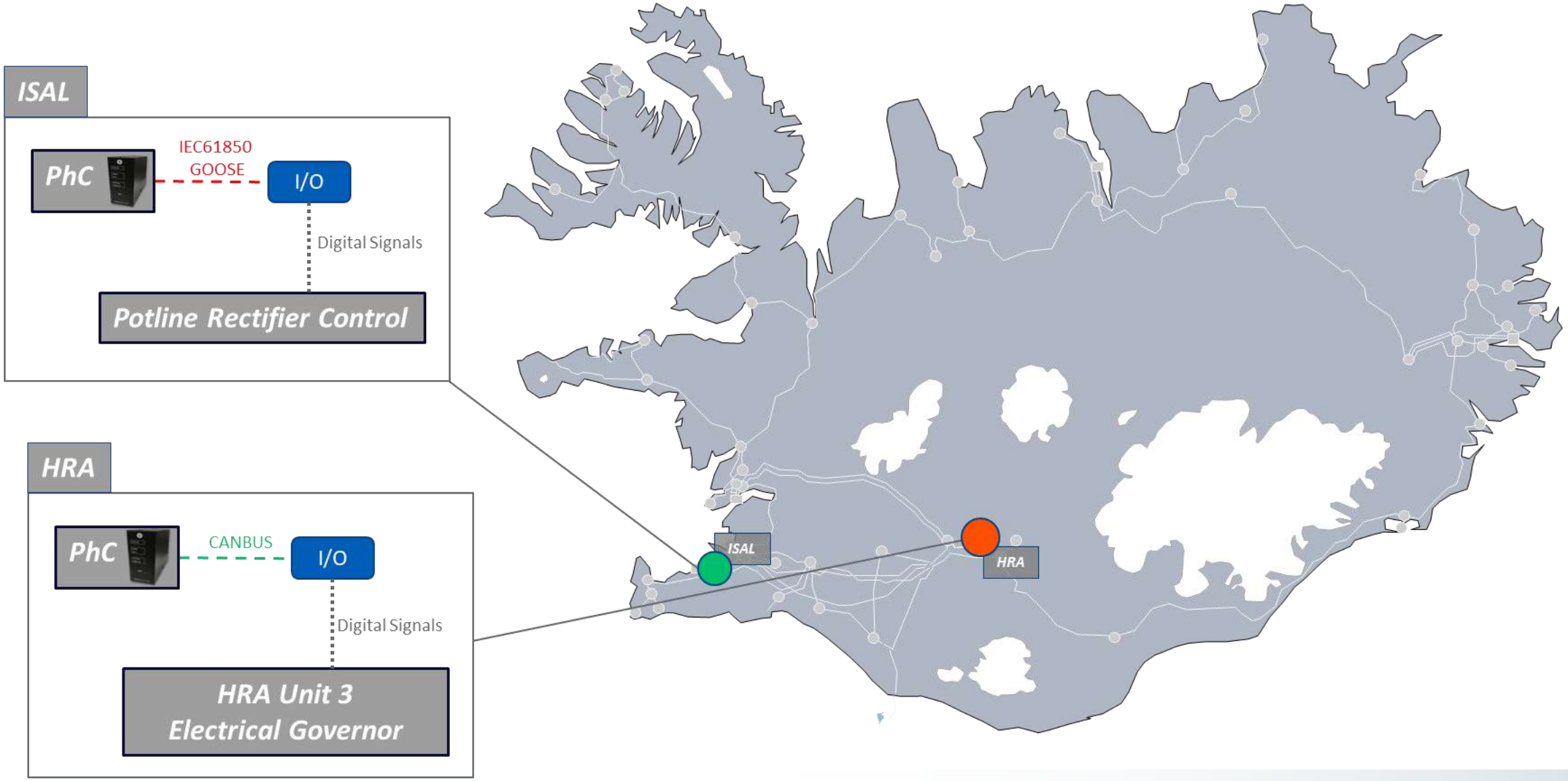
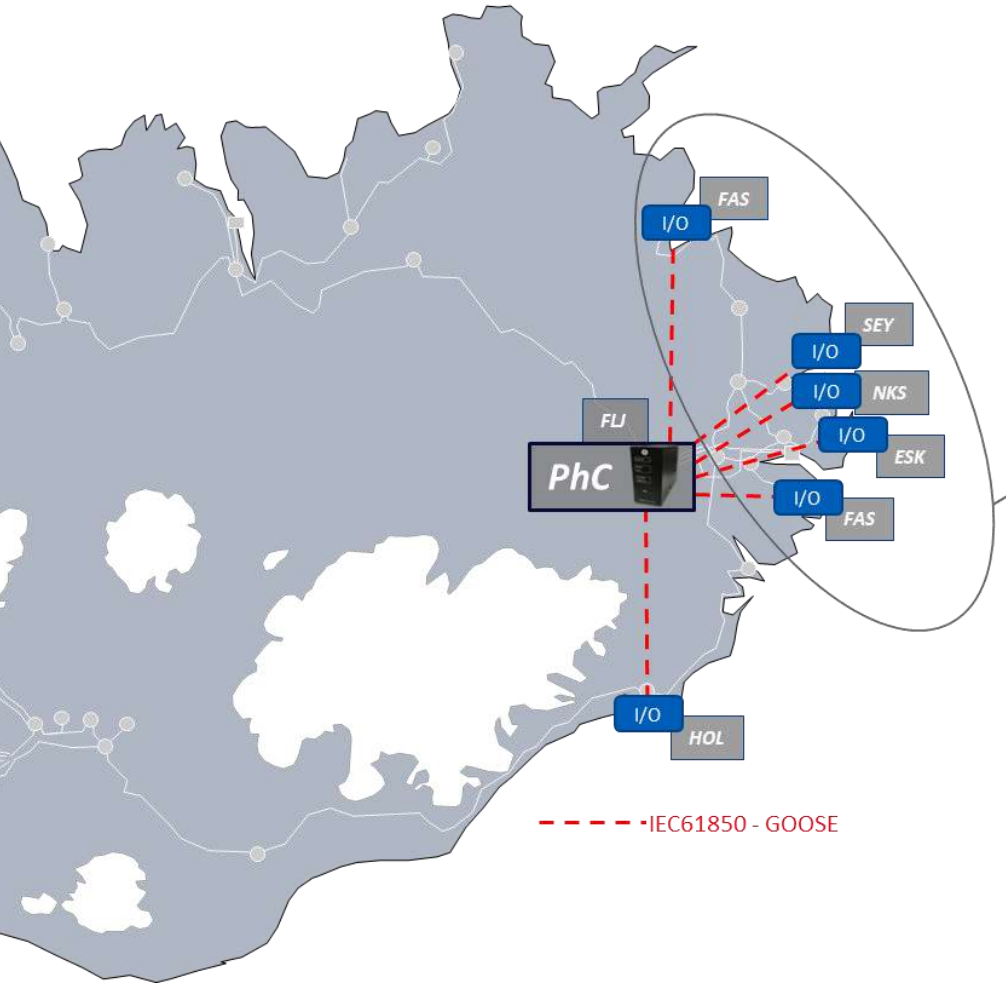
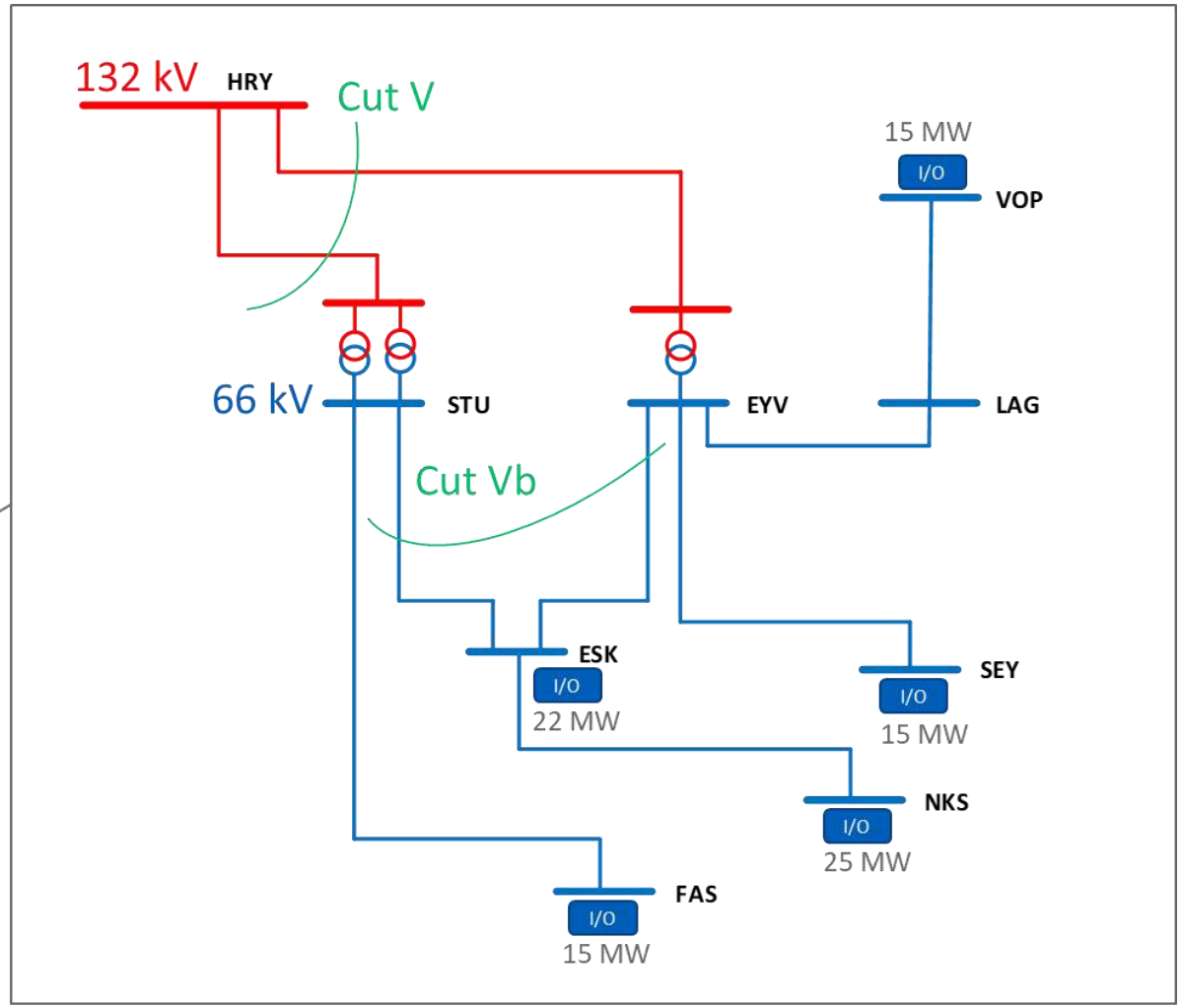
Implementation



Implementation





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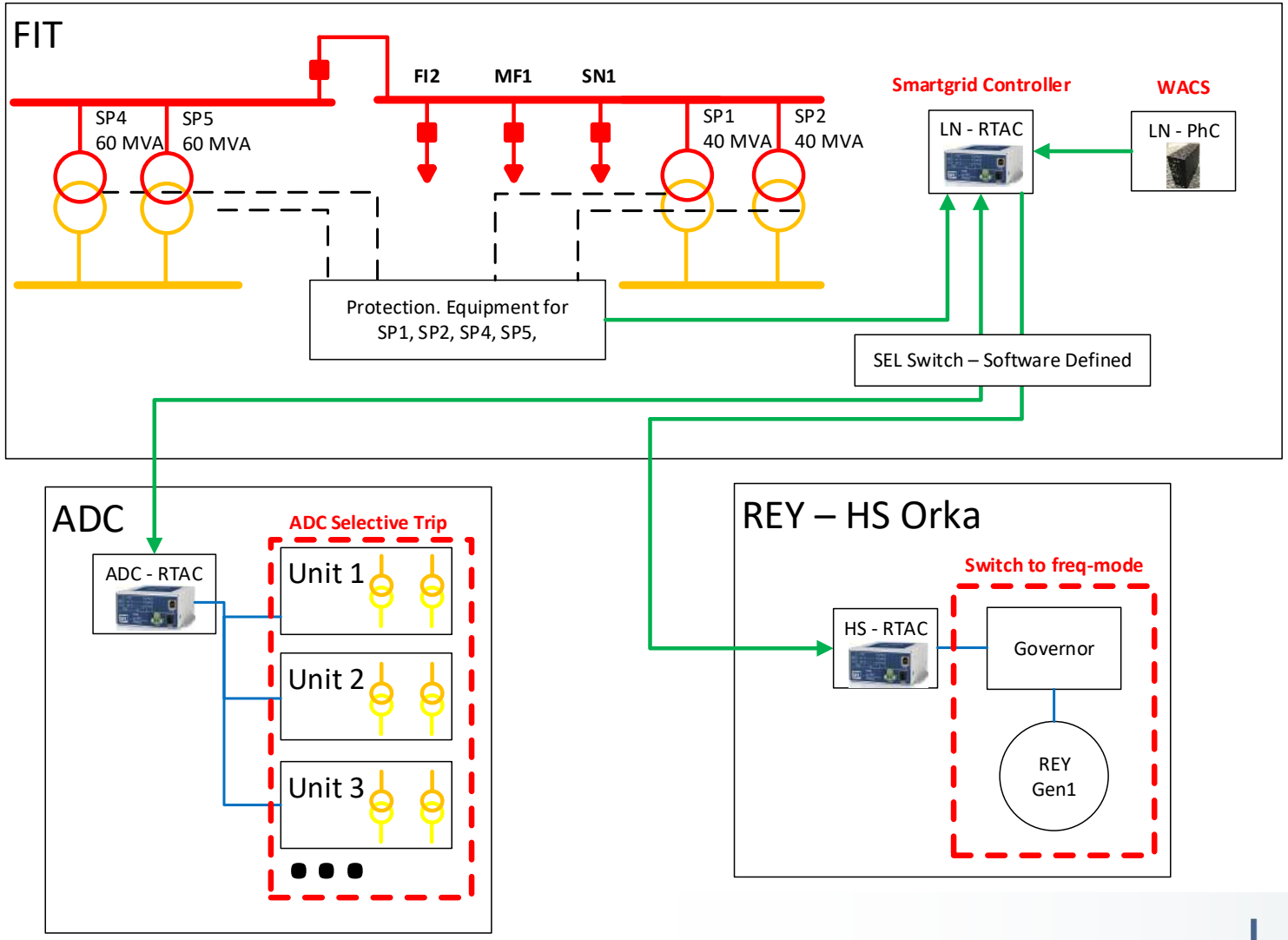
Implementation

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



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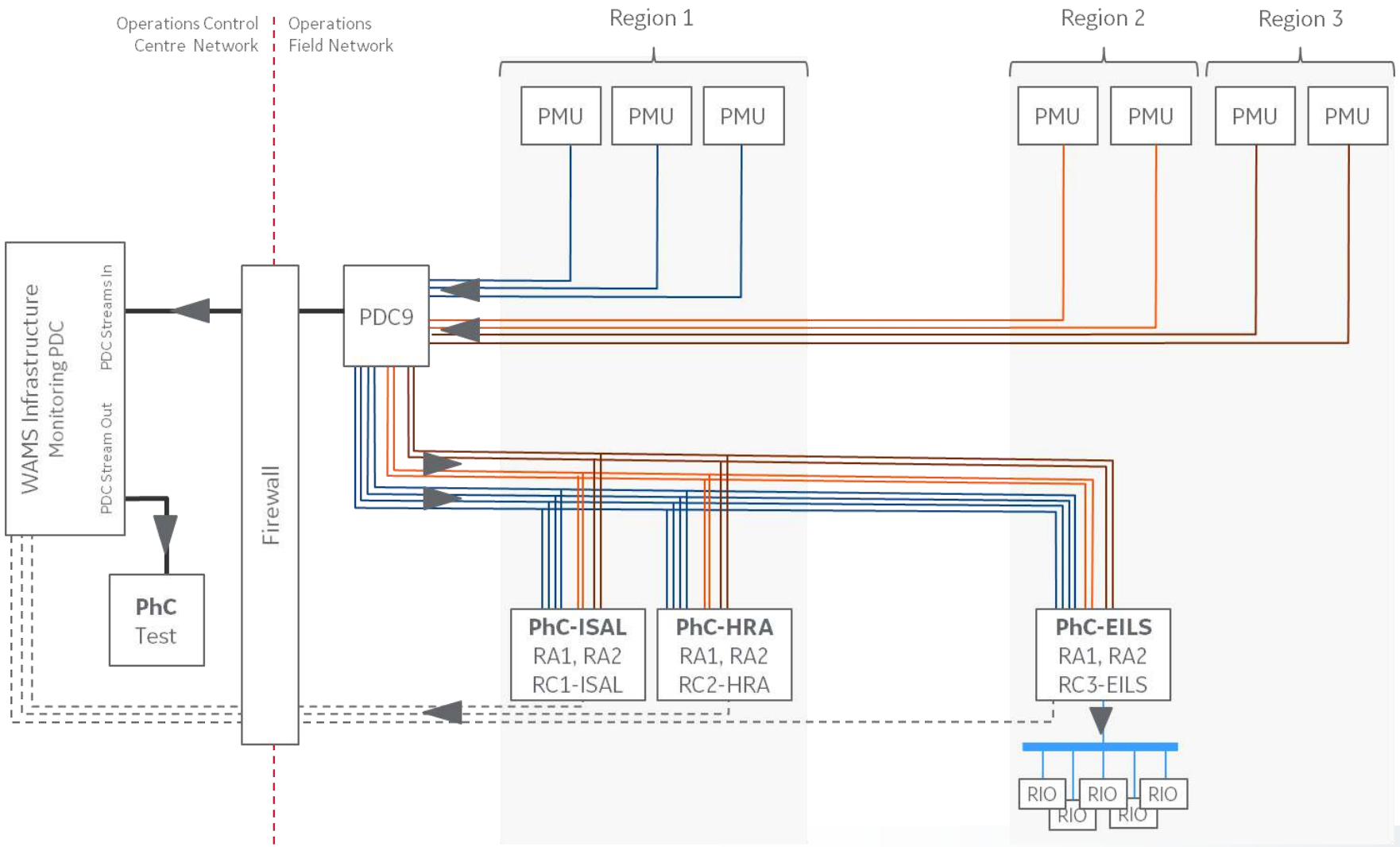
NETWORK INFRASTRUCTURE

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



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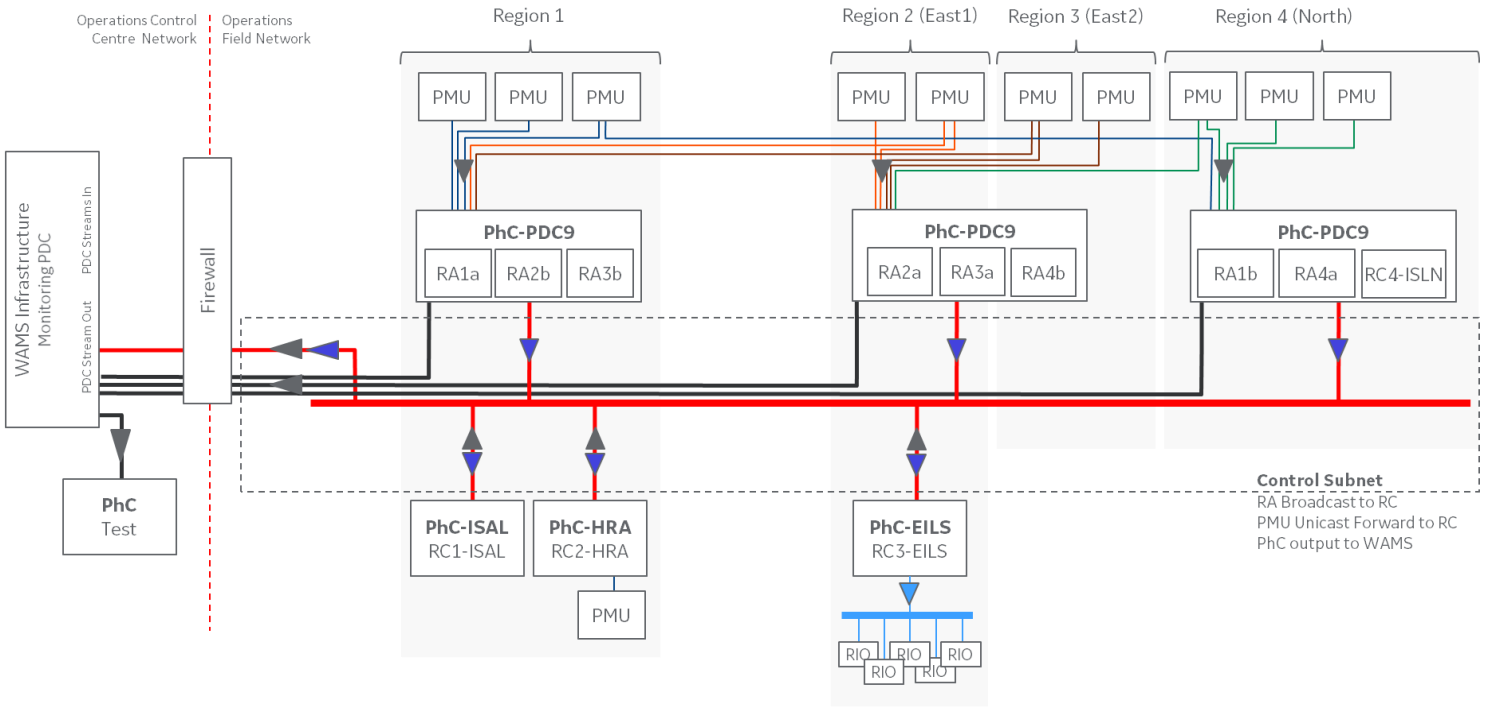
NETWORK INFRASTRUCTURE

Improved network architecture for WAMS/WACS

Scalability & robustness with decentralization & redundancy



- PMU data - Region 1
- PMU data - Region 2
- PMU data - Region 3
- PMU data - Region 4
- PDC data – regions
- PhC data broadcast (PMU format)
- 61850 GOOSE broadcast
- Data direction – unicast C37.118
- Data direction – broadcast C37.118
- Data direction – 61850 GOOSE

PMU	Phasor Measurement Unit
PDC	Phasor Data Concentrator
PDC9	PDC with Stream Forwarding
PhC	PhasorController
RA	Regional Aggregator
RC	Resource Controller
ISAL	Smelter in SW Iceland
HRA	Hydro unit in SW Iceland
EILS	East Iceland Load Shed
ISLN	Islanding North

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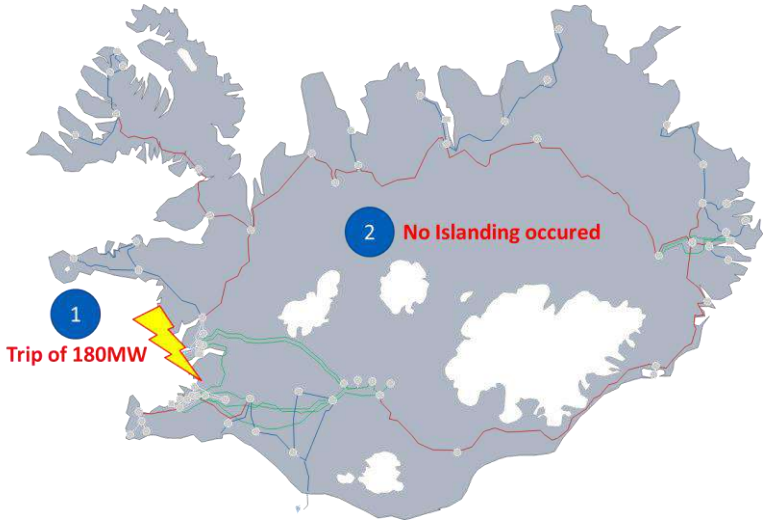
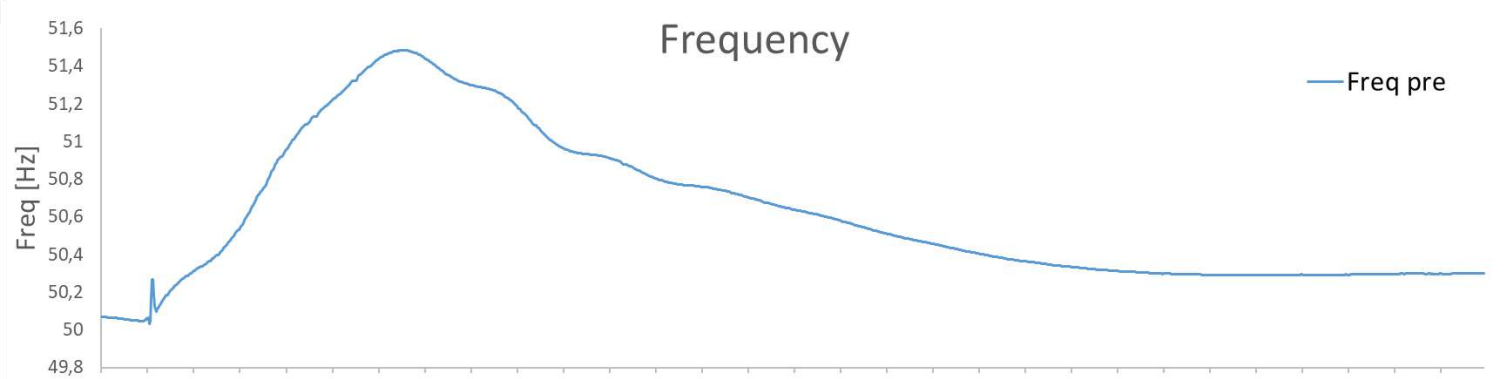
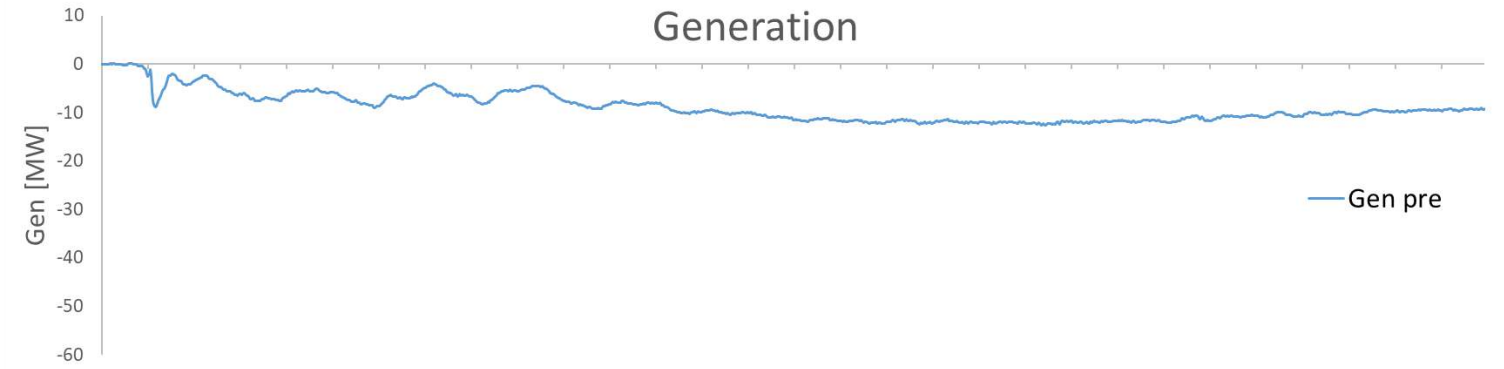
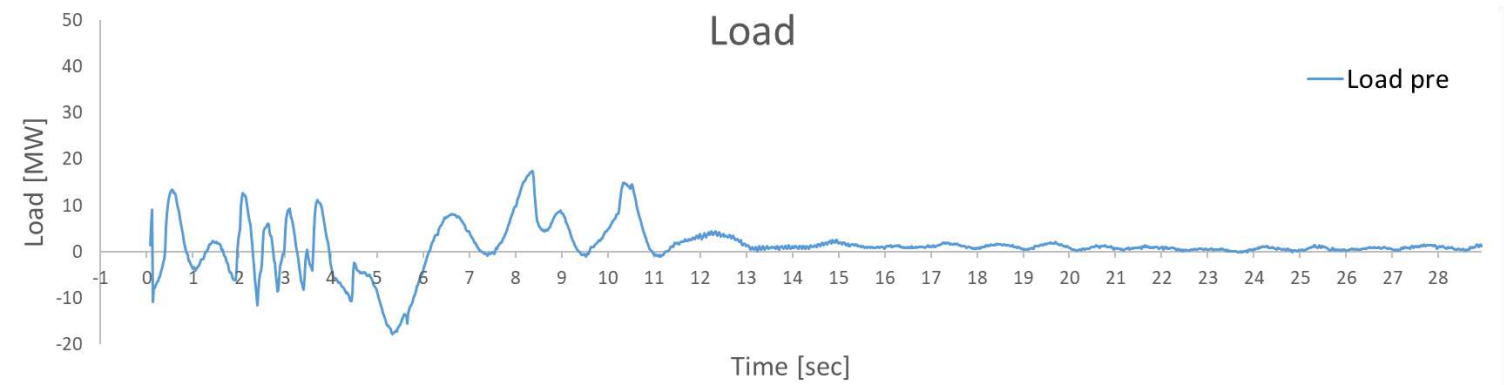
REAL SYSTEM RESPONSES

LOAD LOSS EVENT BEFORE WACS IMPLEMENTATION



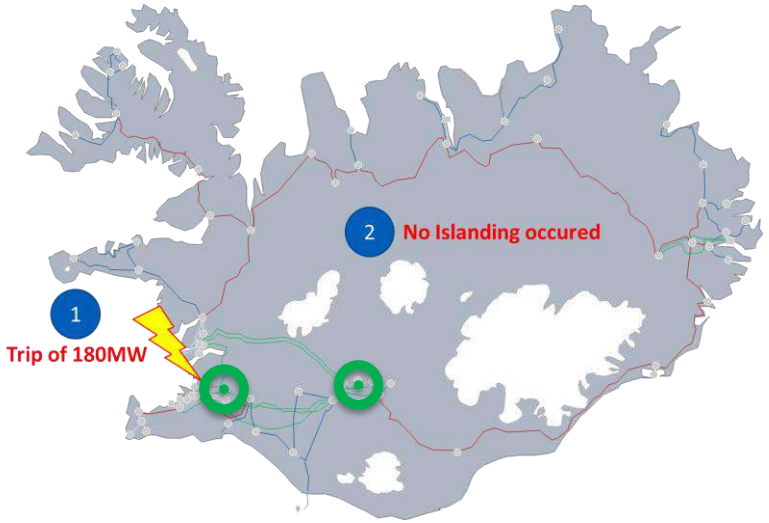


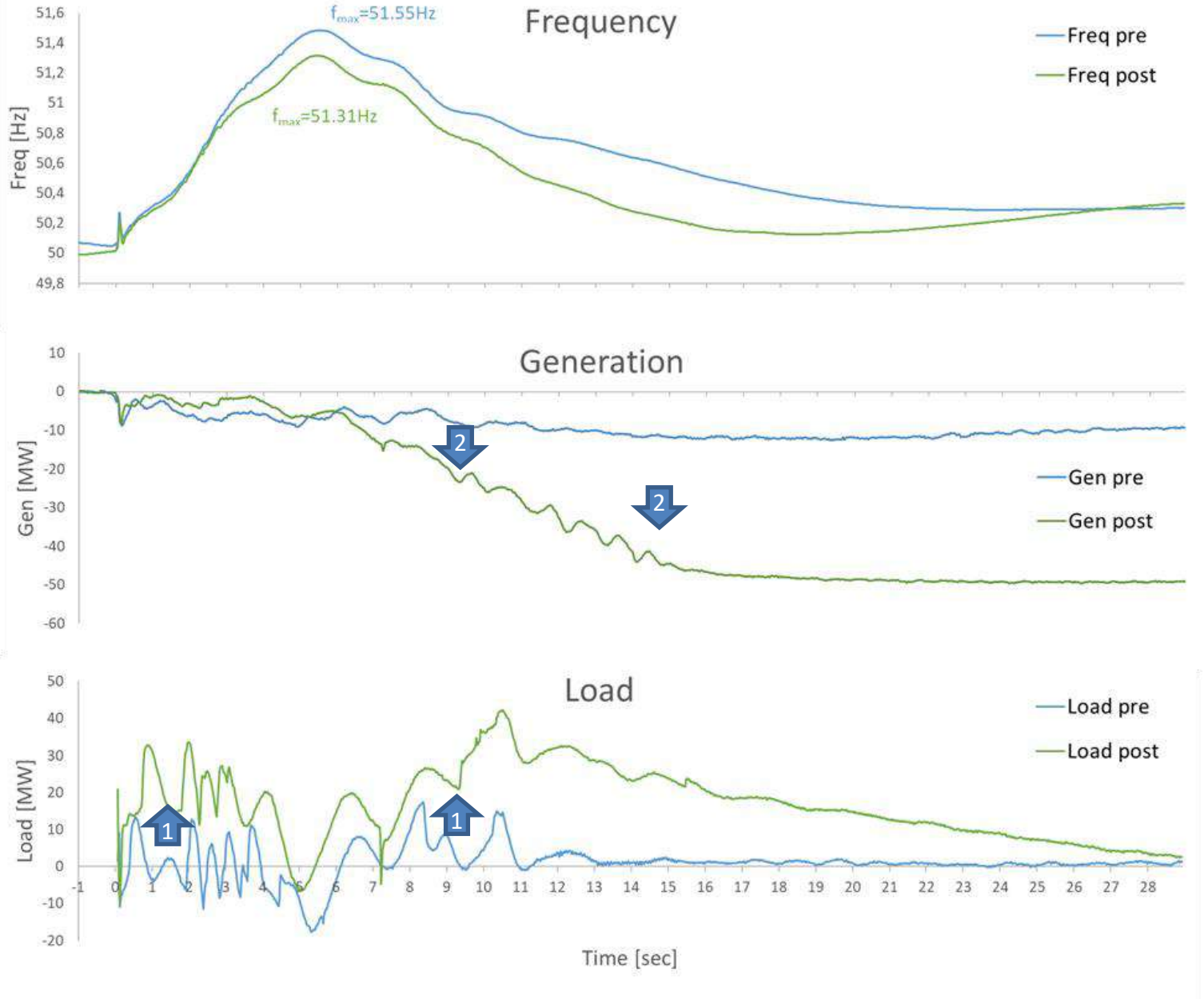




REAL SYSTEM RESPONSES

LOAD LOSS EVENT AFTER WACS IMPLEMENTATION



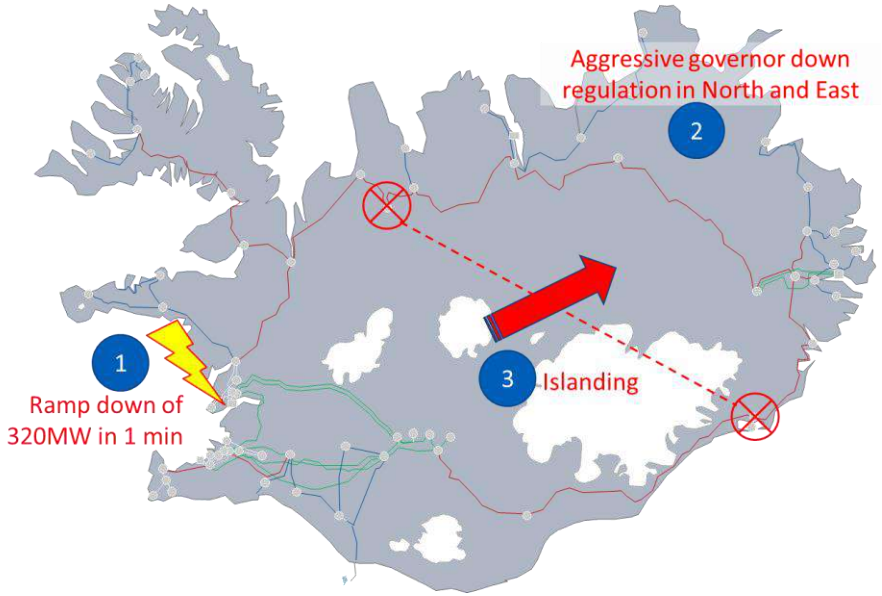


1 *Load response in <0.5s, reduces frequency peak.*

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



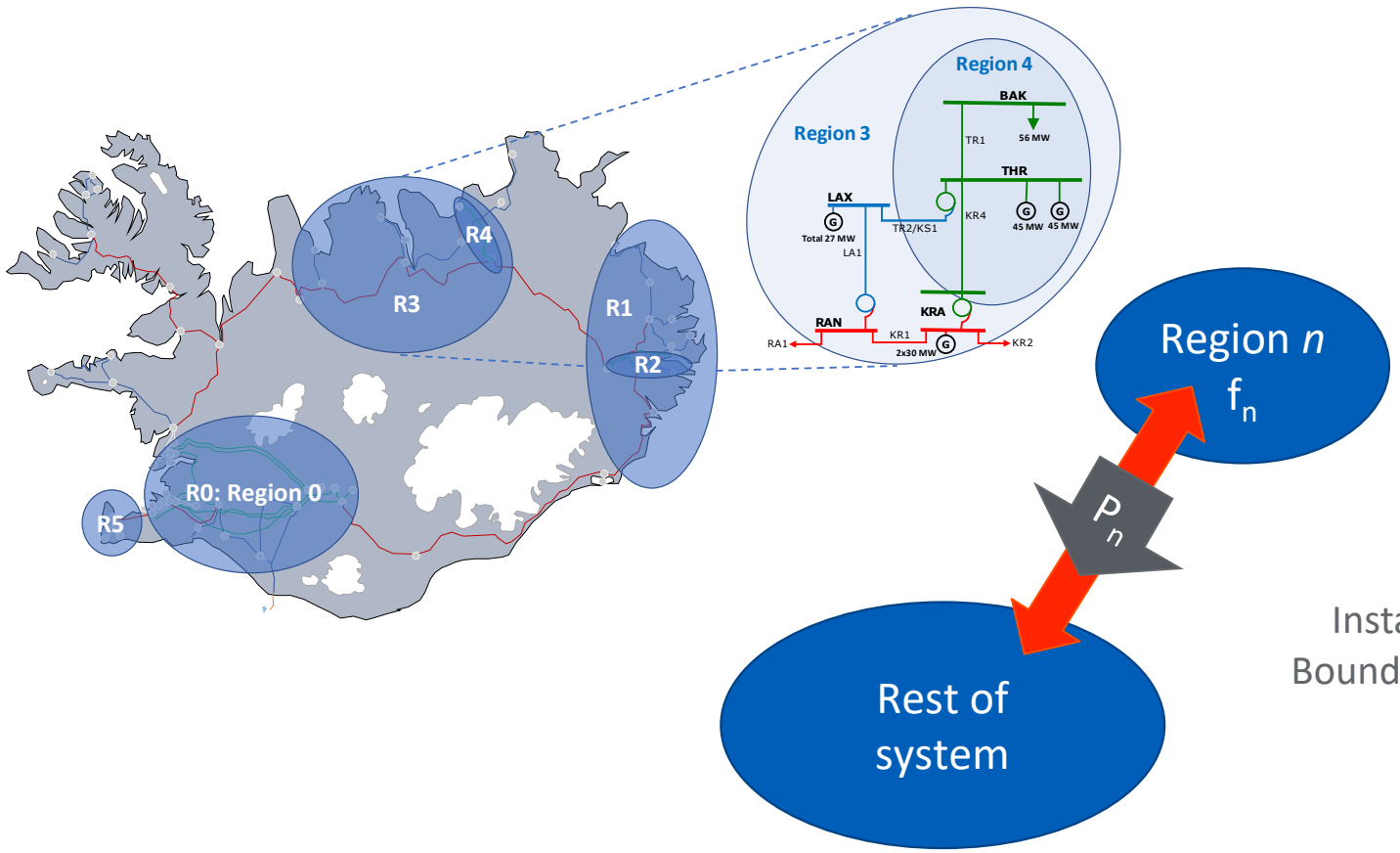
MW div to min

G1: 30 MW

G2: 22 MW

Latest Development in Wide Area Control

for locational frequency response and regional re-balancing

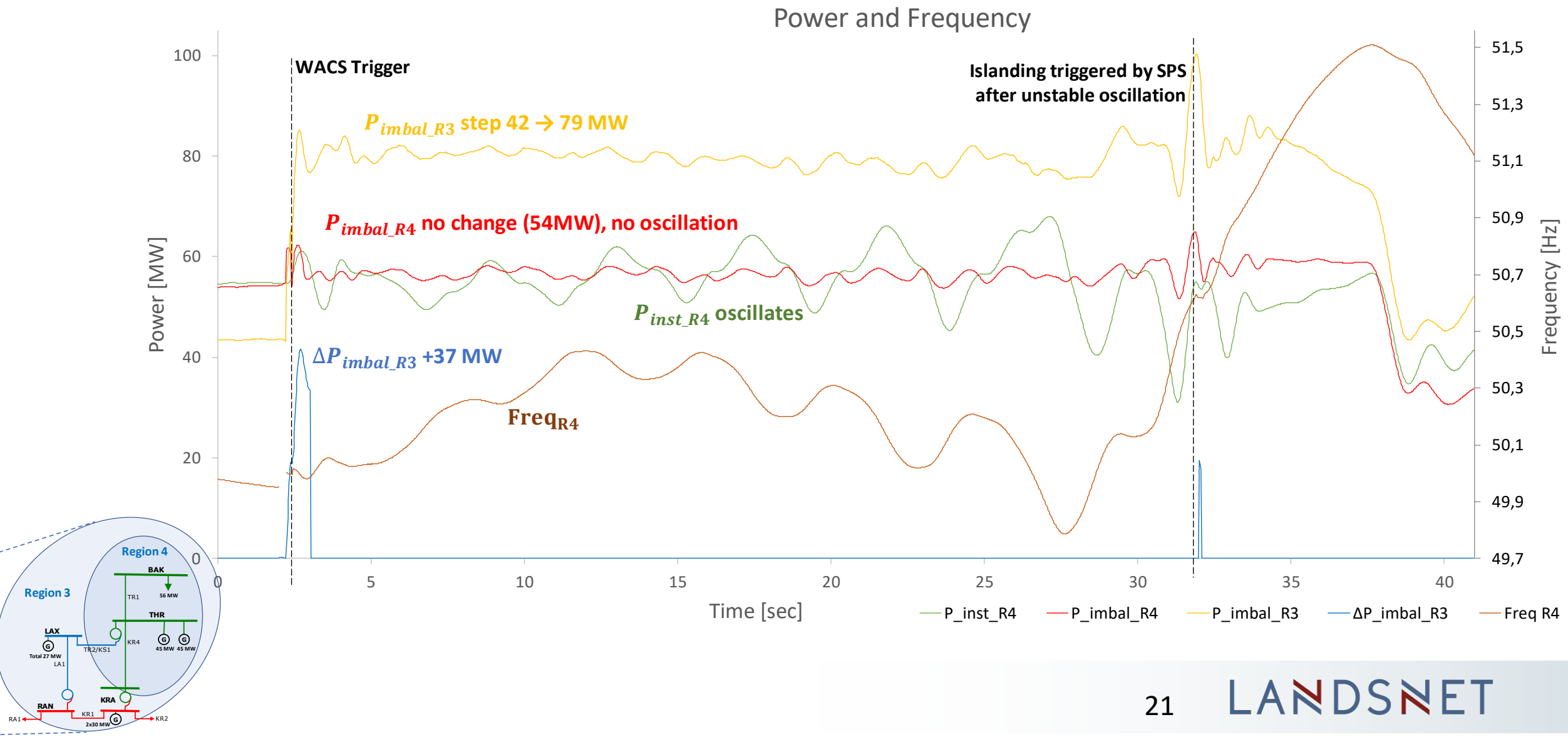


Goal: Quickly find the imbalance of load and generation for a region in the presence of dynamic power swings, so that we can re-balance the area.

$$P_n = P_{Imbal} - H_n . ROCOF_n$$

- P_n: Instantaneous Boundary Power
- P_{Imbal}: **Region *n* Power Imbalance** — not directly measurable
- H_n: **Effective Area Inertia**
- $ROCOF_n$: Region *n* Ctr of Inertia ROCOF

Example of Region 3 load loss and oscillations



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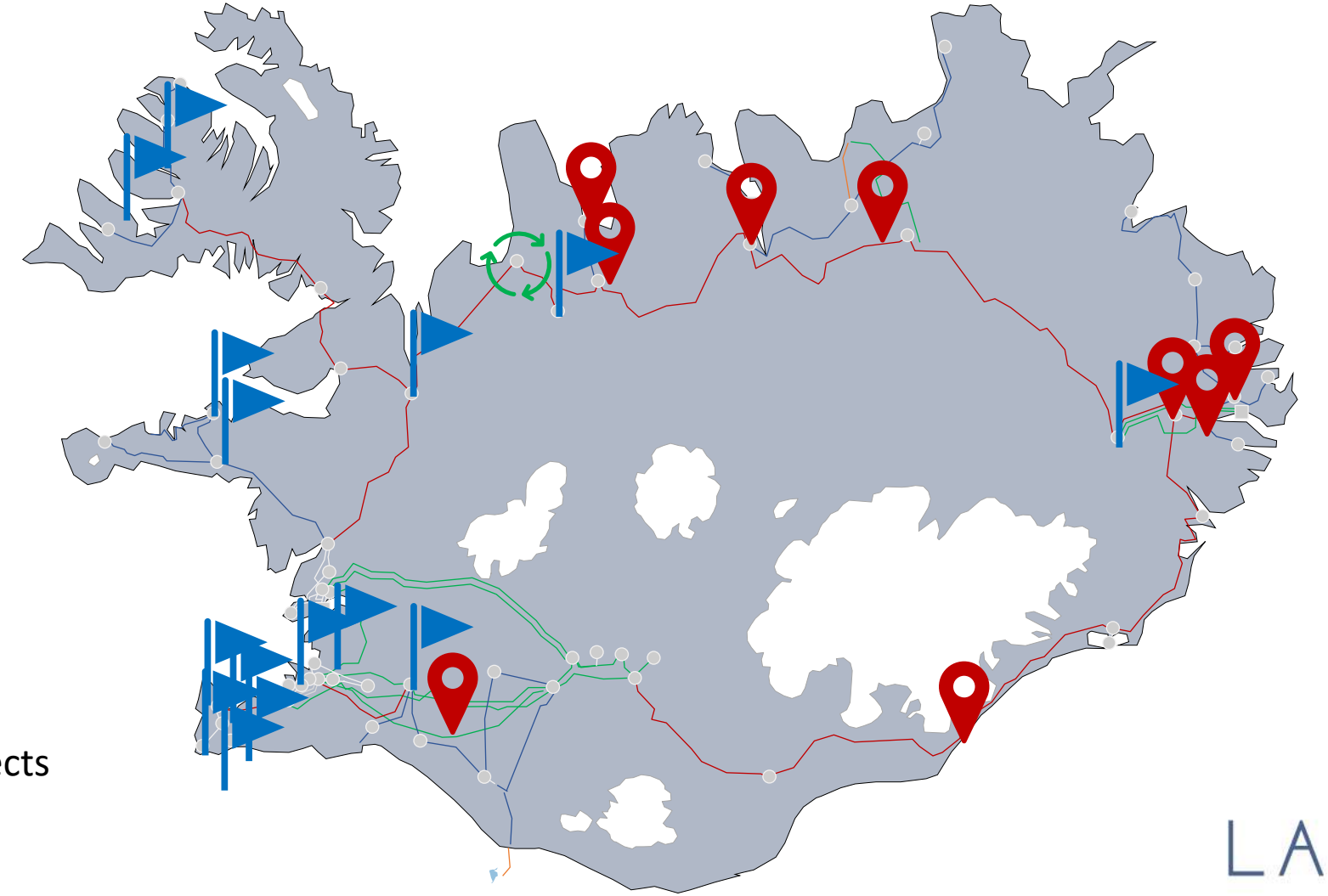
Digital Substation Project Overview



Oct 2020

In operation
One bay

On-going projects

2-3-years plan

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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.


Thank you for your attention
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