Using PMU's in Iceland

NASPI Work Group Meeting

June 2008, Bellevue, Washington

Nils Gústavsson
Manager System Operation

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Overview

1. The Icelandic Transmission System and challenges in System Operations
2. The WAMS project
3. Results and future development

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Location of Iceland with Distances over the Atlantic Ocean

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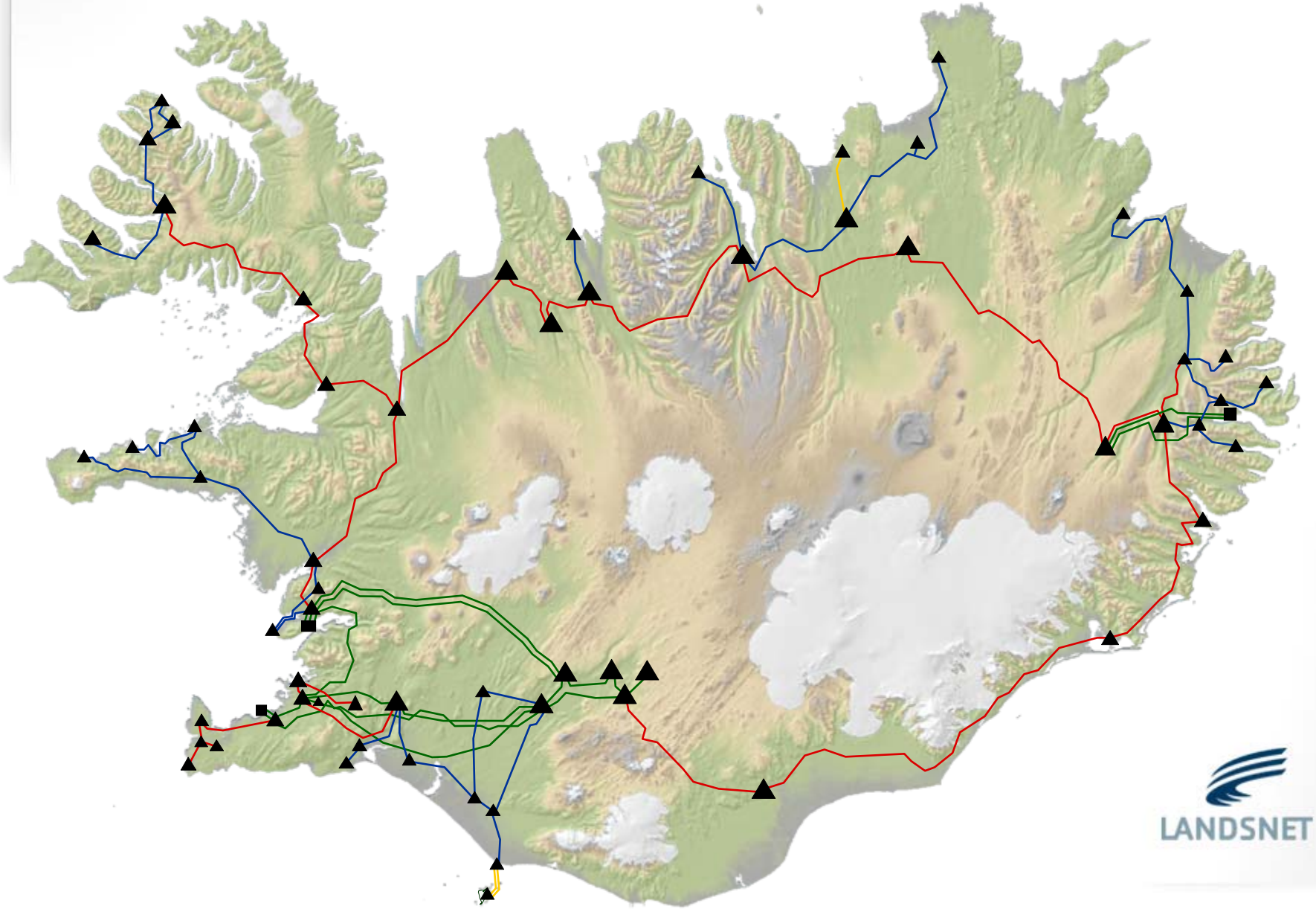
The Transmission System in Iceland



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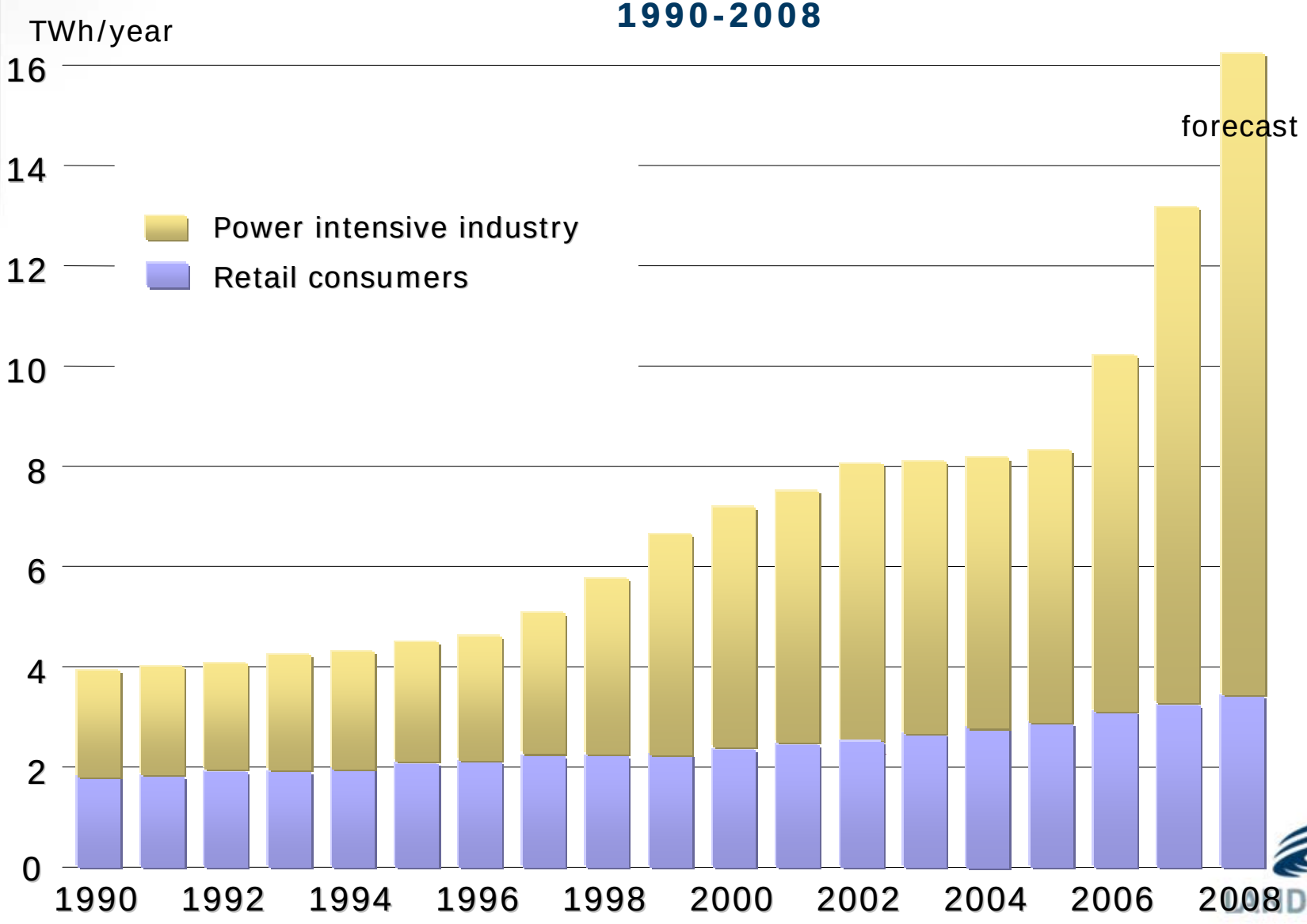
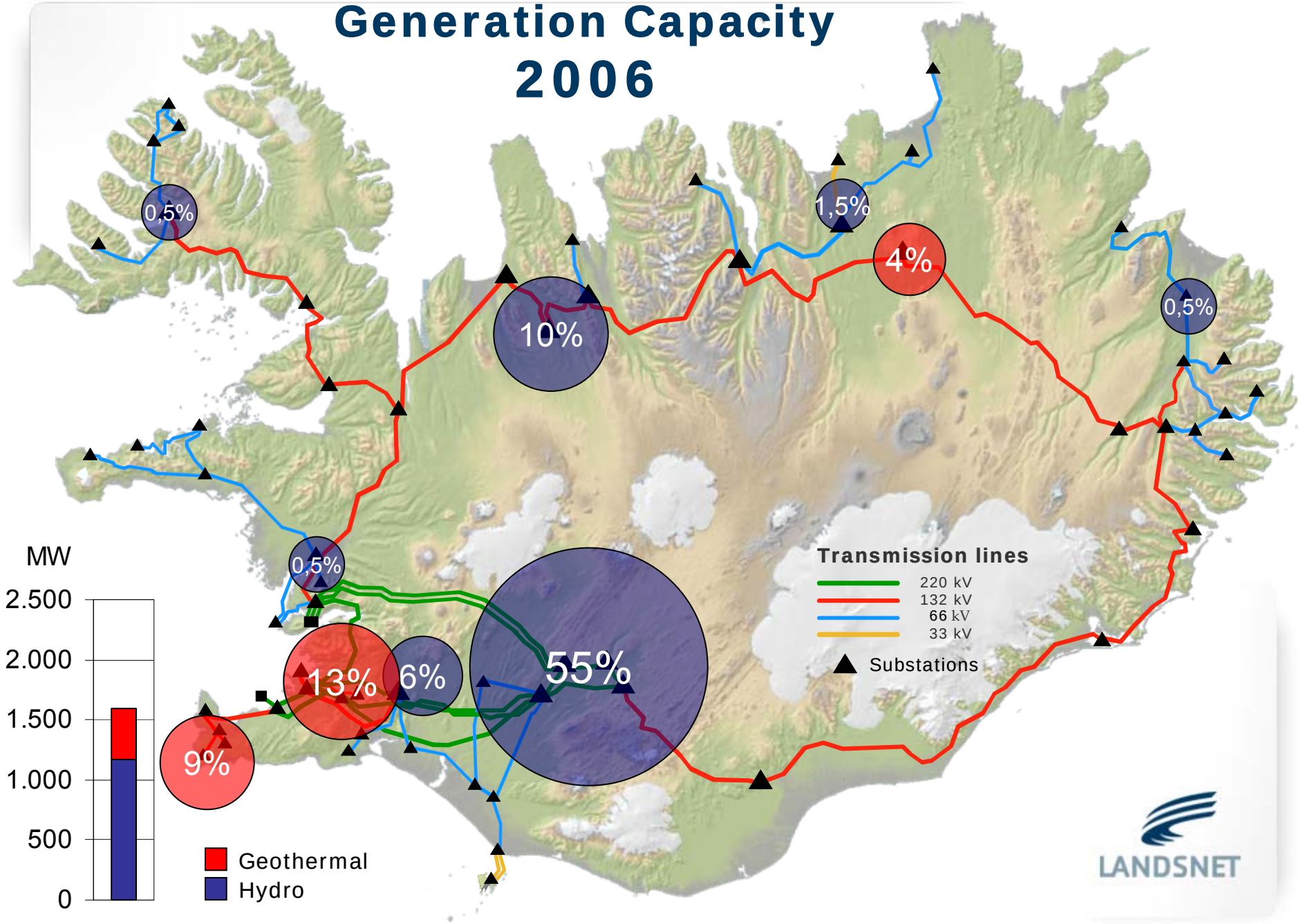
Electricity consumption in Iceland 1990-2008

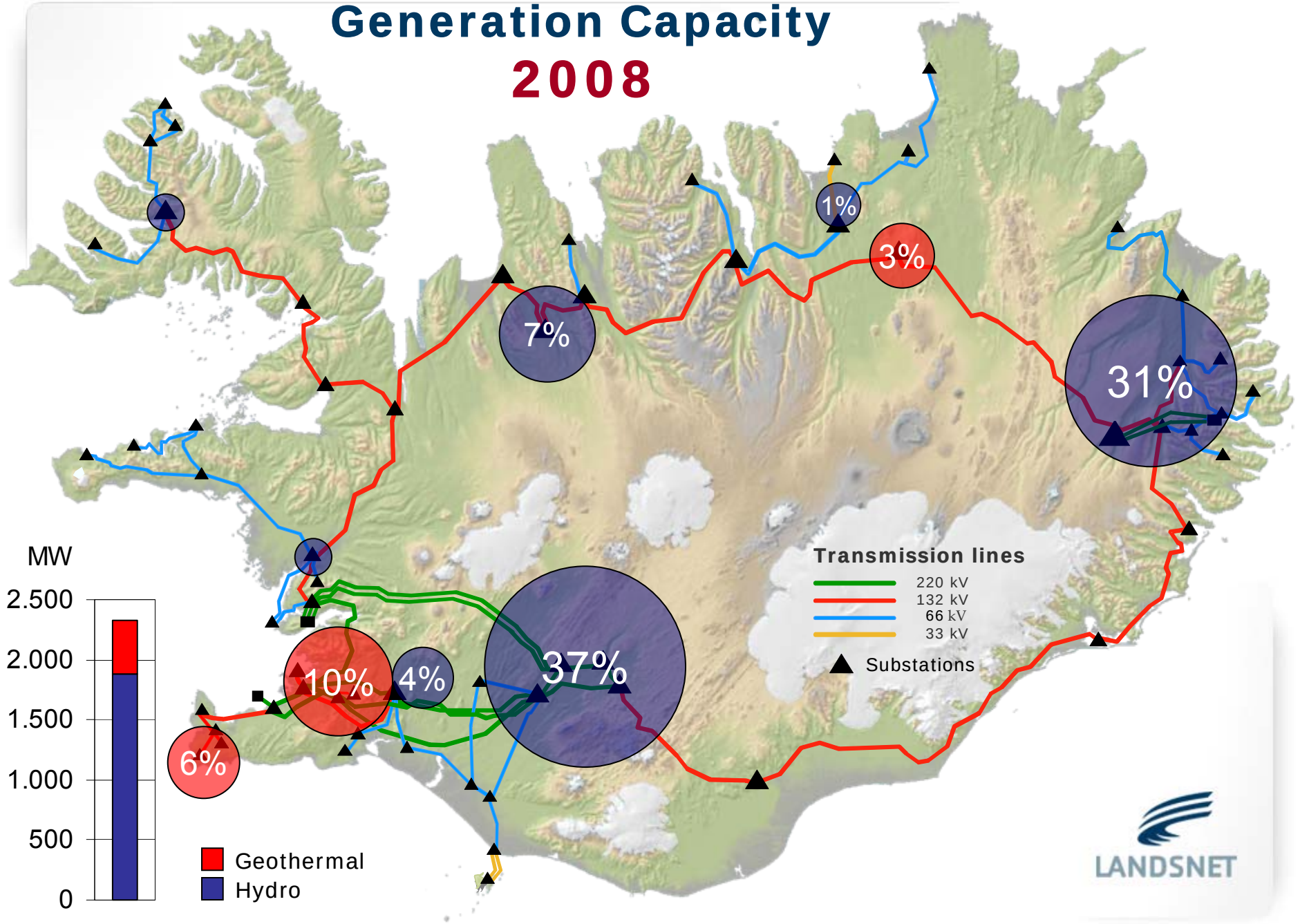


Landsnet Control Center

Generation Capacity 2006



Generation Capacity
2008



Icelandic WAMS Project Goals

- Commissioning and tuning PSS
  - Blanda (3 units, 150MW)
  - Krafla (2 units, 60MW)
  - Fljotsdalur (6 units, 690MW)
- Commissioning of 690MW generation & load
- Real time monitoring of system stability for system operation
- Analysis of disturbances
- On-going processes to improve system stability further

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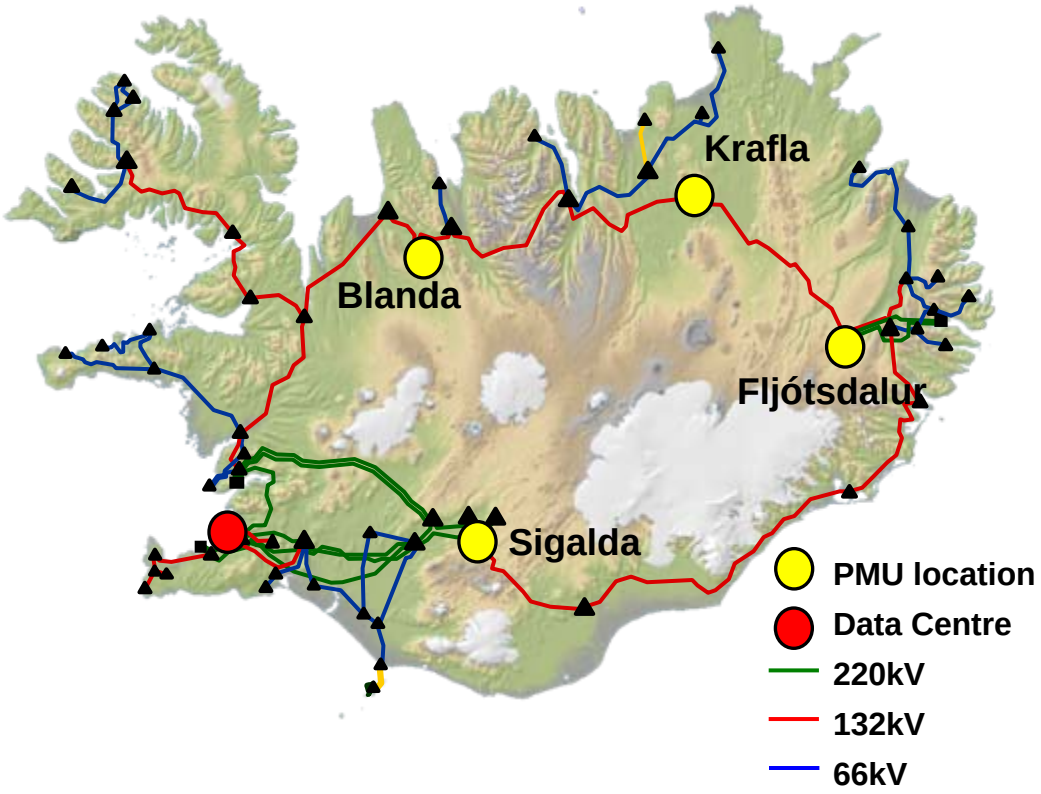
Icelandic WAMS Implementation (1)

- WAMS installed to address stability in 132kV ring
- Currently 7-PMU system
- Data Centre in Landsnet Control Centre, Reykjavik



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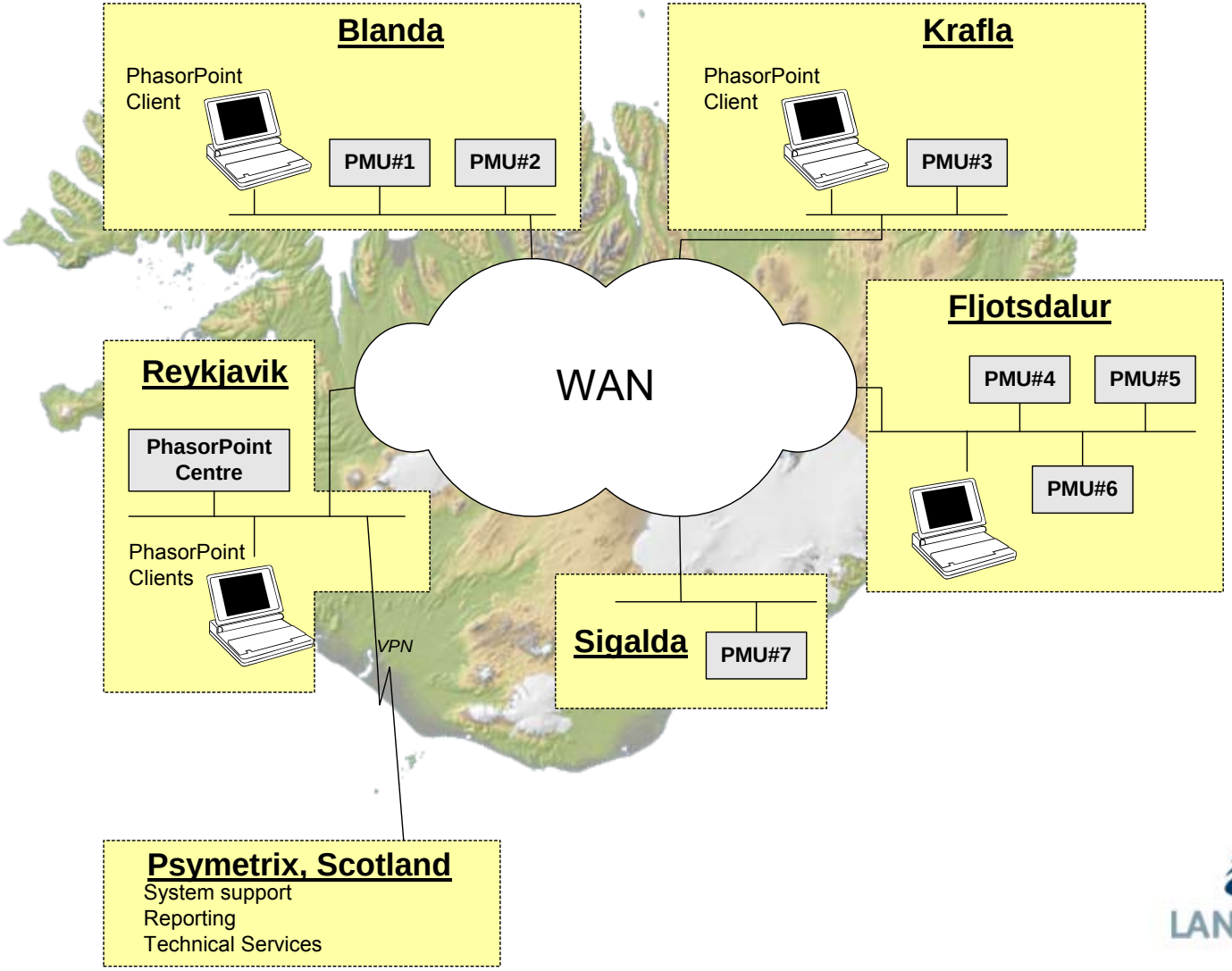
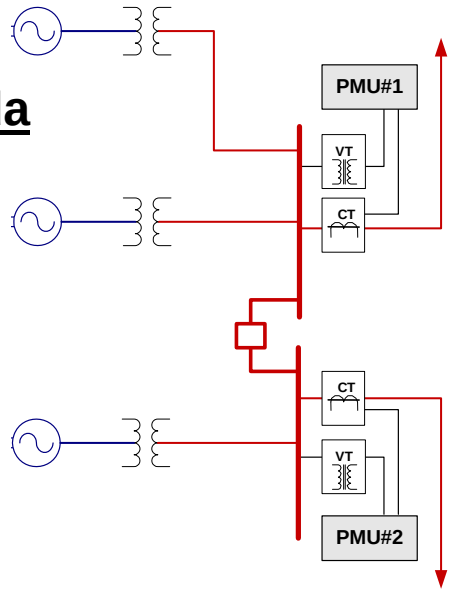
Icelandic WAMS Implementation (2)

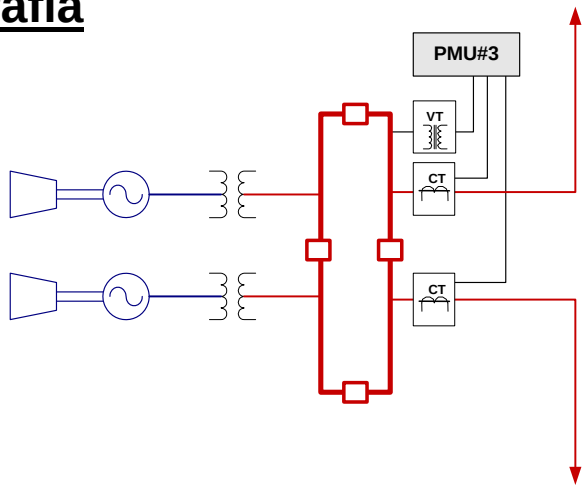


Icelandic WAMS Implementation (3)

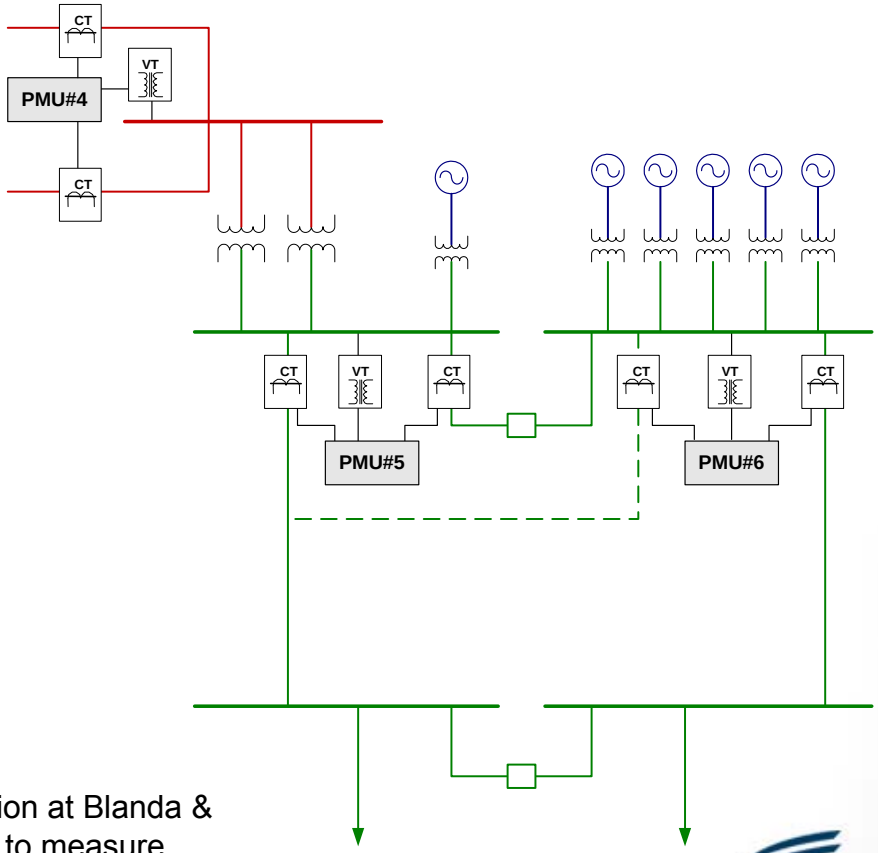
Blanda



Krafla



Fljotsdalur



Note:
Configuration at Blanda & Fljotsdalur to measure angle across open bus tie. Useful for resynchronising.

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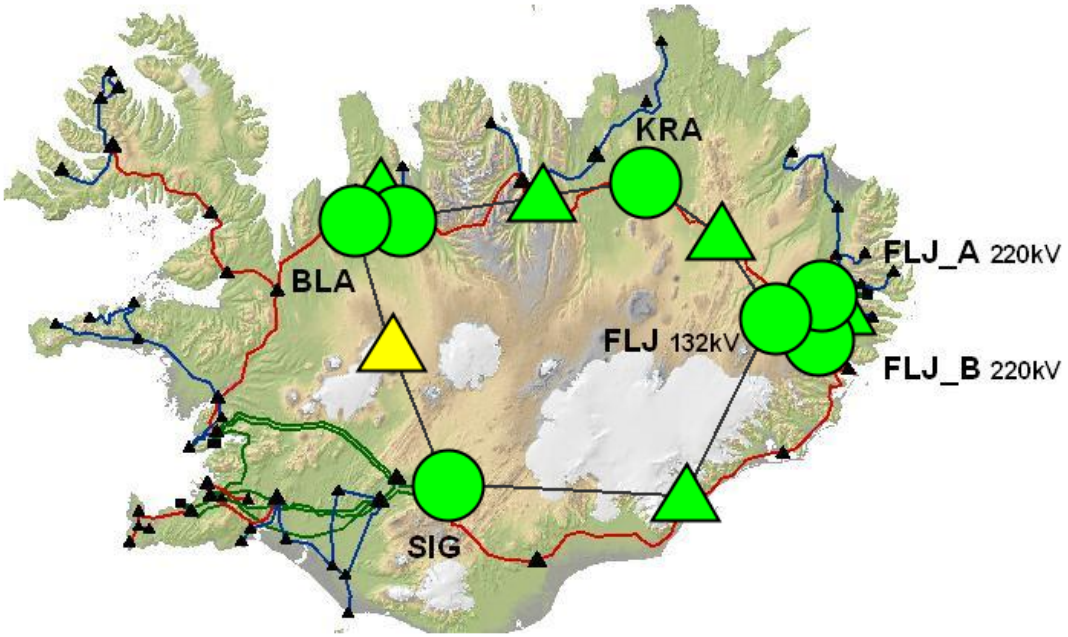
Landsnet Control Room

Psymetrix StormMinder Workbench - Landsnet - Datacentre: pdc-lnd - User: pdmAdmin

File View Settings Help

Dynamics Topological View | Dynamics Circuit View | Phasor Topological View | Phasor Circuit View | Offline | Test Bench

Overview	0,07-0,38 Hz	0,38-0,55 Hz	0,55-0,7 Hz	0,7-0,9 Hz	0,9-1 Hz	1-1,7 Hz	1,7-4 Hz
	3,9 s	3,4 s	12,2 s	3,2 s	2,2 s	11,5 s	4 s



Time	Location	Mode	Message
9.6.2008 11:28:44 GMT	BLANDA_B (V1LPM)/SIGALDA (V1LPM) Angle Differen...	0,55-0,7 Hz	PDX1-3 event status alert
9.6.2008 11:28:19 GMT	BLANDA_B (V1LPM)/SIGALDA (V1LPM) Angle Differen...	0,55-0,7 Hz	PDX1-3 event status alarm
9.6.2008 11:28:09 GMT	BLANDA_B (V1LPM)/SIGALDA (V1LPM) Angle Differen...	0,55-0,7 Hz	PDX1-3 event status alert

Domain Events | System Events

Active Profile: default | Loaded Profile: default | Dynamics | Phasor

Power System Stabiliser Tuning (1)

- WAMS central to PSS commissioning and tuning
- Wide-Area Measurements provided
  - Security during tests
  - Immediate feedback on PSS performance
  - Longer-term assessment of PSS performance
- Performance of PSSs thoroughly proven before acceptance

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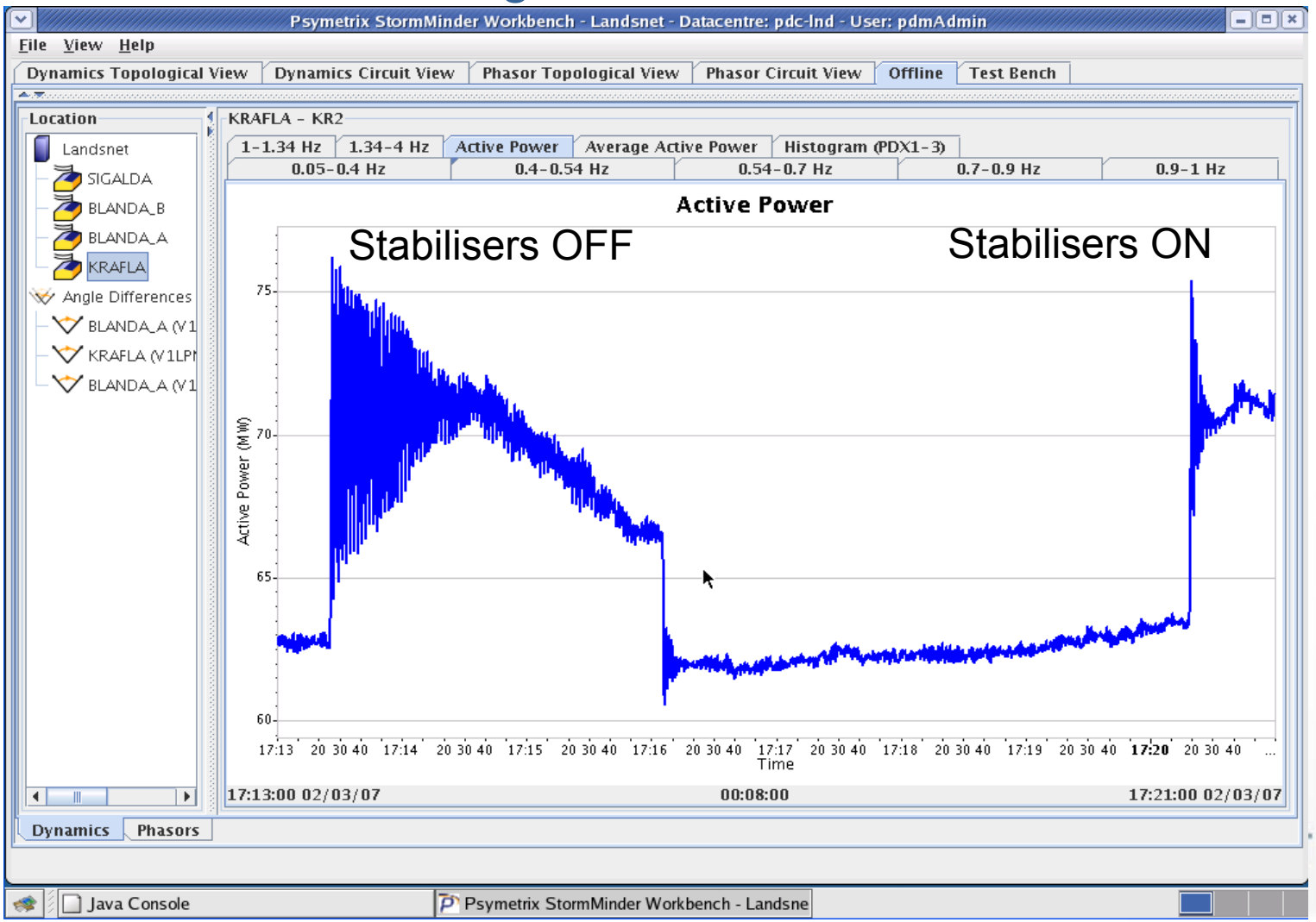
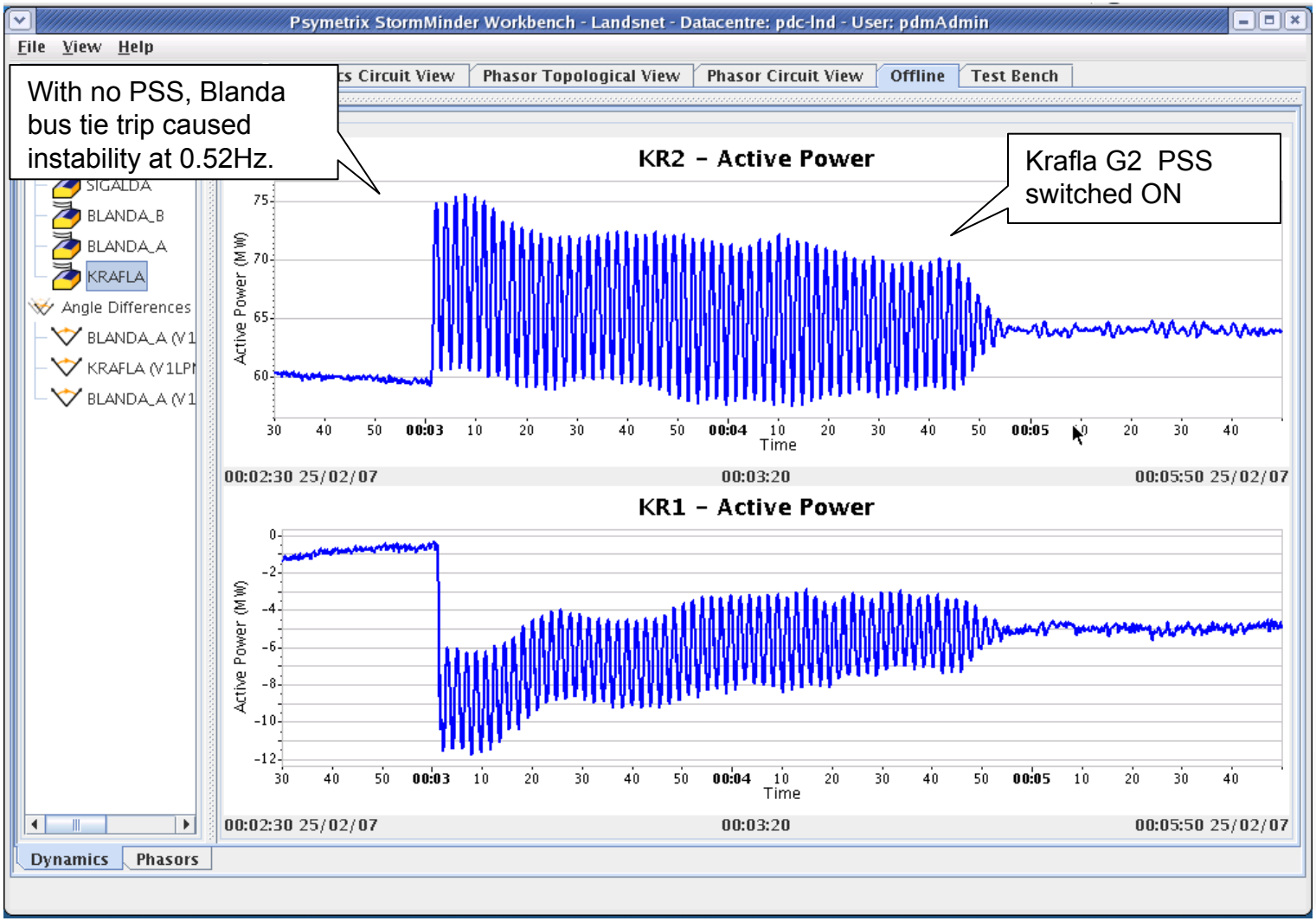
Power System Stabiliser Tuning (2)

- Network switching tests



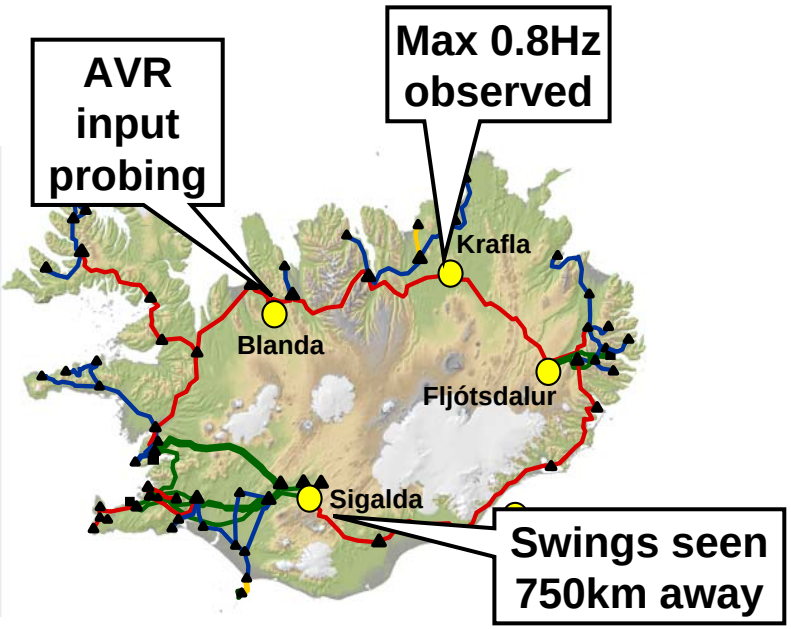
Power System Stabiliser Tuning (3)

- Network & PSS switching tests

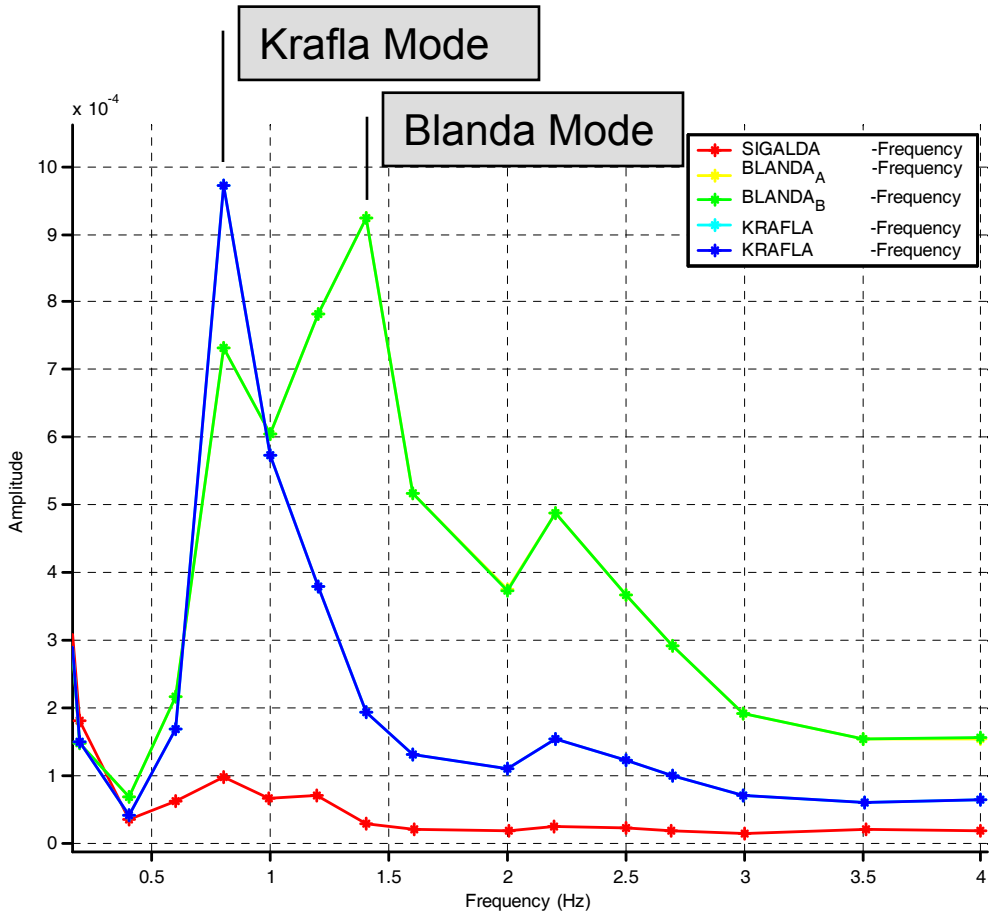


Power System Stabiliser Tuning (4)

- AVR injection probing tests
- WAMS used to
  - Ensure security of tests
  - Identify resonant mode frequencies
  - Identify network to AVR injection (controllability)



Wide-Area Response to Blanda AVR Injection
(System Frequency measurement)



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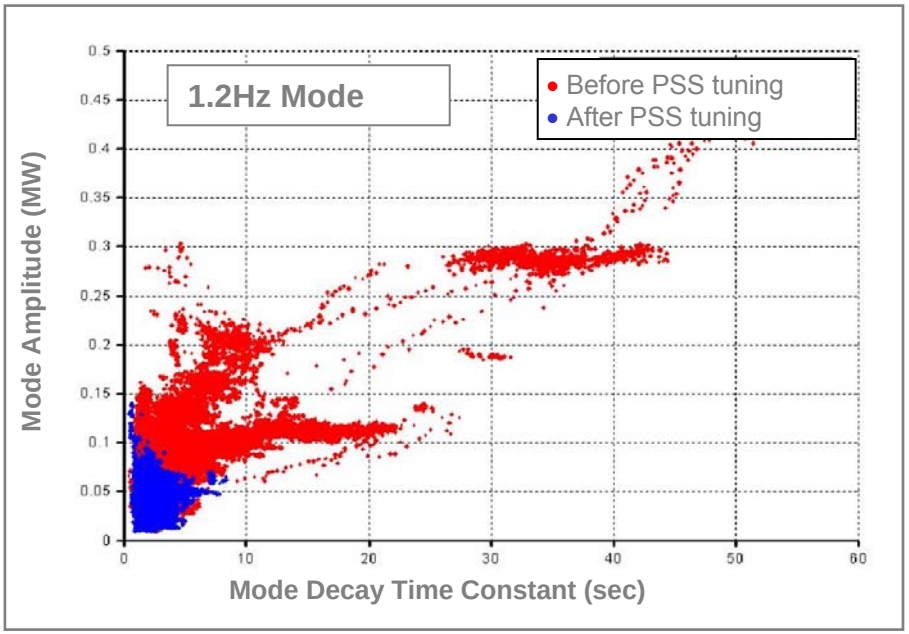
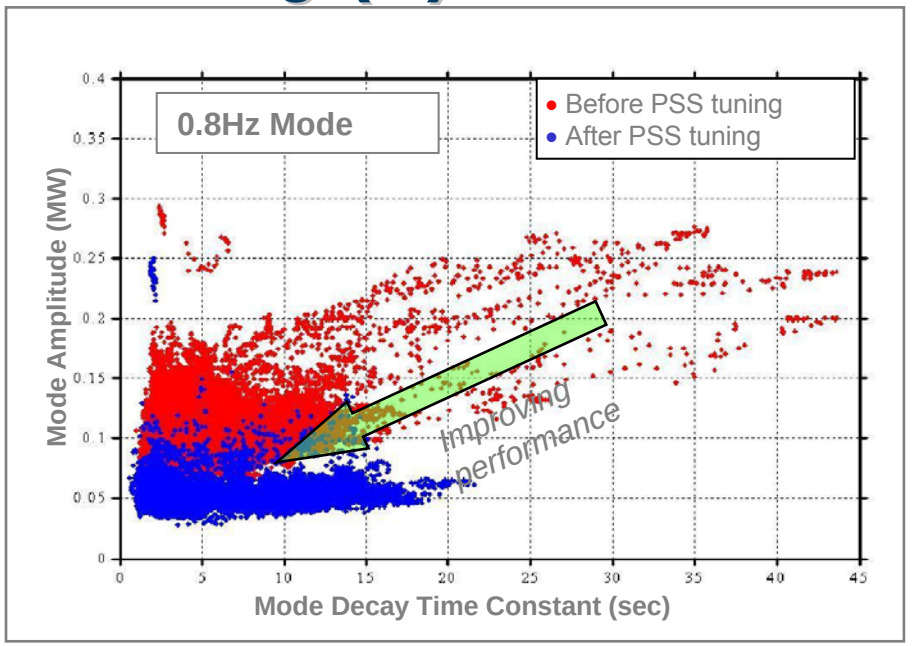
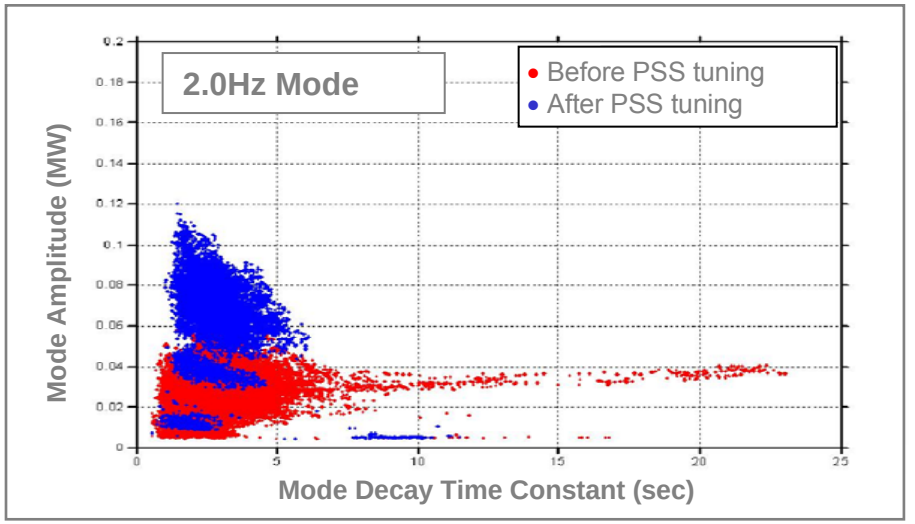
Power System Stabiliser Tuning (5)

- Long-term observation of damping
  - 2 modes clearly improved
  - No degradation in performance





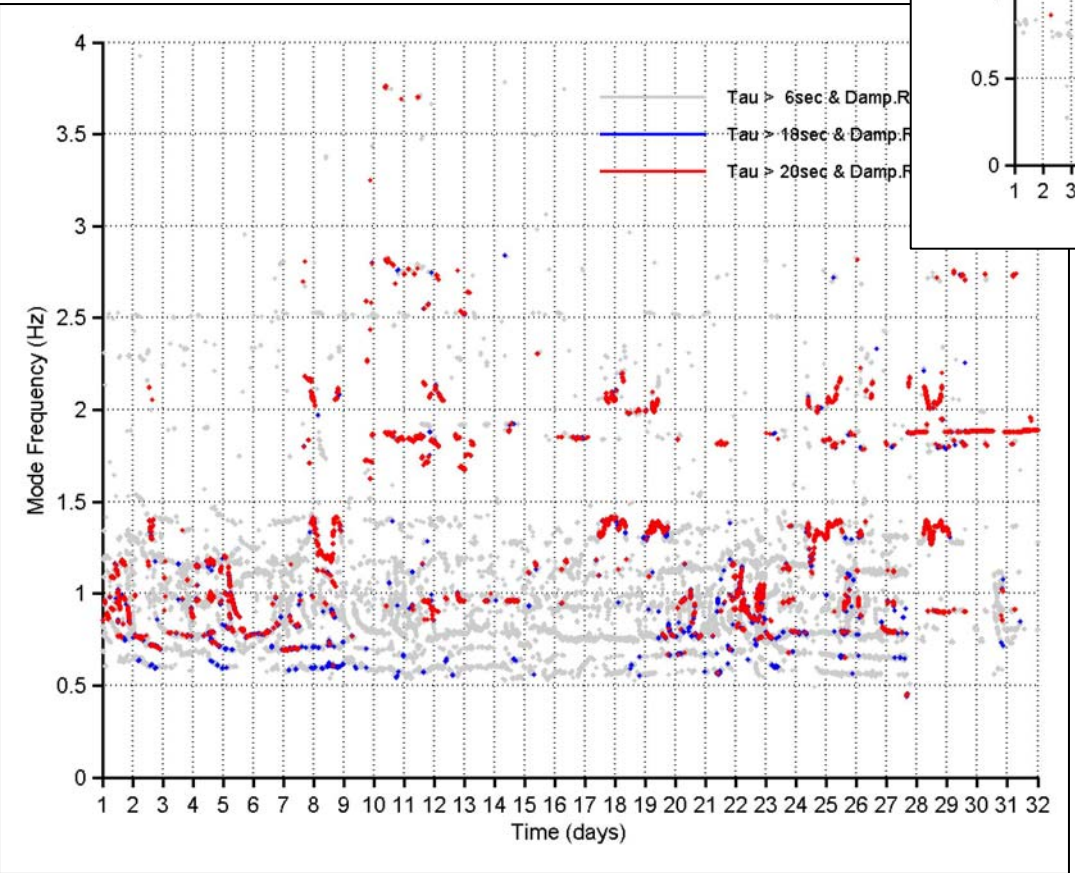


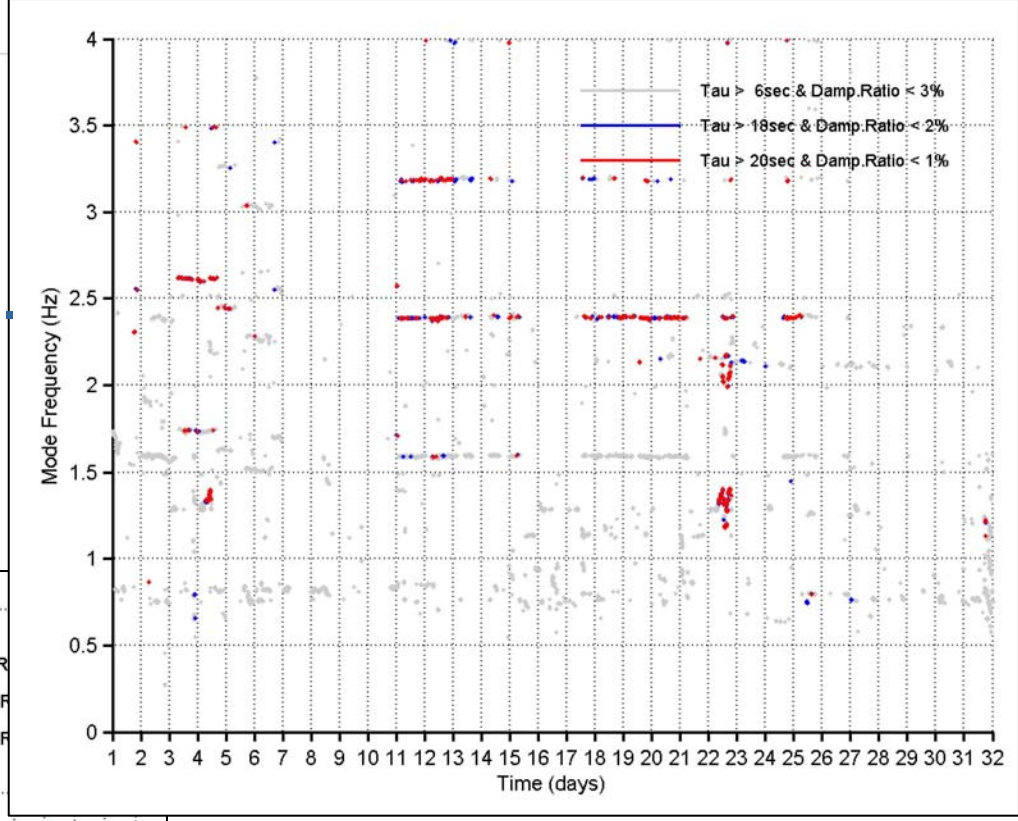
PhasorPoint PDX-2 Analysis

PSS tuning

- New hydroplant online.

Without PSS





With PSS

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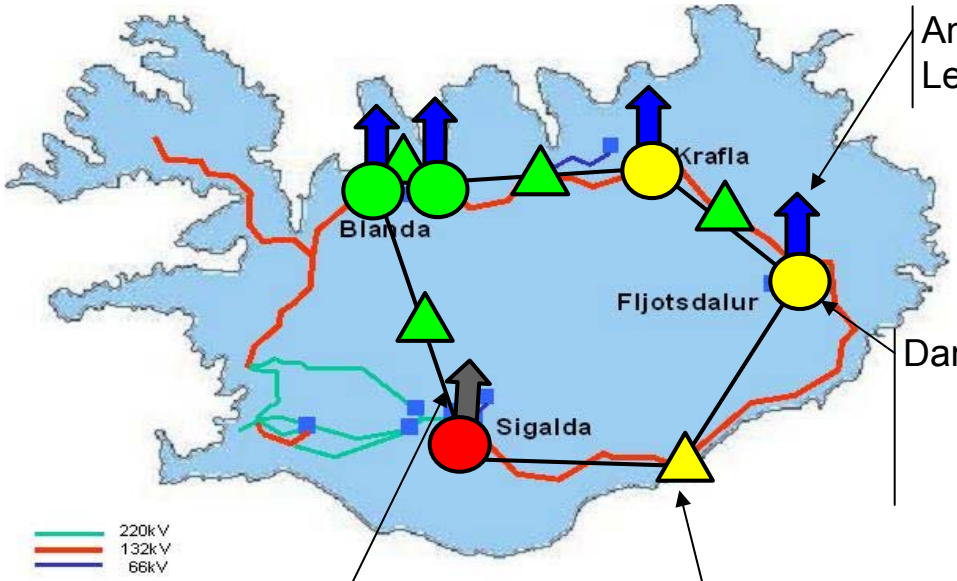
On-going Dynamics Analysis (1)

0.45Hz



Angle: mode phase
Length: relative amplitude

Damping status:
Green OK
Yellow Alert
Red Alarm

Grey arrow: maximum amplitude oscillations in system frequency

Triangles indicate status in voltage angle difference

- Oscillations in phase at all monitored locations
- Largest amplitude in P at Sigalda
- Sensitive to P output of one particular unit

PhasorPoint Voltage Angle Difference with PDX Damping and Mode Phase

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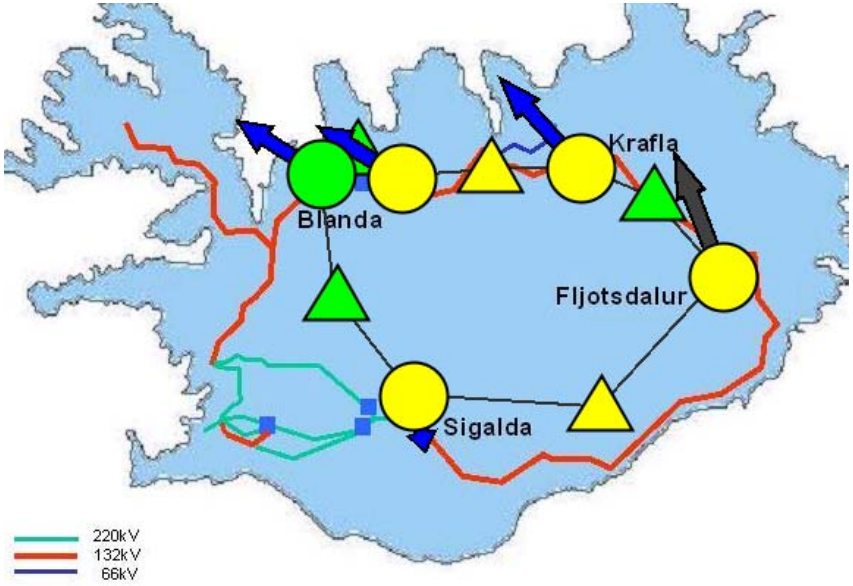
On-going Dynamics Analysis (2)

0.6Hz



- Interarea, dominant in the North and East
- Machines in132kV ring oscillating anti-phase to 220kV network
- More significant after Karahnjukar Unit 1 commissioned

PhasorPoint Voltage Angle Difference with PDX Damping and Mode Phase

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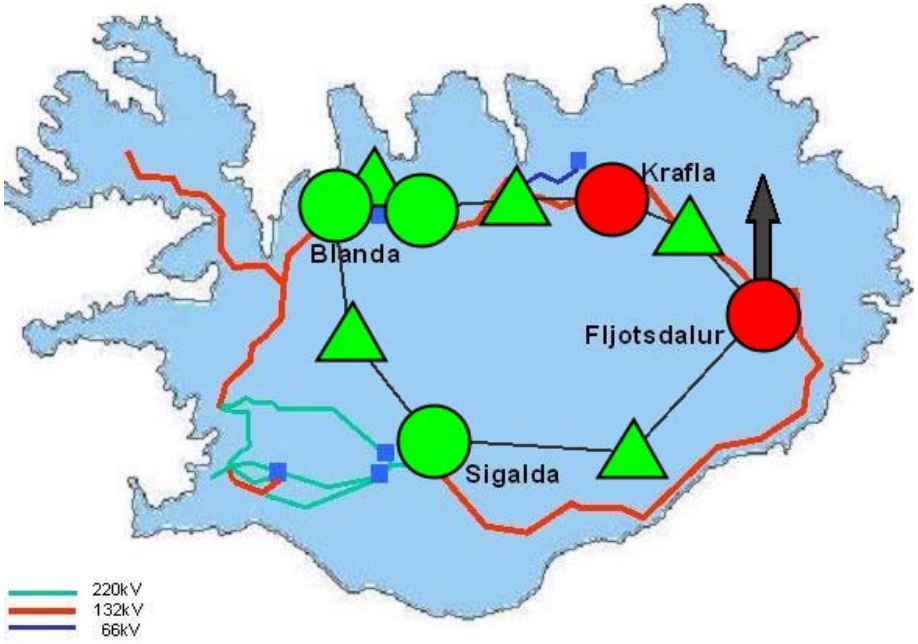
On-going Dynamics Analysis (3)

1.3Hz



- Karahnjukar local mode
- Observed in System Frequency only at Karahnjukar
- Power oscillations largest between Karahnjukar and Krafla

PhasorPoint Voltage Angle Difference with PDX Damping and Mode Phase

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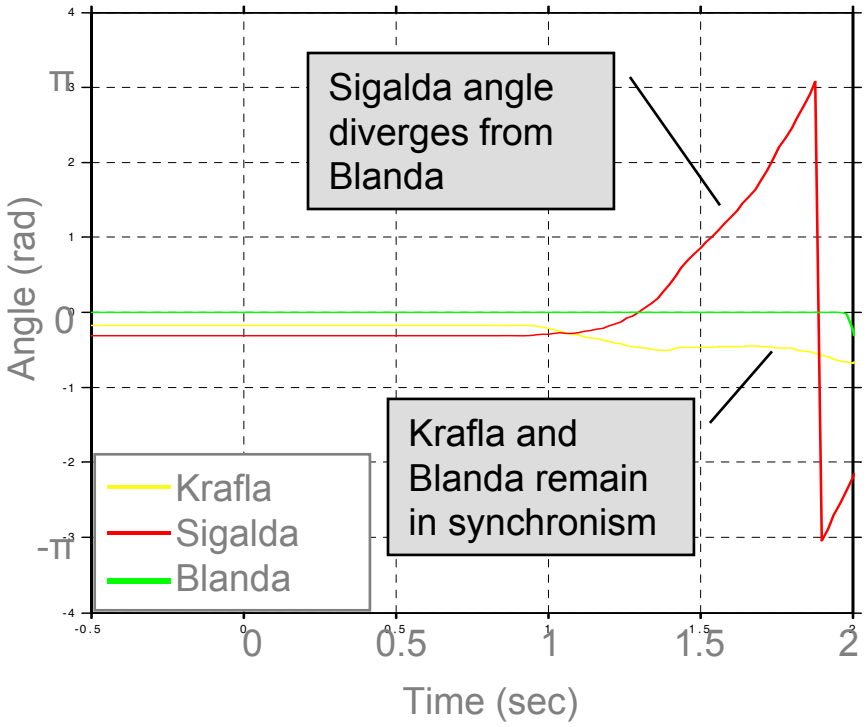
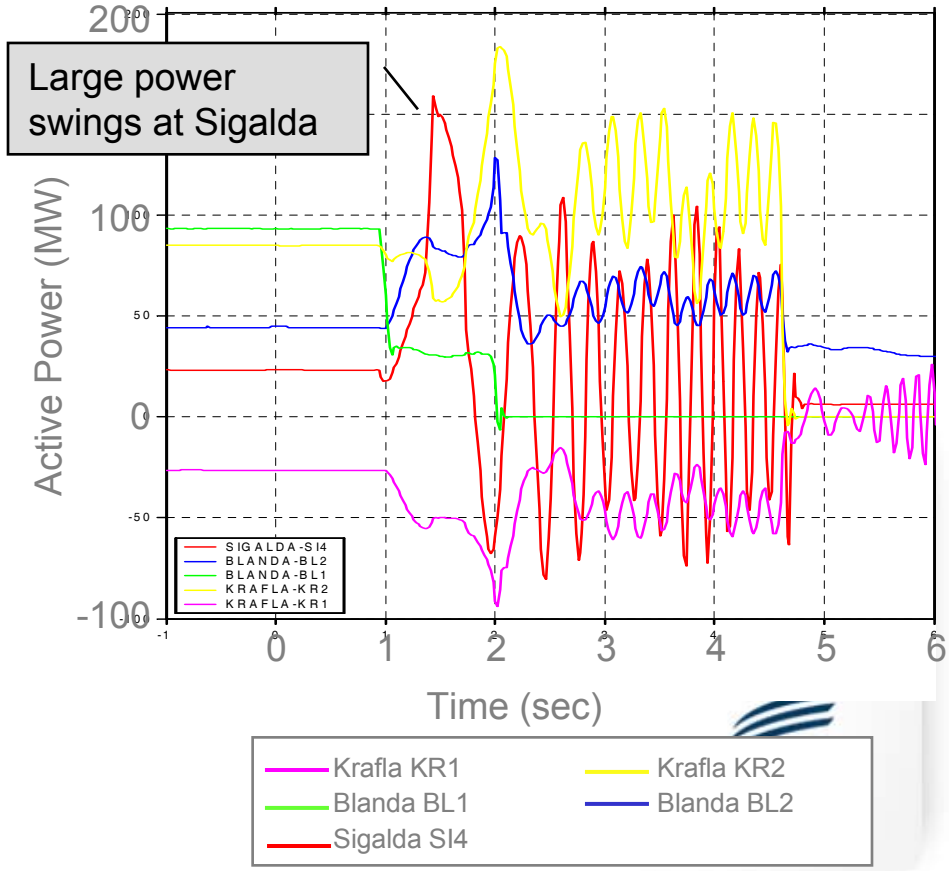
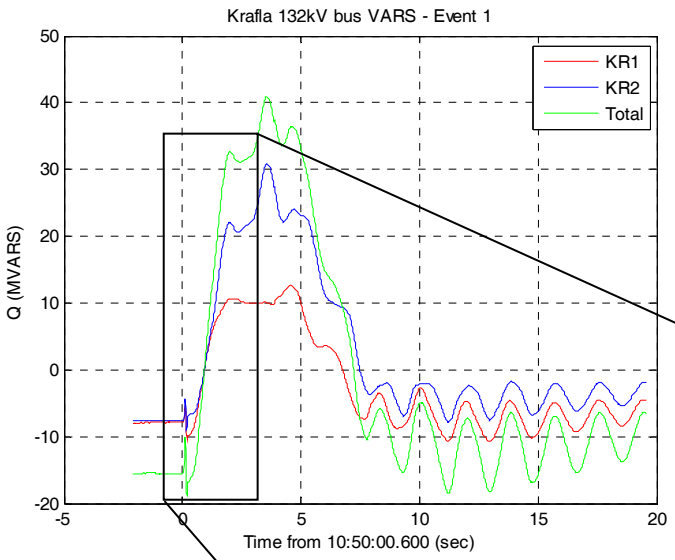
Disturbance Analysis

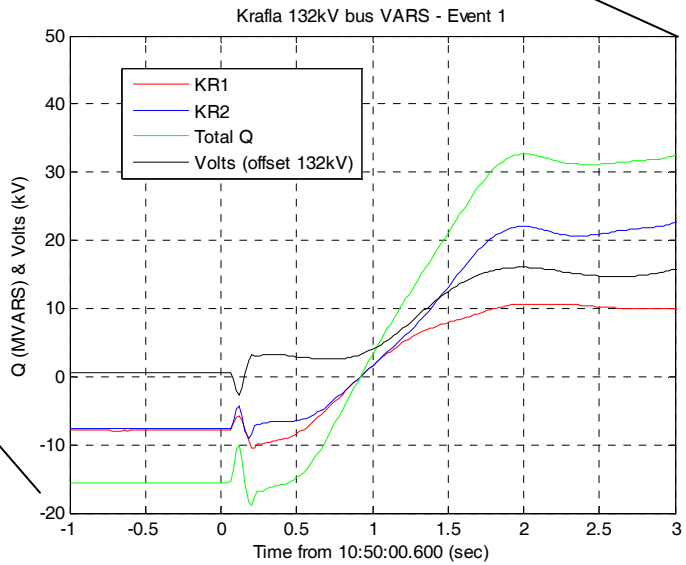
- PMU data used for analysing disturbances
- E.g. Identifying loss of synchronism





Identification of Controller Malfunction





- PMU measurements used to identify incorrect AVR response
- Circuit fault identified and resolved
- Issue resolved – confirmed by PMU measurements

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Tools Used

- Psymetrix - PhasorPoint
  - Incorporates 13+ years direct operational WAMS and dynamics analysis experience
  - Operationally proven
    - proven value in real events
  - Extensive dynamics analysis validation
    - simulated grid signals
    - proven value in real events
    - self-consistency - statistical analysis of long-term results
    - customer power system tests
    - customer benchmarking
    - recent enhancements for planning & analysis applications approved by major transmission system operator

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Results (so far)

- Stability has significantly increased with successful PSS tuning
- Knowledge of system dynamics has increased
- Improved capability to analyse disturbances
- Able to commission new generation with confidence

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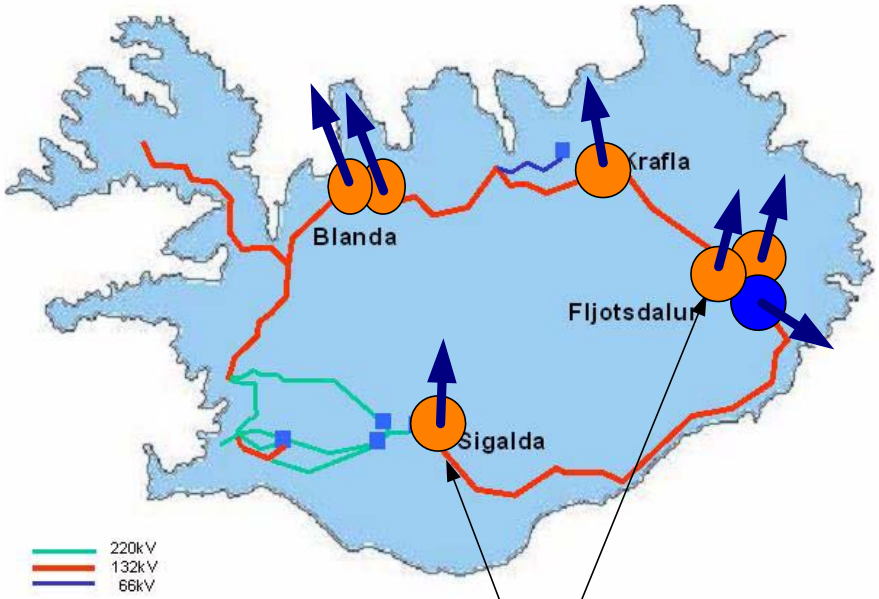
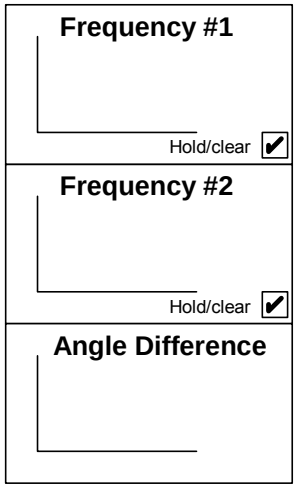
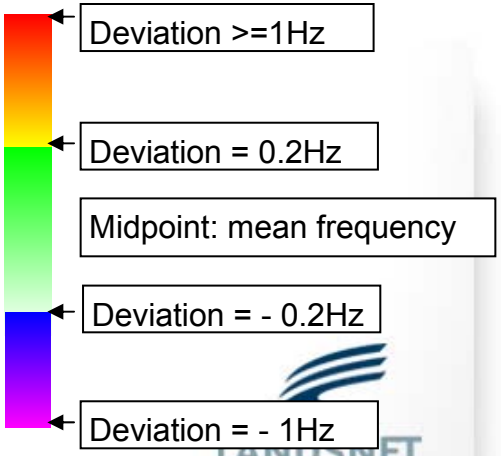
Future: Phasor View for Resynchronisation

- Resynchronising the Fljotsdalur 220kV network



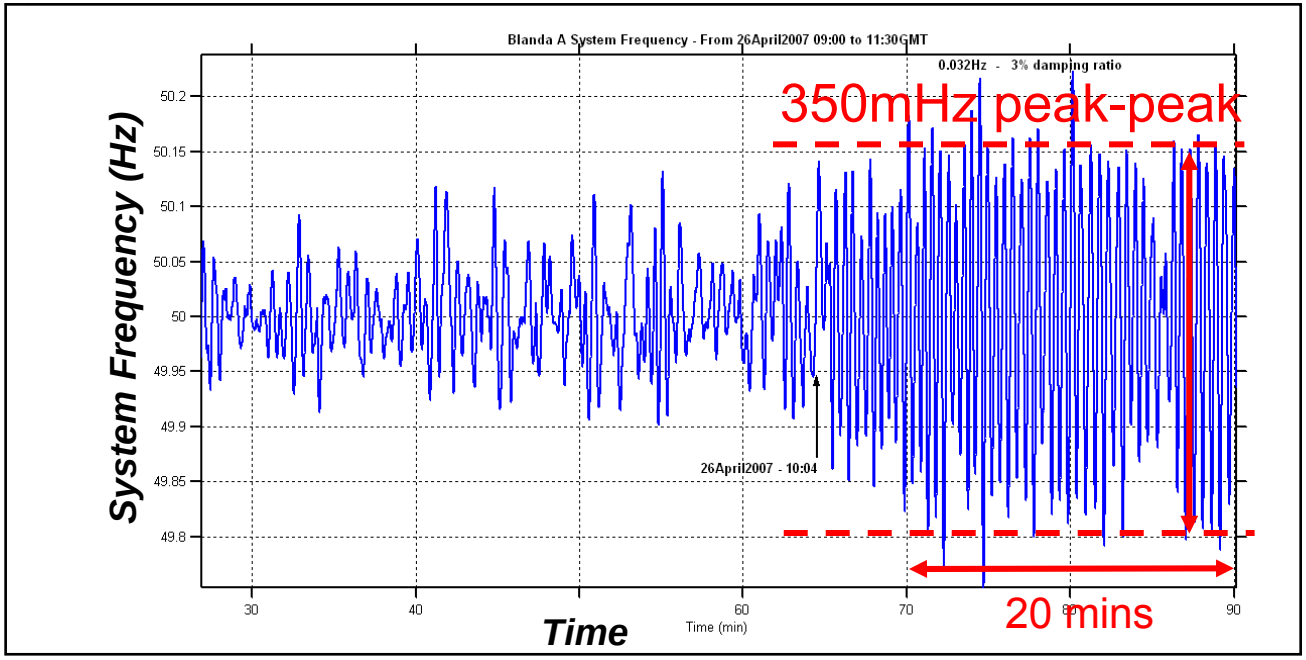
Click on 2 sites to show frequency and angle difference in striptcharts





Future: Governor / AGC Stability

- Addressing Governor/AGC Frequency Oscillations
- Detected frequency 0.015 to 0.045Hz



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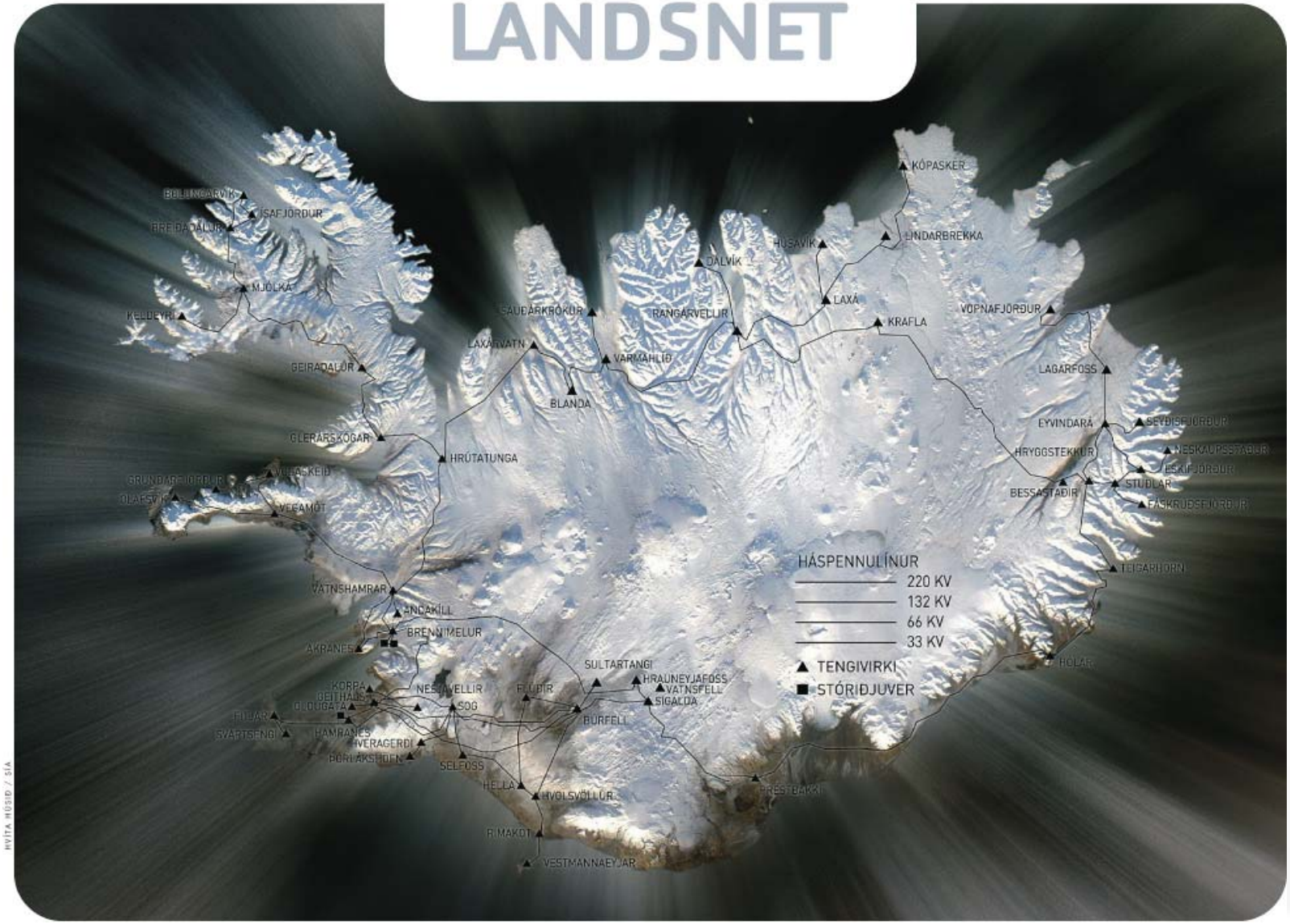

HVÍTA HÚSIÐ / SÍA