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Fast Active Power Regulation strategies for Frequency Support from Renewable Energy Hubs

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DISCLAIMER

Ministry of Infrastructure and Water Management

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OUTLINE

1. The future multi-energy system: stability concerns

2. Approach

3. Results

4. Conclusions

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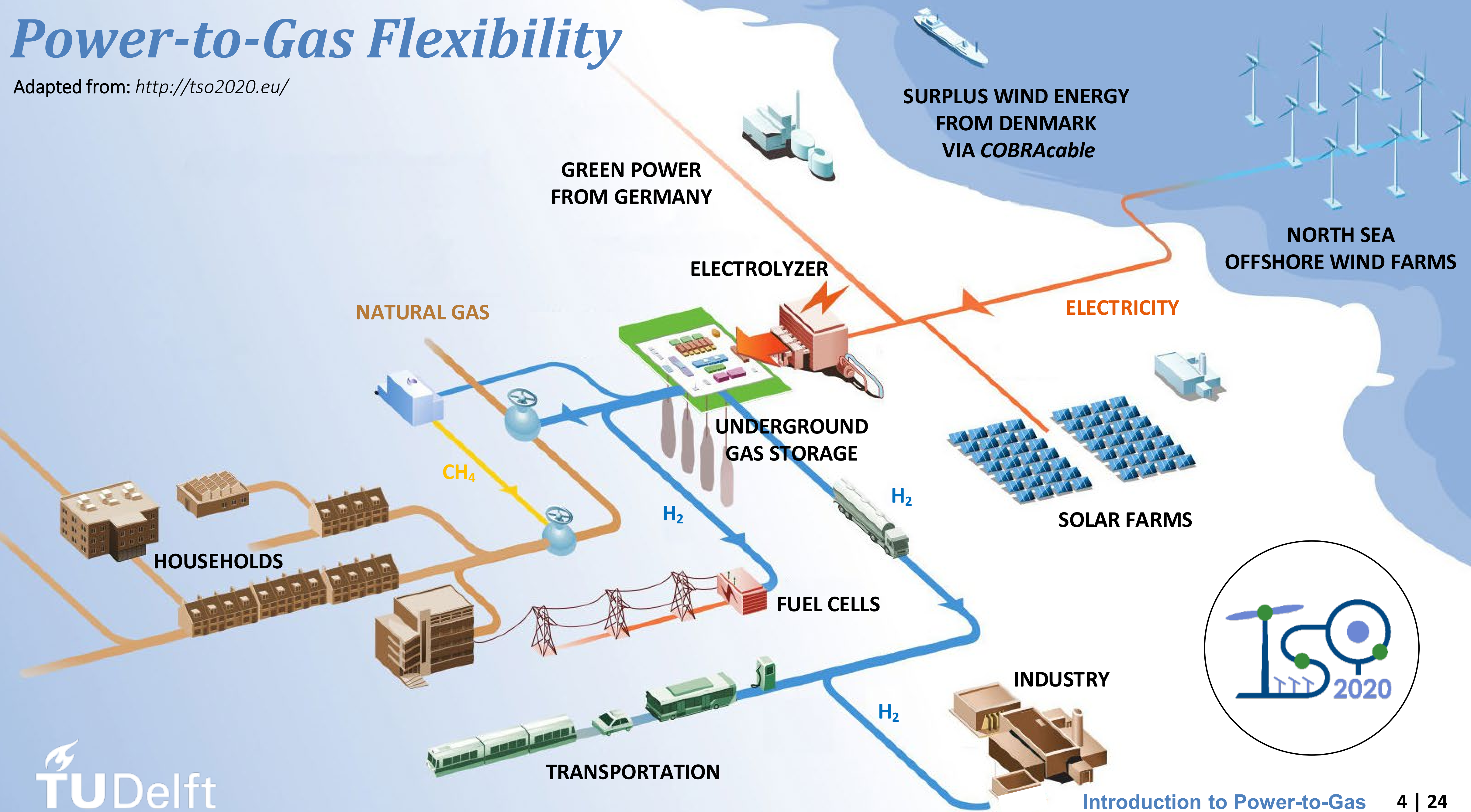
Power-to-Gas Flexibility

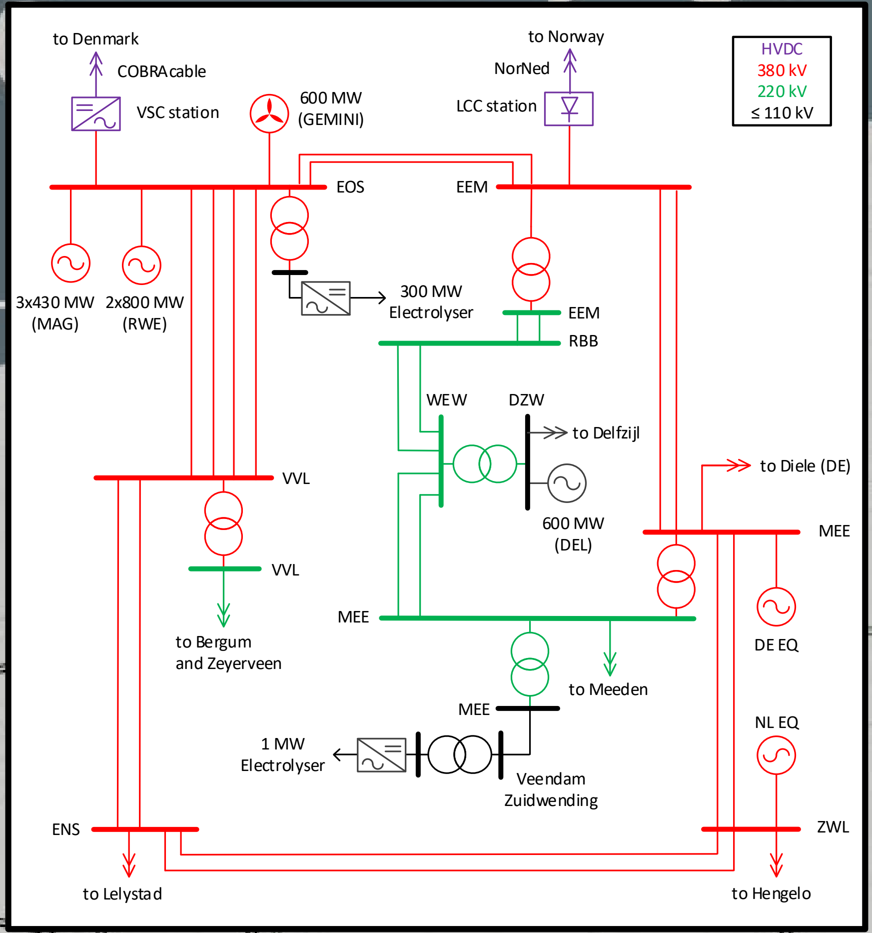
Adapted from: *http://tso2020.eu/*

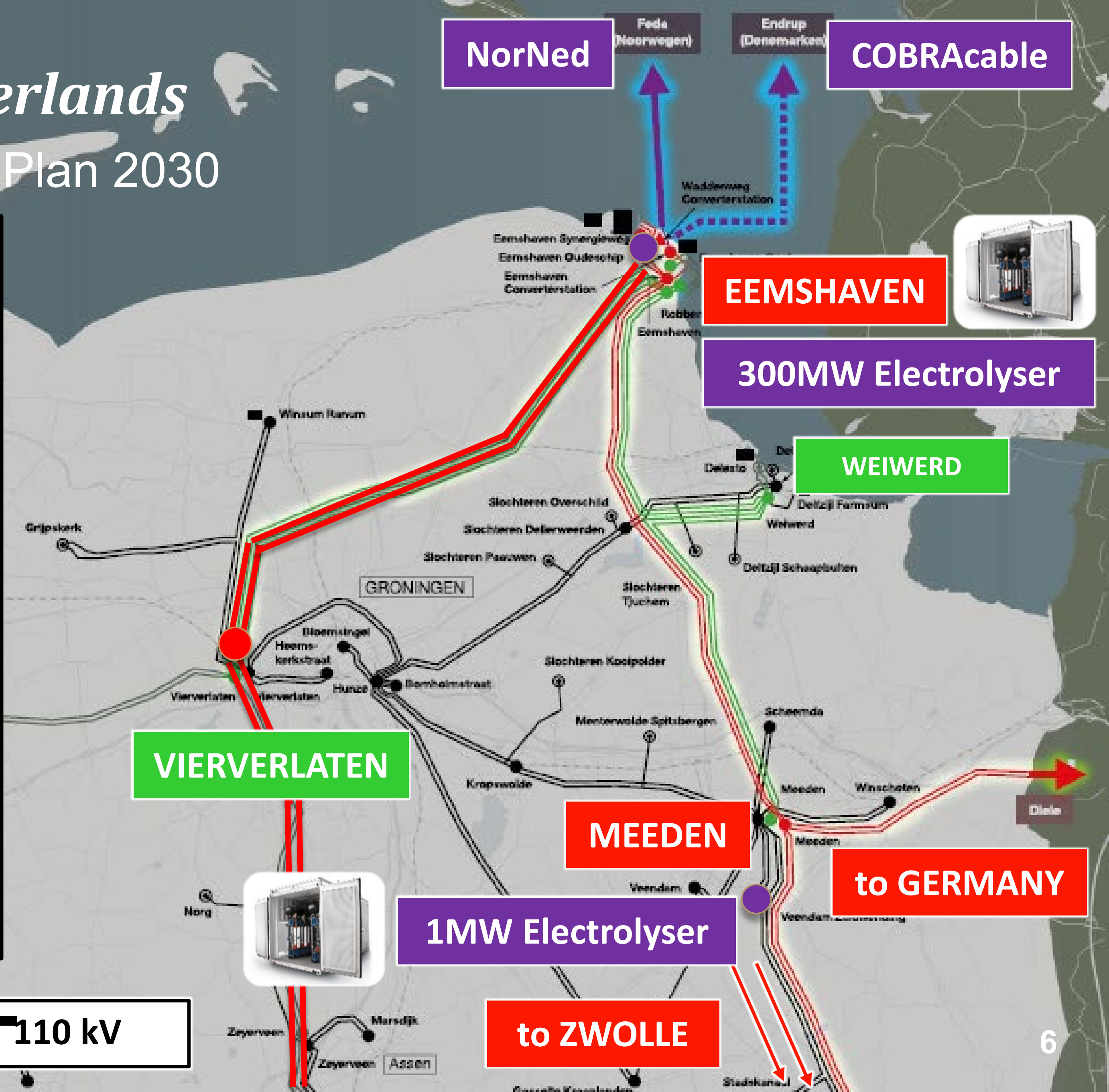


Northern Netherlands Case Study

Test System: Northern Netherlands

Based on: TenneT's Development Plan 2030





380 kV	220 kV	110 kV

1.2 TSO2020 PROJECT: OBJECTIVE AND ACTIVITIES

TSO2020

Electric “Transmission and Storage Options” along TEN-E and TEN-T corridors for 2020

Objective: to demonstrate the technical and commercial viability of power-to-hydrogen solutions in the context of the Groningen region (NL) and to assess the replicability of the solutions to other regions.

Activities:

1) General coordination
2) Power system stability analysis
3) Cost-Benefit Analysis (CBA)
4) Electrolyser pilot and hydrogen hub
5) Analysis of scale-up to mass application
6) Dissemination and engagement

Project Partners:

gasunie

EASE European Association for Storage of Energy

energy valley

Green Planet

TU Delft

TenneT

Co-financed by the European Union
Connecting Europe Facility

Ministry of Infrastructure and Water Management

Official website: *http://tso2020.eu/*

1.3 OVERVIEW OF TSO2020 TASKS BY TU DELFT

Scope: To study the dynamic interaction between international connected electrical transmission networks and the large-scale demand side response associated to power-to-gas conversion.

- *Recommendations for the exploitation of ancillary services*
- *Hardware-in-the-Loop (HIL) tests of a mock-up rectifier and controllers in RTDS*
- *Investigation of ancillary services provision by a 300-MW electrolyser in Eemshaven*
- *Modelling of the Northern Netherlands electrical transmission network in RTDS (including COBRAcable)*
- *Development and validation of a 1-MW electrolyser model in RTDS (Real-Time Digital Simulator)*

Official website: *http://tso2020.eu/*

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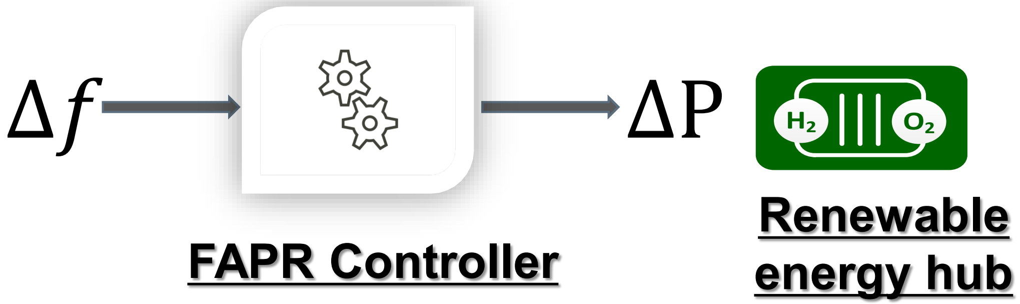
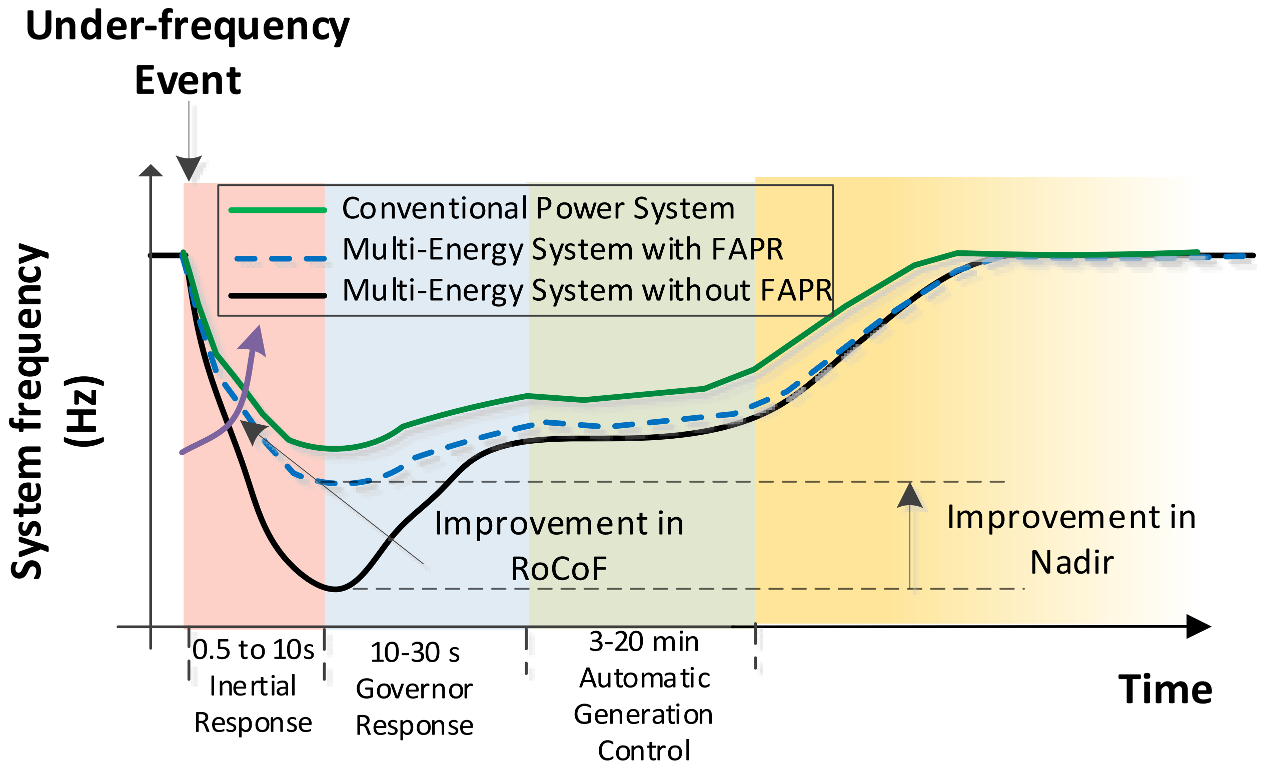
2.1 RESEARCH OBJECTIVE

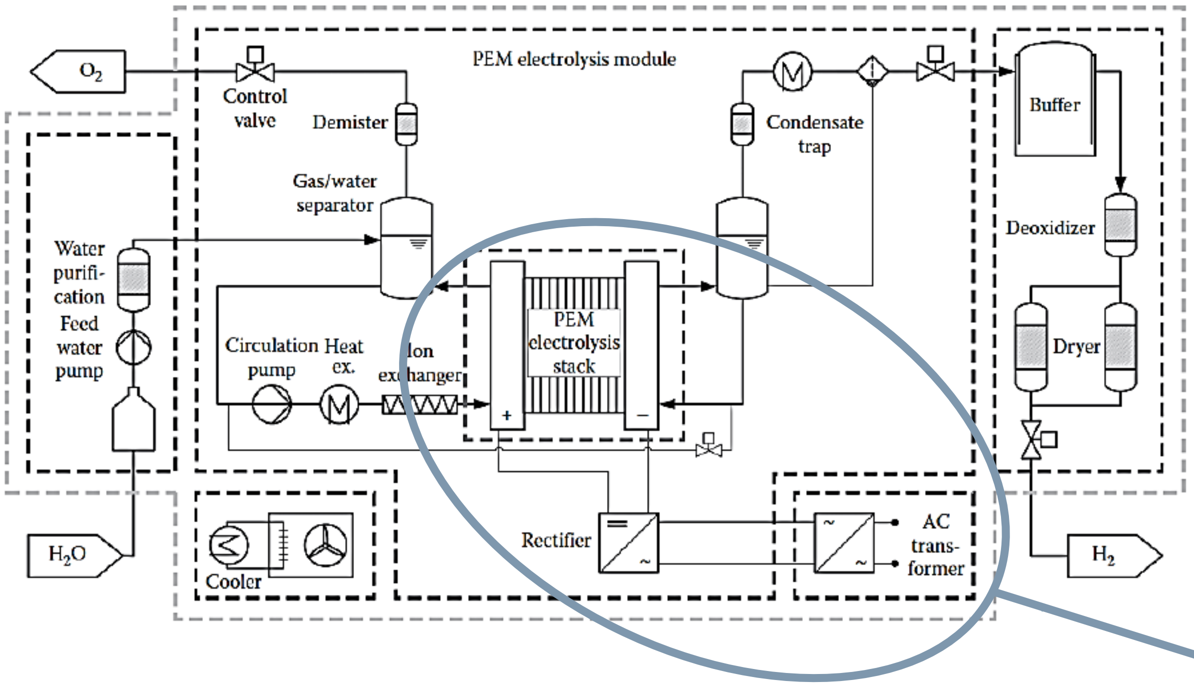
Investigation of the performance and impact of fast active power regulation (FAPR) control strategies implemented on renewable energy hubs (incl. MW-scale controllable electrolysers)



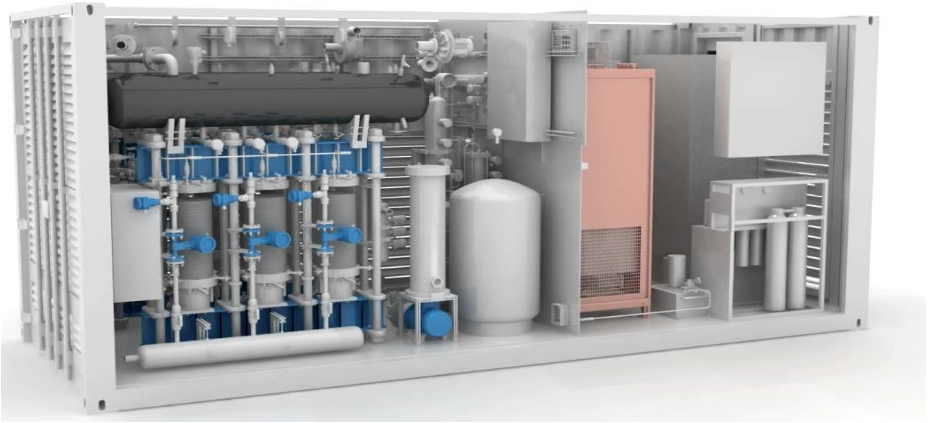


2.2 ELECTROLYSER MODEL CONFIGURATION

Electrolyser layout (example)

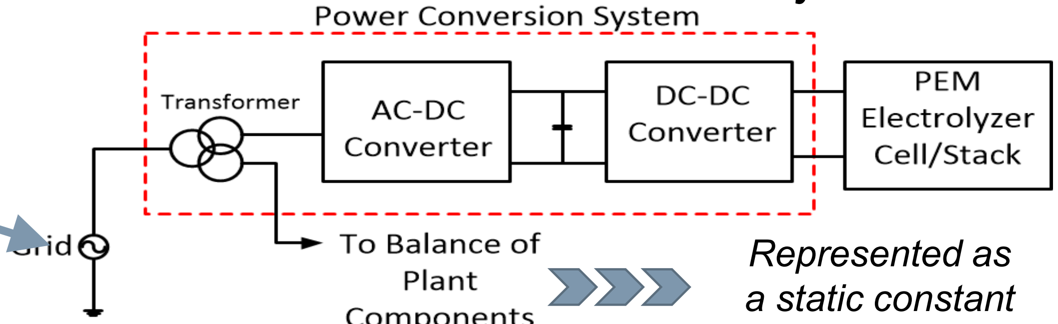


Example electrolyser (ITM)



Source: ITM Power

Generic model of 1-MW electrolyser

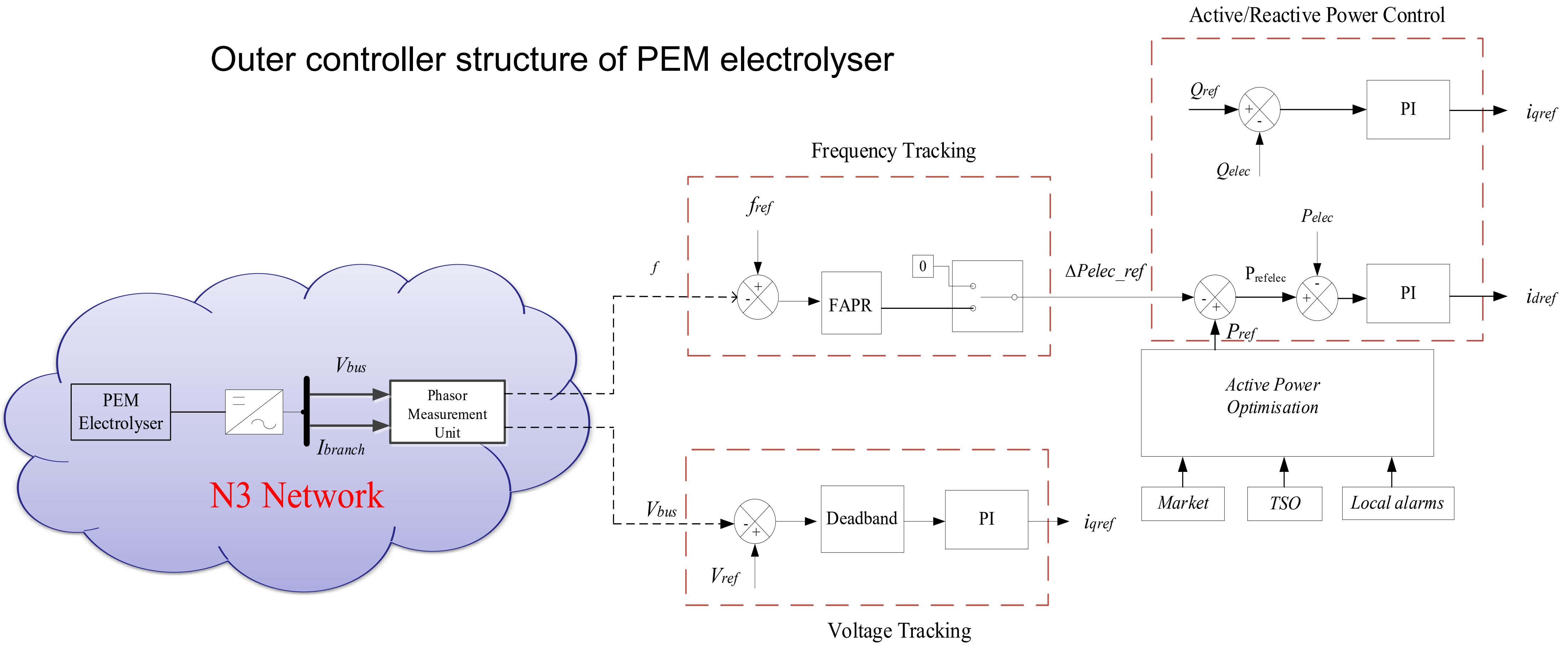


Represented as a static constant PQ load

PEM: Proton-Exchange Membrane

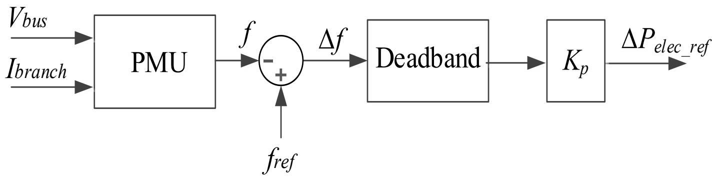
2.2 ELECTROLYSER MODEL CONFIGURATION

Outer controller structure of PEM electrolyser

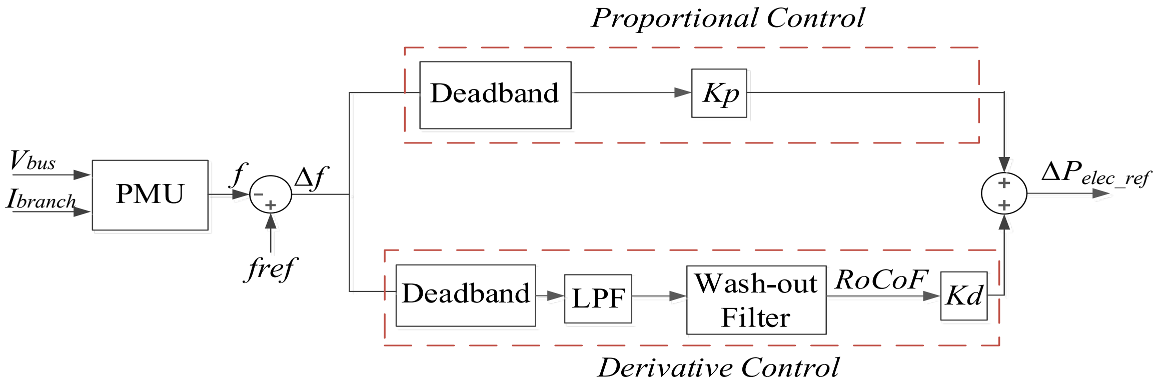


2.3 FAPR METHODS

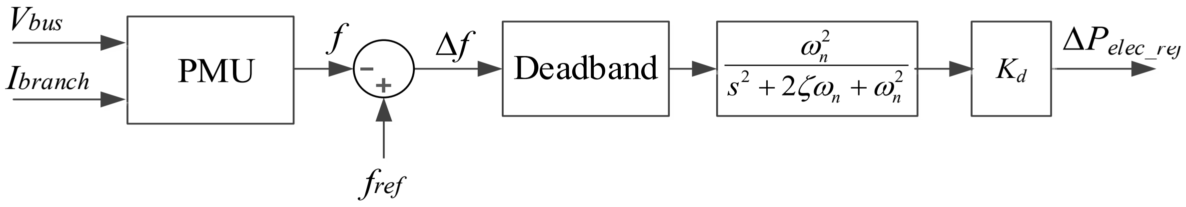
Droop FAPR

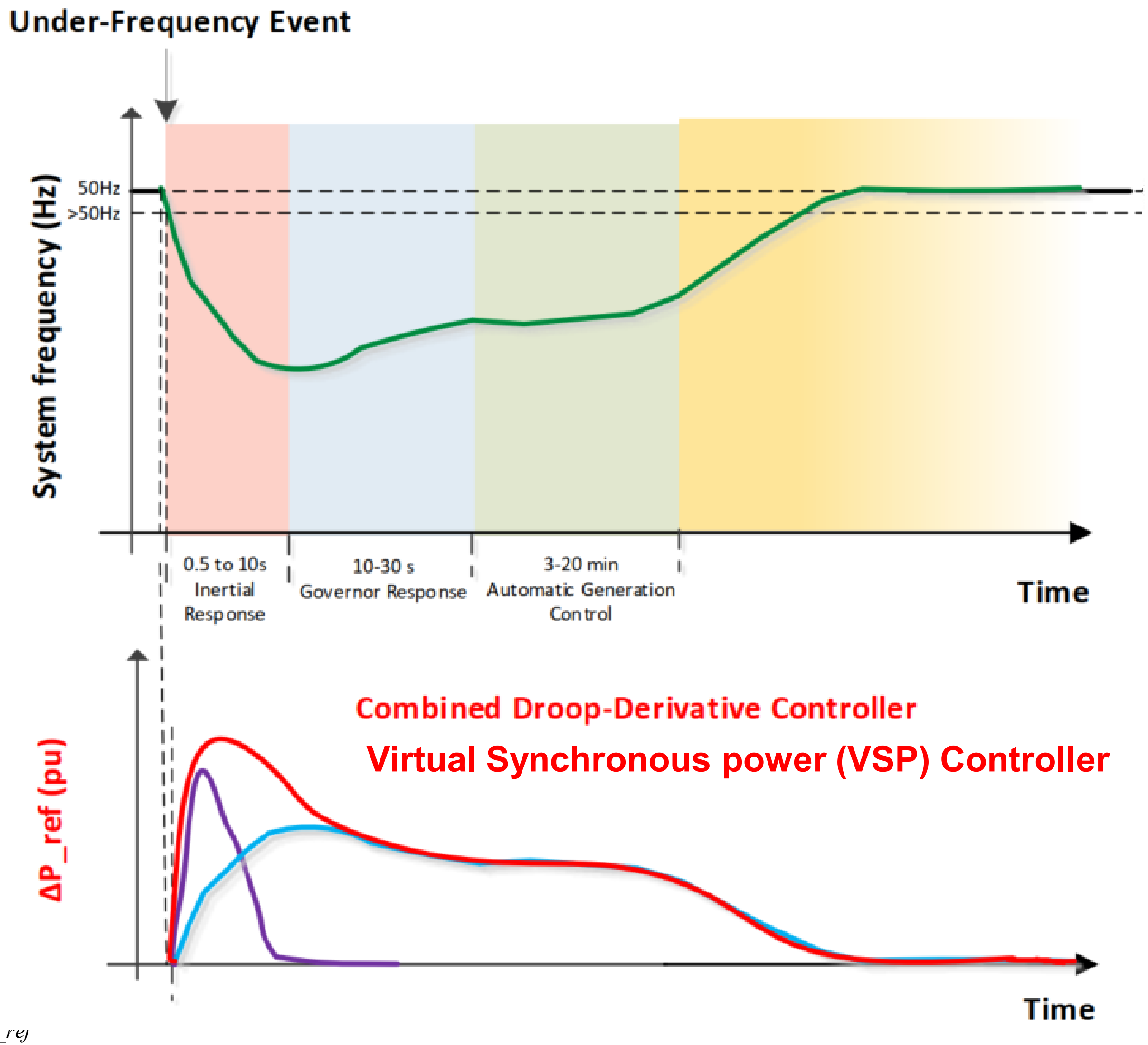


Combined droop-derivative FAPR



Virtual Synchronous Power (VSP) FAPR





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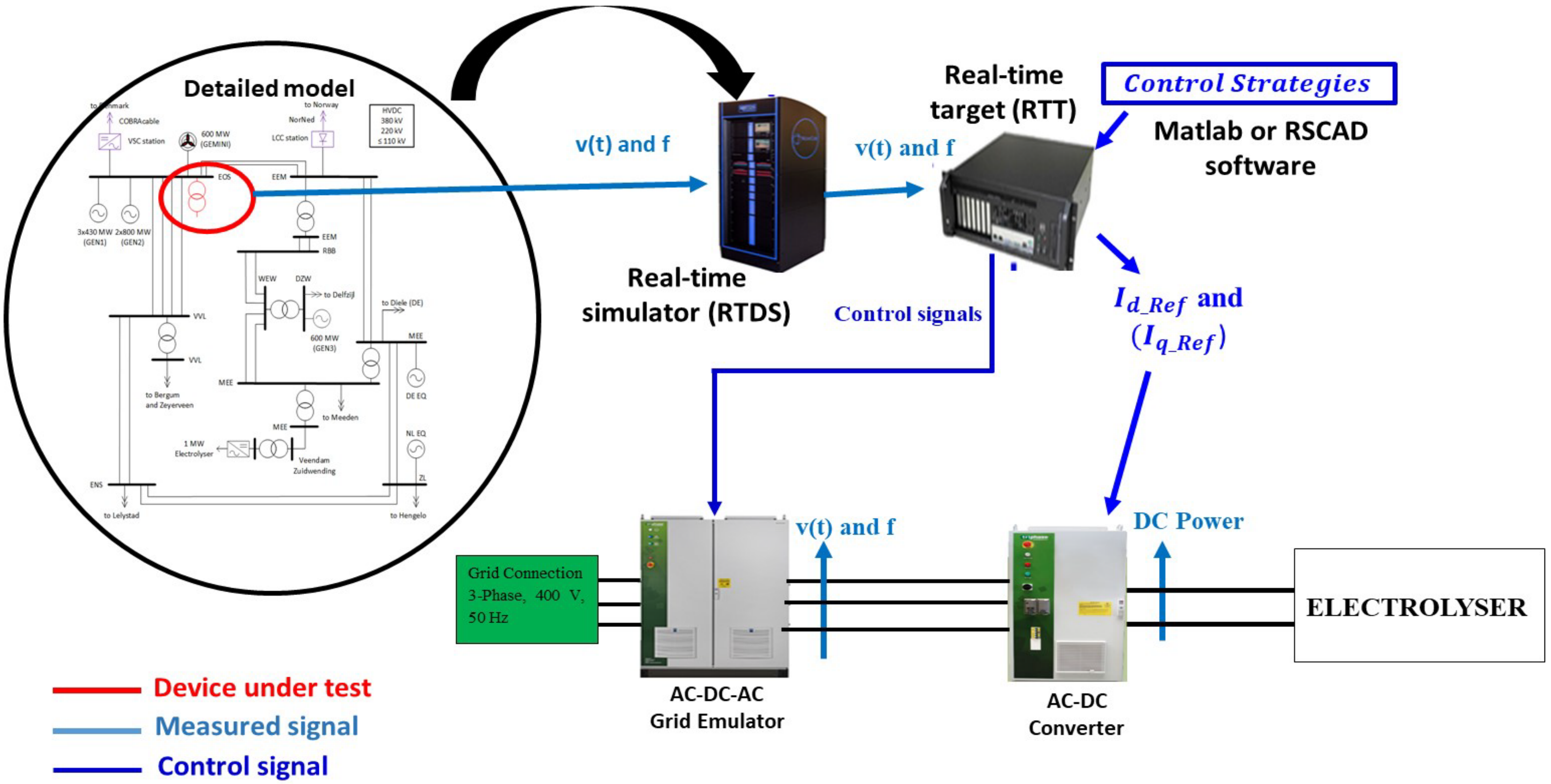
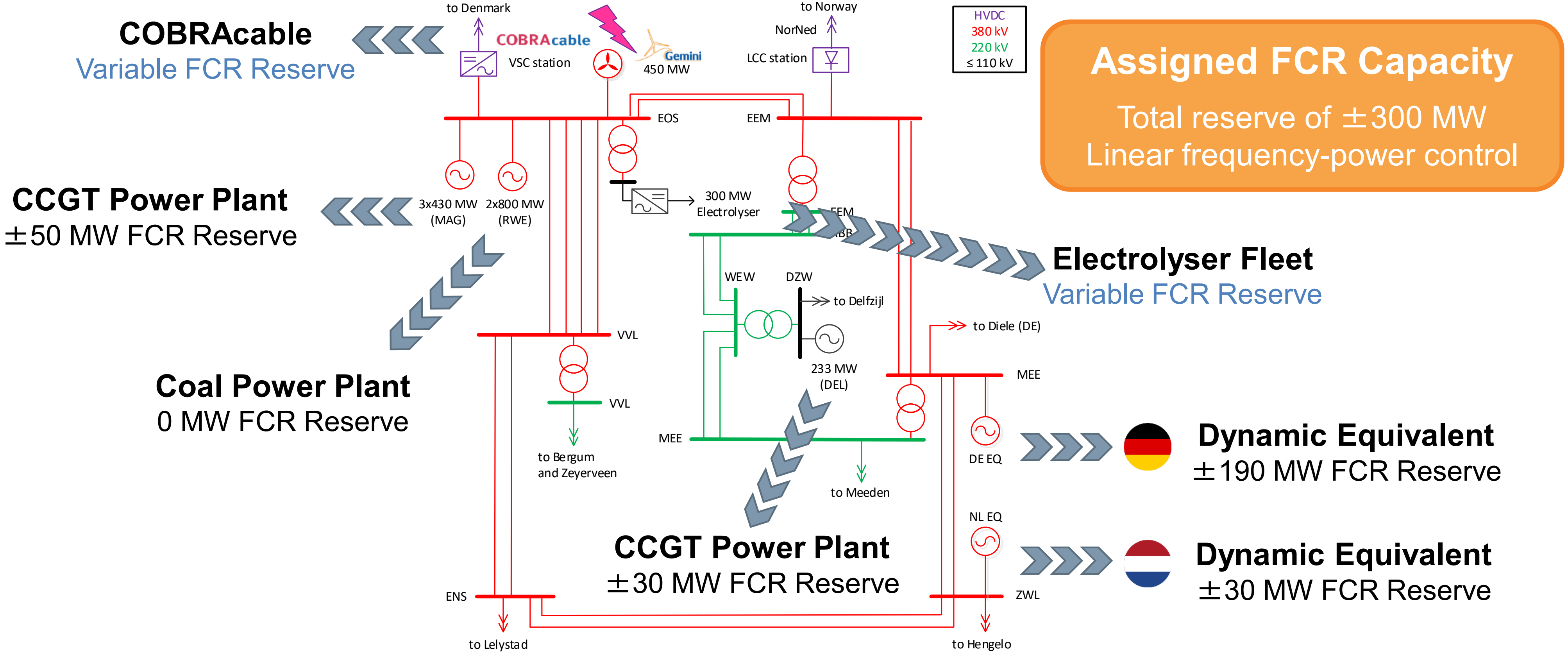
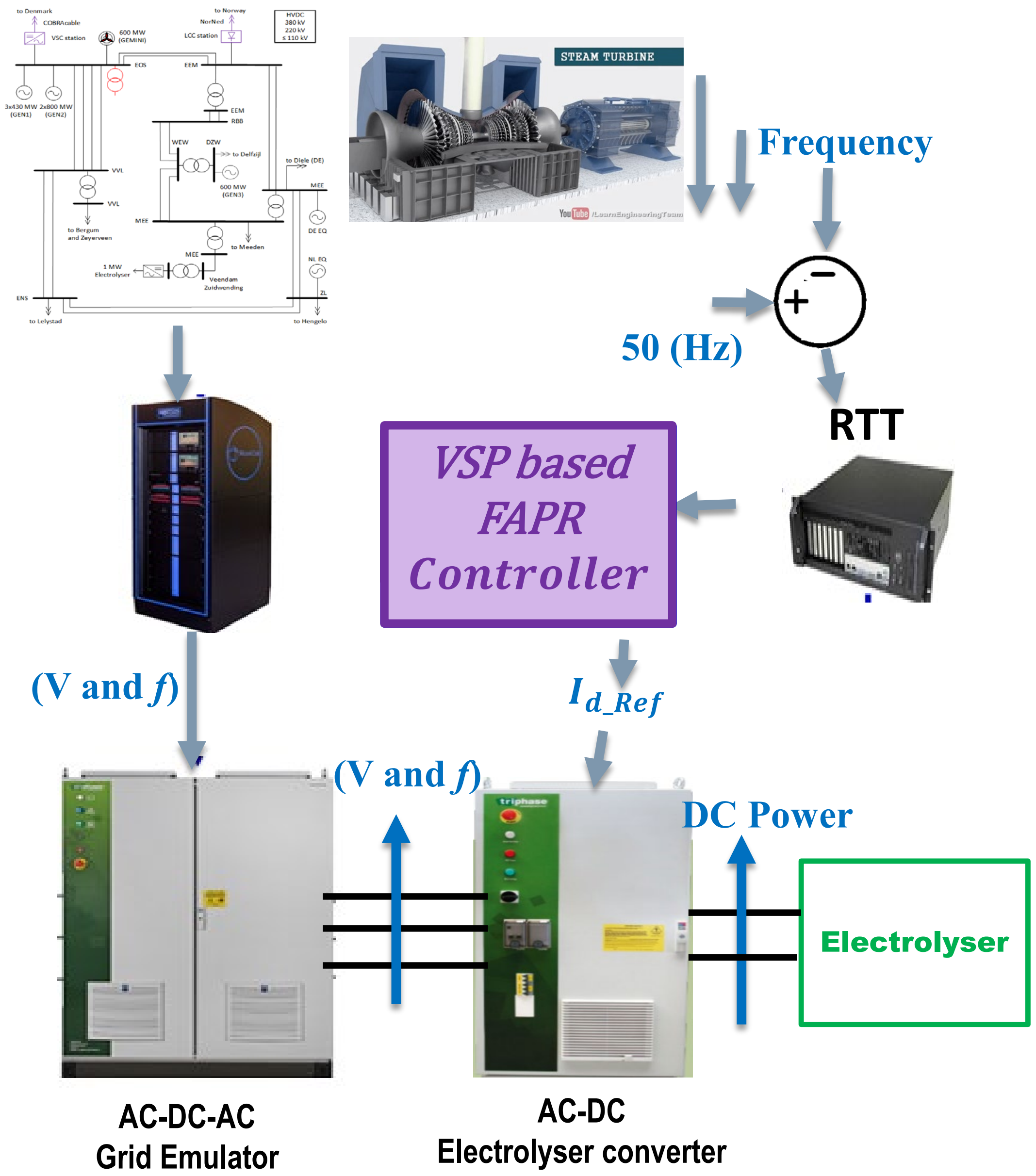
3.1 HARDWARE-IN-THE-LOOP TESTING SET-UP

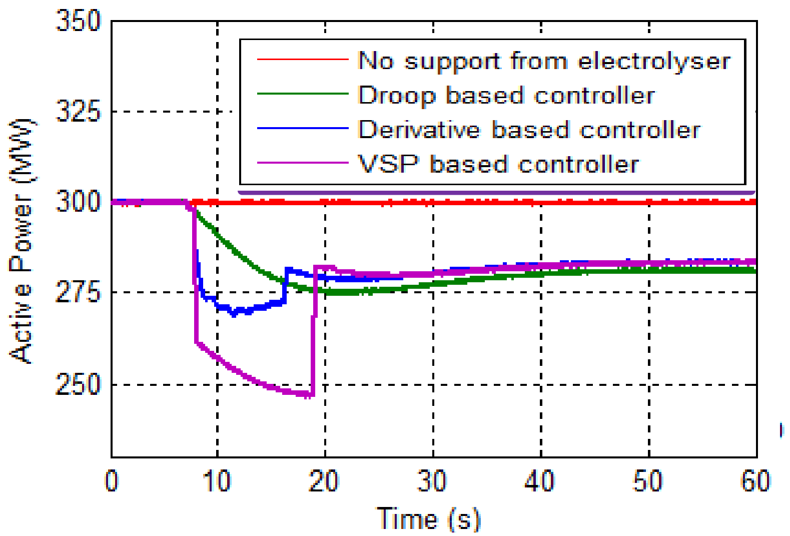


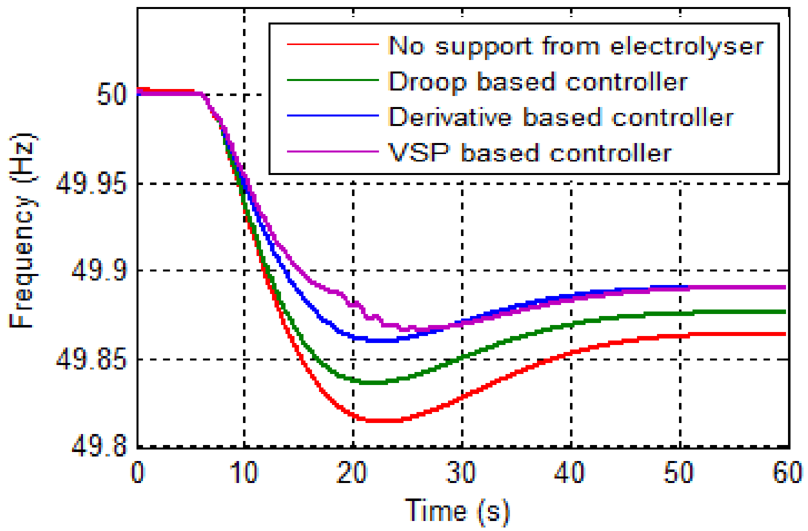
3.2 DISTURBANCE: LOSS OF 200 MW OF WIND GENERATION



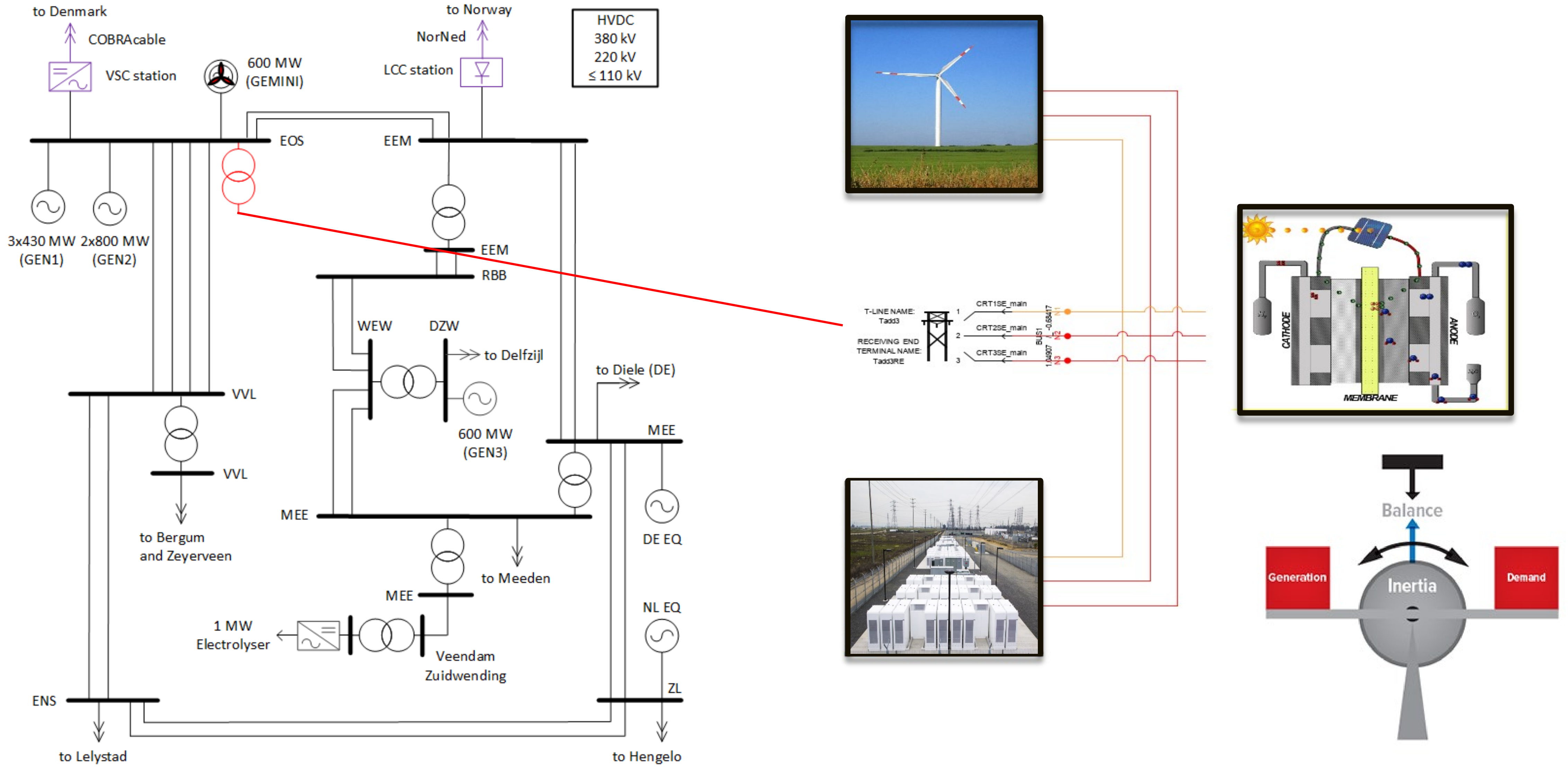
3.3 TESTING OF CONTROL STRATEGIES ON PEM ELECTROLYSER





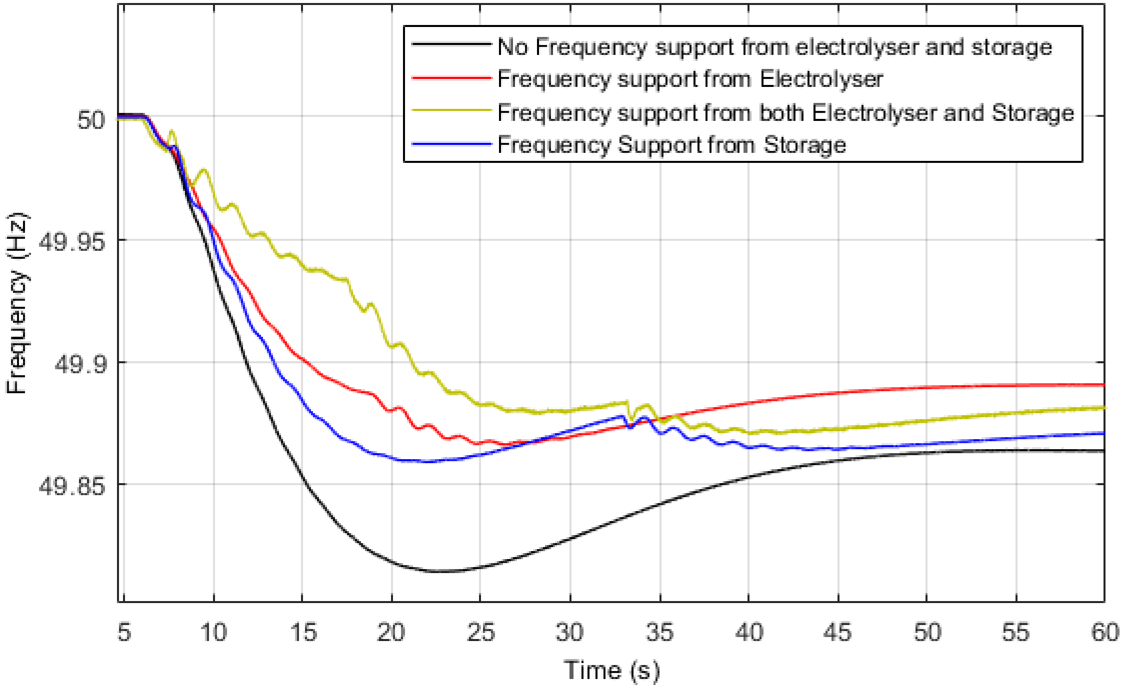


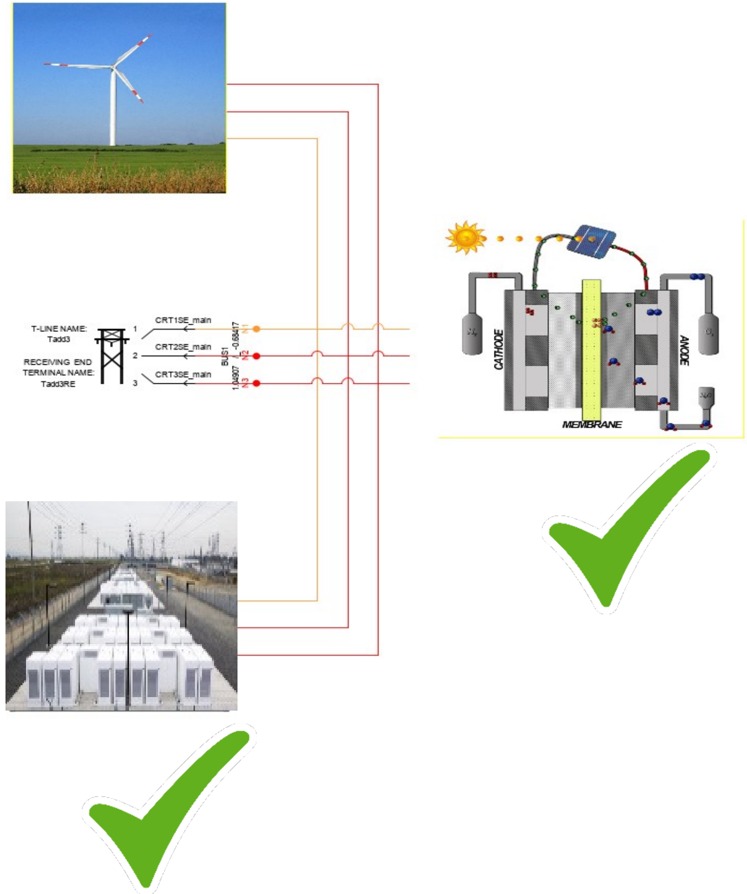
3.4 FAPR IMPLEMENTED IN RENEWABLE ENERGY HUB



3.2 PERFORMANCE AND IMPACT OF FAPR CONTROL STRATEGIES

VSP based FAPR outperforms other FAPR control strategies: significant improvement of rate-of-change of frequency and maximum frequency deviation (specially if more P sources are available)





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4 CONCLUSIONS

- Large-scale electrolyser capacity is technically promising for the procurement of ancillary services (e.g. primary frequency control). Yet, the business model of power-to-gas will determine the market participation.

- This paper showed the impact of different methods to improve the frequency nadir and Rate-of-Change-of-Frequency. VSP based FAPR outperforms other FAPR control strategies

- Although not the case for the studied Northern Netherlands Test Network, electrolysers could improve network congestion, local voltage stability and rotor angle stability.

Thanks for your attention!

TU Delft