EERA DeepWind conference, 17-19 January 2024
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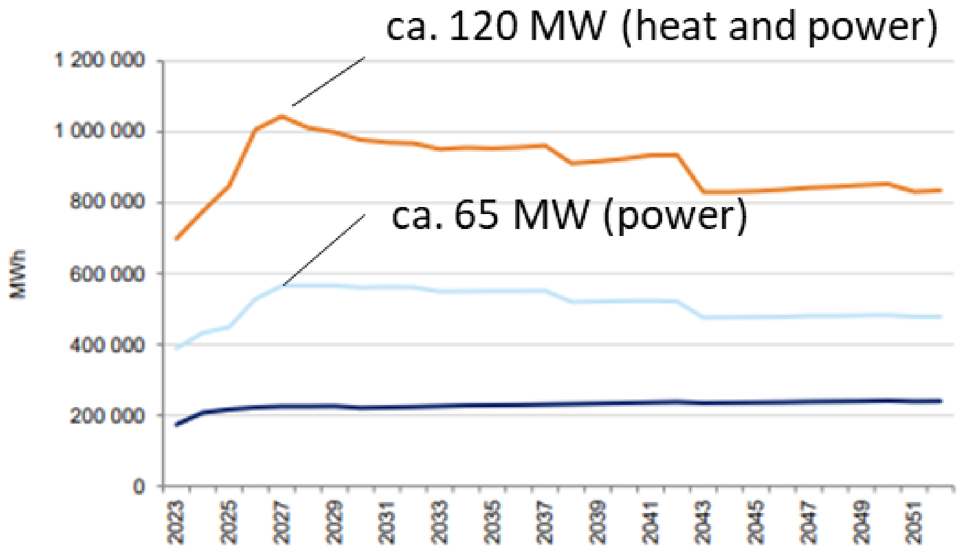
LOWEMISSION
CleanOFF Hub
SINTEF NTNU

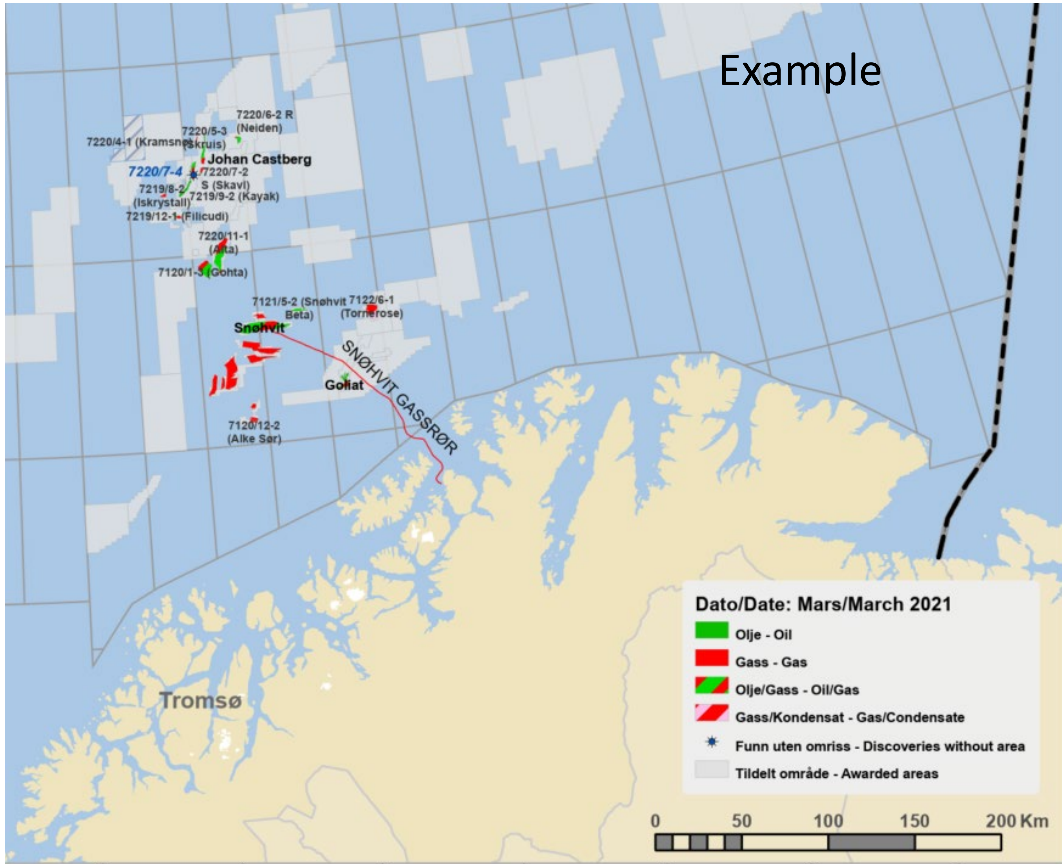
Analyzing a grid-forming storage hub for an offshore platform cluster supplied by wind energy

Daniel dos Santos Mota, Hallvar Haugdal, Valentin Chabaud
January 2024

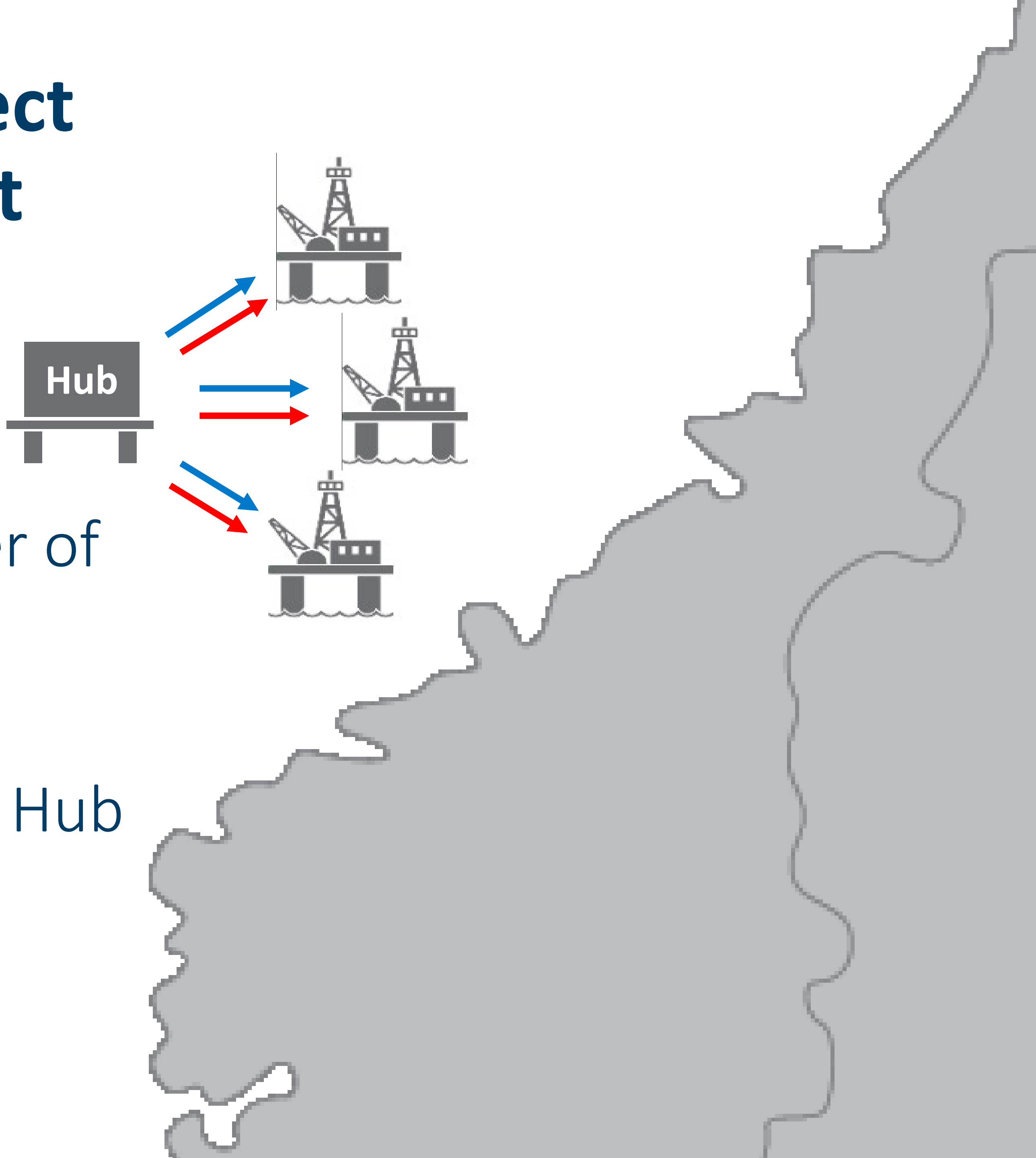
CleanOFF Hub Concept



- Several facilities with both oil and gas production
- Power demand: 50-150 MW per facility at plateau
- Heat demands: 30-70 MW per facility at plateau
- Expected future load profiles: Build-up, plateau, decline, tail
- Expected lifetime: ≥ 30 years
- Distance from shore: ≥ 240 km



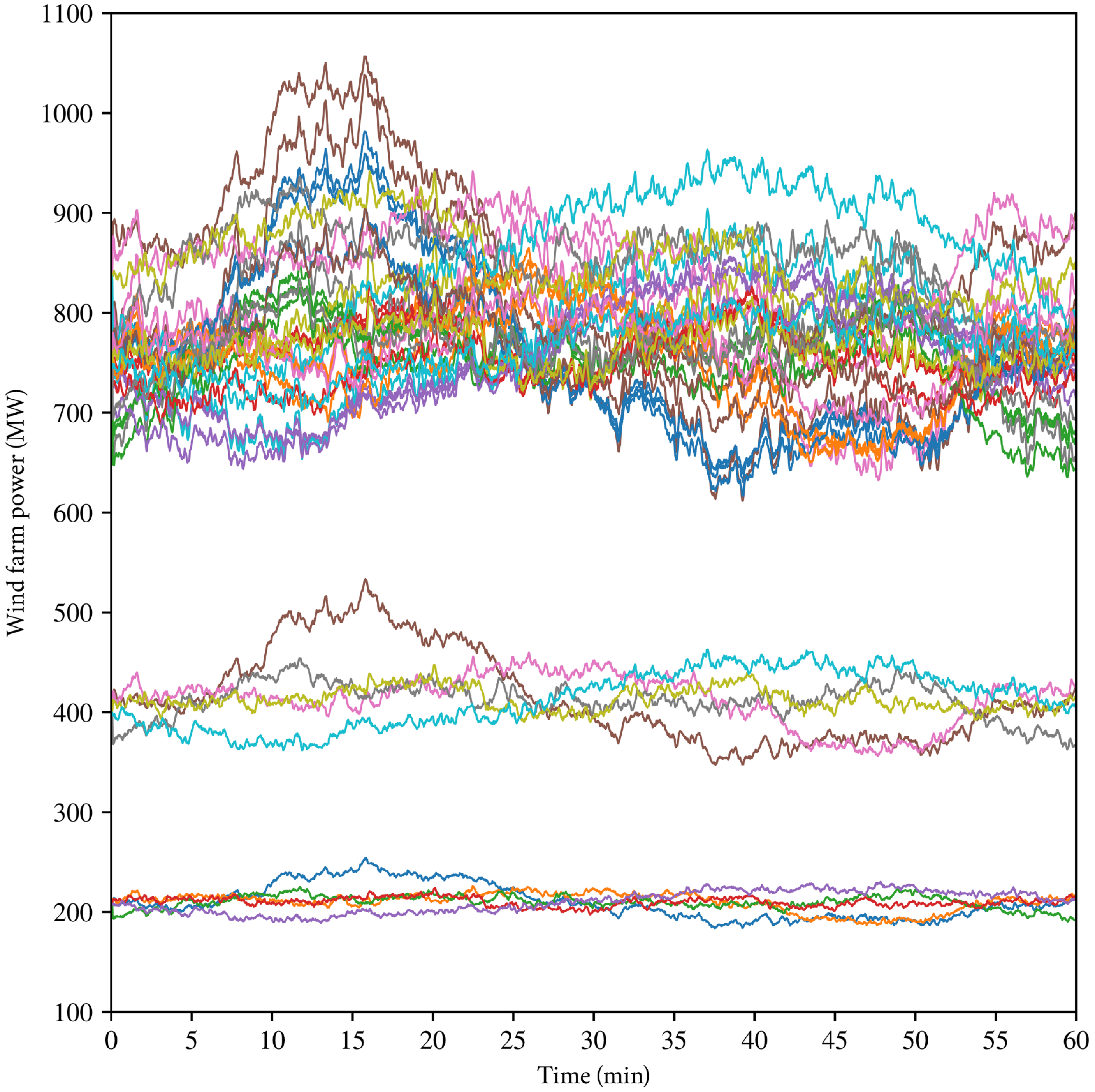
CleanOFF Hub Project
Energy Hub Concept



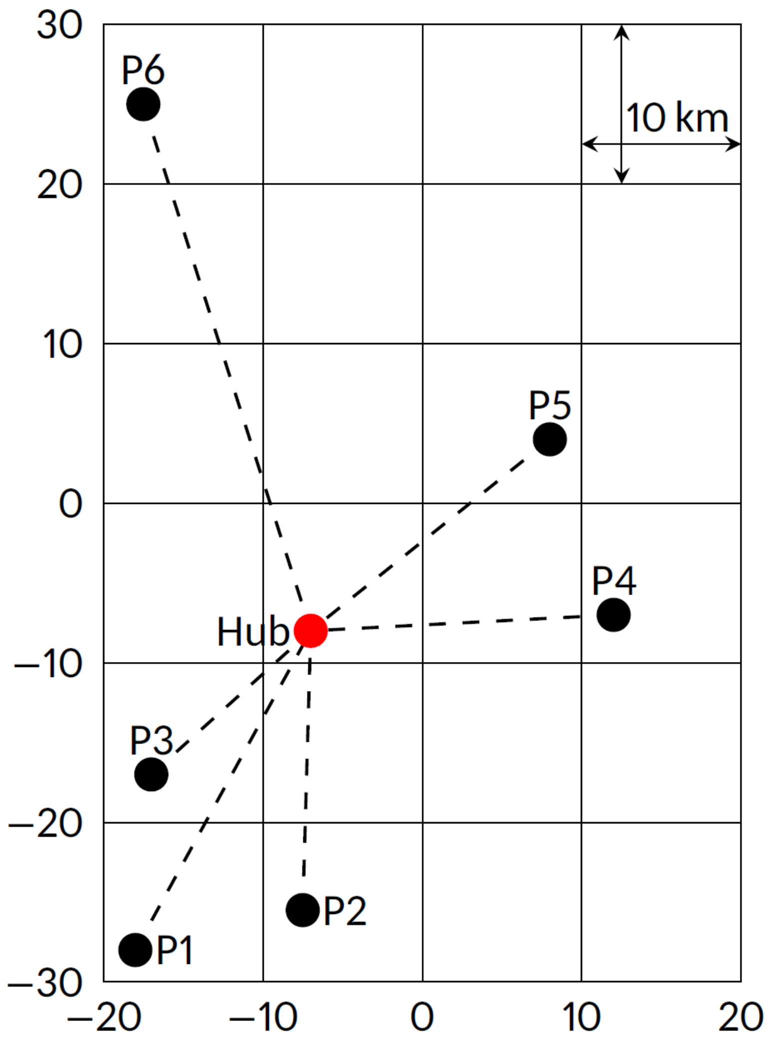
- Offshore power hub for a cluster of platforms
- Offshore wind farm feeding the Hub

Wind Power

- Surrogate model wrapping up data from state-of-the-art aerodynamic simulations
- Encompasses wake losses and power spectral density characterizing correlated wind fluctuations between turbines arising from farm-scale turbulence
- Time series with power output
  - 1 second resolution
  - 1 hour window



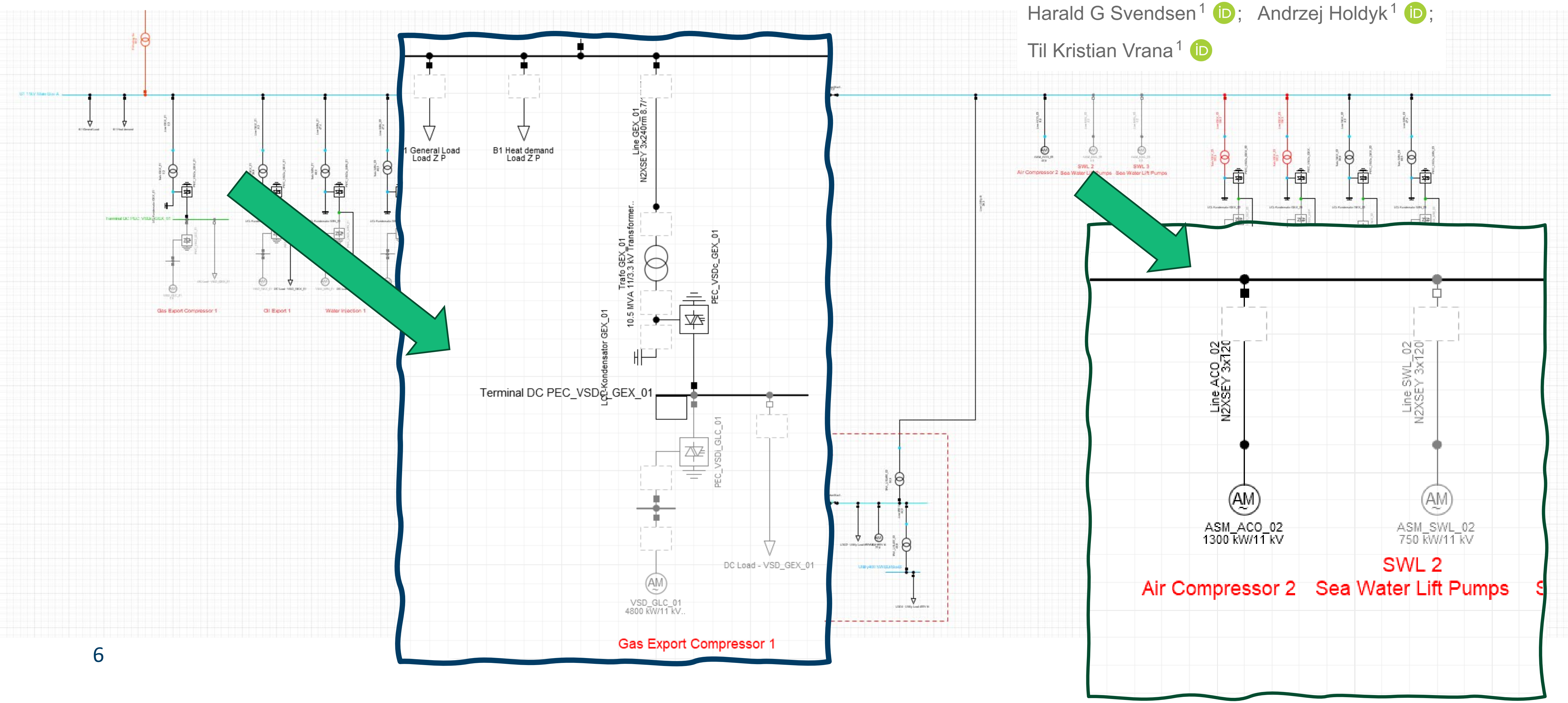
Study Case
Oil and Gas Platform Cluster



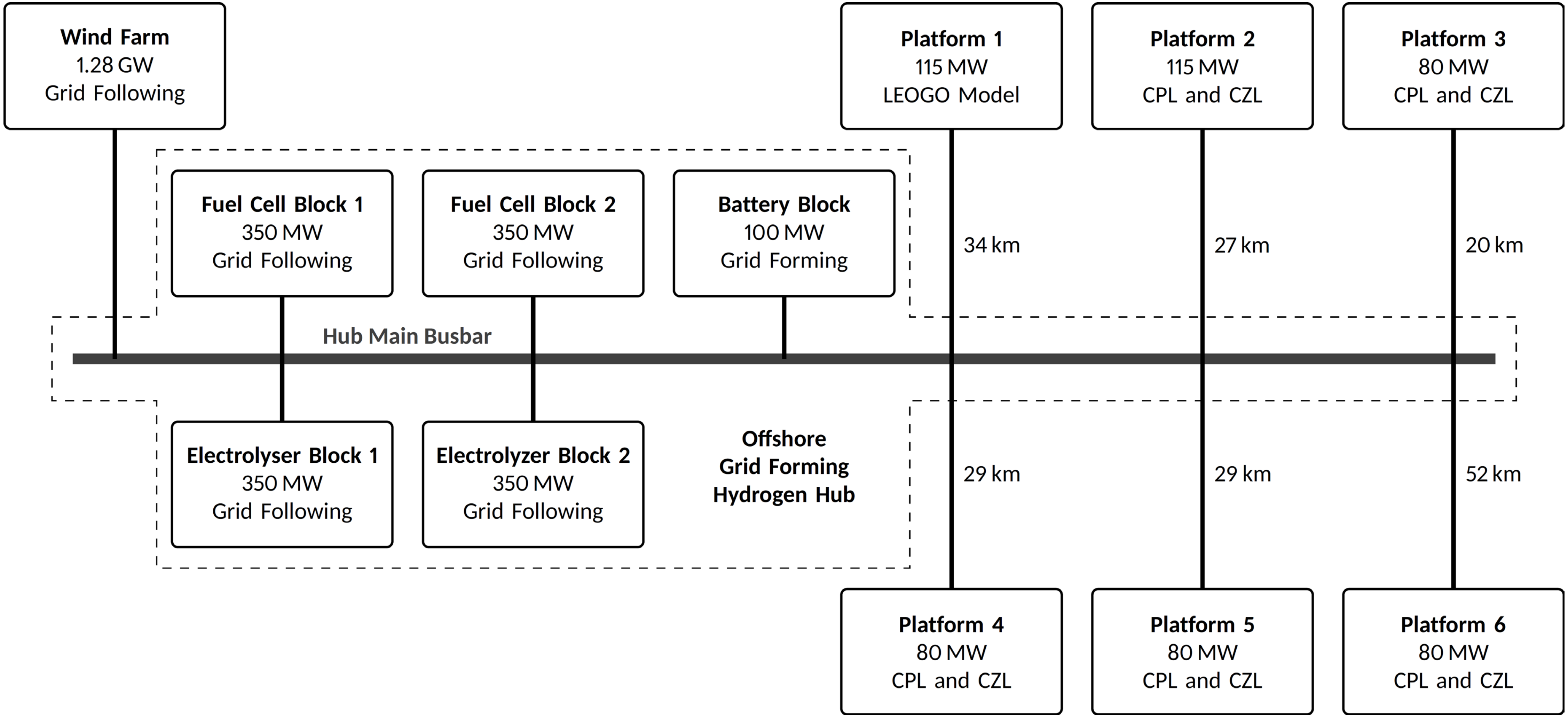
Platform	Load	Model Base
P1	115 MW	LEOGO
P2	115 MW	70% CPL, 30% CZL
P3	80 MW	70% CPL, 30% CZL
P4	80 MW	70% CPL, 30% CZL
P5	80 MW	70% CPL, 30% CZL
P6	80 MW	70% CPL, 30% CZL
Total load	550 MW	

Low Emission Oil and Gas Open (LEOGO) platform specification

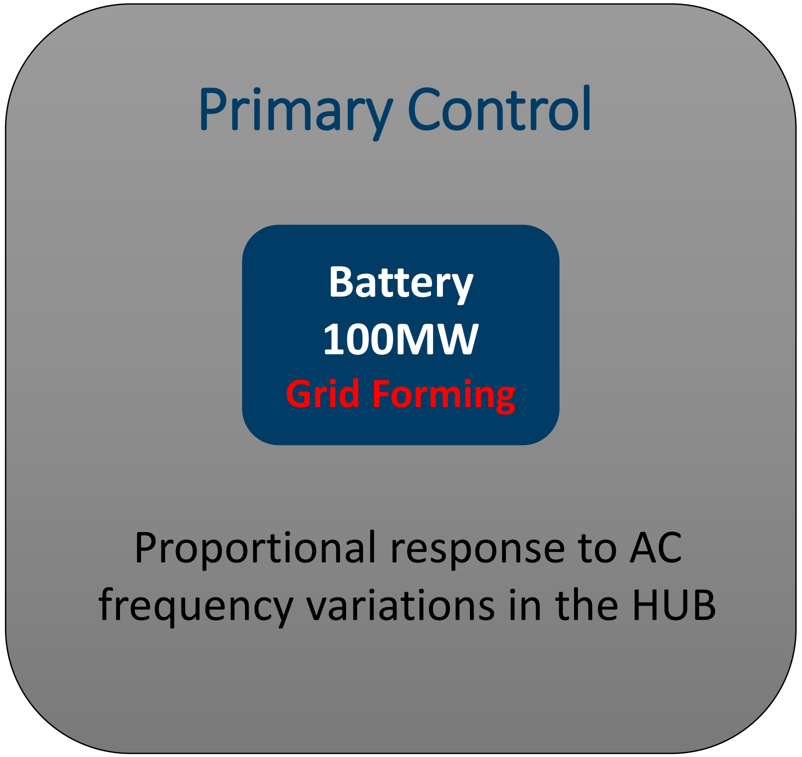
Harald G Svendsen[1]; Andrzej Holdyk[1]; Til Kristian Vrana[1]

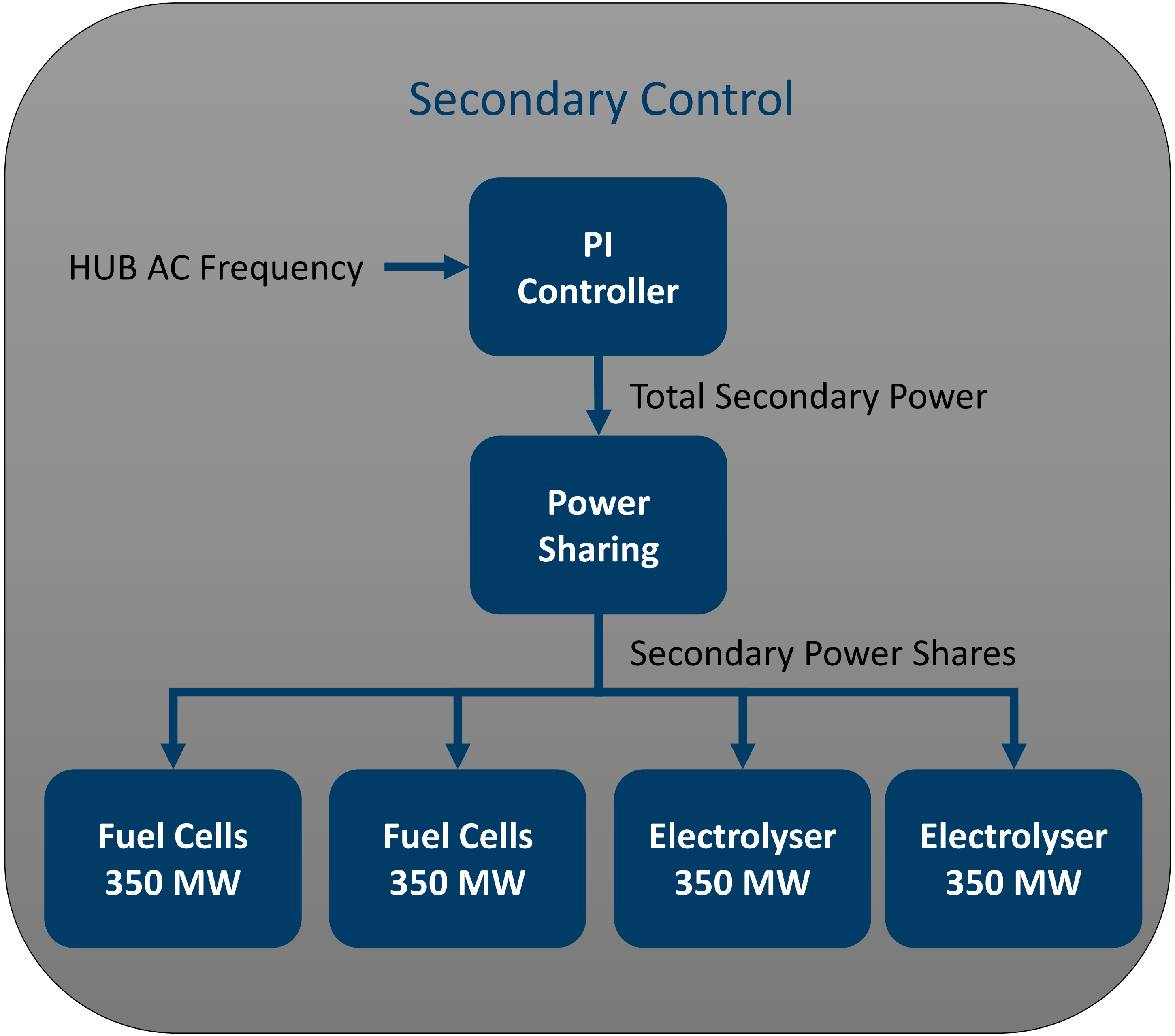


Offshore Grid Forming Hydrogen Hub

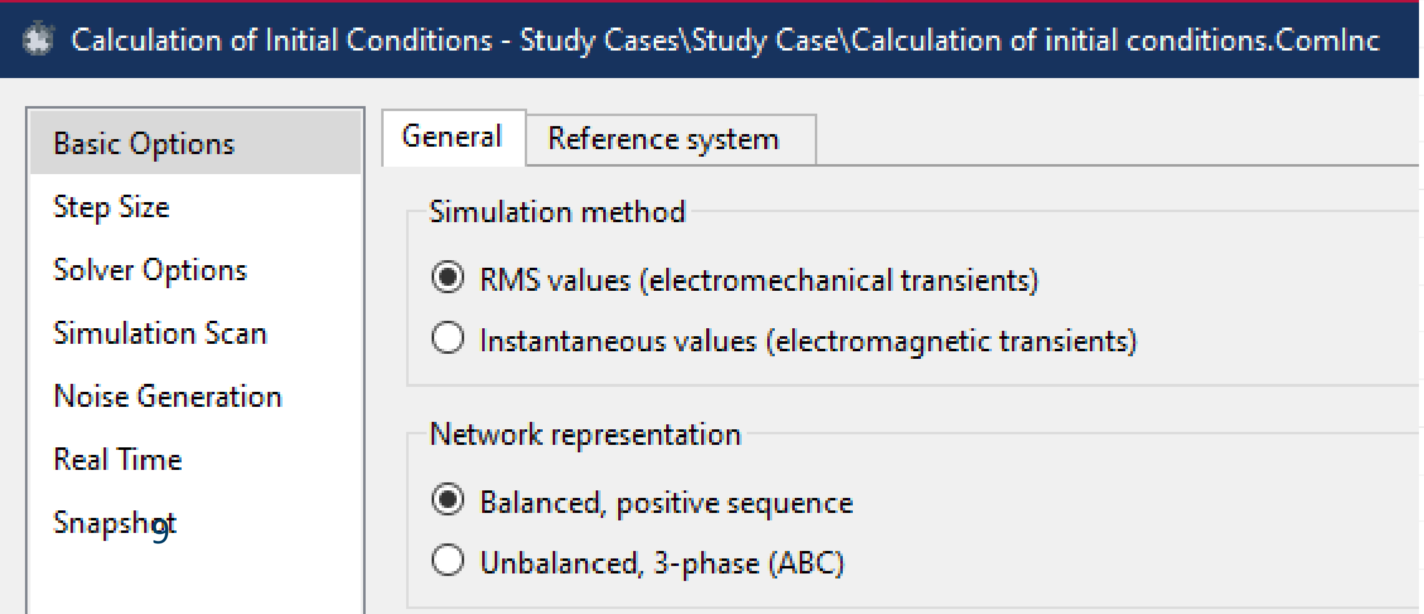


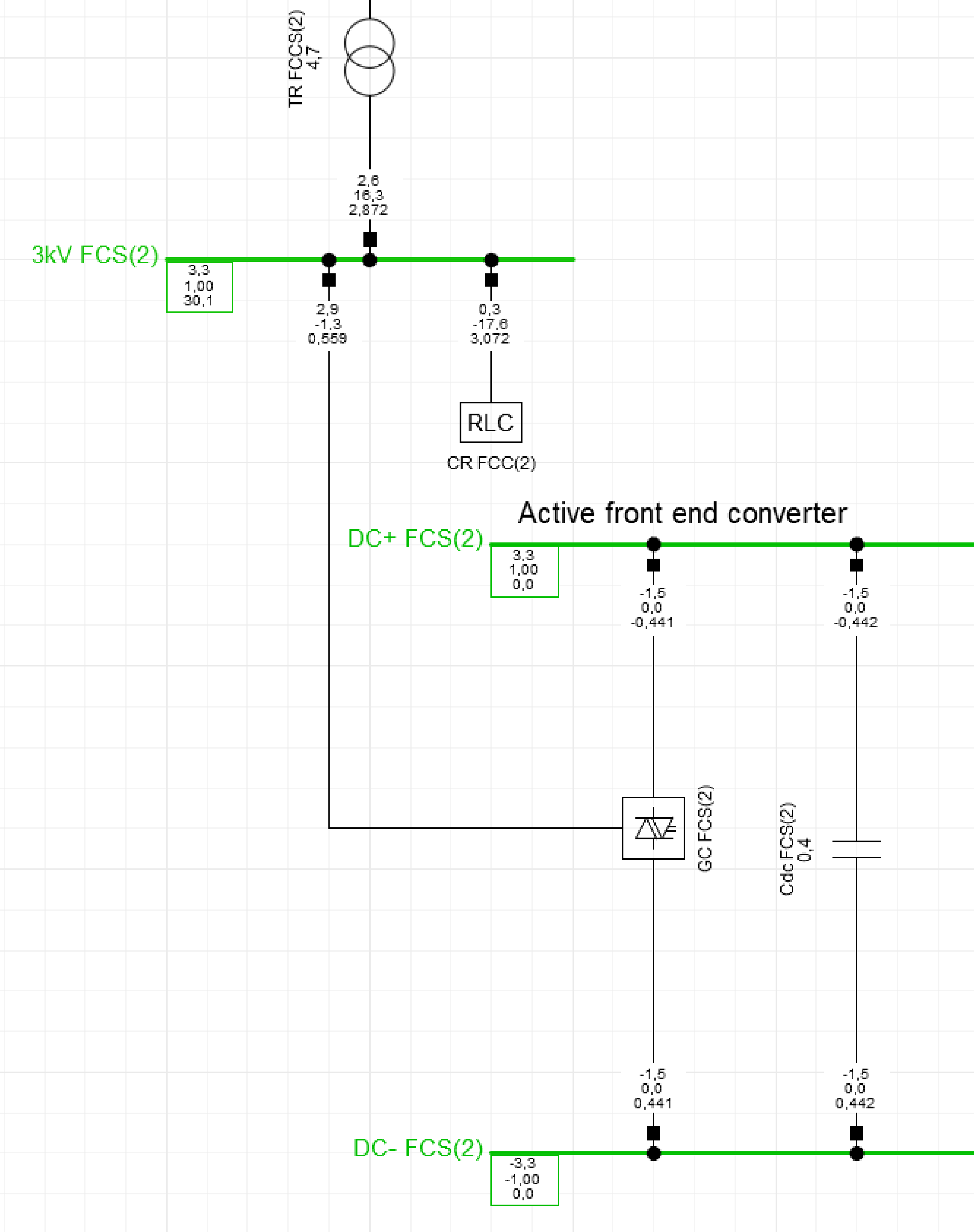
Frequency Control





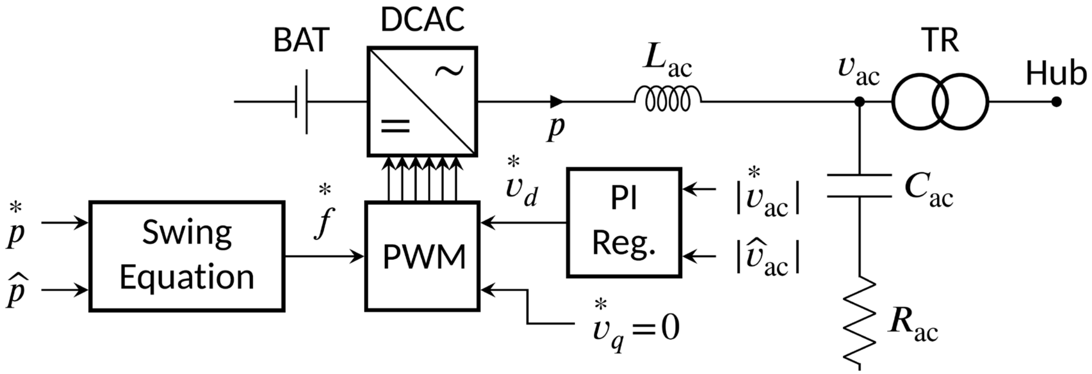

DIgSILENT
POWERFACTORY
PowerFactory 2023

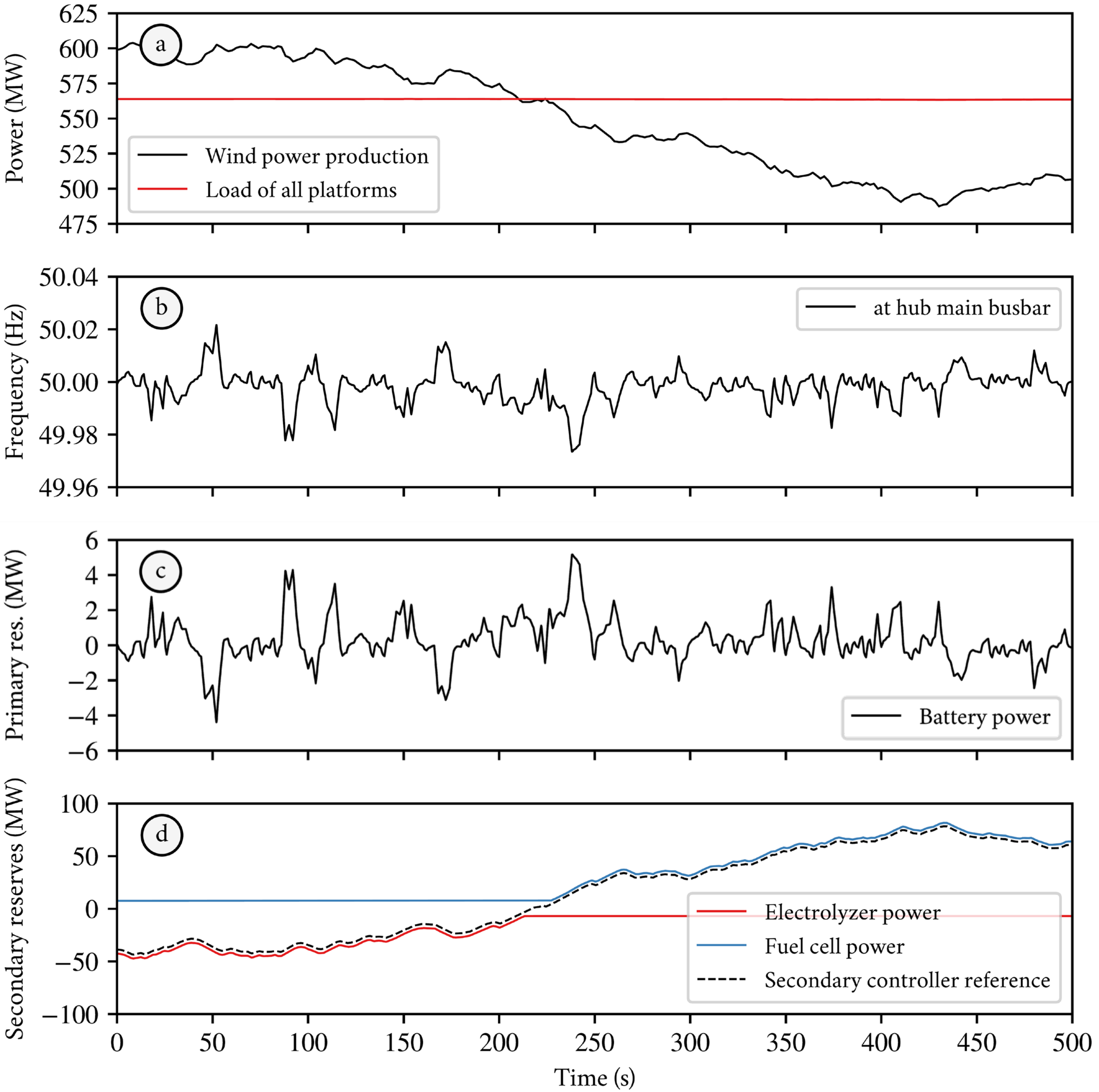

Calculation of Initial Conditions - Study Cases\Study Case\Calculation of initial conditions.ComInc
Basic Options
Step Size
Solver Options
Simulation Scan
Noise Generation
Real Time
Snapshot
General
Reference system
Simulation method
RMS values (electromechanical transients)
Instantaneous values (electromagnetic transients)
Network representation
Balanced, positive sequence
Unbalanced, 3-phase (ABC)


TR FCCS(2)
4,7
2,6
16,3
2,872
3kV FCS(2)
3,3
1,00
30,1
2,9
-1,3
0,559
0,3
-17,6
3,072
RLC
CR FCC(2)
Active front end converter
DC+ FCS(2)
3,3
1,00
0,0
-1,5
0,0
-0,441
-1,5
0,0
-0,442
GC FCS(2)
Cdc FCS(2)
0,4
-1,5
0,0
0,441
-1,5
0,0
0,442
DC- FCS(2)
-3,3
-1,00
0,0

Primary Frequency Controller

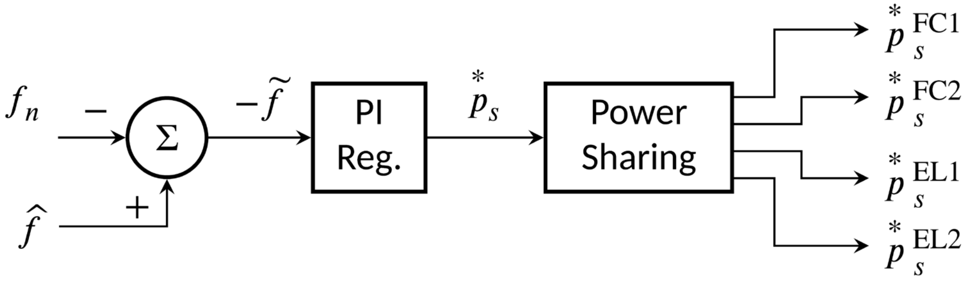
- Grid Forming Battery System
- Virtual Synchronous Machine
  - Proportional response to frequency variations
- Always active

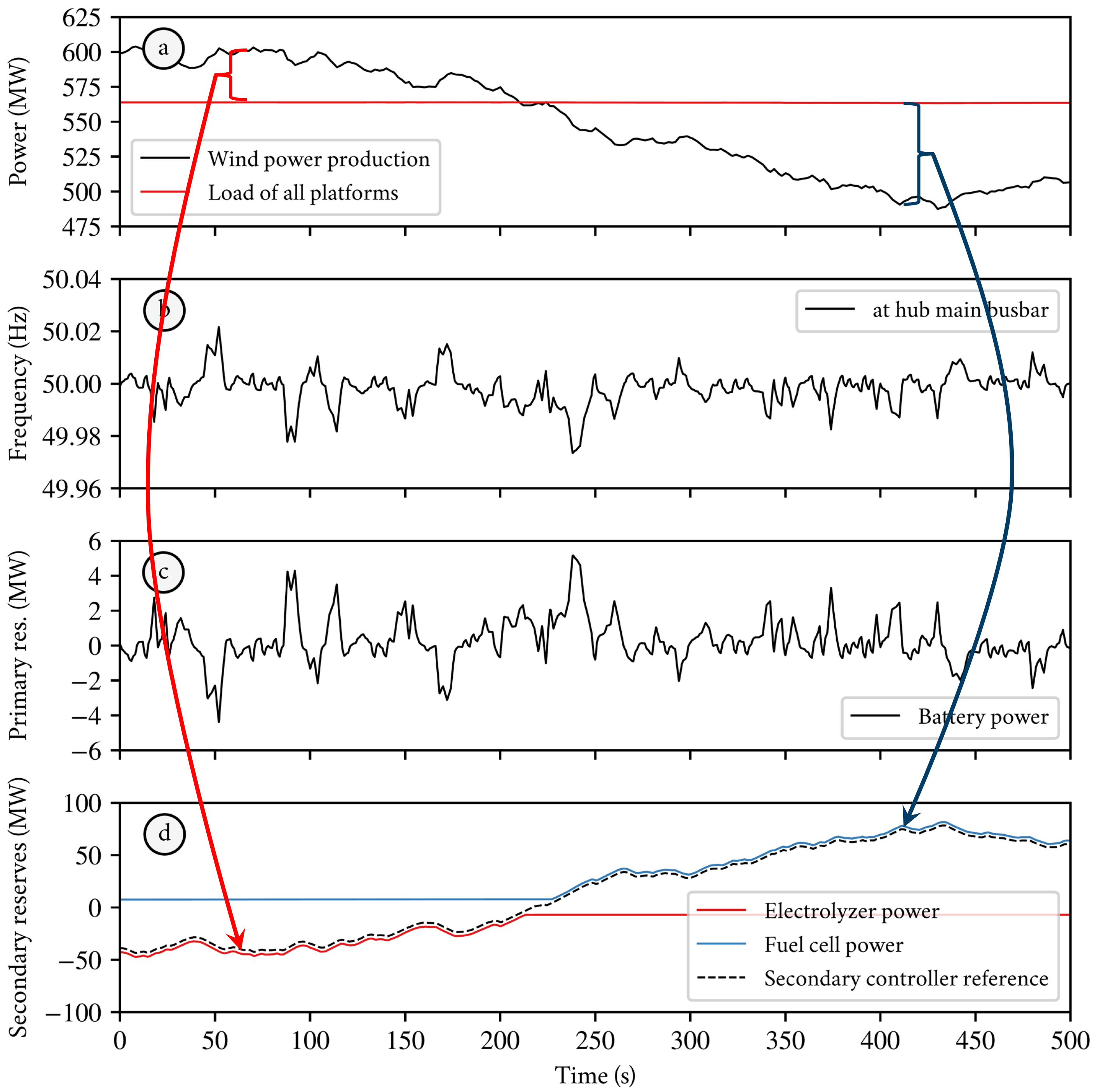




Secondary Frequency Controller

- Centralized PI controller
- Secondary Power Setpoint
- Power Setpoint Sharing
- Always active

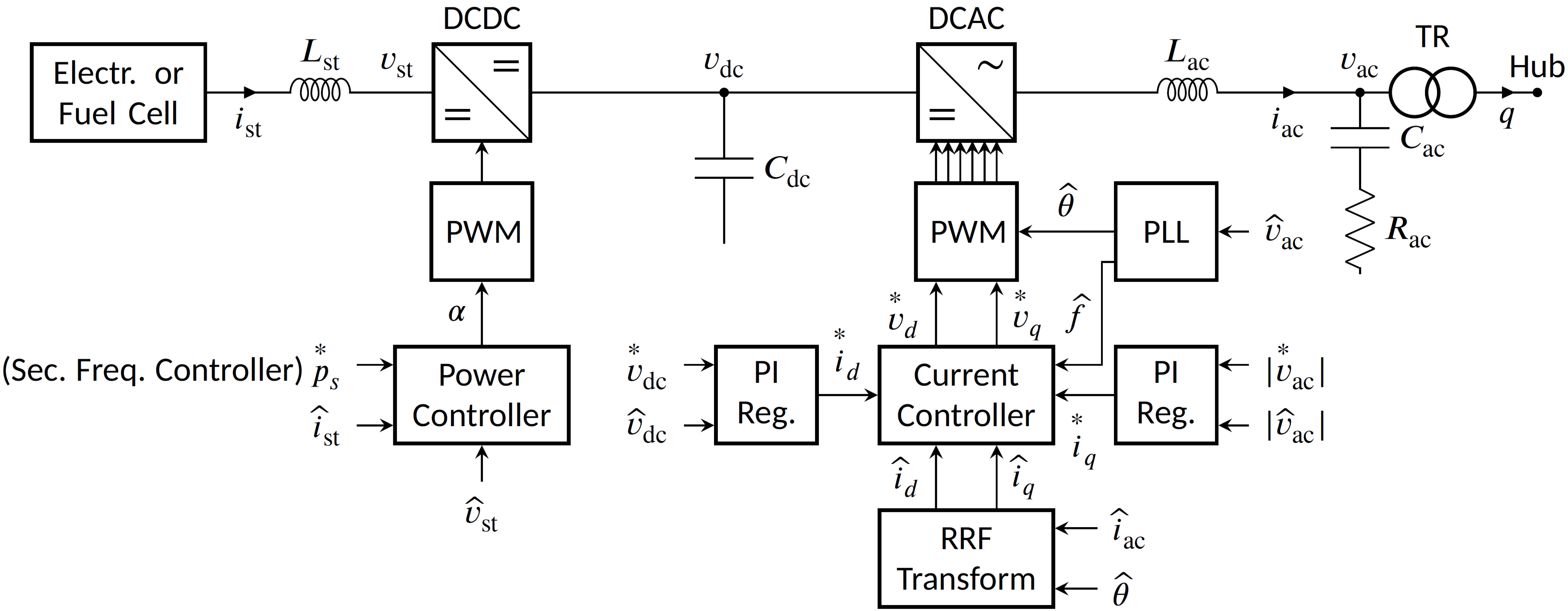




Secondary Frequency Reserves

Table 1. PI regulators of the DCAC converters of the energy storage devices.

DCAC converter	Voltage (v_{ac})	Voltage (v_{dc})
Battery (100 MW)	Active	Not present
Fuel cell block 1 (350 MW)	Active	Active
Fuel cell block 2 (350 MW)	Active	Active
Electrolyser 1 (350 MW)	Disabled	Active
Electrolyser 2 (350 MW)	Disabled	Active

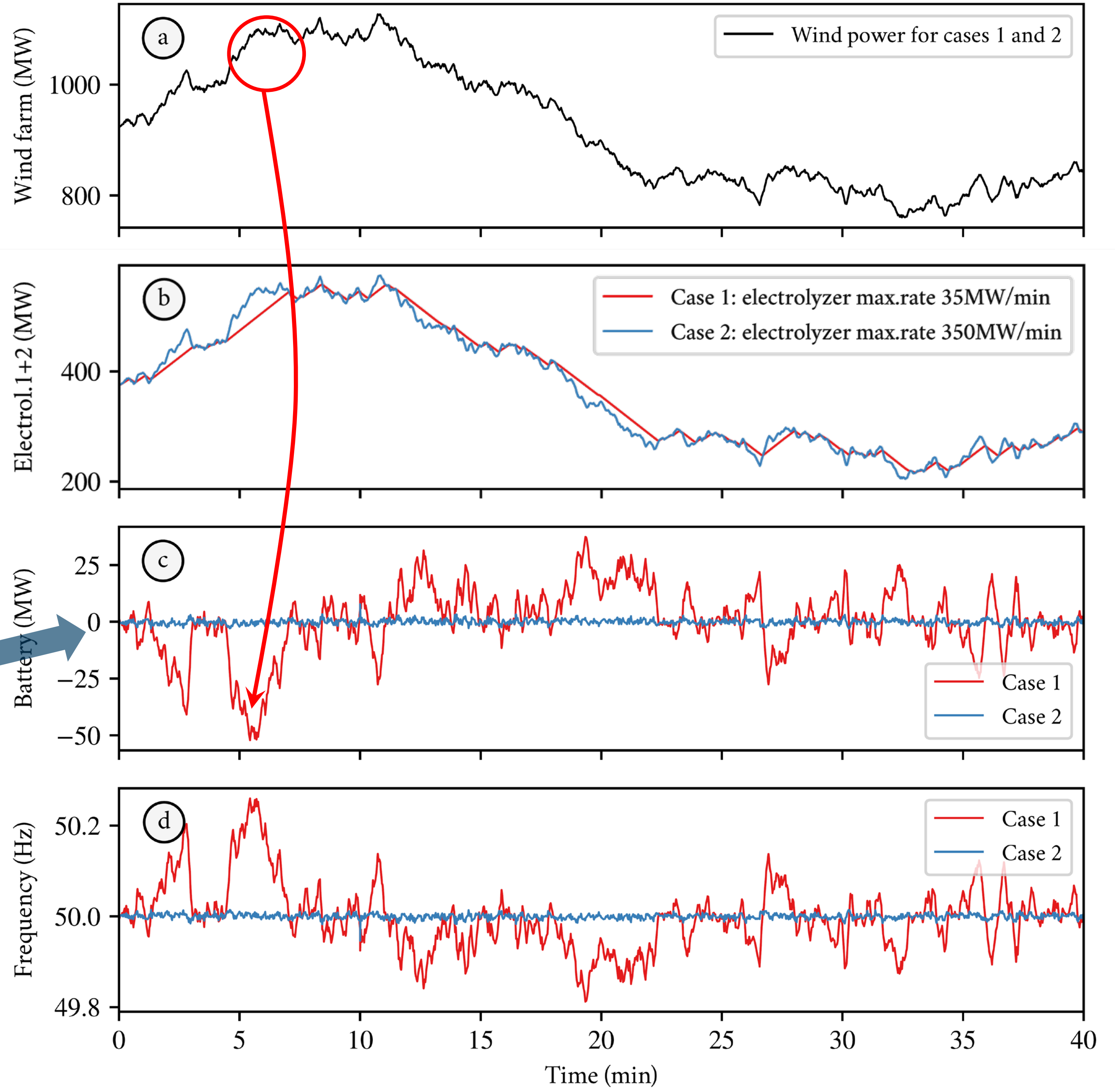


Power Ramping vs Sizing BESS

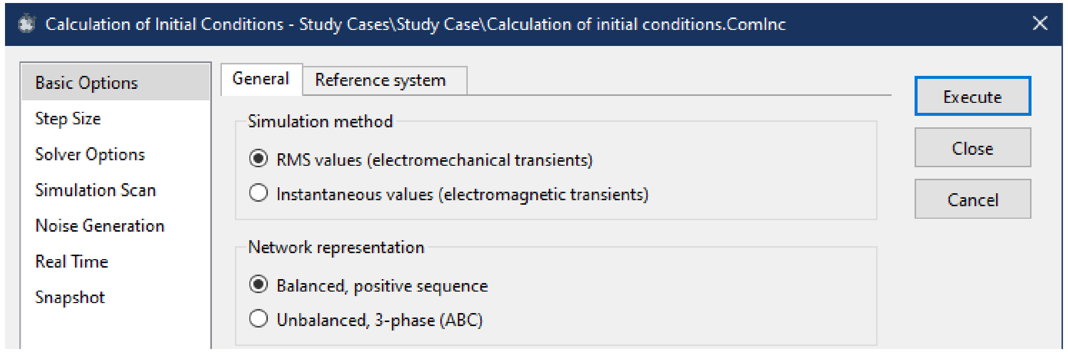
Secondary Reserves
Maximum Ramping Rates

- Case 1
  - Max 35 MW/min
- Case 2
  - Max 350 MW/min

Easier life for the batteries



Fast Transients



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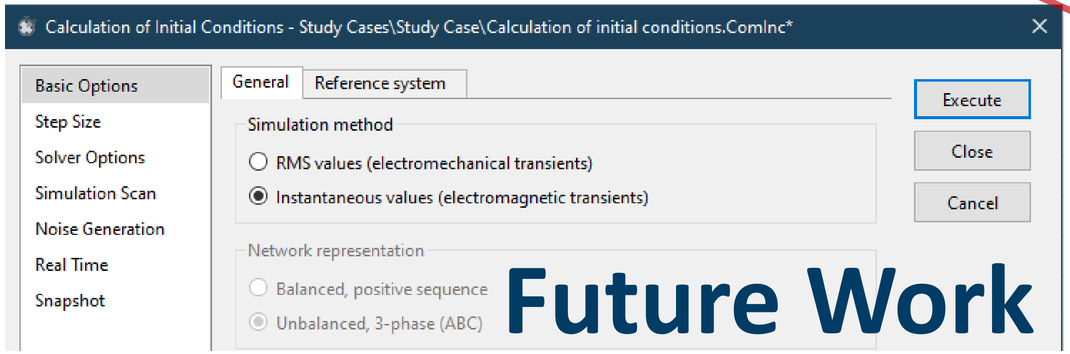
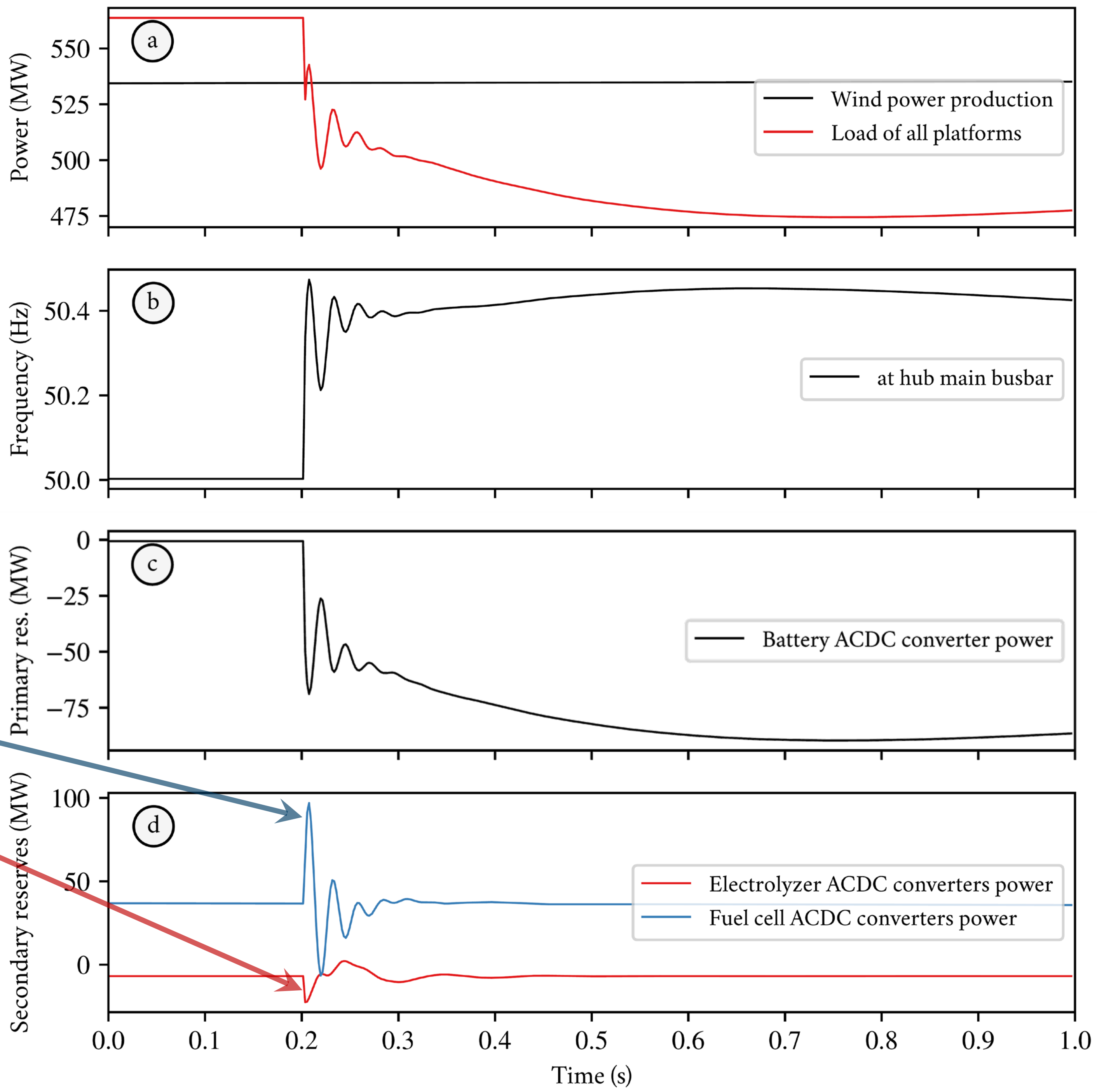


Future Work



SINTEF

Thank you!

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Energy Systems

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Technology for a better society