ENERGINET

DEVELOPING AN EMT STUDY AND ANALYSIS ENVIRONMENT FOR A 100% INVERTER BASED POWER SYSTEM

G-PST/ESIG Webinar Series

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Agenda

- Energinet
- Visions – The four principles of “stability”
- Stability challenges
- Development of system level EMT study environment
- Challenges and applications

ENERGINET
- WE WORK FOR YOU

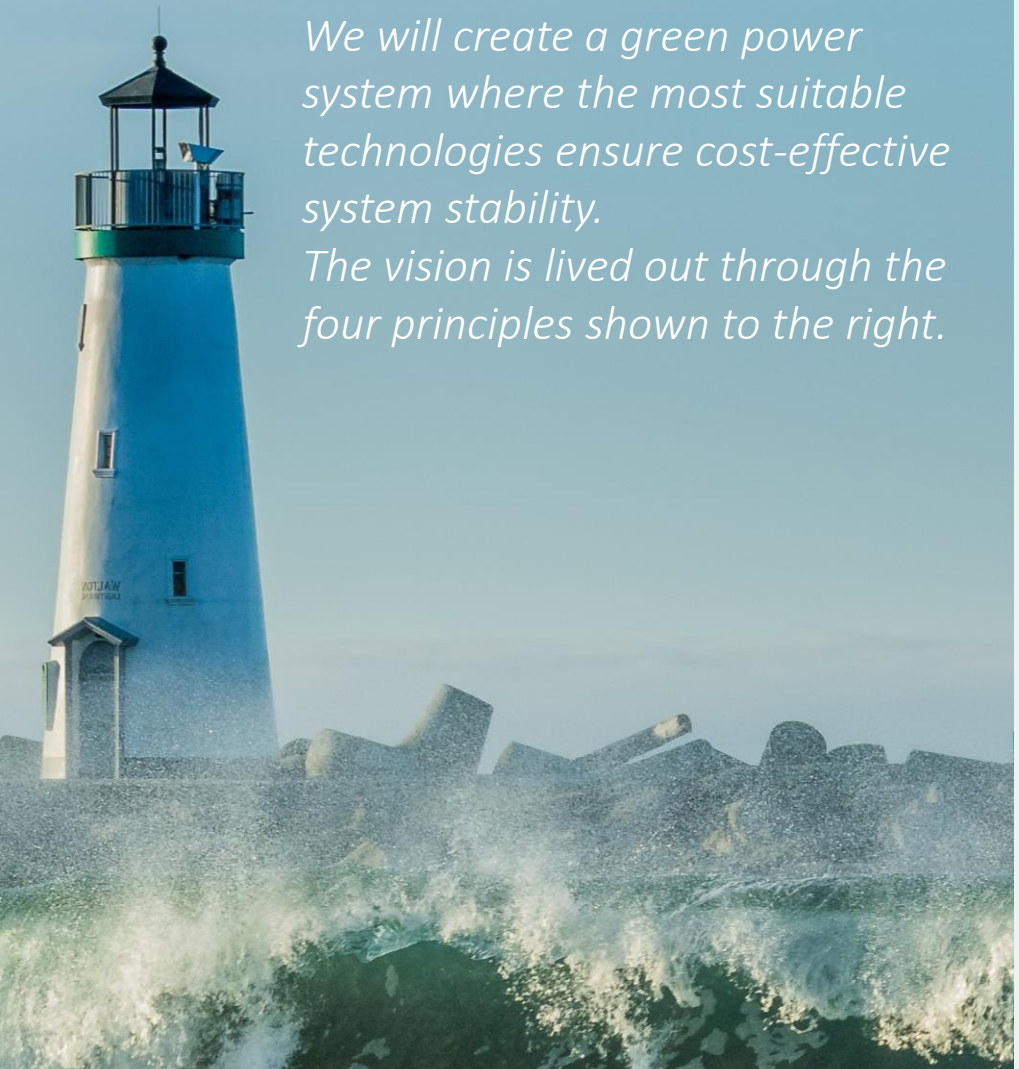
We safeguard society's interests as we move to a 100% green energy system.

We are owned by the Danish Ministry of Climate, Energy and Utilities.

Our head office is in Fredericia.

A workforce of around 2,000 split between 8 locations.

VISIONS



We will create a green power system where the most suitable technologies ensure cost-effective system stability.
The vision is lived out through the four principles shown to the right.

THE FOUR PRINCIPLES OF STABILITY

1. The aim is to predict and mitigate all stability phenomena that would lead to critical system events, over-conservative operation of the electricity system or delay grid connection of operator installations.

2. The aim is to tackle the stability issue through the application of the right construction, operational and market solutions.

3. The aim is to have access to the most appropriate technologies to meet the stability challenges of the future.

4. The stability challenges can be communicated so that everyone who needs to understand the problem, the solution space and the strategic choices does so at a level that they can be informed in the debate and contribute to solving the task.

THE THREE CATEGORIES OF STABILITY CHALLENGES

An unmanaged system stability will lead to a number of challenges that can generally be divided into three categories.

Critical System Event Occurred

Type:

- Sudden unplanned outage of one or more production or consumption plants.

Consequence:

- Local congestion, system imbalance or consumption decoupling.
- Component or plant damage.

Preventive limitation and downregulation

Type:

- A stability problem is addressed by down-regulating production or consumption in an area or by limiting foreign capacity.

Consequence:

- Economically unfavorable operation of the power system

Unforeseen delays and costs

Type:

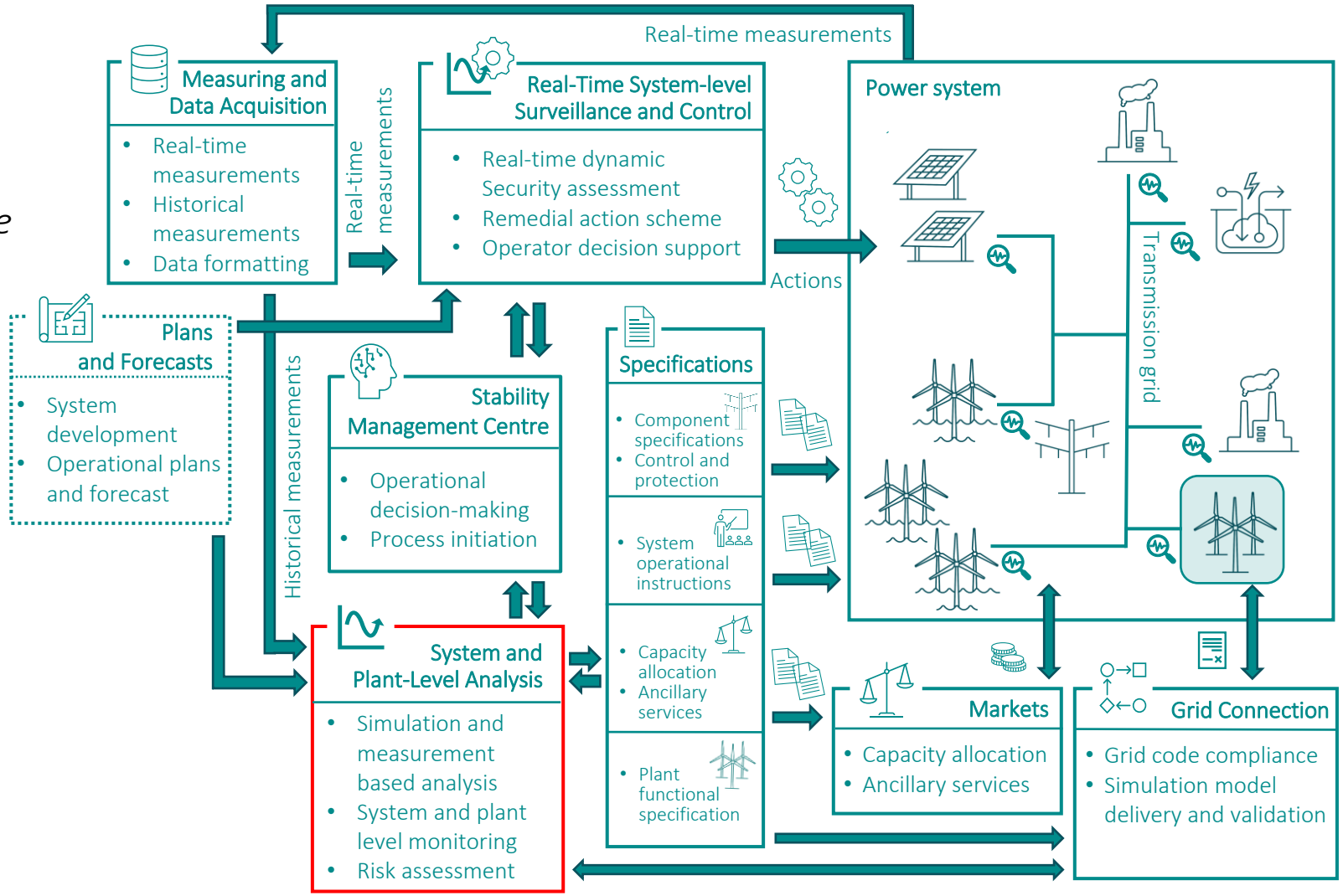
- Challenges are discovered late in the project phase, either during compliance testing or early operation.

Consequence:

- Delays and cost of projects.

HOLLISTIC METHODOLOGY

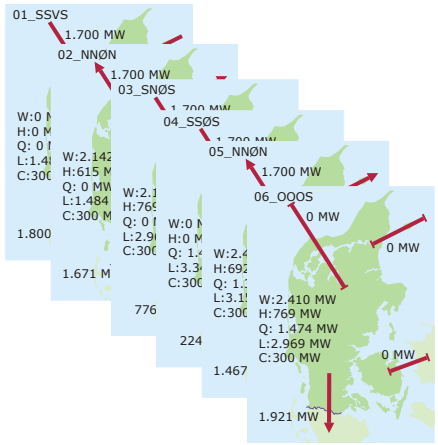
The methodology gives Energinet (SO) the opportunity to develop and operate a stable electricity system



RMS BASED STABILITY ASSESSMENTS

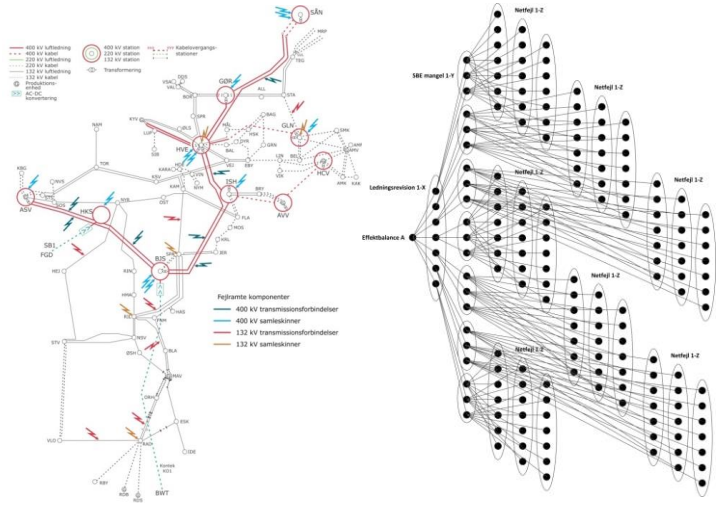
Initializations

- Worst-case set up



Batch fault simulations

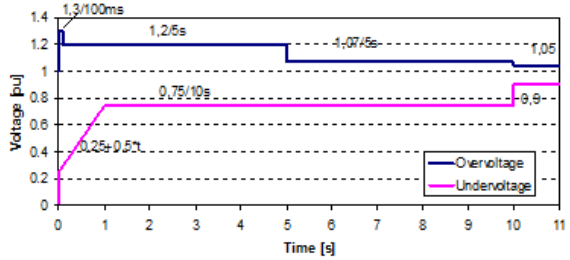
- Fault definitions

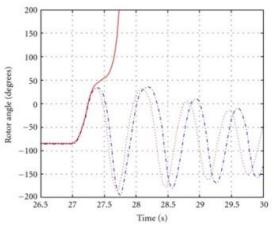


➡ Possibility to execute system level EMT analysis

Evaluations

- Evaluation according to predefined criterion

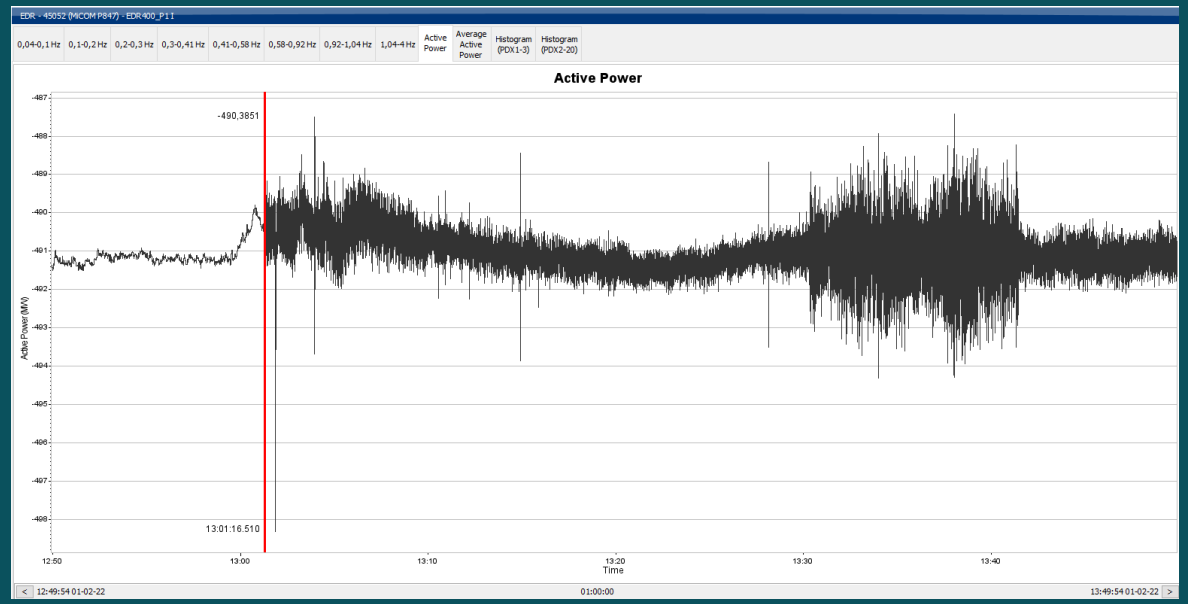


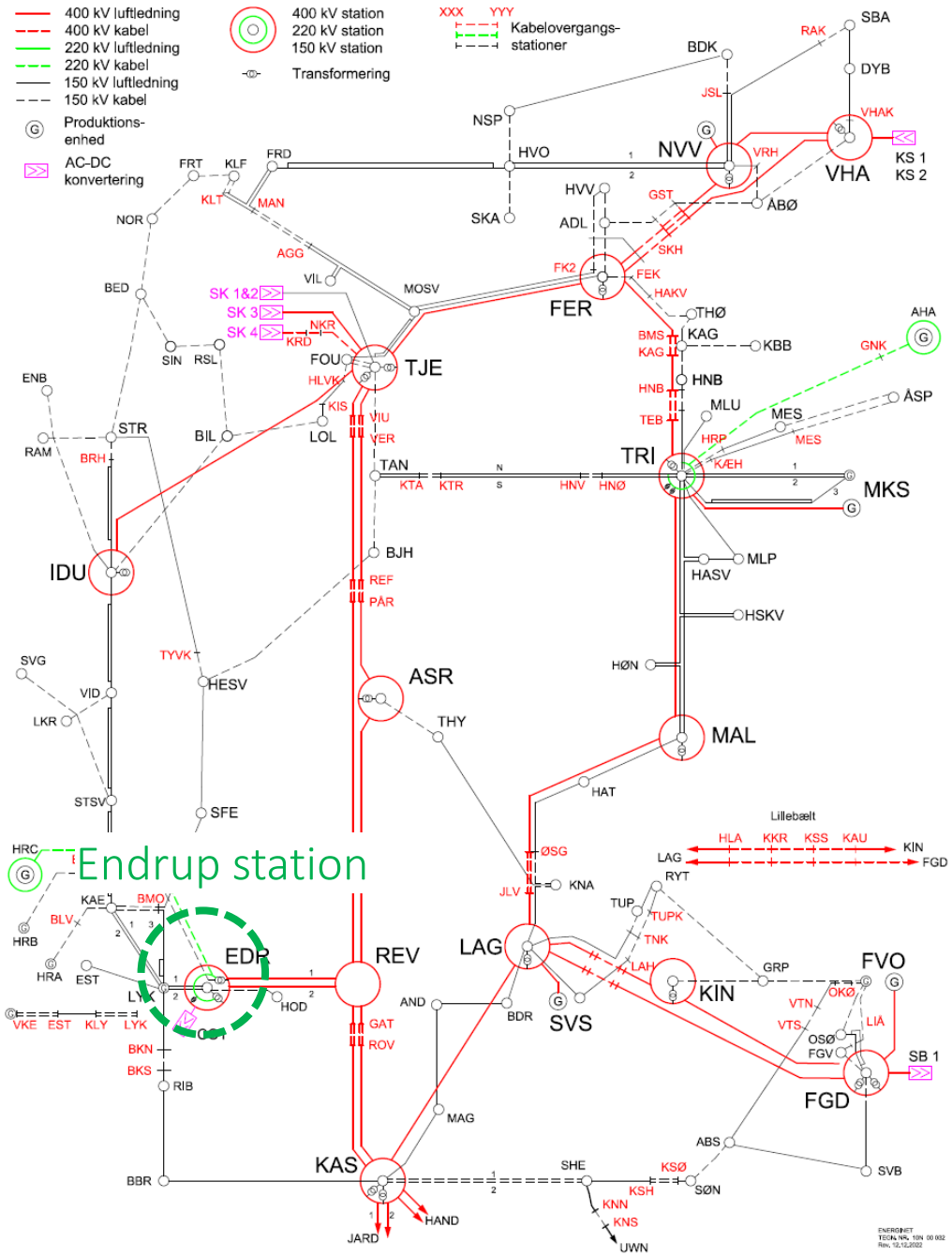


OSCILLATIONS AT ENDRUP STATION

Oscillations on ENDRUP station, where COBRA cable, HR1/2/3 are in operation and Vinking Link are to be in operation.

- Oscillations (2-3 Hz, +/-5-10 MW) has been ongoing and are still present to this day depending on power flow. The oscillations are most severe during export.

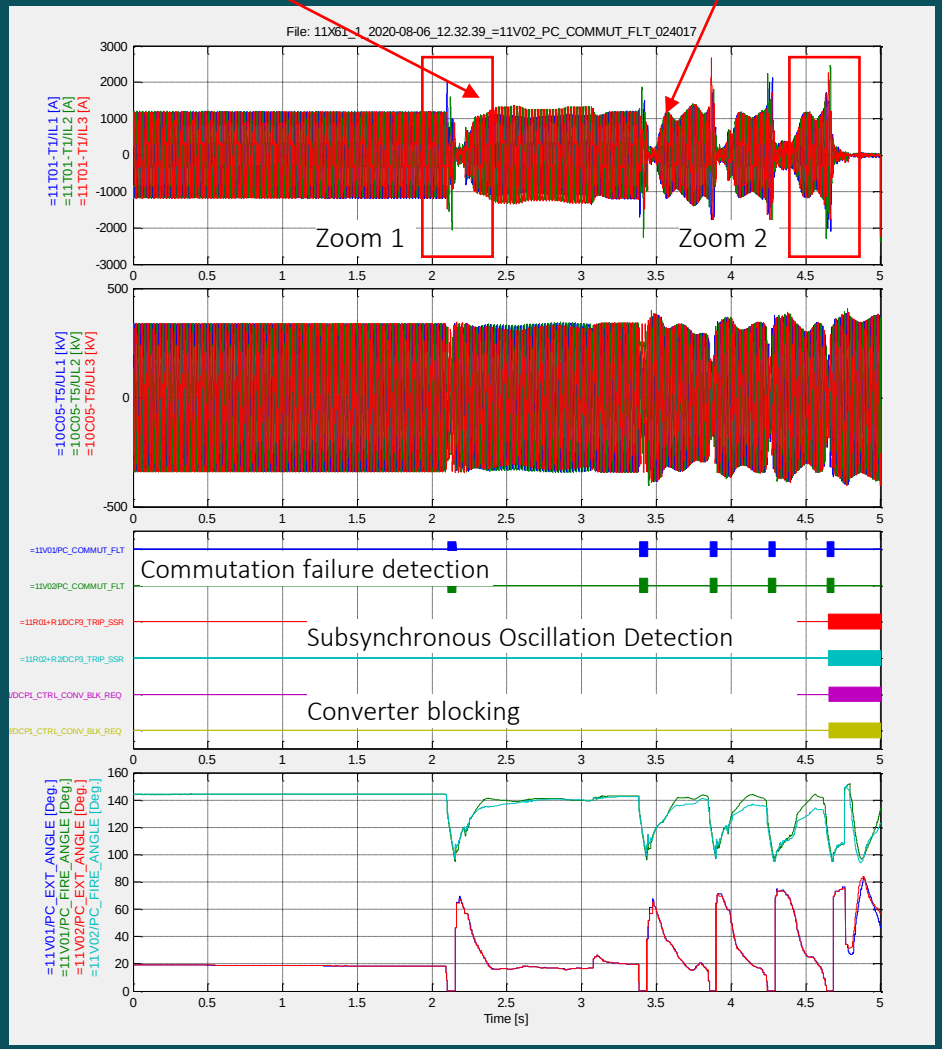


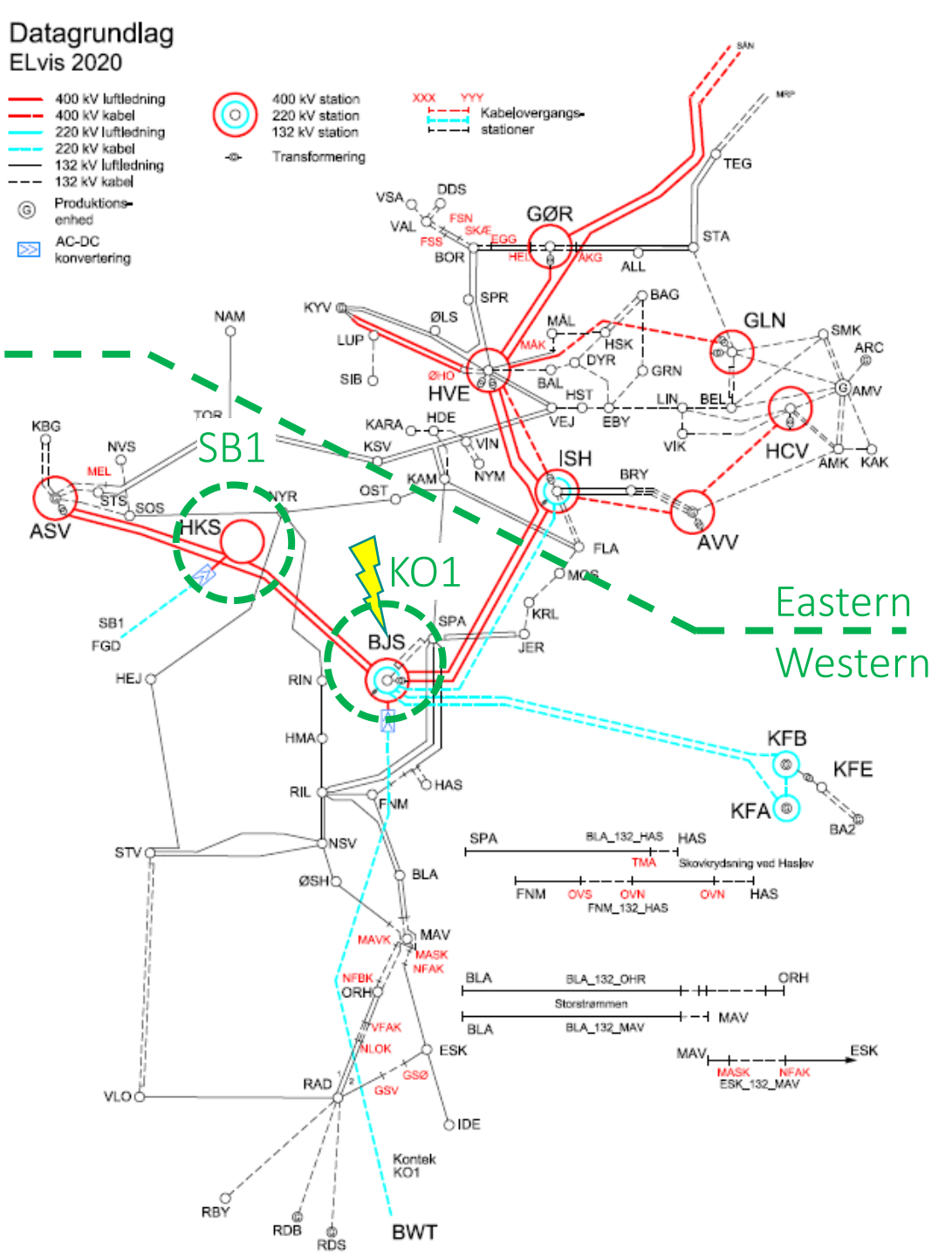


DK2 INCIDENT-AUG. 20, 2020

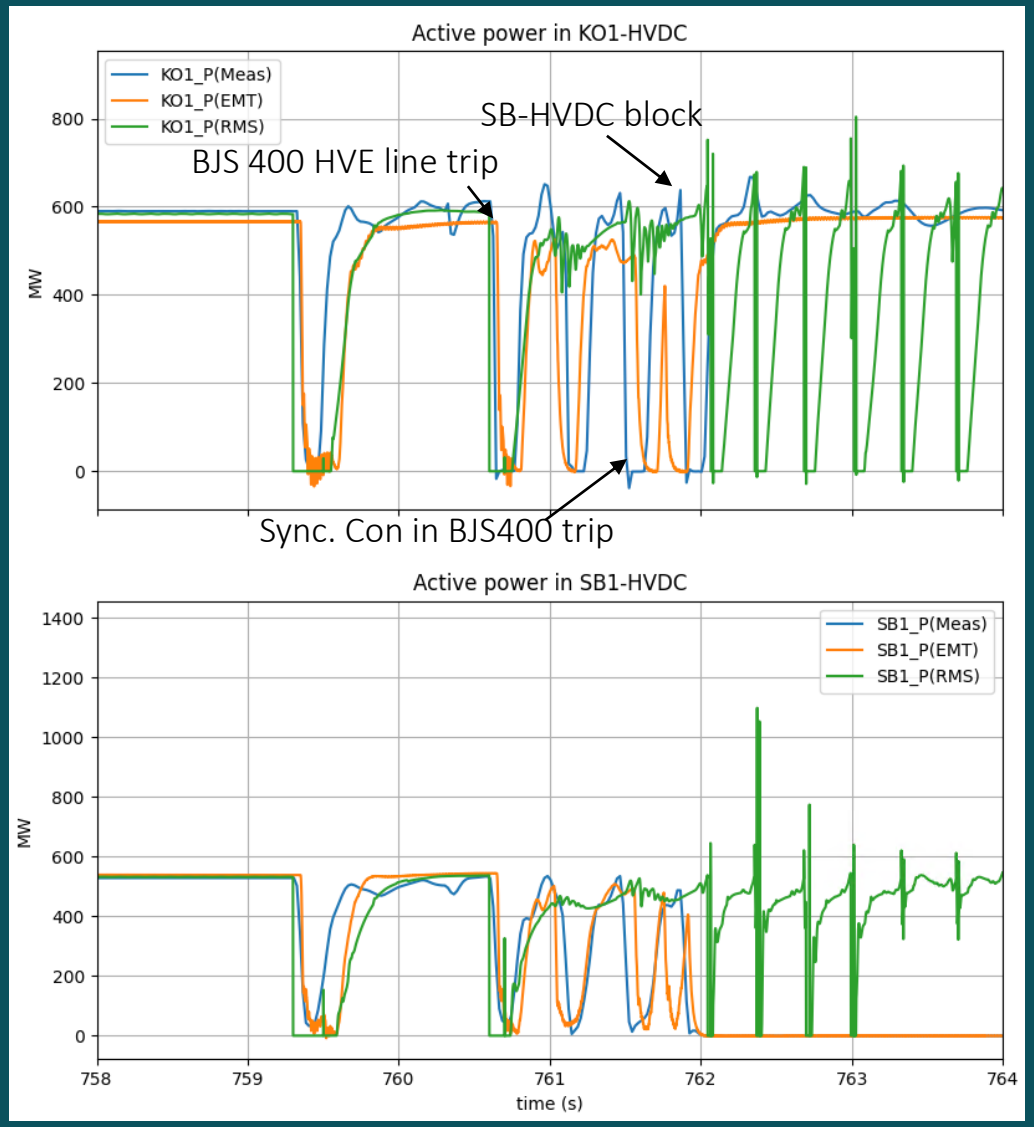
Single / two phase faults in BJS 400

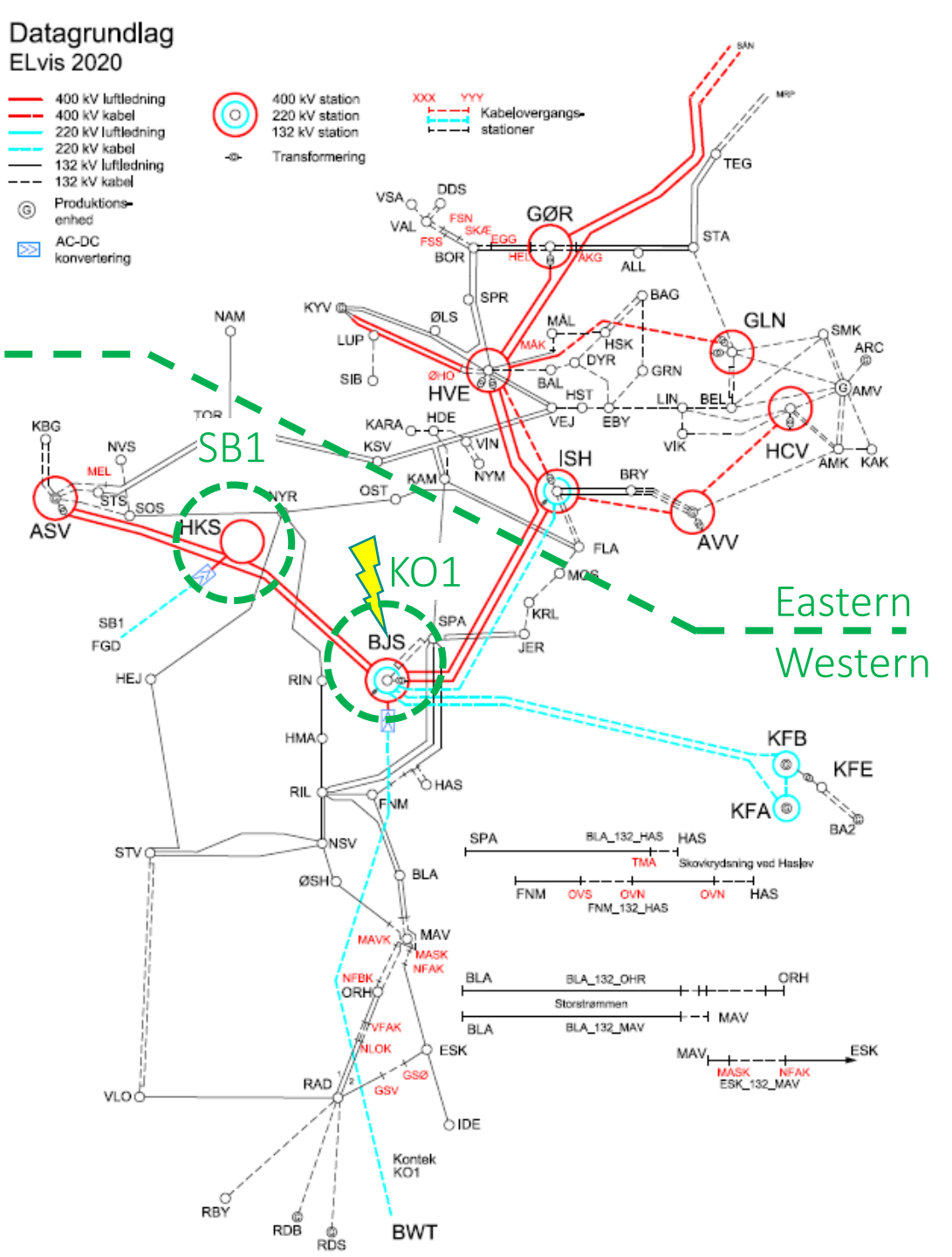
Sequential commutation failure





DK2 INCIDENT-AUG. 20, 2020





DEVELOPMENT OF SYSTEM LEVEL EMT MODELS

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Collaboration with MHI

ENERGINET + Manitoba HYDRO INTERNATIONAL PSCAD

2020. Jan — 2023. Dec. — 2024

- Validation of vendor models since 2013
- Data mapping process / model initialization process
- DK1 EMT network models
- DK2 EMT network models
- Develop UDM / functions for system level EMT models
- Pre/ Post processing for System EMT model preparation

Involve the models to more projects

- Daily Grid connection process
- Deployment of future technology (e.g. GFM) considering PE dominant power systems

Model improvement and validation

- Debugging to improve robustness
- User friendly EMT data management to improve system level study features.

EMT STUDY PROCESS

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PF model preparation

Balance data

Full model

Reduced model

DGS data

PSCAD model preparation

Expand network + data mapping

Load flow check

If graphical issues or other bugs

Initial EMT model check with Thevenin/SG sources

Final EMT model with vendor models

EMT model preparation

EMT simulation

Scenario data

Automatic simulation

Entire EMT model

Result analysis

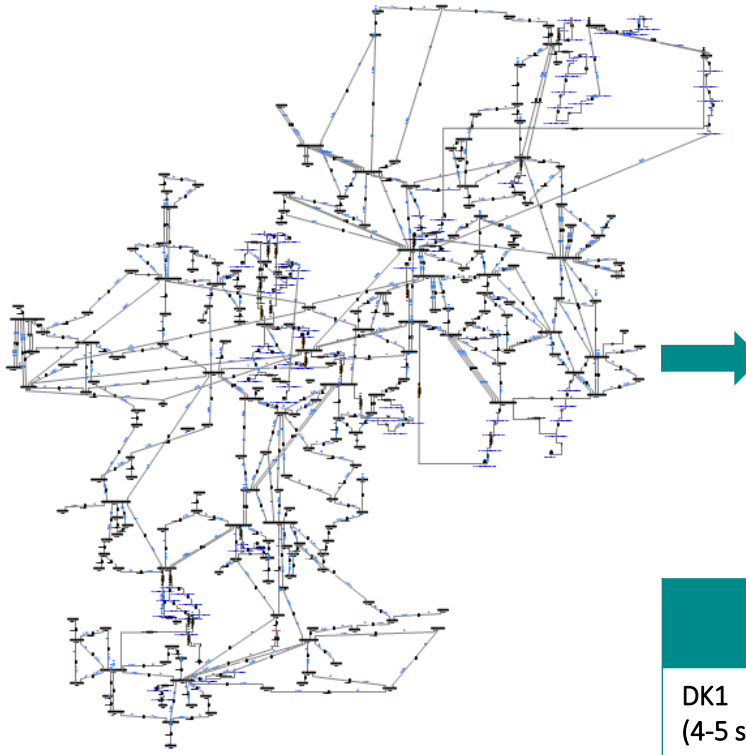
Further process, e.g. visualization, overview, etc.

Data preparation

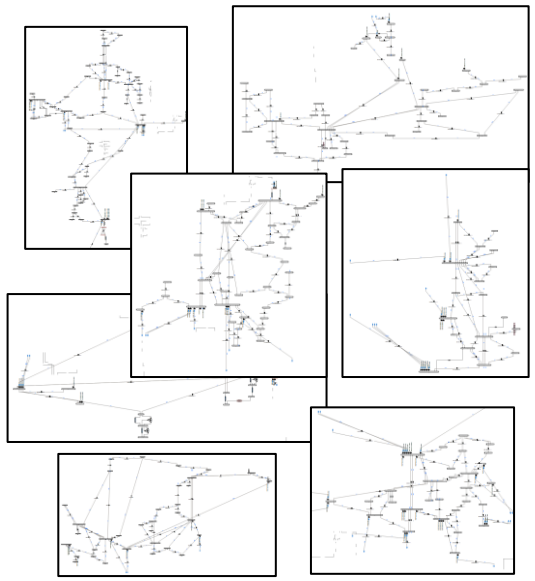
Post processing

SYSTEM LEVEL EMT MODELS IN ENERGINET

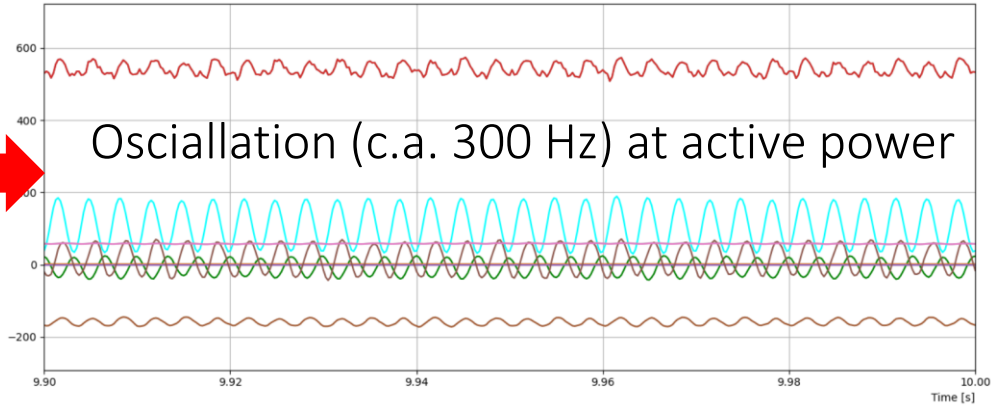
DK1 and DK2

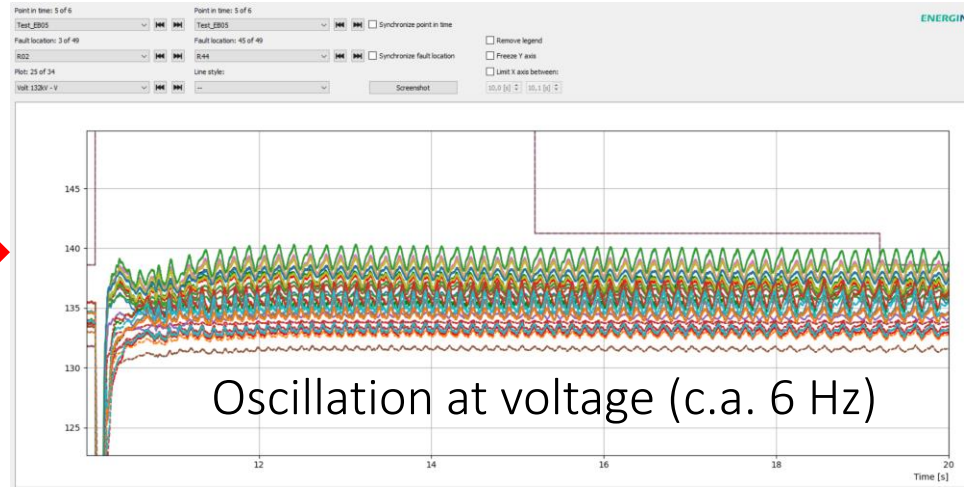


Example : DK2 system level EMT model



	Vendor models	Total PNI simulation	Simulation time (10sec)
DK1 (4-5 subnet)	40 ea	45 PNI	16 min
DK2 (7 subnet)	40-50 ea	47 - 57PNI	17 min





Example : Technical challenges (oscillation) observed in one of System EMT simulations in DK2

OSCILLATION ANALYSIS BASED ON 2028 DK2 REI STUDIES

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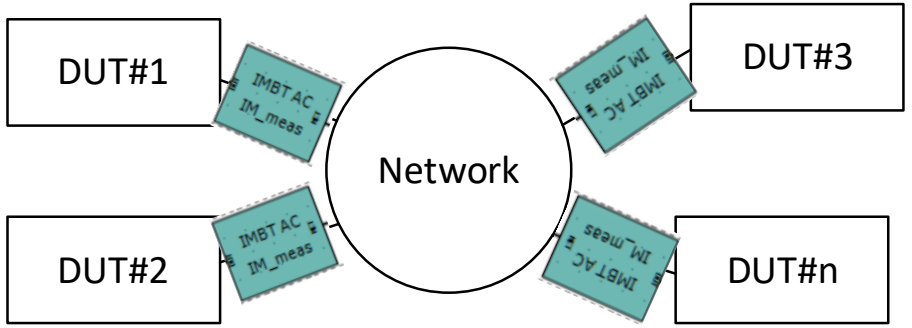
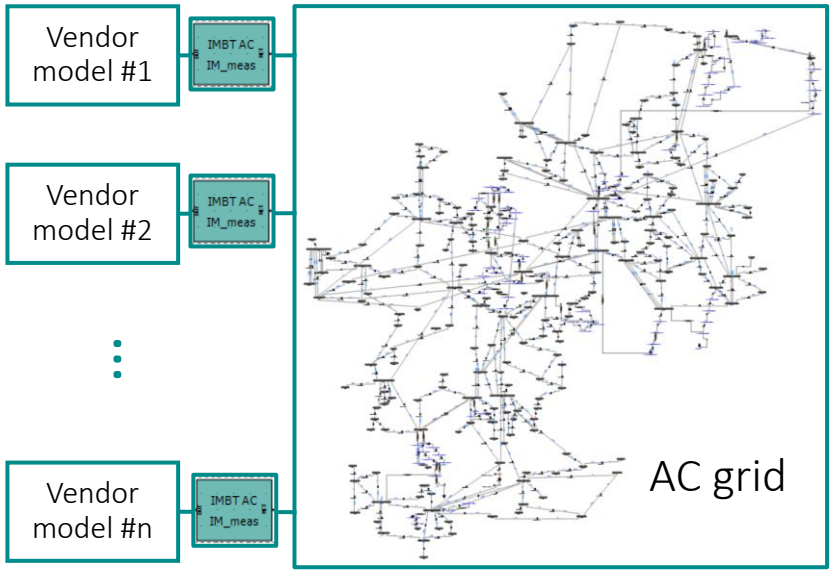
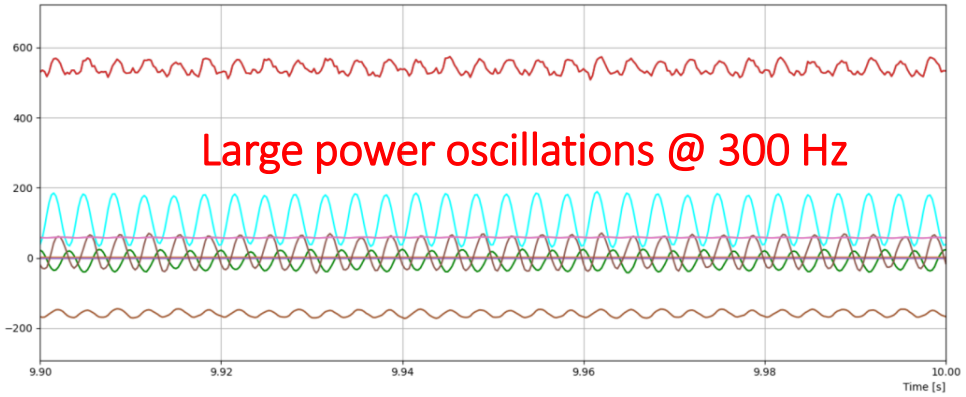
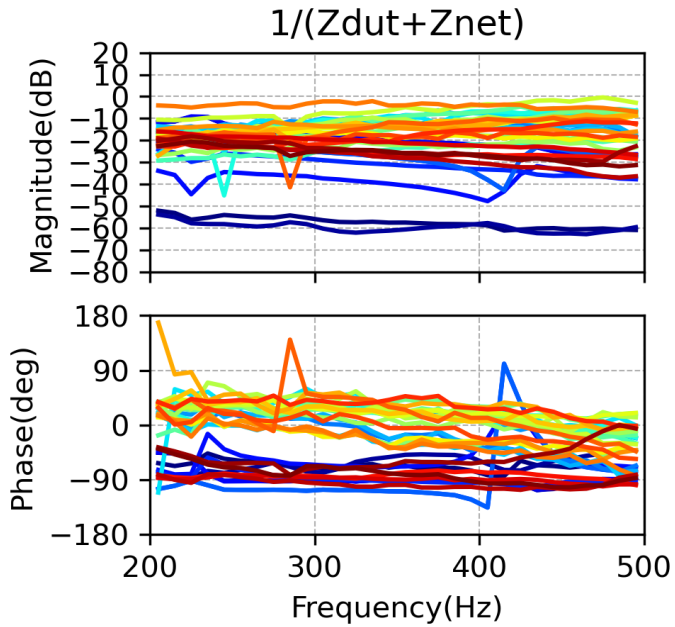
DUT – device under test



Measure impedance for both DUT & network sides







Impedances can be measured at all vendor model PoCs

PRACTICAL CHALLENGE

Systematical model and data management in an EMT environment:

- Model deployment, e.g. system-level protection, disturbance component
- Compiler compatibility issue with parallel computation. E.g. VS, IF
- Data acquisition and post processing of large data and their visualization for system overview
- Update grid connection model requirement considering extra needs from system level EMT simulation

FUTURE/ CURRENT APPLICATIONS

- Support Grid connection cases in system level EMT simulation
- Support Energy island
- Deployment of future technology (e.g. GFM deployment)
- Revision studies for some critical scenario
- Validation and analysis of real events
- Integrate more extra tools (State space, impedance scan tools, etc) to deep dive into details of dynamic behaviour

ACKNOWLEDGEMENT

ENDK Team

- System-level EMT development
- Develop pre/ post processing of data mapping
- System-level studies in EMT

- Prepare RMS models
- Develop model reduction process
- Visualization in DSAlight

MHI Team

- Component modeling in EMT
- Support data conversion
- Support system-level EMT studies
- Support UDM development

Questions