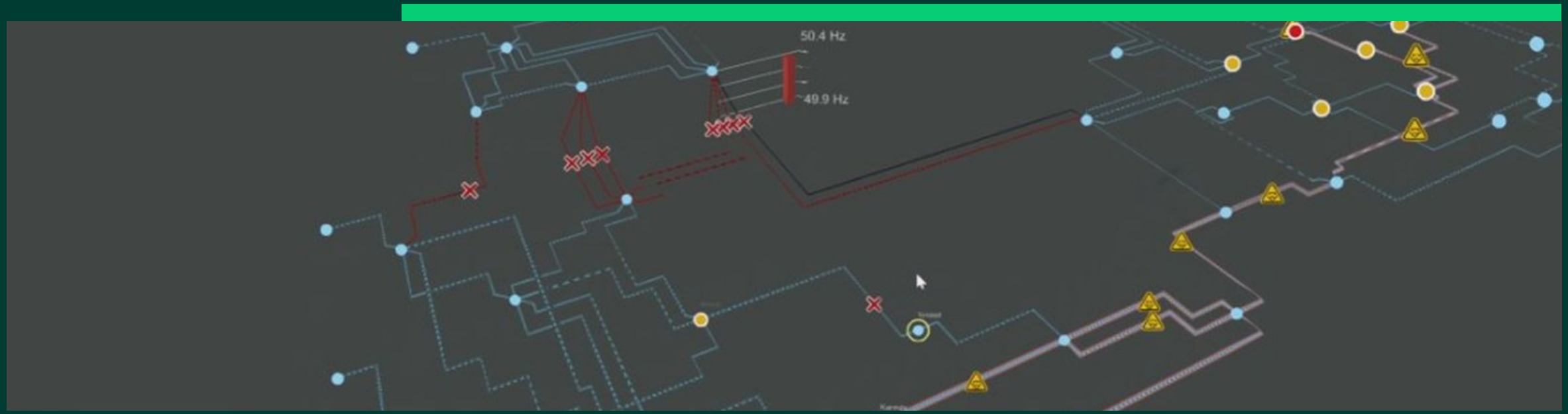
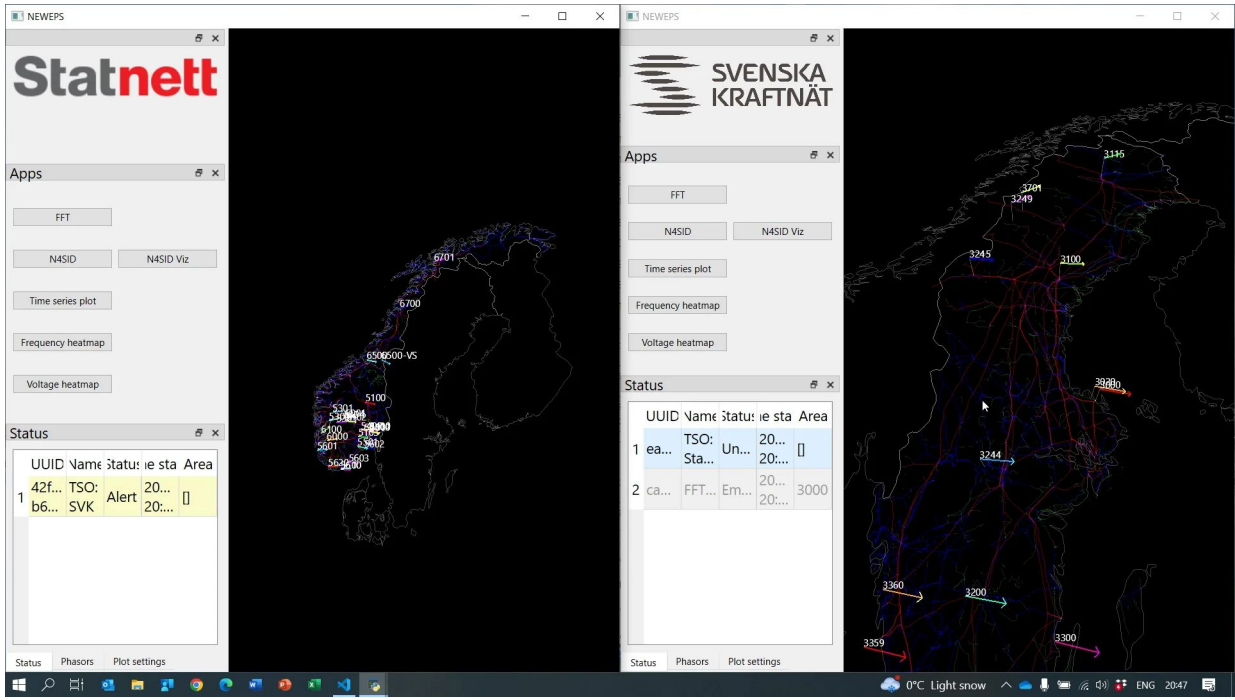
Statnett

– Statnett R&D WAMPAC power- Stability Wide Area Monitoring Protection (p-SWAMP)



Motivation



[What's Happening in Spain? The 2025 Blackout and the Global Threat Ahead!]

[28 April Blackout]

[NEWEPS - Nordic Early Warning Early Prevention system]

[NEWEPS Demo C - Part 2, Voltage Stability Monitoring on Vimeo]

Statnett SF
The Norwegian Transmisjon System Operator (TSO)

Owned by the Norwegian State through the Ministry of Energy

Owns and operates the national high voltage transmission grid in Norway, i.e. the electricity highways.

Operation of the Nordic power grid is a collaboration between Statnett in Norway , Svenska kraftnät in Sweden, Fingrid in Finland and Energinet in Denmark.

[Grid Map downloads]

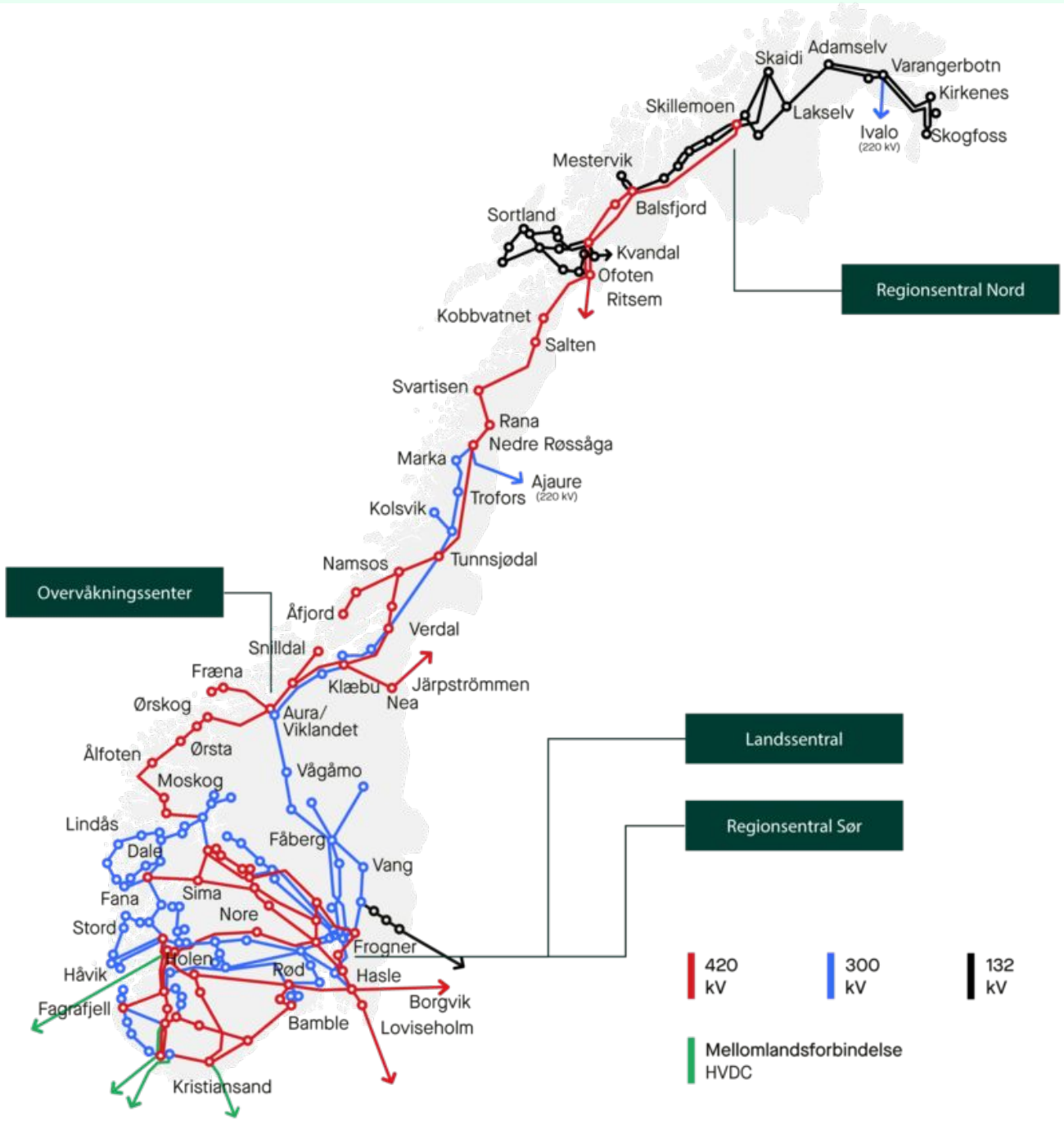
Statnett SF

11 500 km high voltage lines

2 550 km subsea and underground cables

190 substations

1 600 employees, 5 office locations (Oslo, Alta, Trondheim, Sunndalsøra and Sandnes)

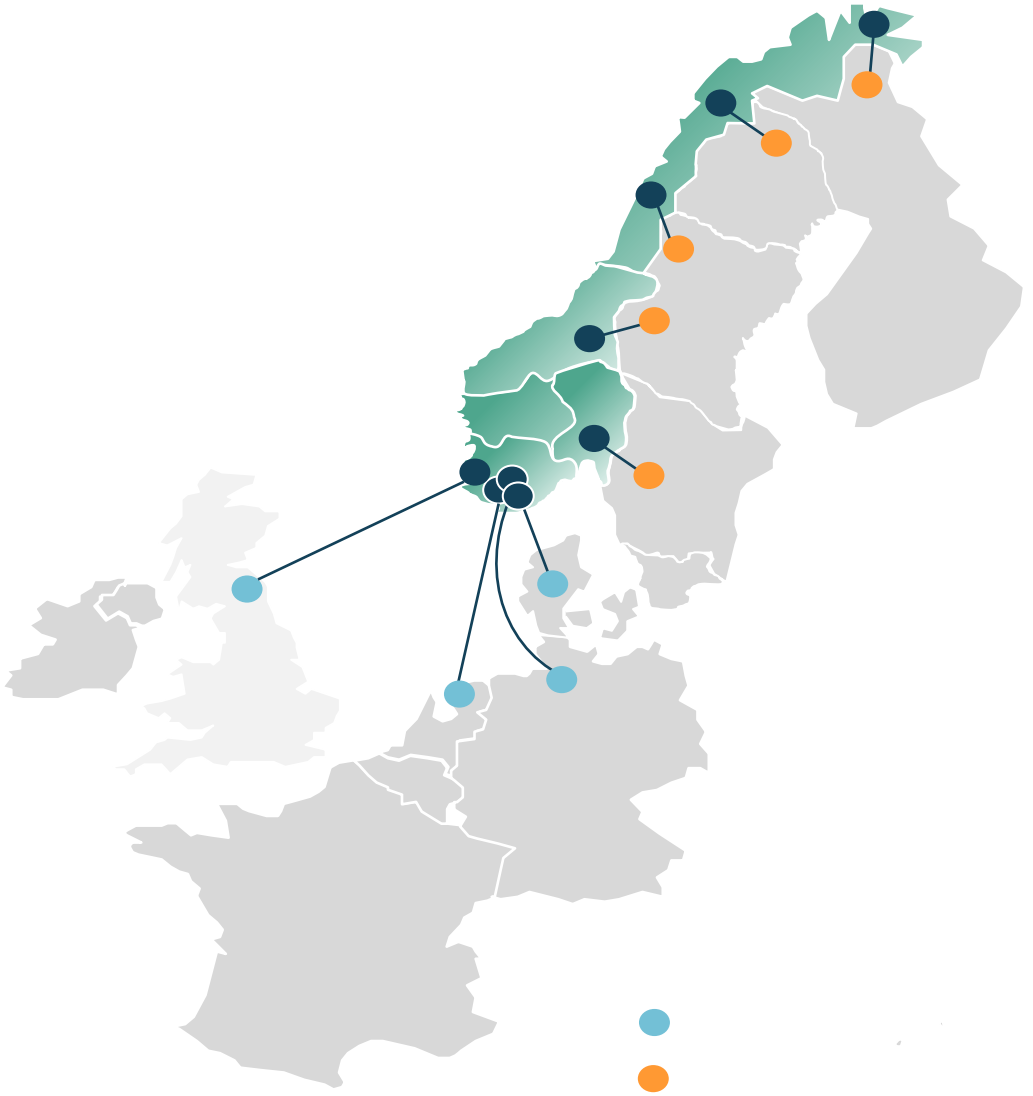


The Norwegian power system

Consumption
134 TWh

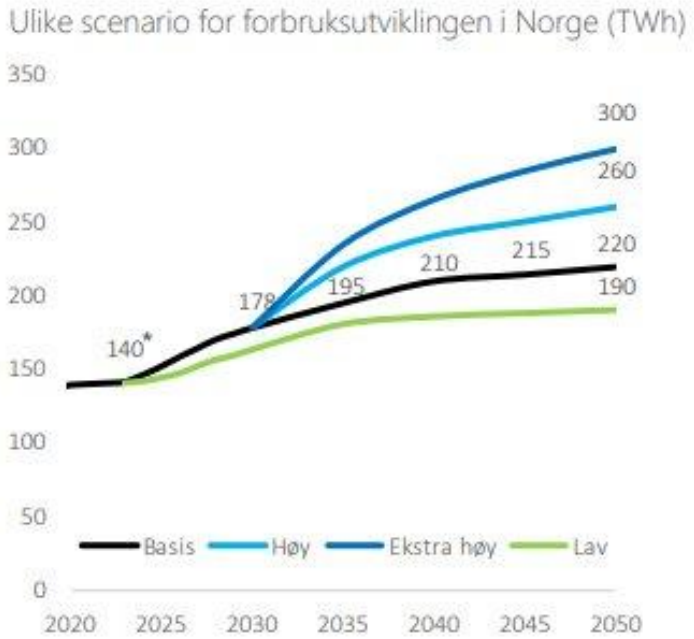
Production
146 TWh

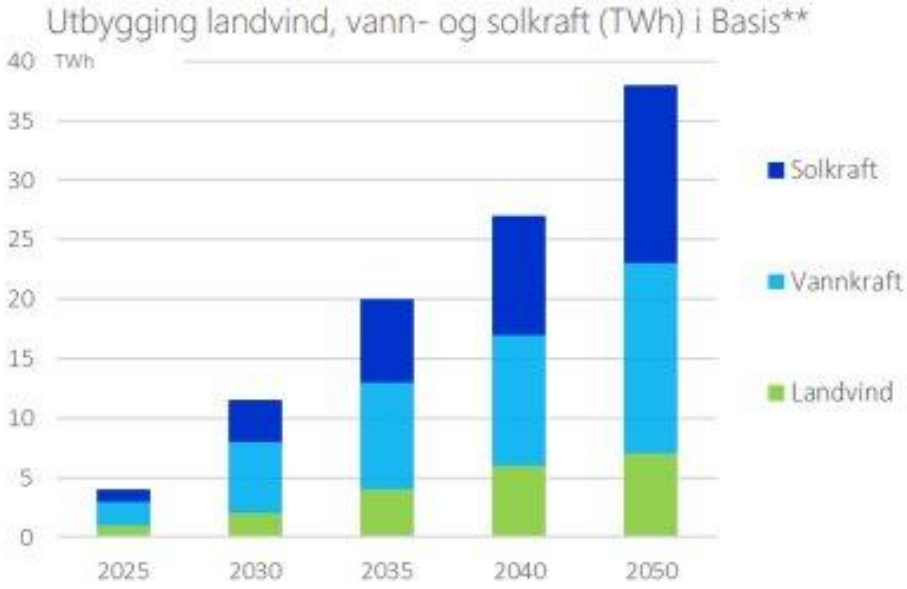
Net exchange
12.5 TWh to:
Sweden, Finland, Denmark, UK, Germany and Netherlands



Statnett – Challenges

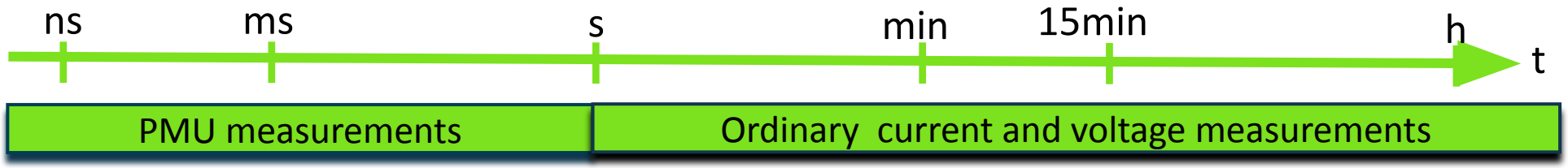
Prognoses indicate higher consumption in Norway, connection of new larger consumers and more renewable production units (off-shore wind, on-shore wind and photovoltaic).



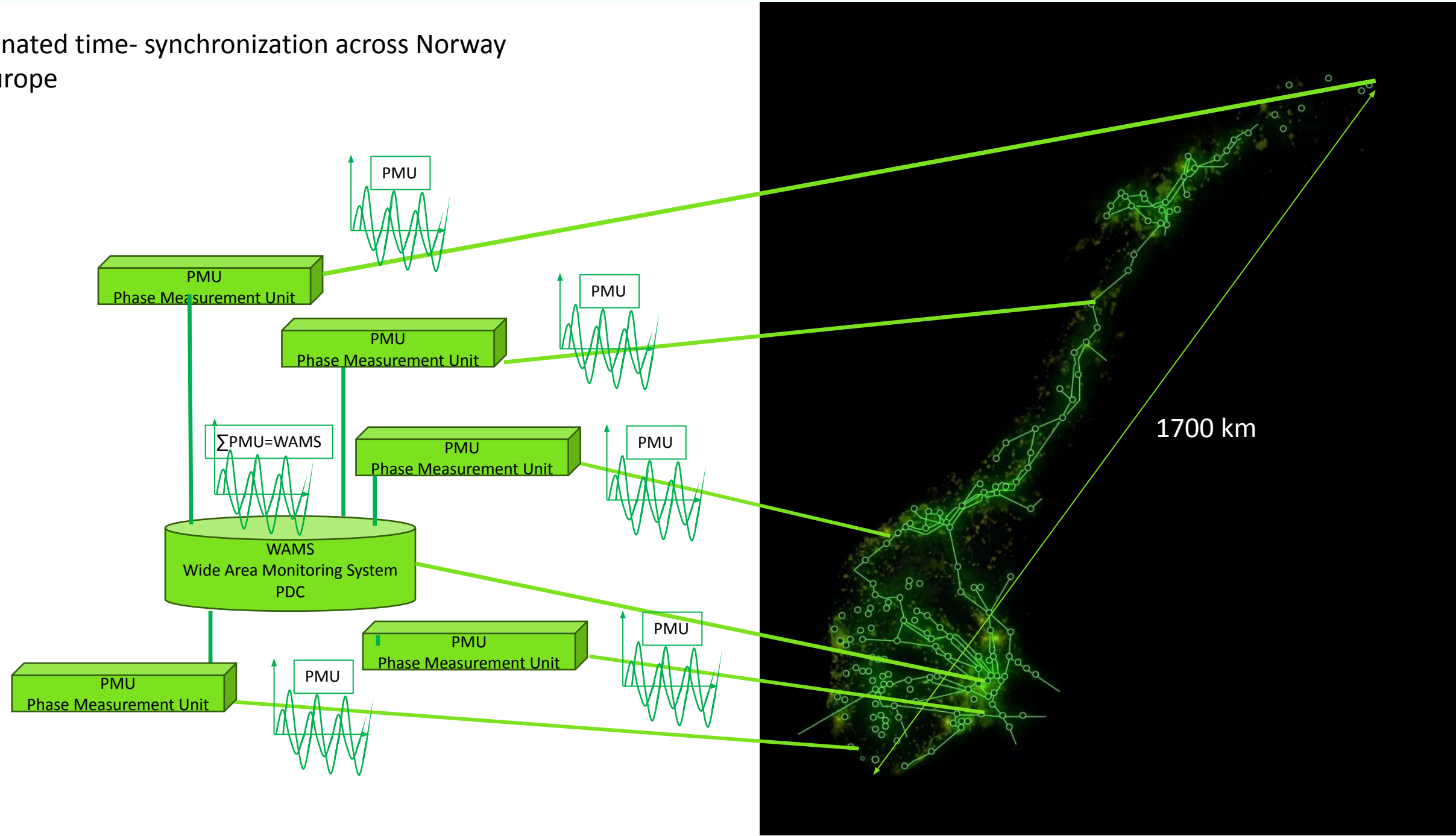


Power production change from hydro, to mix of sun and wind, connected to the grid via power electronics, gives the grid new characteristic, and needs to be monitored in a new way.

The grid needs to be monitored at millisecond level.

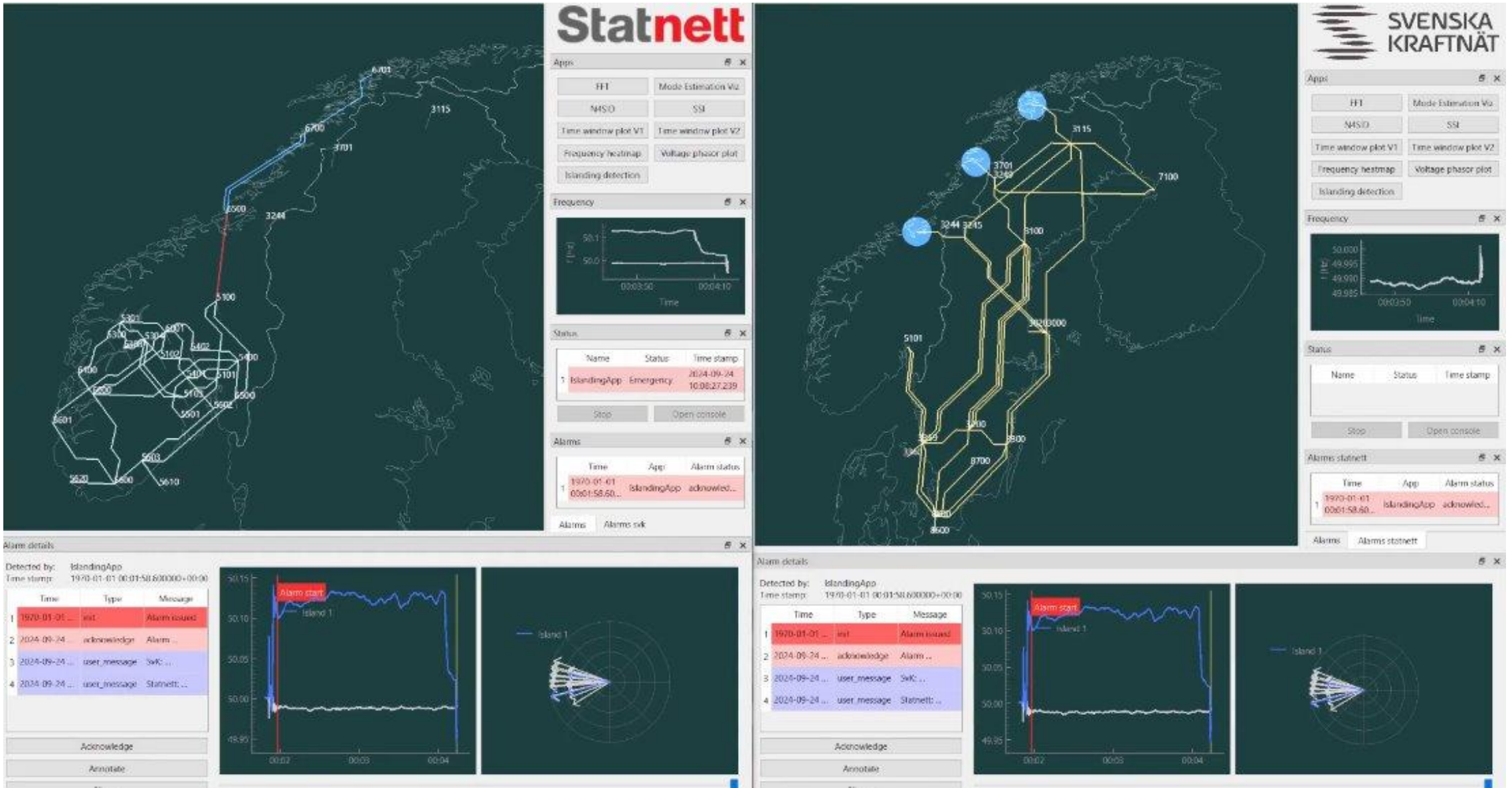


Coordinated time- synchronization across Norway and Europe

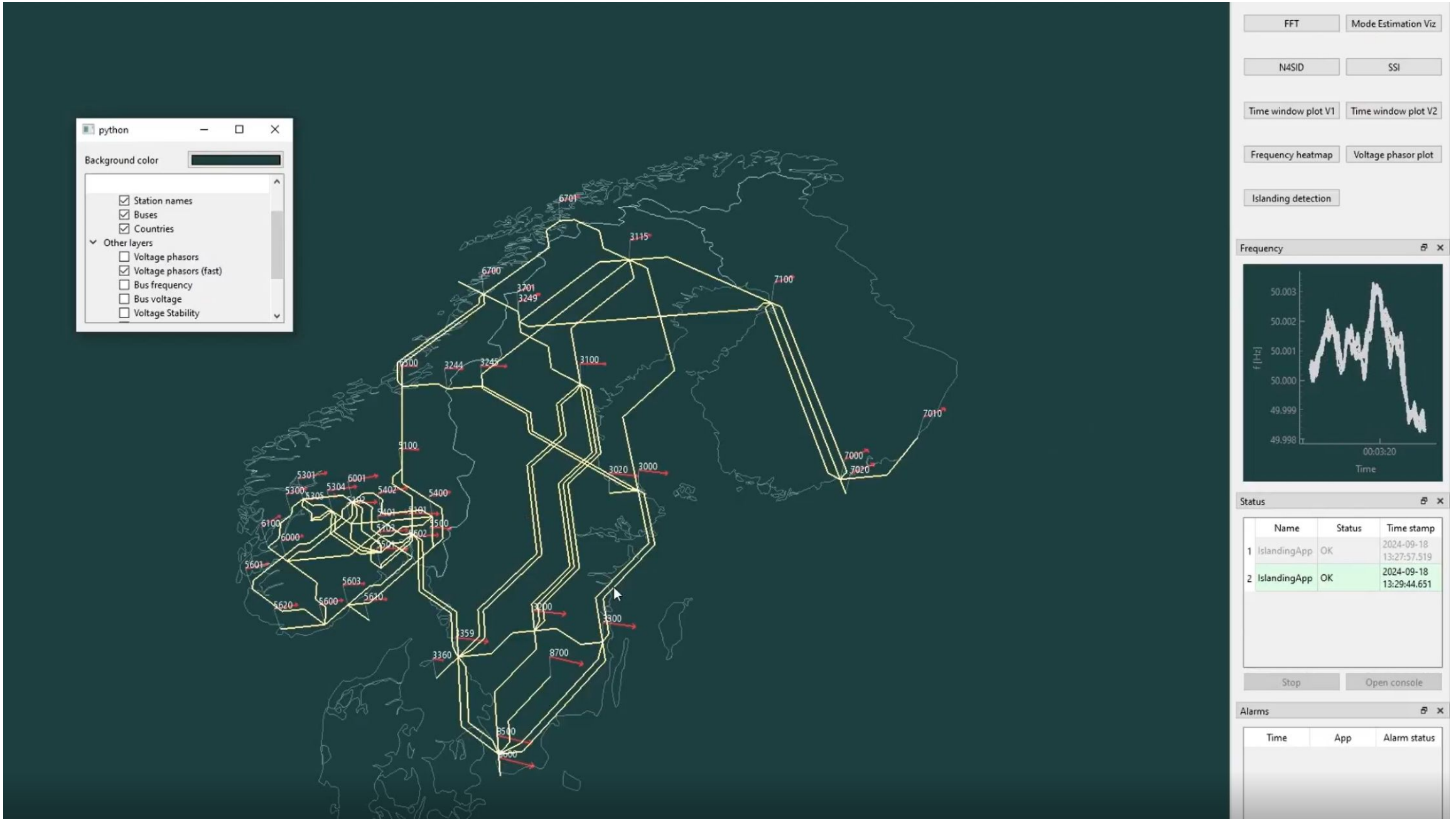


Alarm coordination between TSOs

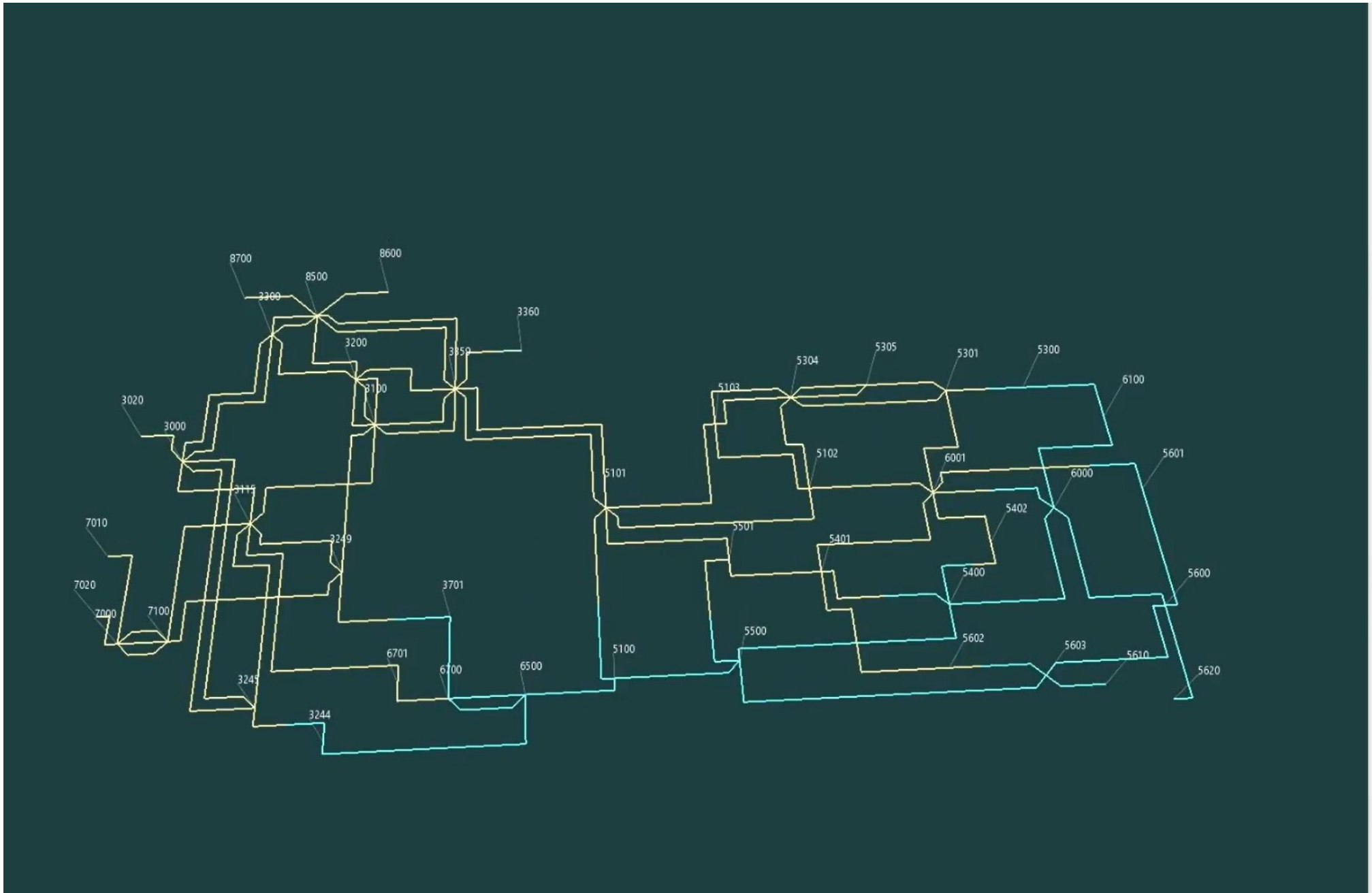
Alarm coordination between TSOs for Island detection

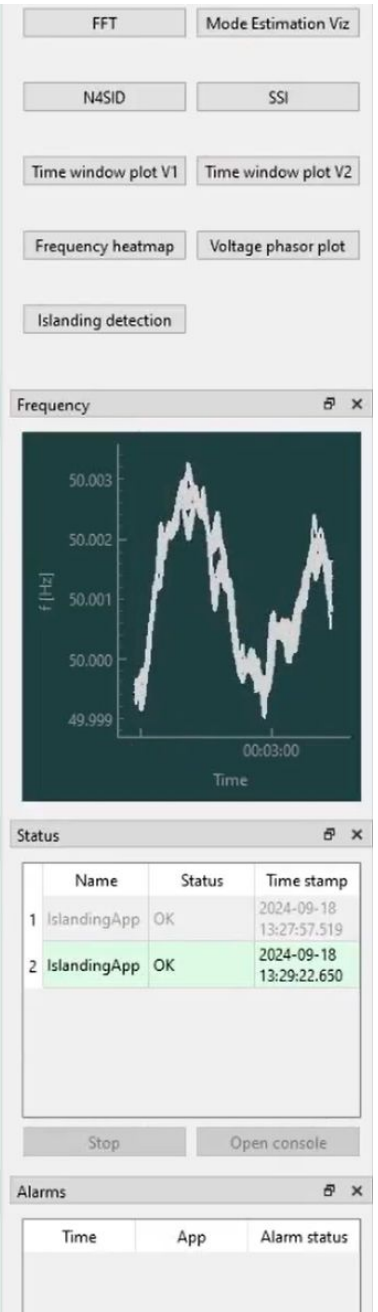


All simulations based on CIM -models

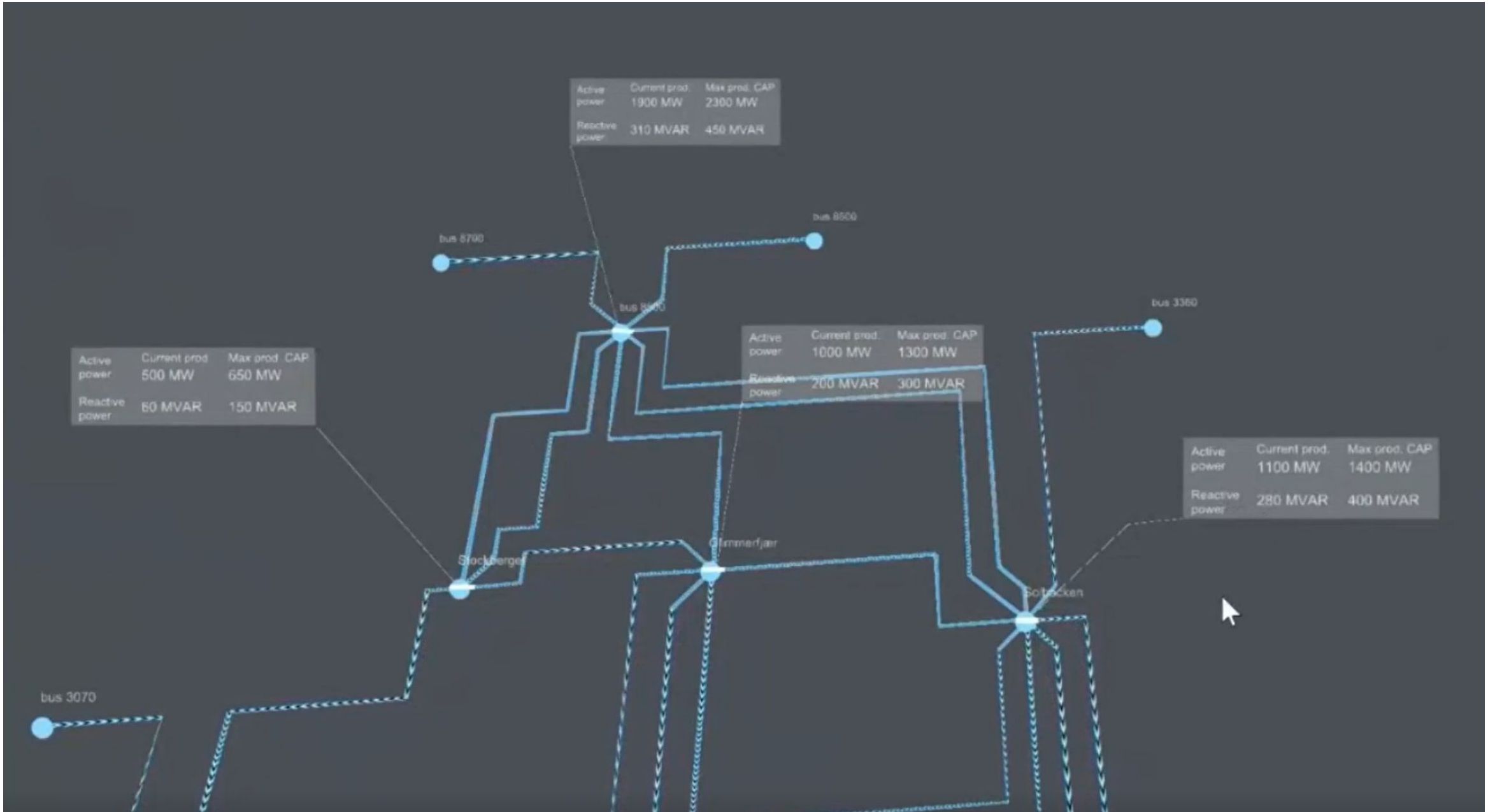


All simulations based on CIM -models

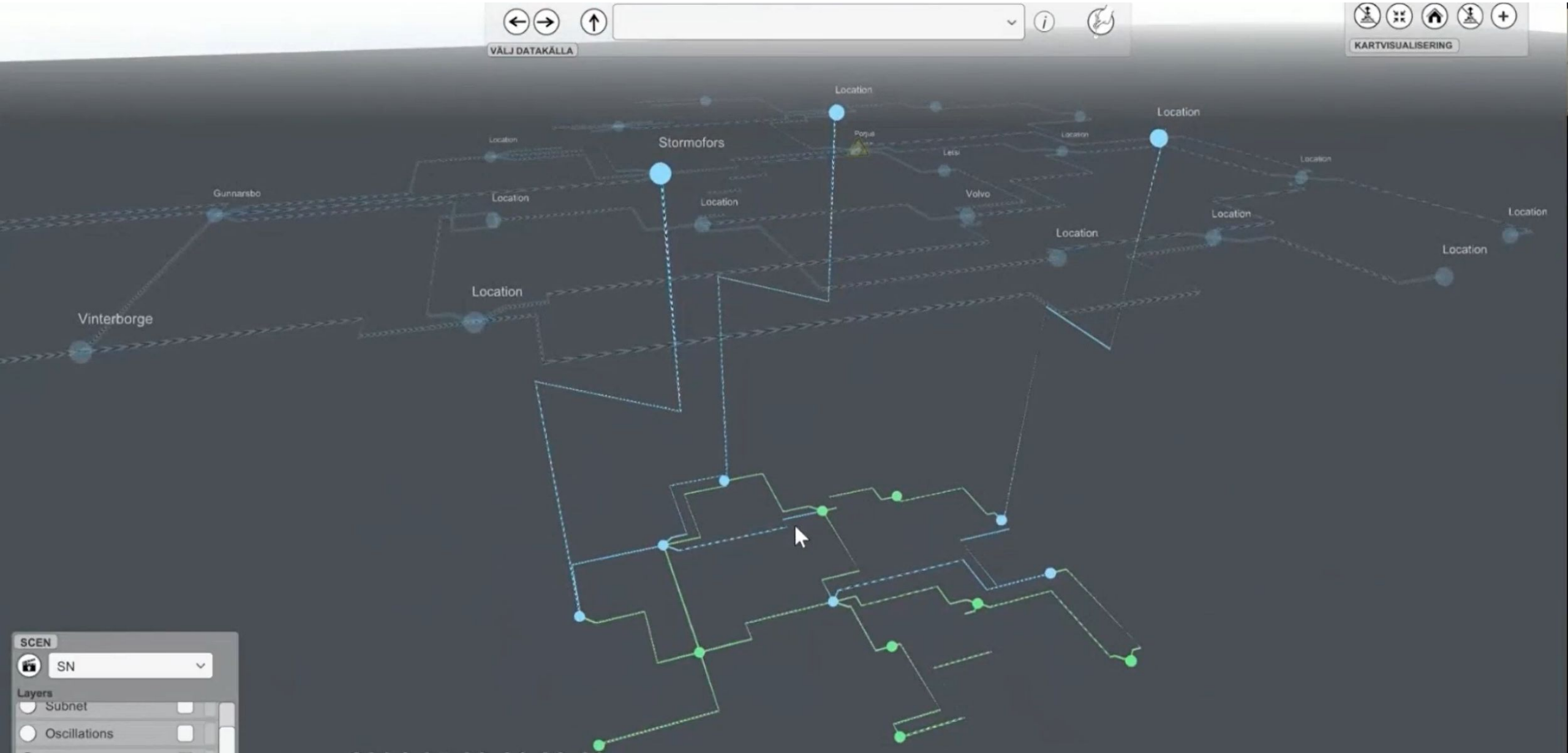




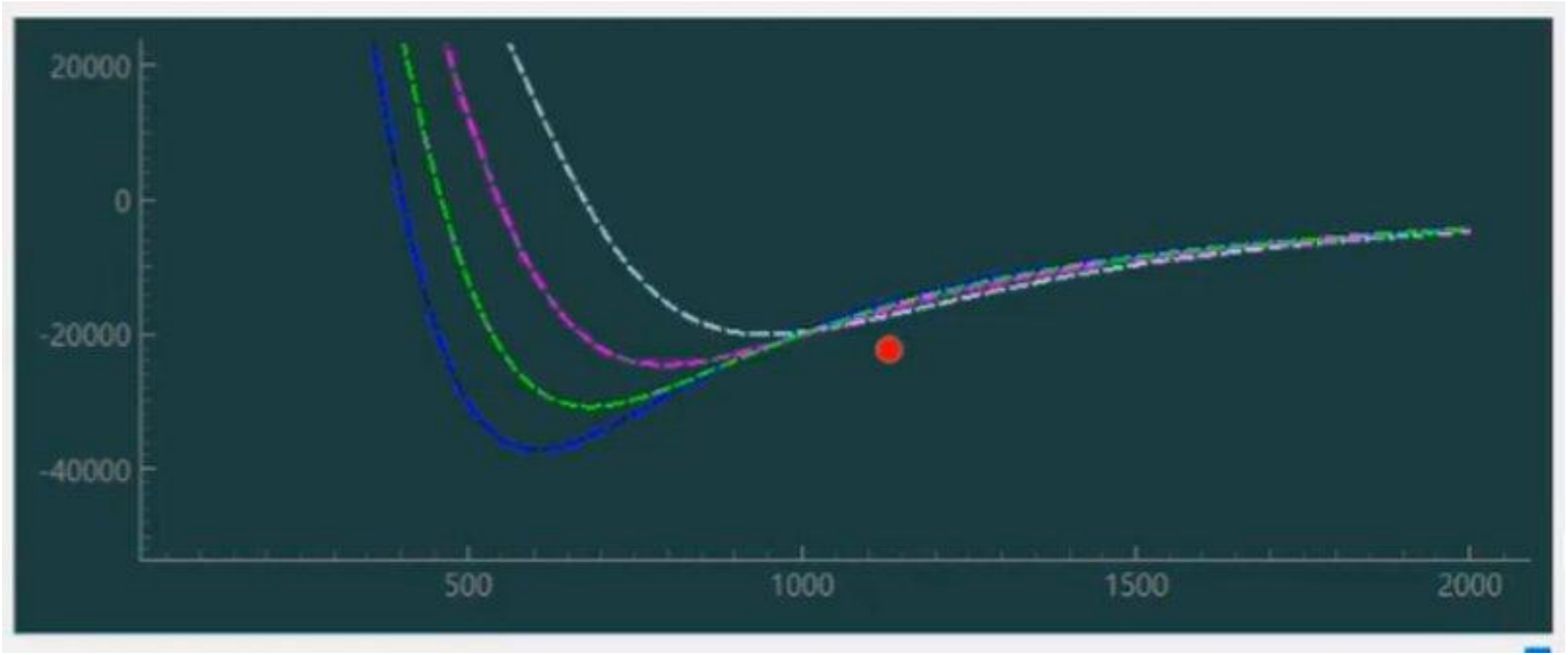
Drill down functionality for alarm handling in sub grid by use of 3D



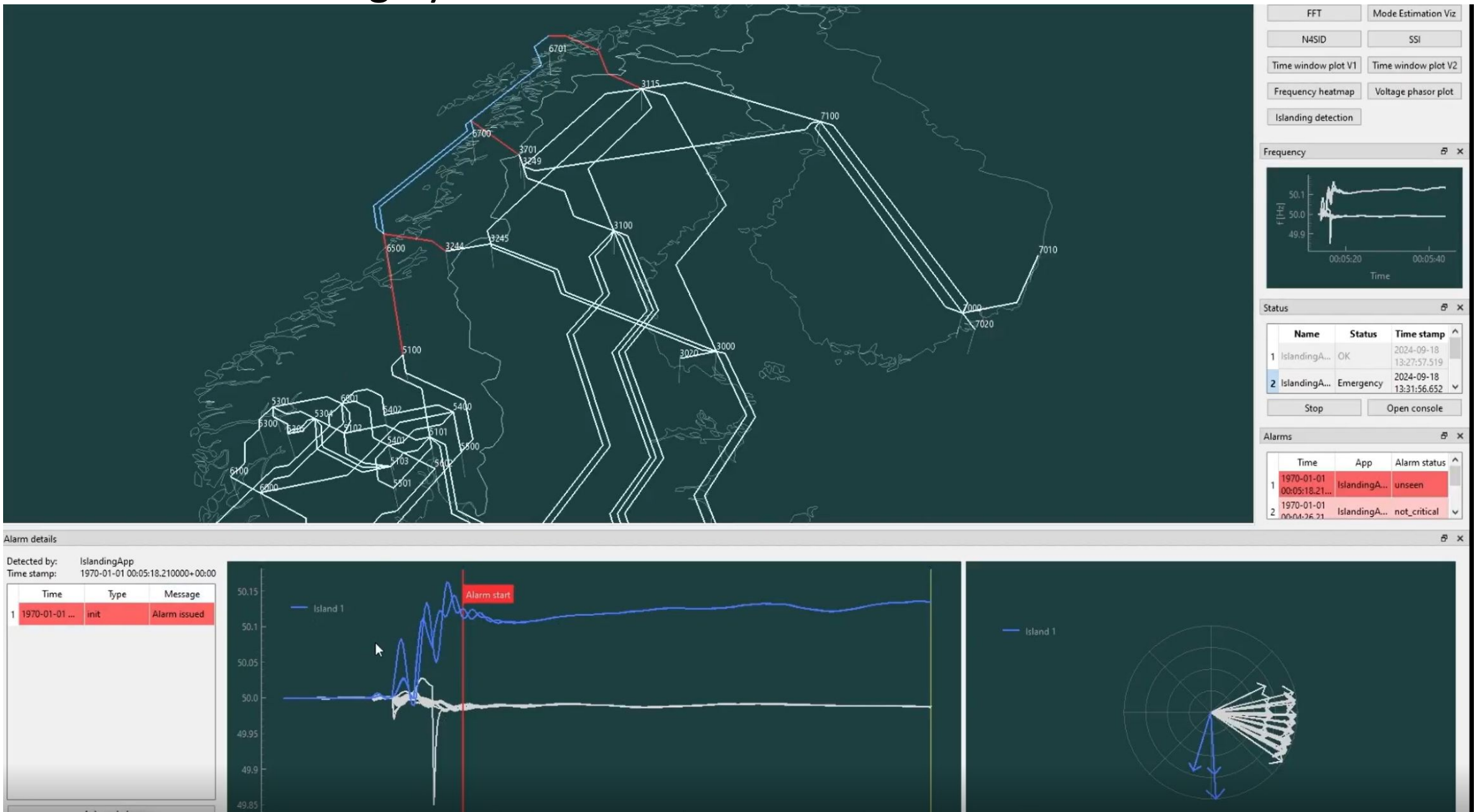
Drill down functionality for alarm handling in sub grid by use of 3D



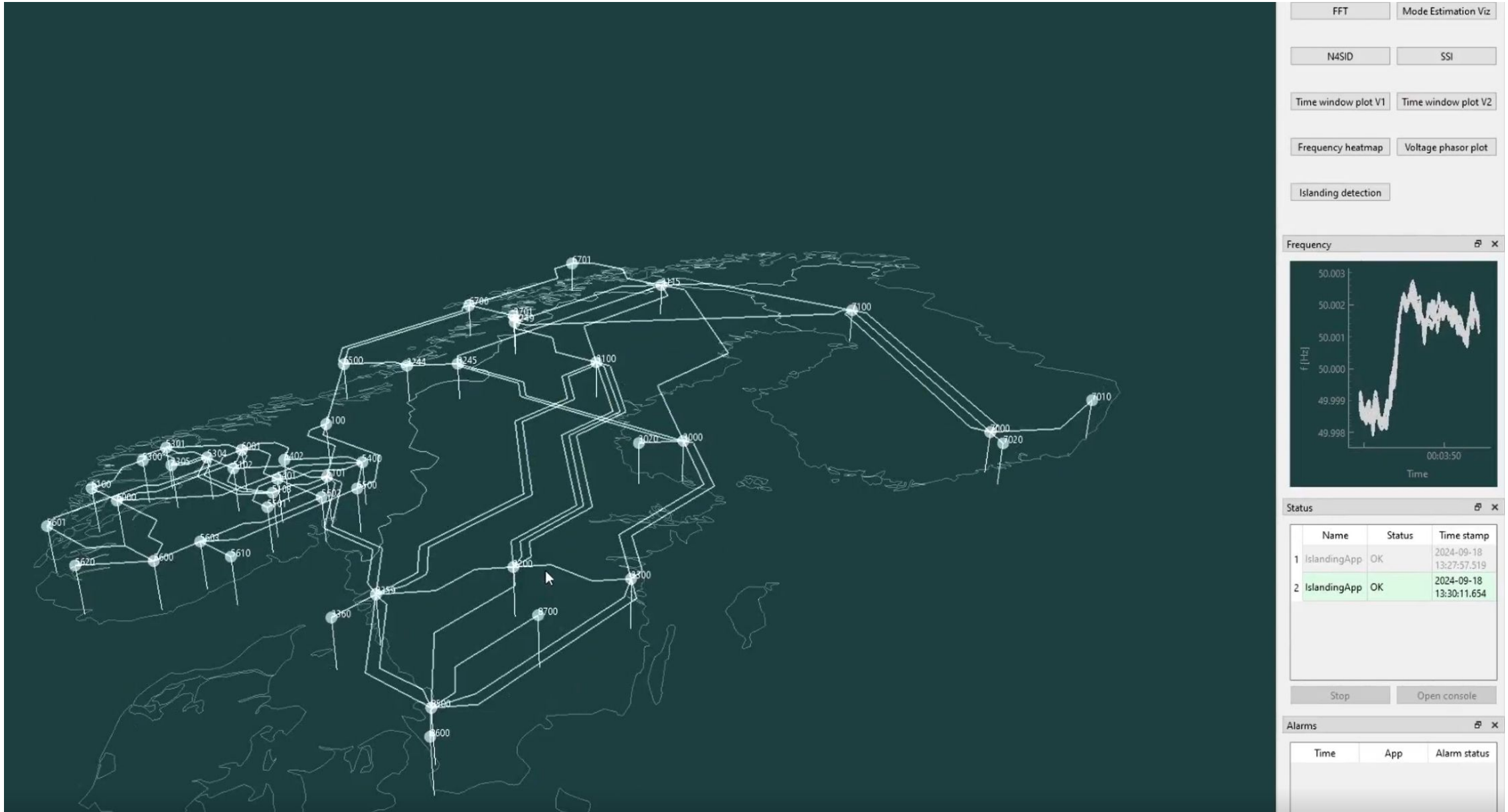
Detection voltage stability



Detection of Islanding by use of 3D



Oscillation detection by use of advanced UI to show how nodes interacts

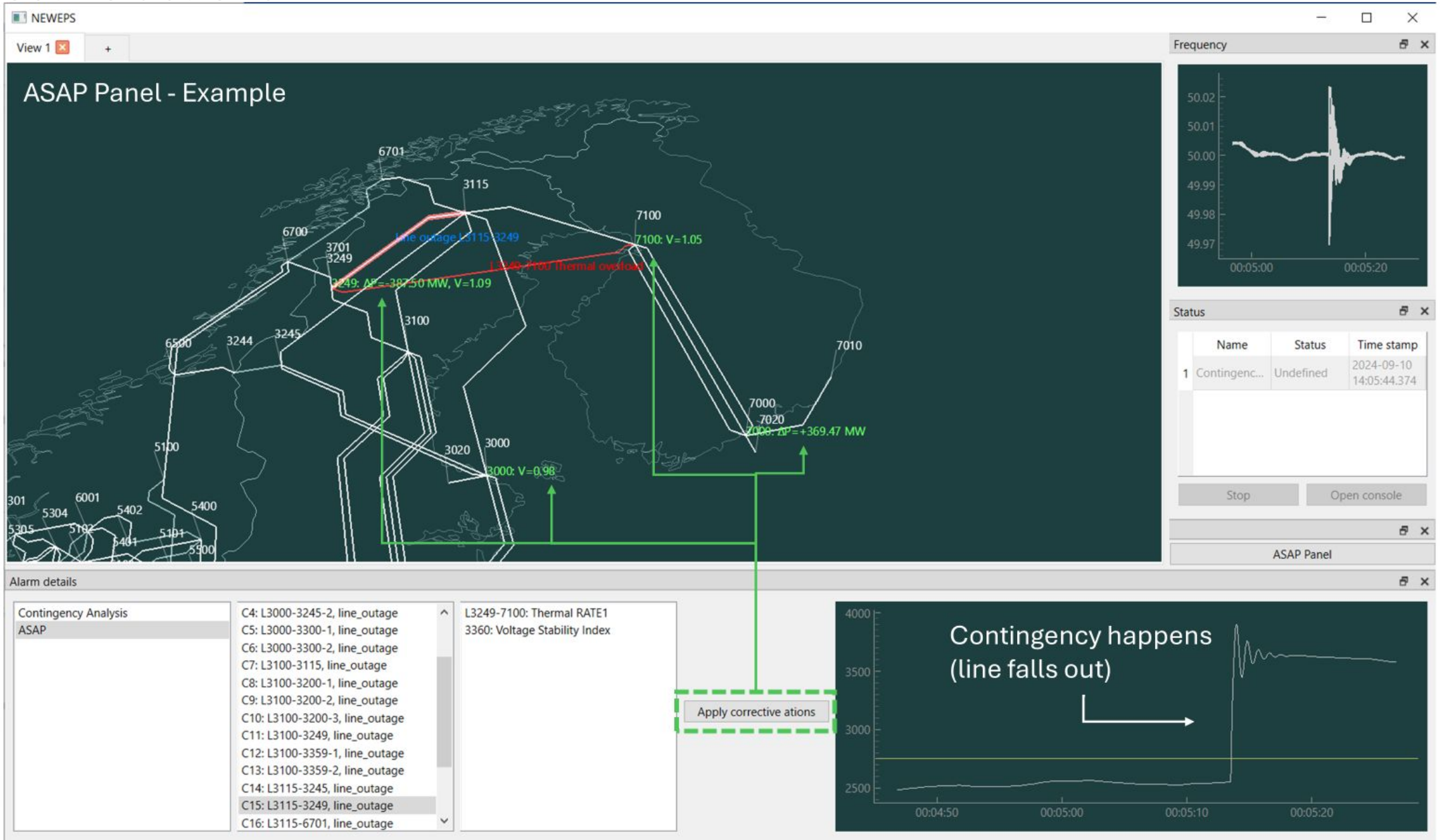


Visualization of Oscillation by use of 3D

Oscillation detection by use of advanced UI to show how nodes interacts

Detection of Islanding by use of 3D

Operation awareness on contingency analyze and Corrective actions



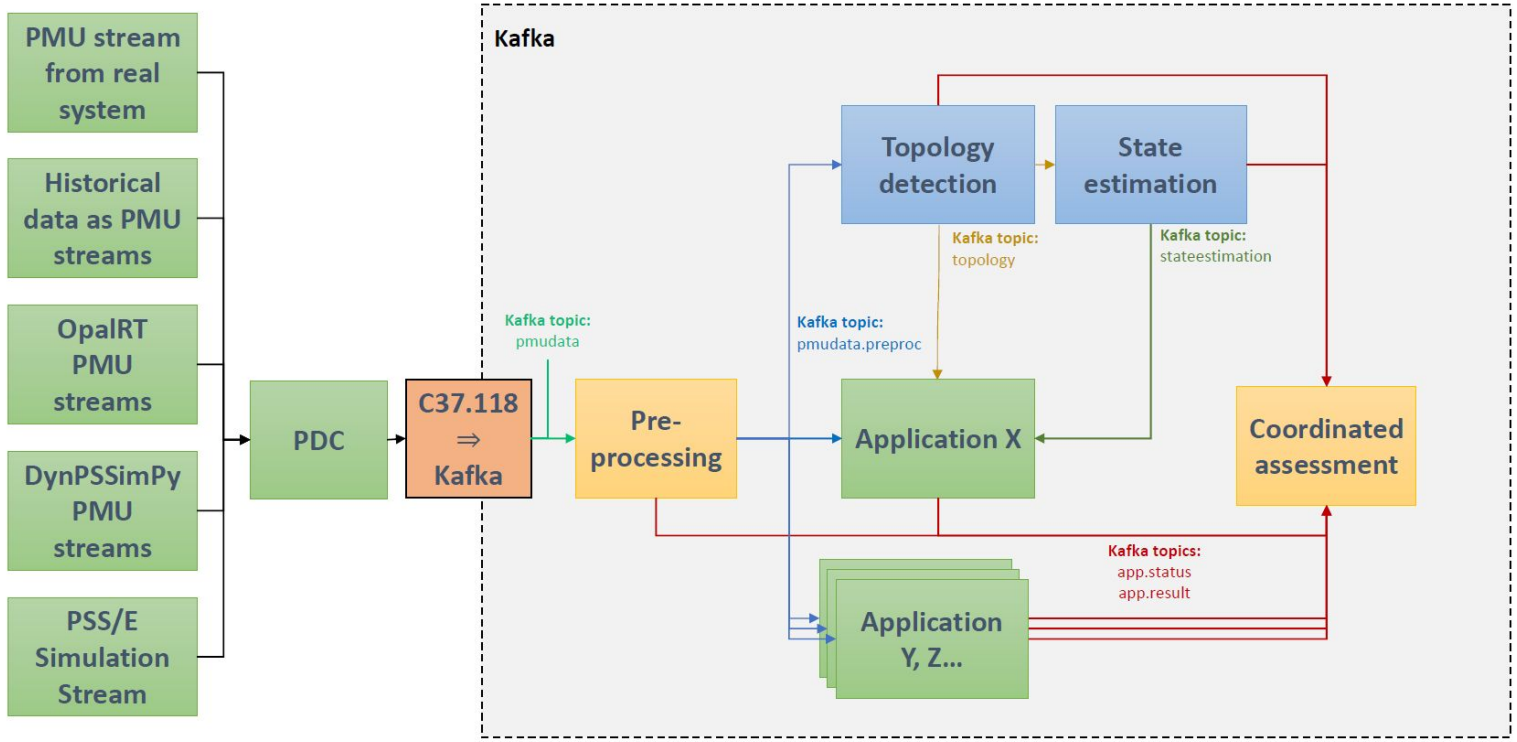
Architecture of the implemented platform

Development of a software platform to validate the detection and visualization methods

Core programming in Python

Modular structure with several independent applications

Communication between applications with a Kafka stream

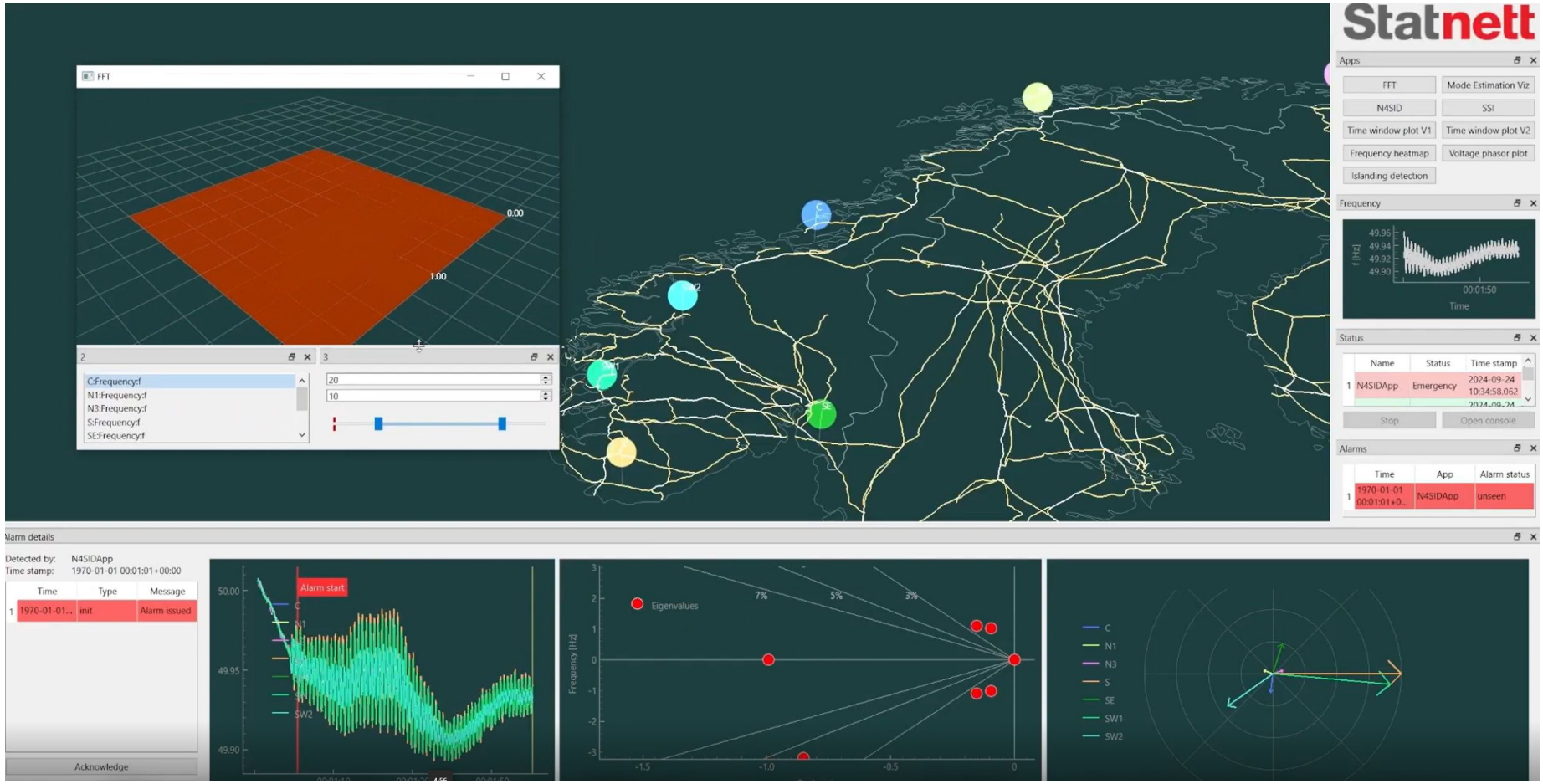


Voltage Stability
https://youtu.be/B2XXrjwevcs

Oscillations
https://youtu.be/IB7JYJ0BG9U

TSO Coordination
https://youtu.be/PCm2WNXBtj0

SCOPF (ASAP-NEWEPS)
https://youtu.be/wAdYy3pgG5A



RNDP Platform

Kubernetes hosted on Azure

Notebook interface (Jupyter)

- Robust ecosystem for data science
- Rich visualizations
- Supports Python (mamba), R, Julia, and more

Shared POSIX filesystem (Ceph)

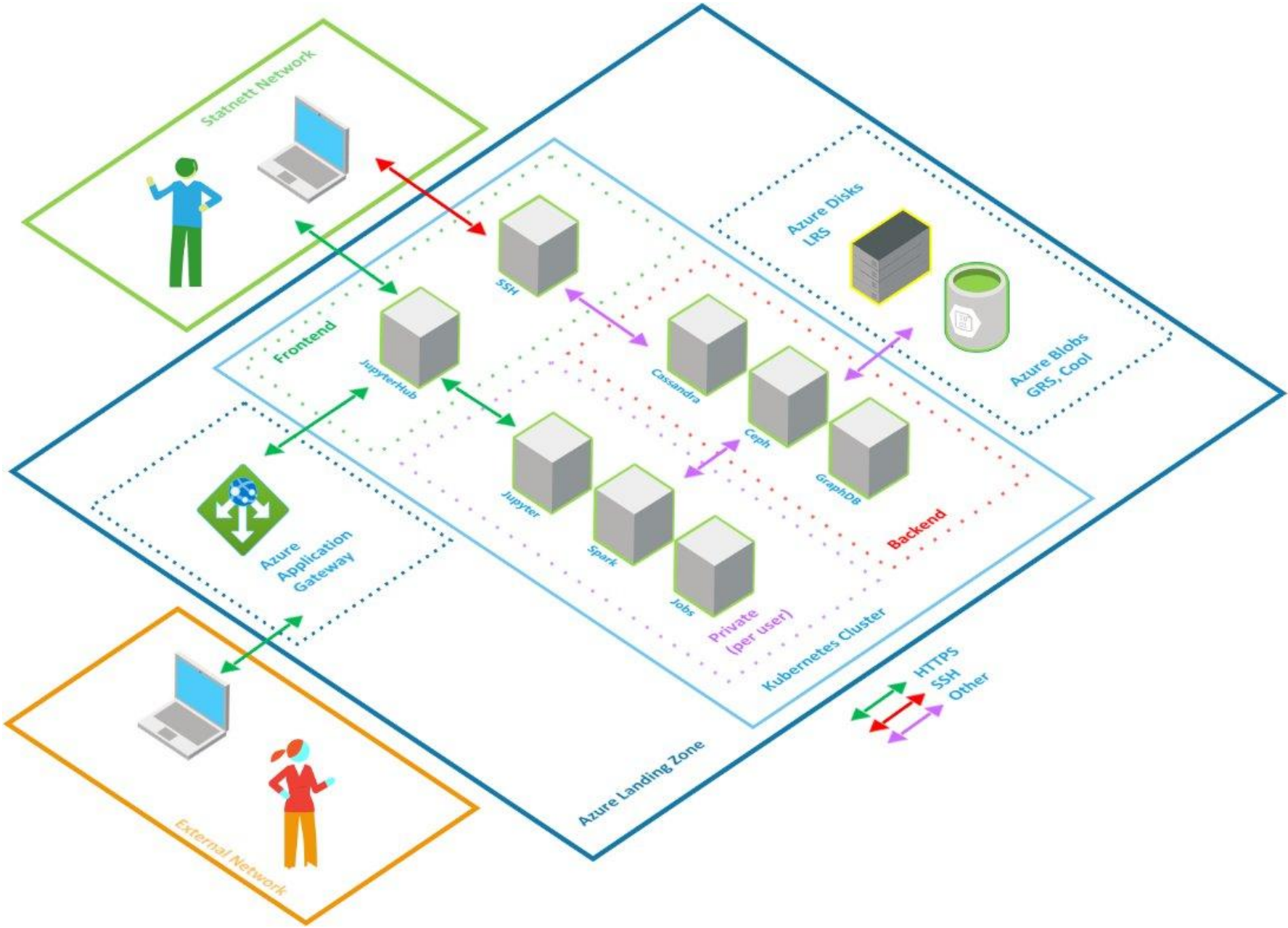
Kubernetes namespace isolation

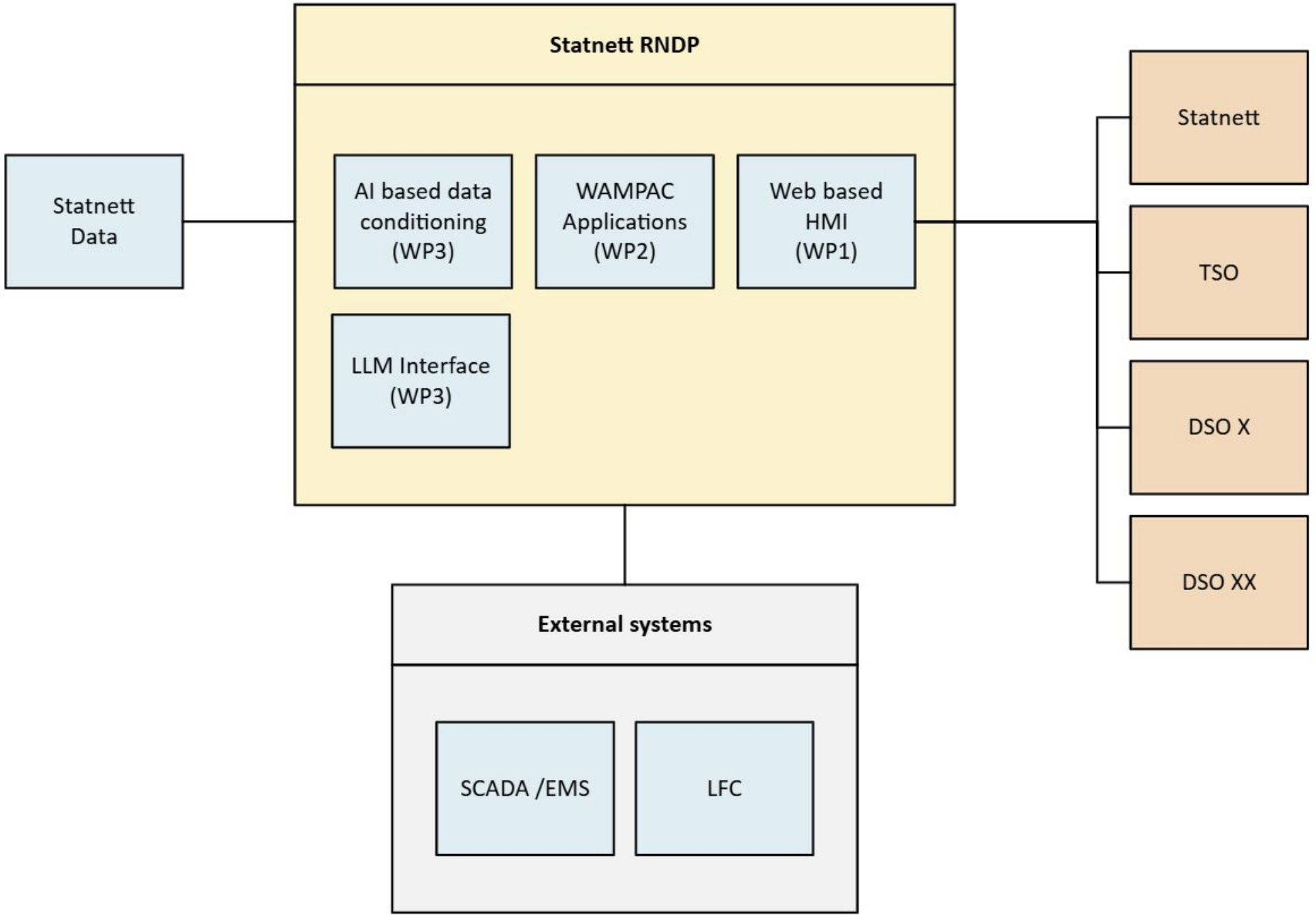
- Spark clusters for big-data workloads
- Kubernetes jobs for long-running workloads

Statnett integrated

- Entra
- GitLab
- Artifactory

- Backend
  - Ceph
  - Cassandra
  - Hosted (GraphDB)
- Frontend
  - JupyterHub
    - Services
  - SSH
  - Hosted
- Private
  - Jupyter
  - Spark
  - Kubernetes (Jobs)





Project p-SWAMP Tasks and work packets

- WP0 Managament, communication, dissemination
- WP1 Advanced Web based HMI
- WP2 WAMPAC applications for operation support
- WP3 Data conditioning and linear state estimation
- WP4 Modules integration and deployment
- WP5 Module validations and pilot demonstration

Project p-SWAMP timeline