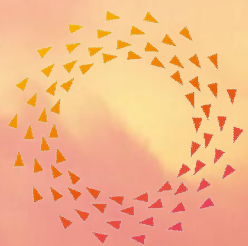


# MODELLING OF 100 % RENEWABLE ELECTRIC GRIDS - CASE ÅLAND -

**Pasi Peltoniemi**  
**LUT**

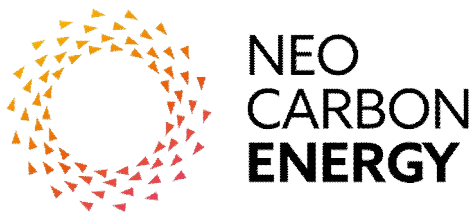


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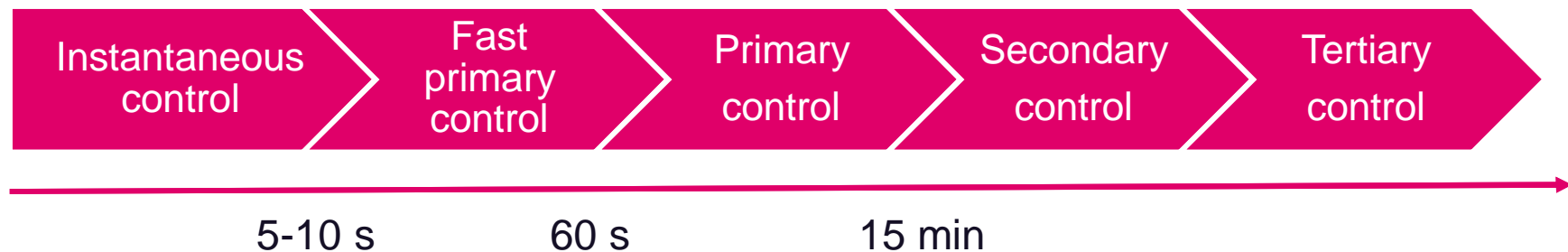
Researchers' Seminar, 29.-30. August 2016, Lappeenranta

# Introduction

- PtG grid interfacing technologies
    - Commonly used power converter types for electrolyser
  - Frequency control using PtG plants
    - Dynamic response to comply with frequency control in electric grids
  - Inertia in grids including high shares of renewables
- 
- In 100 % RE grids where energy is mostly produced with wind and solar, depending on the technology applied, majority of power plants are connected to grid via power electronic (PE) converter
    - Units connected through PE unit don't naturally respond to frequency variations in the grid
    - Worst-case scenario: every power plant is connected to the grid via PE unit -> there is no inertia ( $H=0$ )



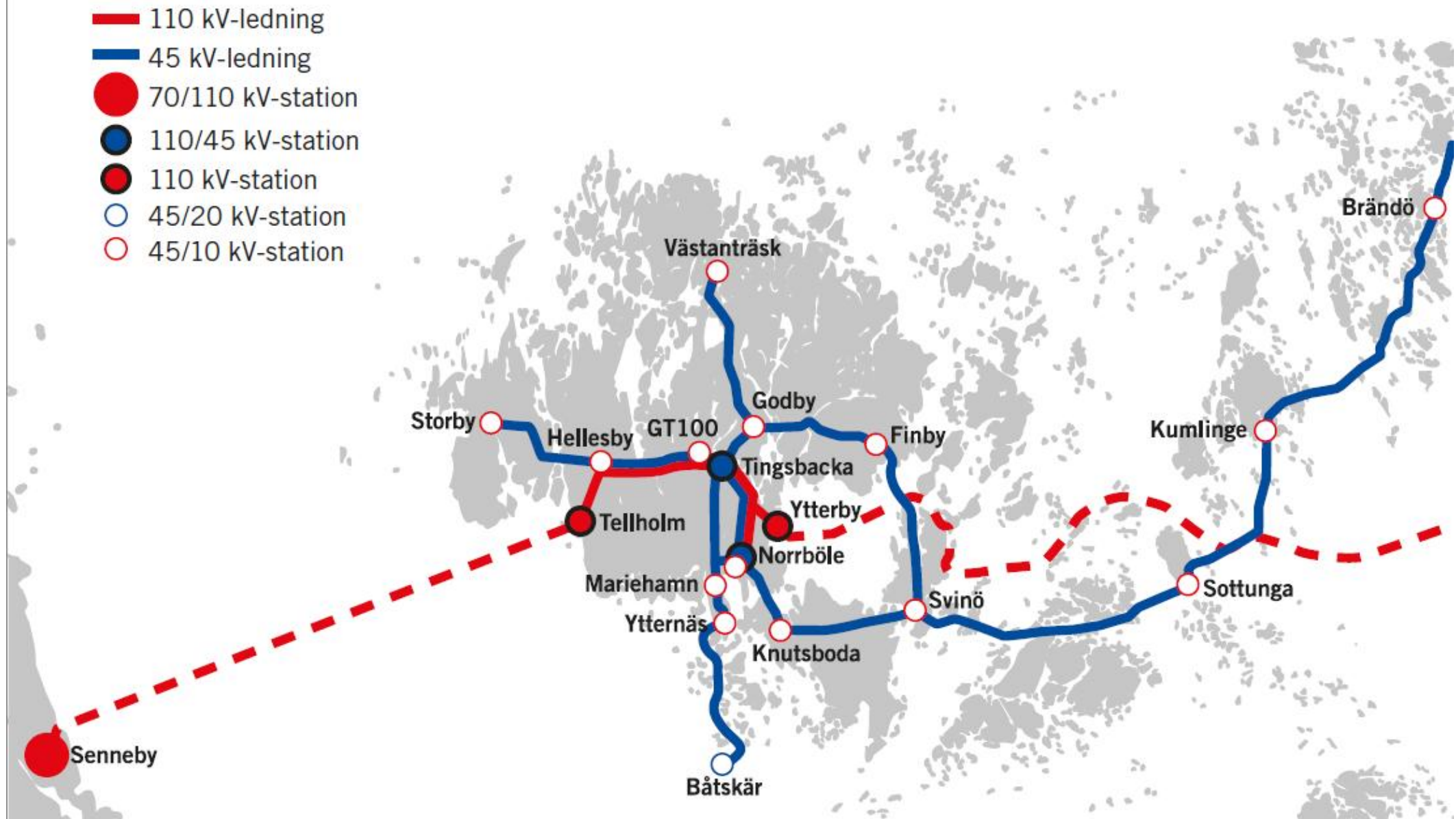
# Frequency control in 100 % RE grids



- Instantaneous control: synthetic inertia, frequency-dependent loads
- Fast primary control: BESS, PtX (if fast enough)
- Primary, secondary, tertiary controls: PtX plants, flexible loads, other power plants
- **This is tested with 100% renewable åland network model**

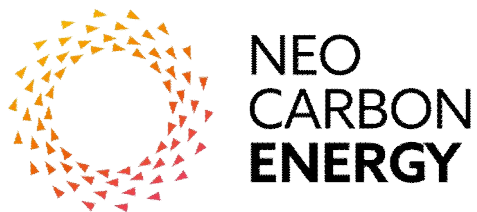
# Åland's electric grid with main land connections

Source : Kraftnät Åland ([http://www.kraftnat.ax/files/kraftnataland\\_arsredovisning2015\\_uppslag\\_3.pdf](http://www.kraftnat.ax/files/kraftnataland_arsredovisning2015_uppslag_3.pdf))



# Åland's electric grid with main land connections

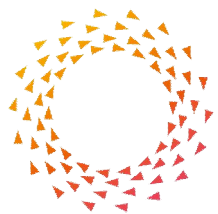
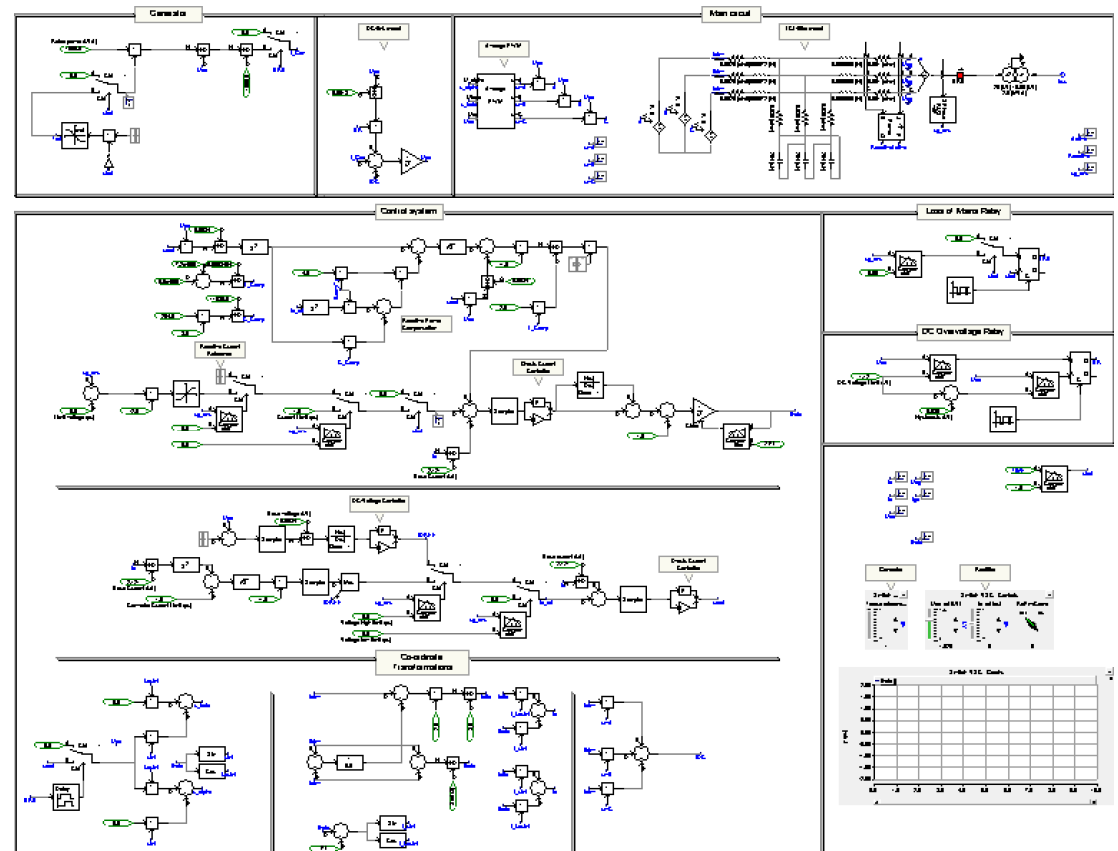
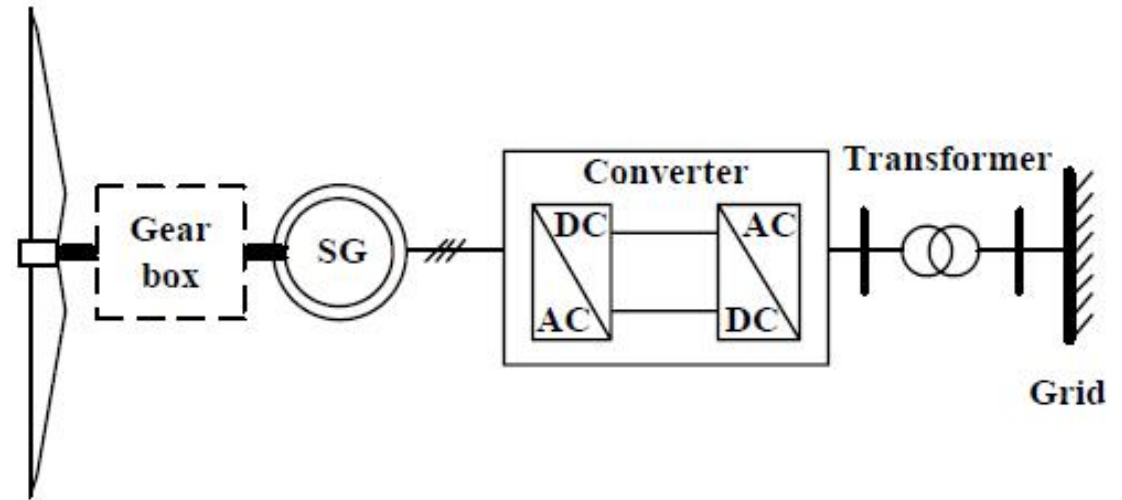
- Built submodels
  - Wind power plant
  - Solar power plant
  - Power-to-X plant
  - Battery energy storage system (EV)
  - Connections to Finland and Sweden
  - Loads



# Åland's electric grid

## - Wind power plant -

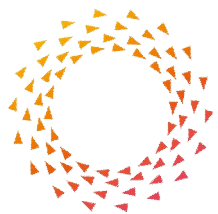
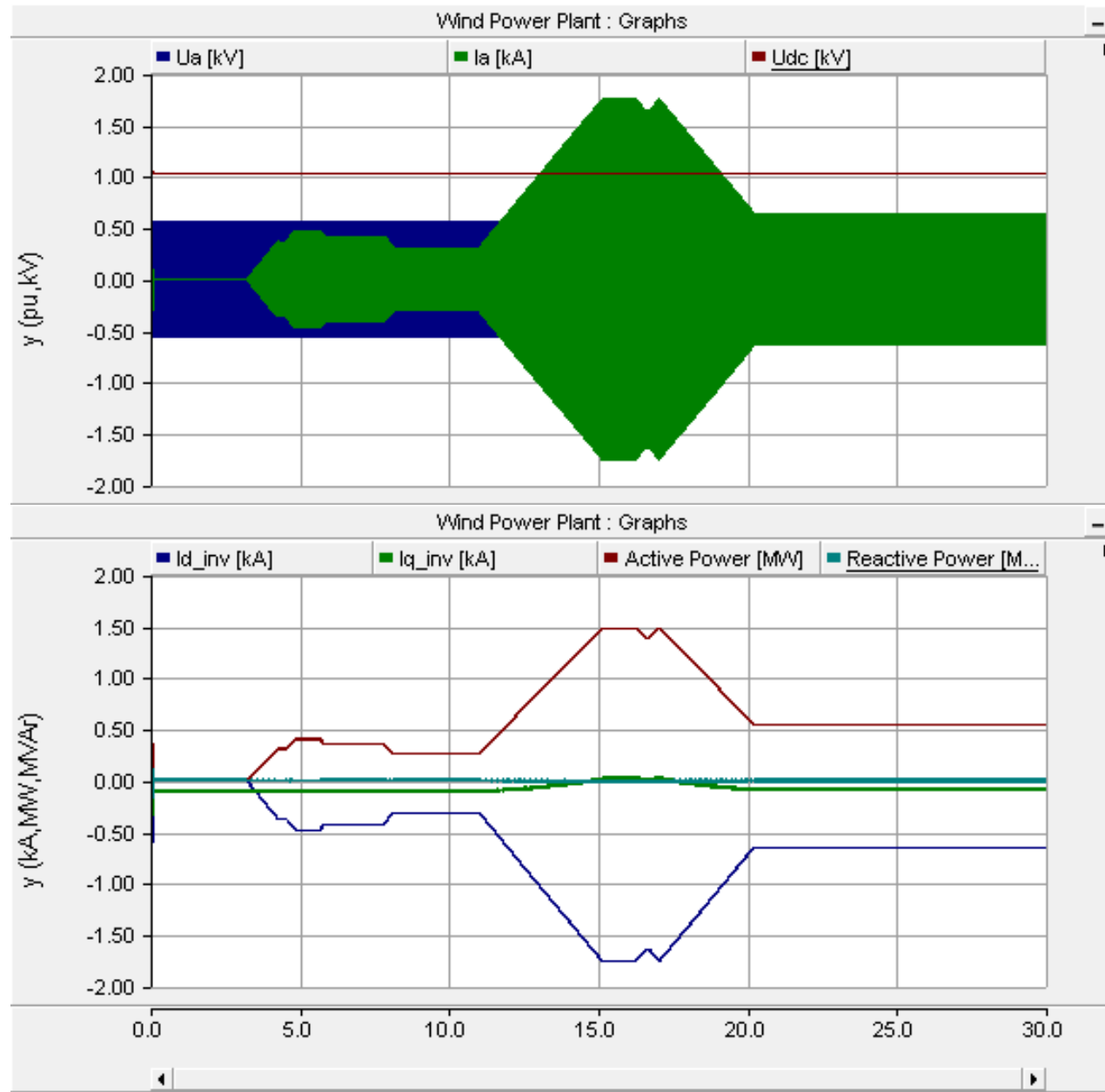
- Full power converter WPP
- Features
  - Reactive power control
  - Synthetic inertia operation



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# Åland's electric grid

## - Wind power plant -

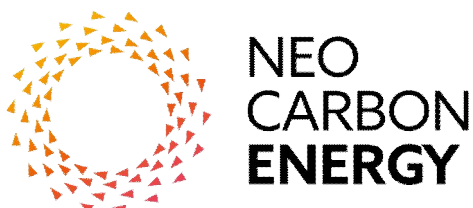
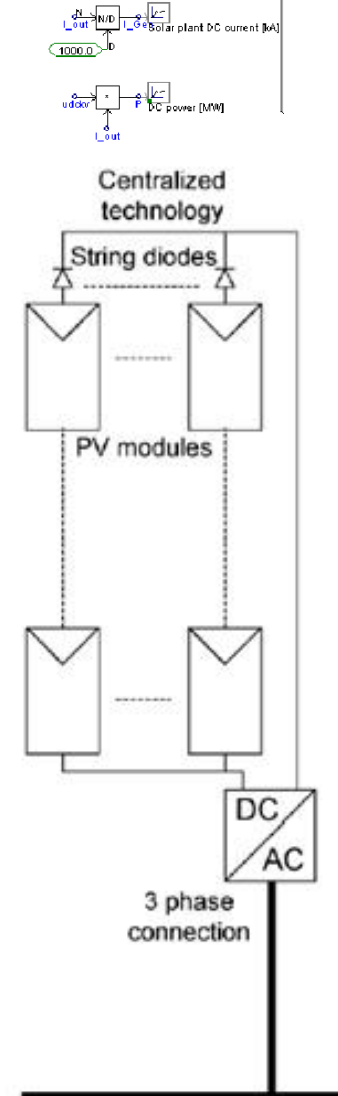
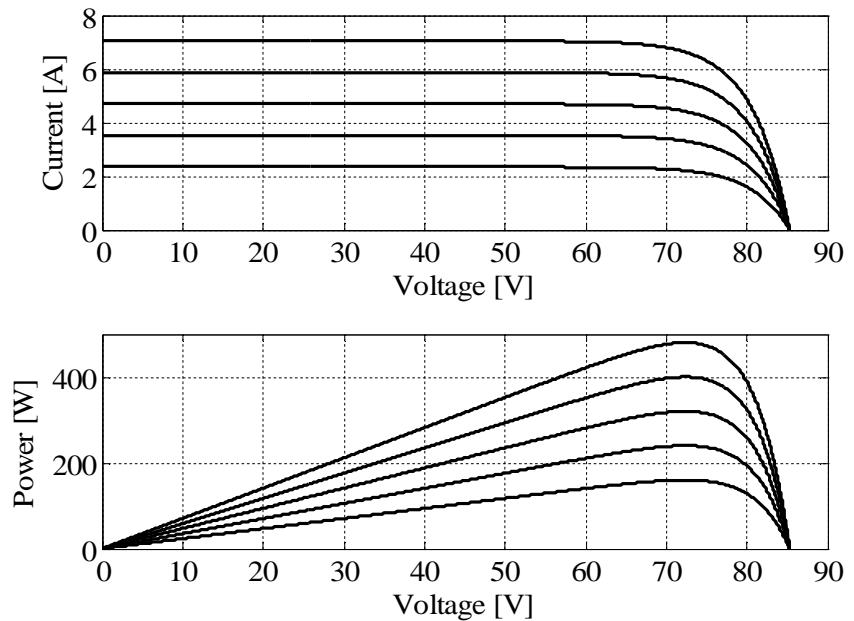
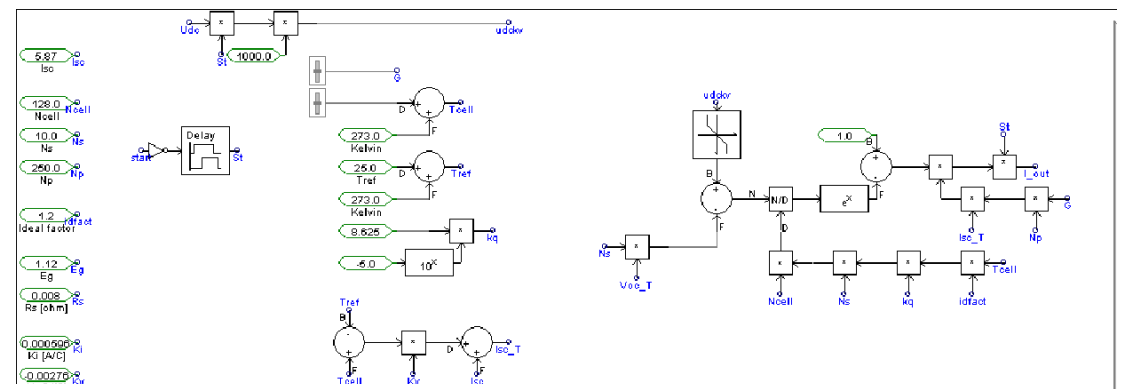


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# Åland's electric grid

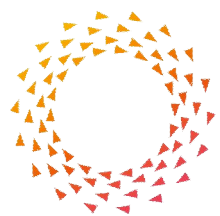
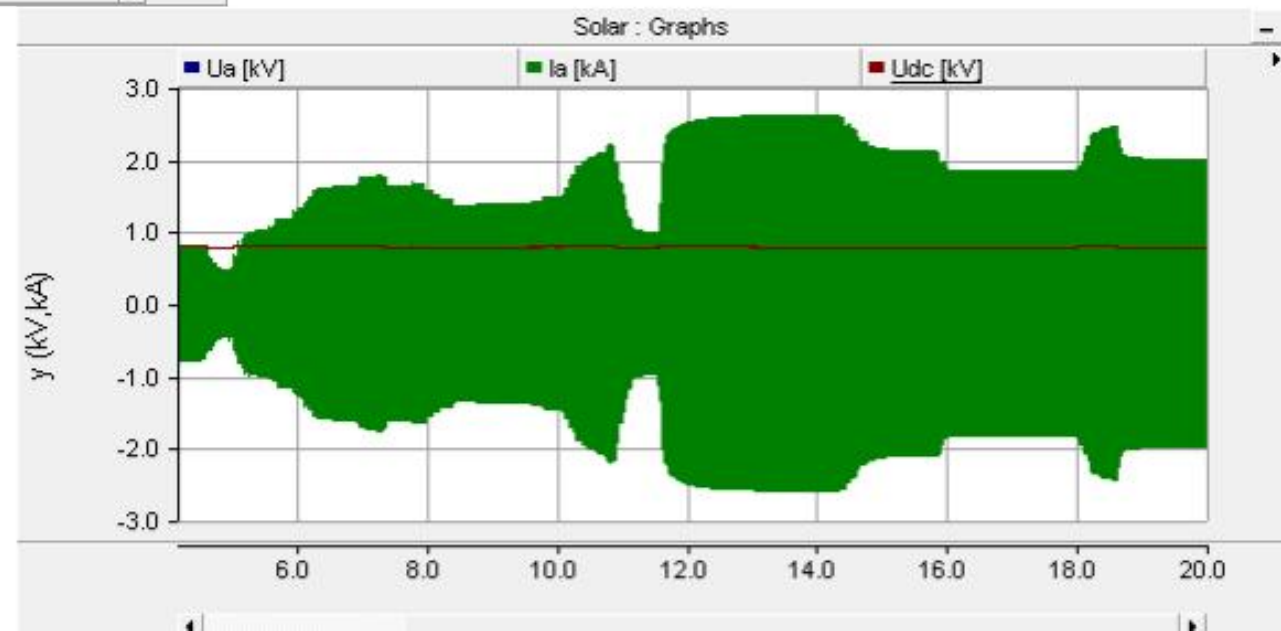
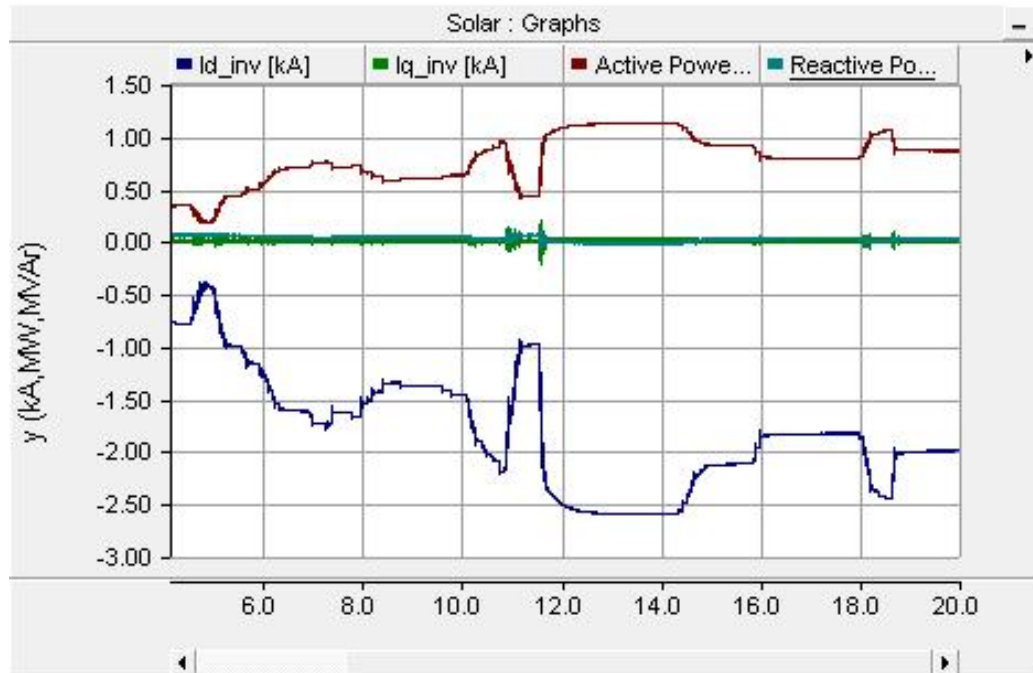
## - Solar power plant -

- Centralized structure SPP using full power converter
- Features
  - Synthetic inertia operation
  - Reactive power control
  - Fault-ride-through
  - Maximum power point tracking (MPPT)
  - Manufacturer based panel data can be used to specify the panels





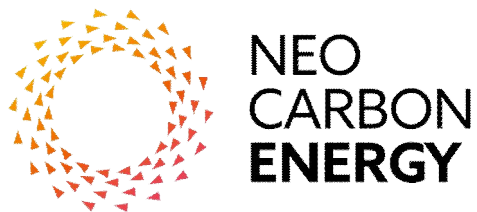
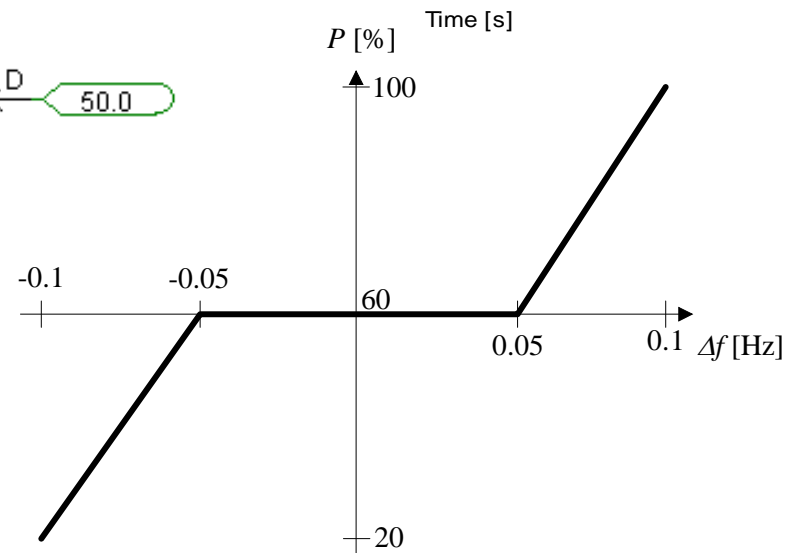
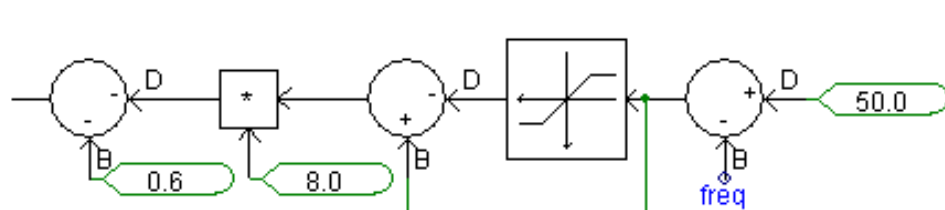
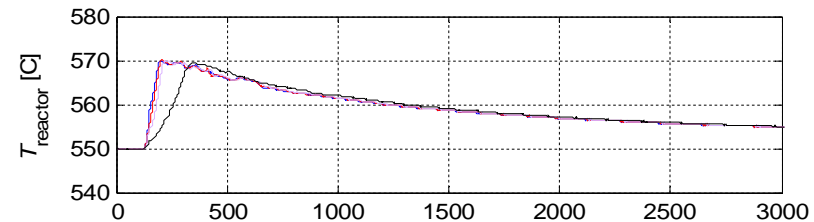
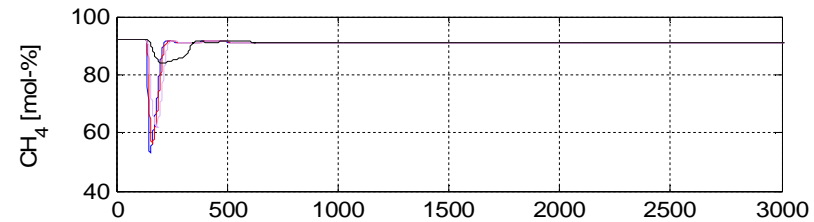
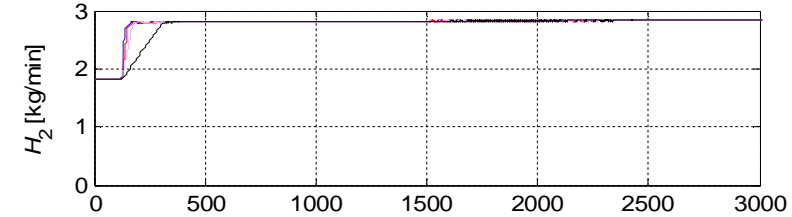
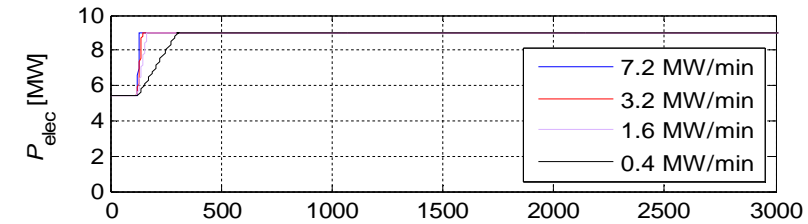
# Åland's electric grid -Solar power plant -



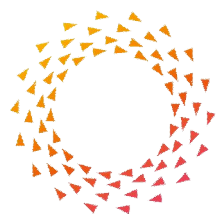
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# Åland's electric grid - PtX plant -

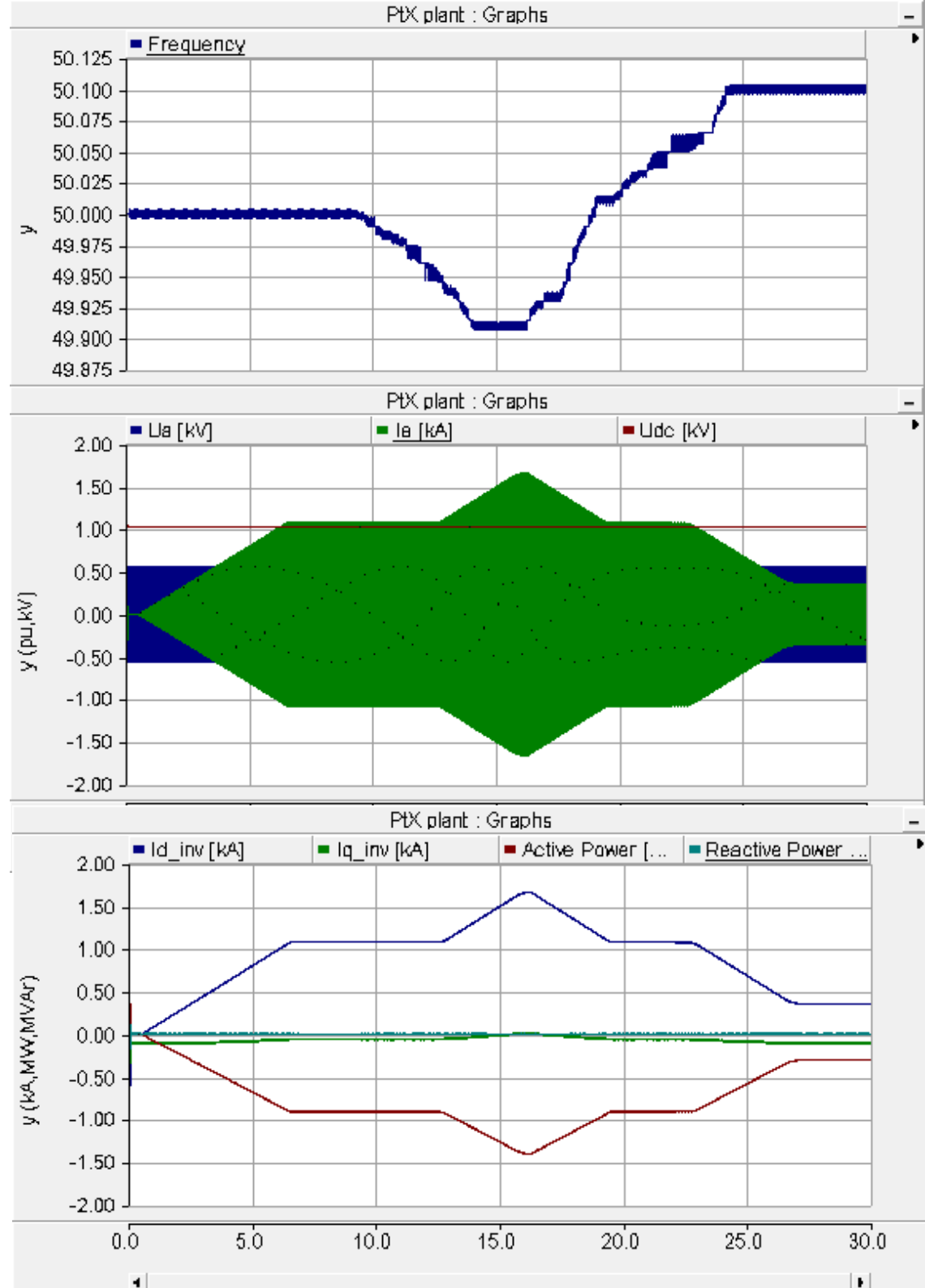
- 1.5 MW PtX plant
  - Can be used to connect in parallel e.g. 9 MW plant consisting of 6 parallel connected 1.5 MW electrolysers
- Features
  - Adjustable plant dynamics
  - Frequency control operation



# Åland's electric grid - PtX plant -



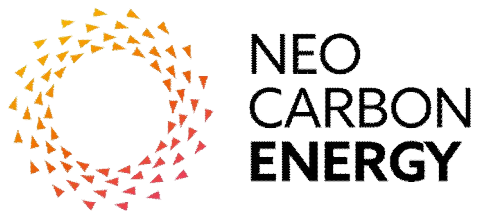
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# Åland's electric grid

## - BESS -

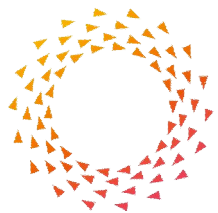
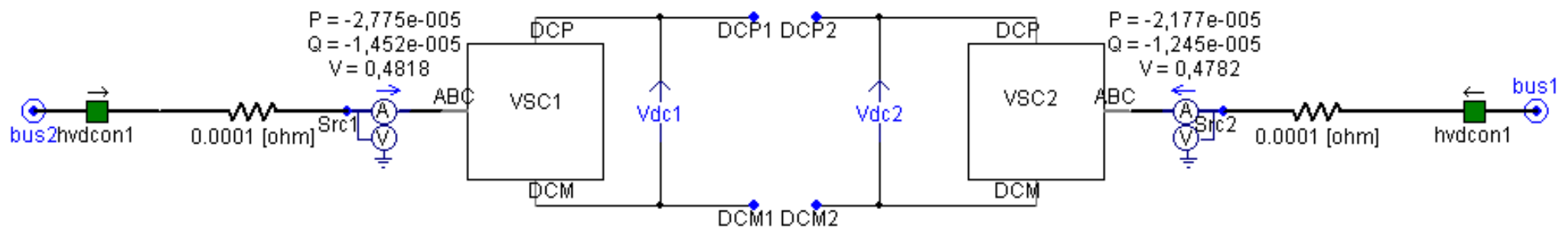
- Grid forming controls
  - Voltage controlled plant
- Grid supporting controls
  - Reactive power control
  - Frequency support
- Features
  - Adjustable plant dynamics
  - Battery chemistry not considered



# Åland's electric grid

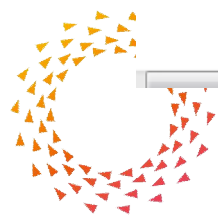
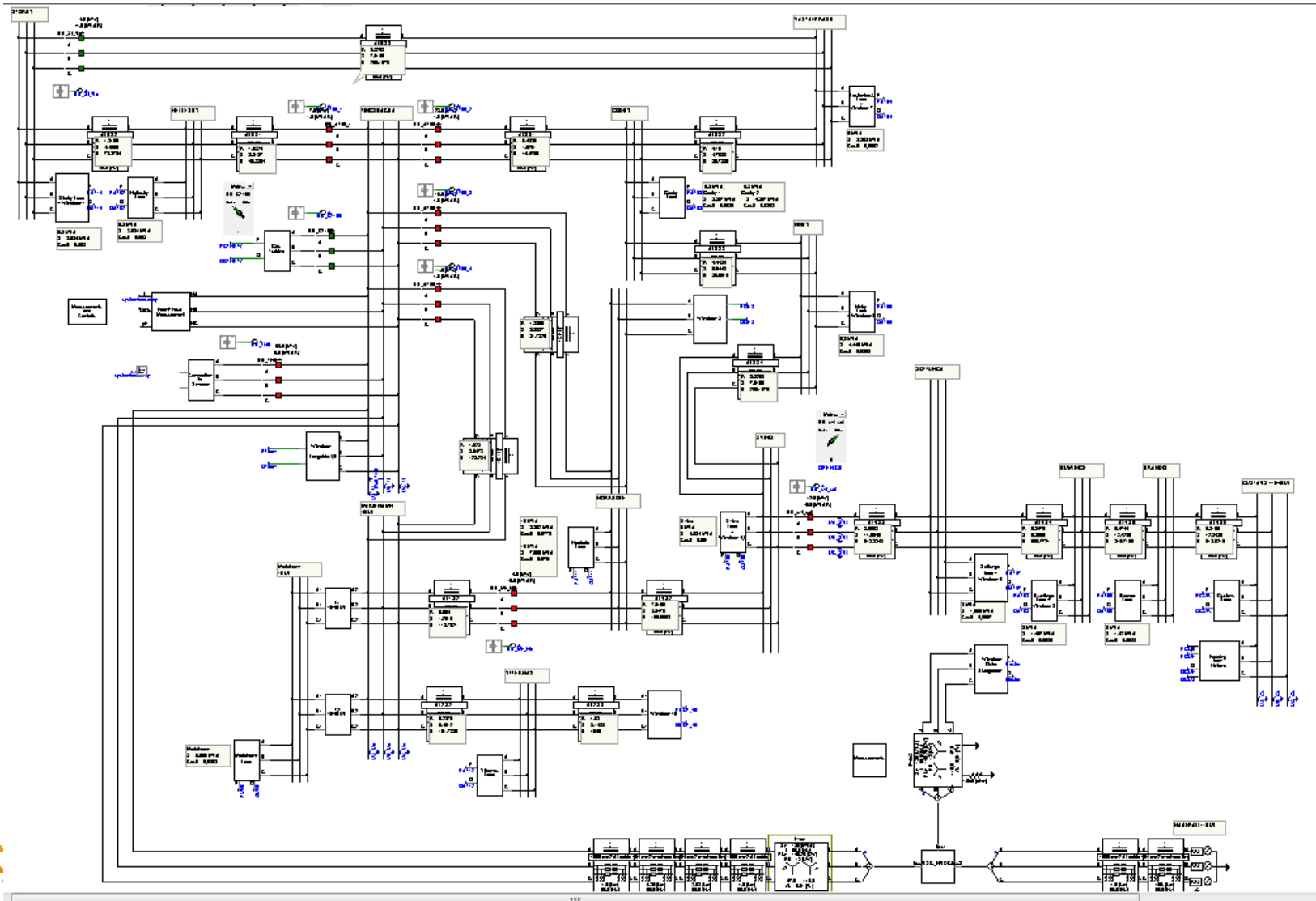
## - HVDC link -

- From Naantali to Ytterby
  - 80 kV DC
  - Other end controls DC voltage and other just transfers power
  - The converter transferring the power can perform synthetic inertia functions
- Grid supporting controls
  - Reactive power control
  - Frequency support



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# Åland's electric grid



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NEO-CARBON Energy project is one of the Tekes strategy research openings and the project is carried out in cooperation with Technical Research Centre of Finland VTT Ltd, Lappeenranta University of Technology LUT and University of Turku, Finland Futures Research Centre.