Grid Integration of Wind Energy in the Western Cape – Results of Feasibility Studies

ESKOM/DIgSILENT/GTZ – 24.07.2009

Grid Integration of Wind Energy in Western Cape: General Scope of Work

- Stage 1: Wind farm connection to a subtransmission grid
  - Identify potential issues and mitigation options
  - Example: Connection of 150MW wind farm at Laingsburg to 132kV grid

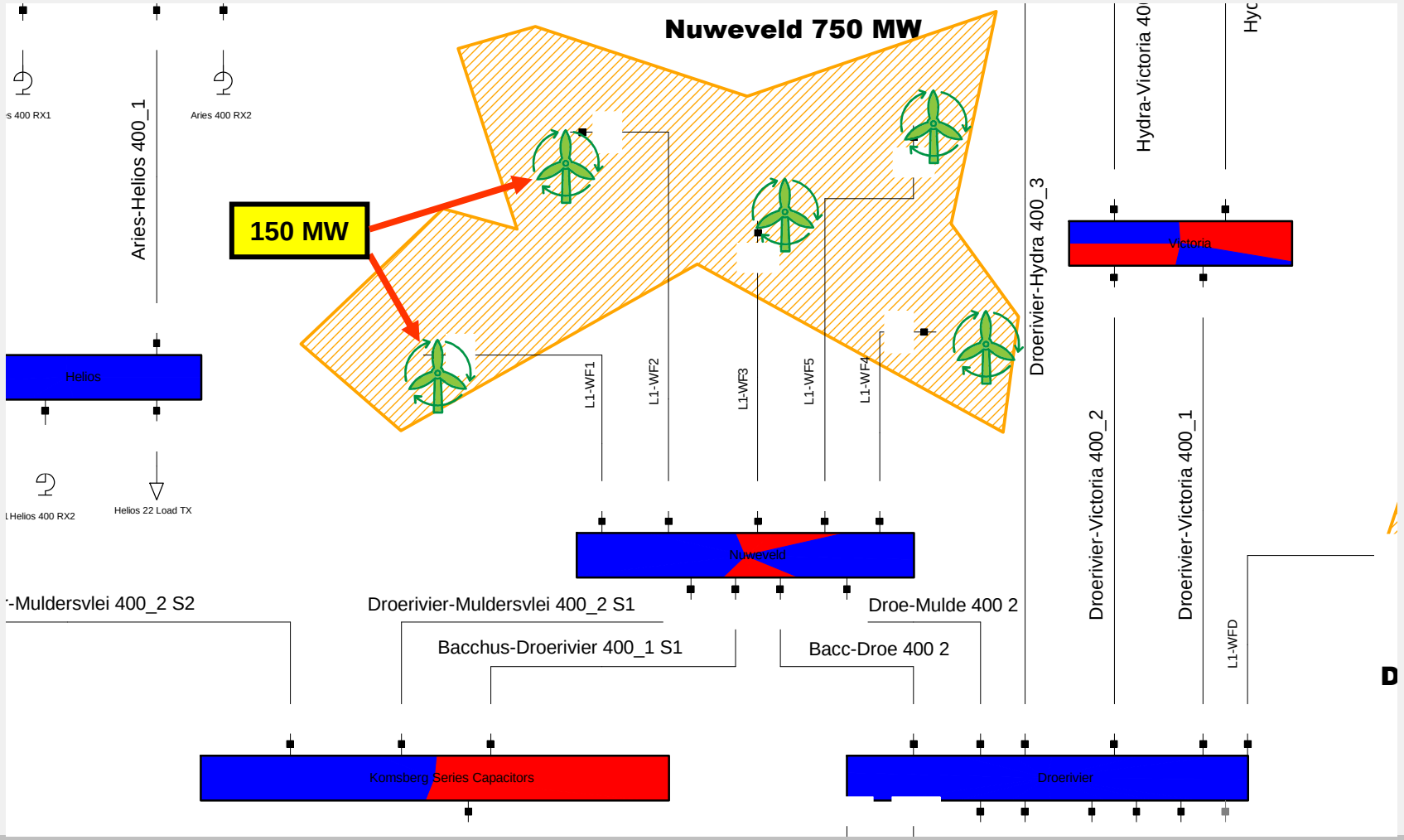
- Stage 2: Wind farm connection to the transmission grid
  - Identify potential issues and mitigation options
  - Example: Connection of 750MW of wind farms in Karoo area to the 400kV grid

- Stage 3: Study the impact of all wind farms in the Western Cape, for which applications exist (2796MW in total), on the existing ESKOM transmission system (400kV/765kV network).
  - High level feasibility studies for the integration of up to 2800MW of wind generation into the Western Cape.
  - Analyse the impact of wind generation on the transmission system

Stage 2: Example for the Integration of a 750MW Wind Farm

Stage 2 – 750MW of Wind Generation in Karoo Area

Connection to the 400kV grid:



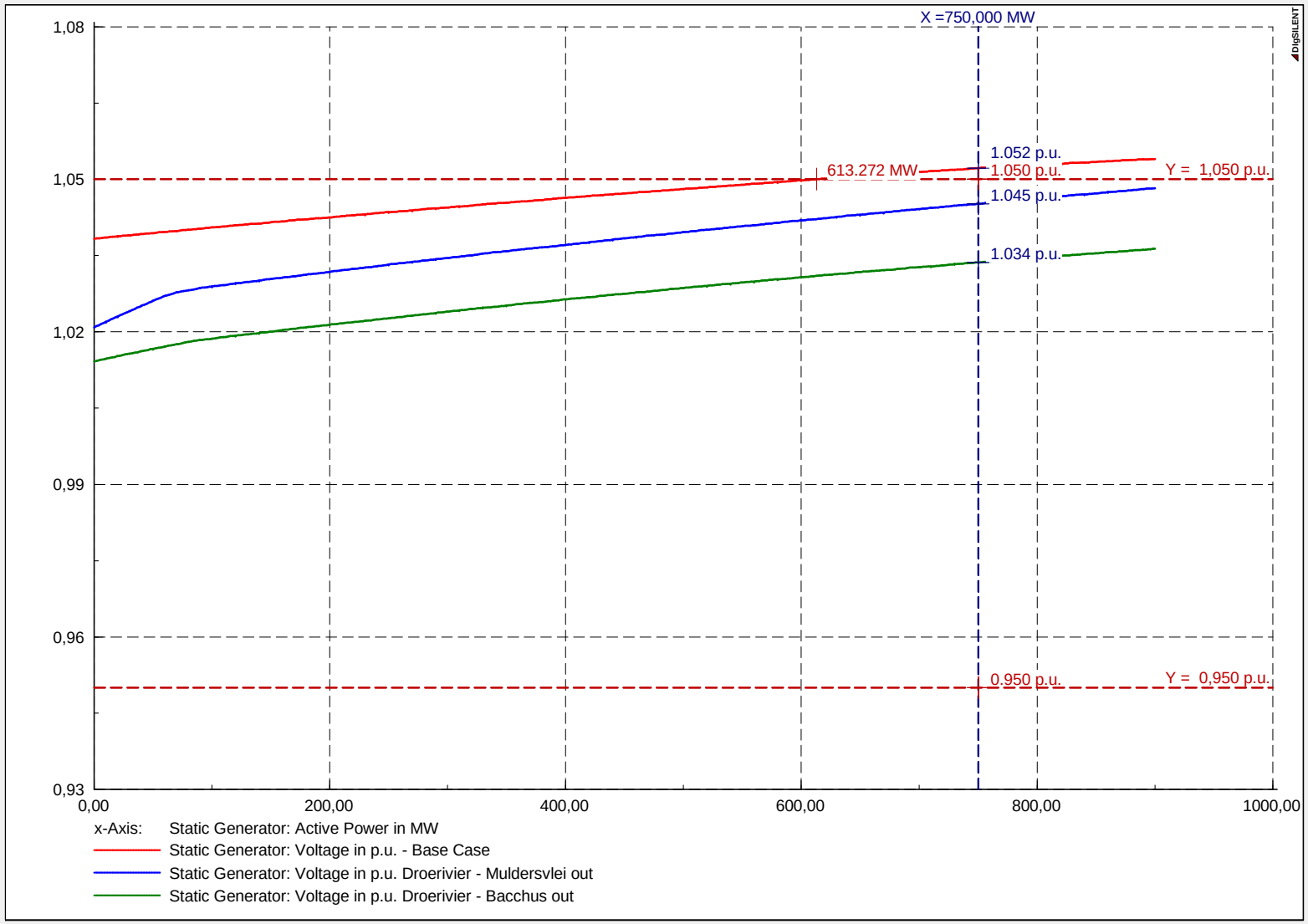
Stage 2 – 750MW – Scenarios for Studies

- System 2009 (without new 765kV running into the Cape)

- Analysed cases:
  - High load, 1Koeberg units in
  - High load, 2 Koeberg units in
  - Low load, 1 Koeberg unit in
  - Low load, 2 Koeberg units in

- Generation Balancing/High Wind:
  - Reduction of Gas Turbine Generators (running in SCO mode where possible)
  - Reduction of pump storage generation at Palmiet
  - Reduction of coal power plants outside the Cape

Stage 2 – 750MW of wind capacity in Karoo area - Voltages



Stage 2 – 750MW – Summary of Results

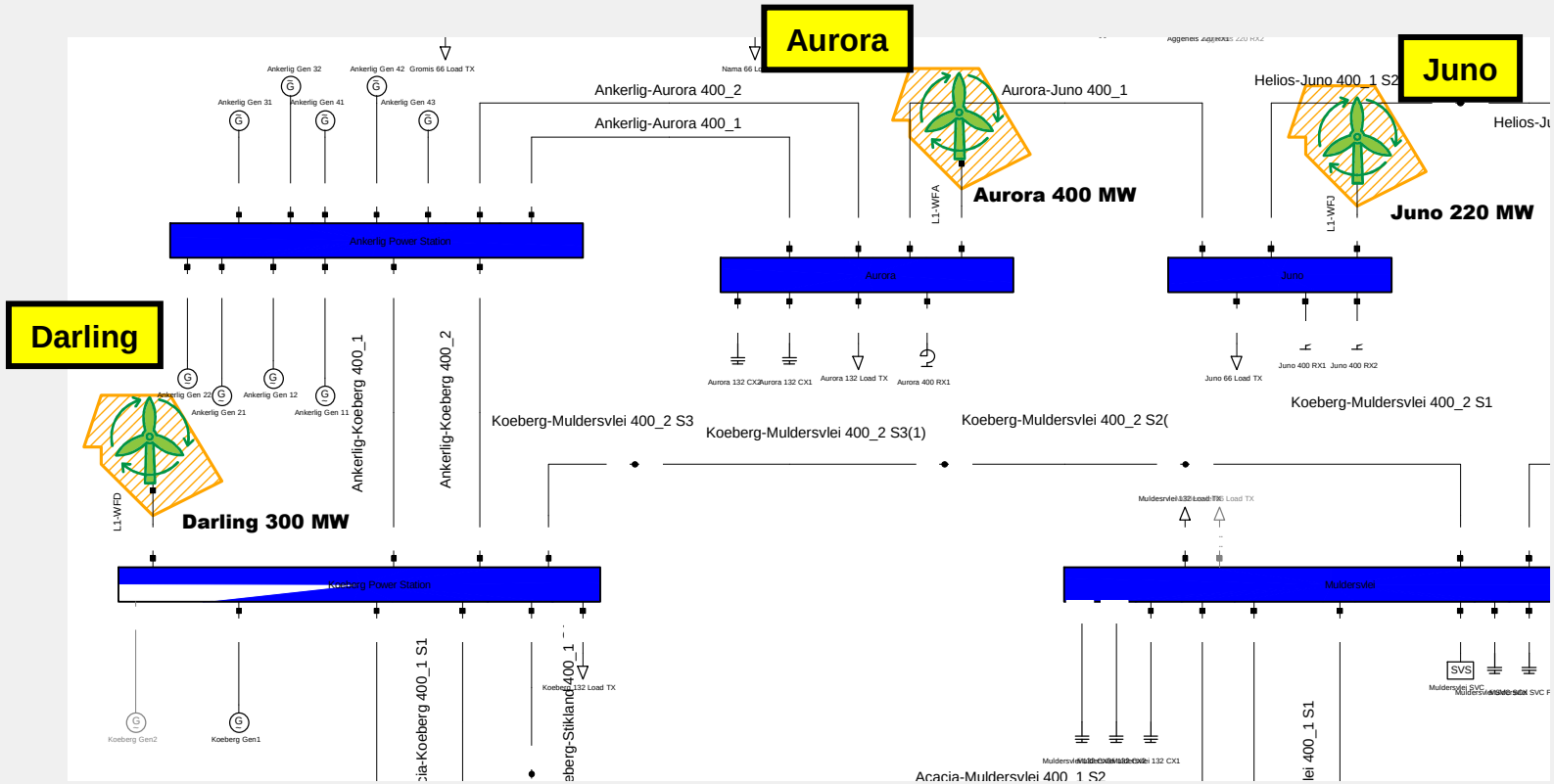
- No thermal overloads under n-1 conditions
- Voltage variations very small, even in constant power factor operation.
- Operation with constant Q (var-control) is appropriate. (Slow) voltage control is possible and should be considered.
- 4x100Mvar shunt reactors required at Nuveweld substation (or equivalent var-absorption of the wind farms) because of proximity to Komsberg series compensation.
- Series compensation at Komsberg should be resized for considering new line configuration.
- With adjusted series compensation, shunt reactors at Nuveweld might not be required.
- No power quality issues because of the large number of turbines and high fault level at the grid connnection point

Stage 3: Feasibility Studies for the Integration of up to 2800MW of Wind Generation in the Western Cape into the ESKOM Transmission Grid

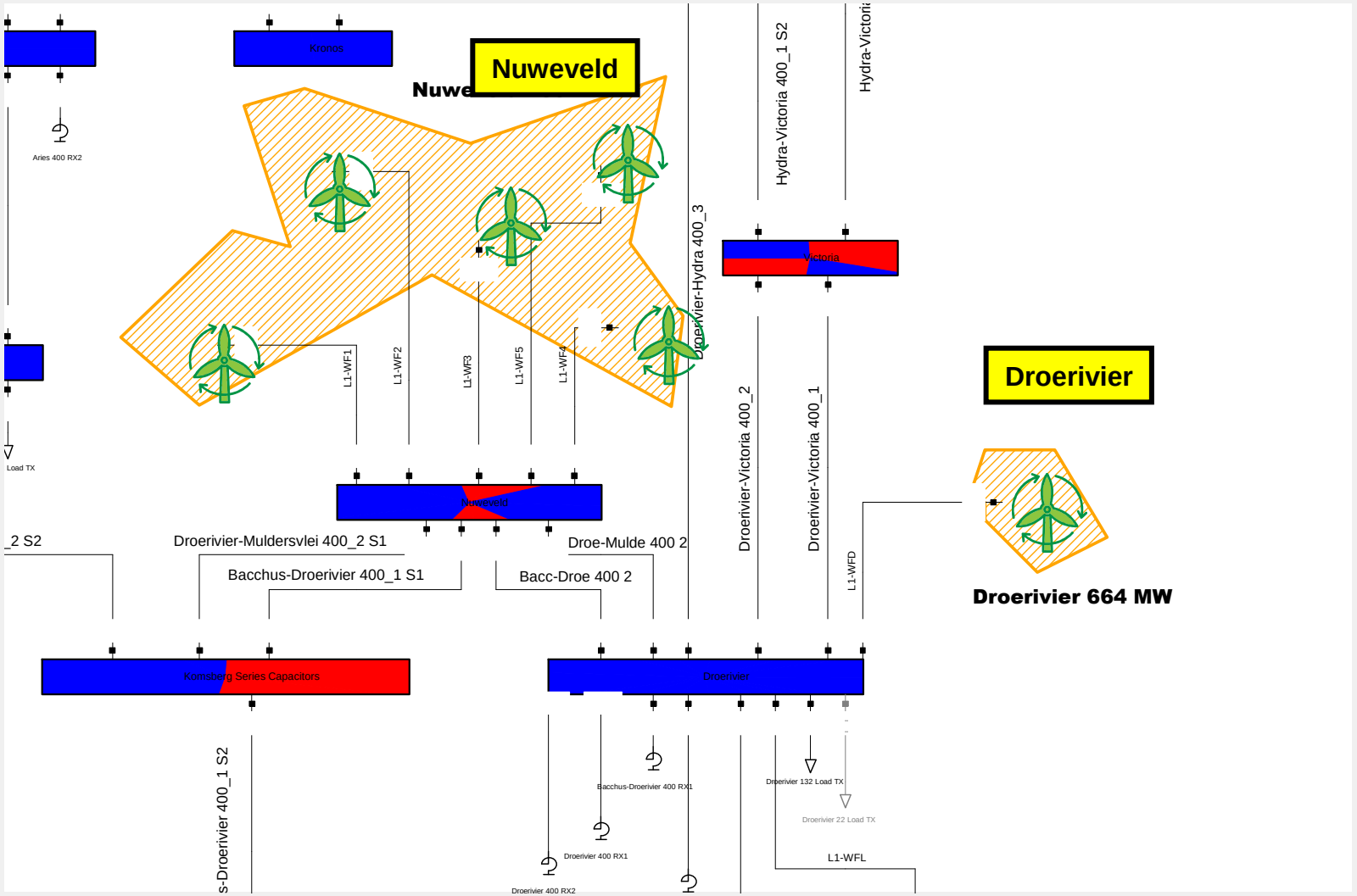
Stage 3 – 2800MW of Wind Generation in the Cape

- Consideration of all wind farms in the Western Cape, for which application exist (2798MW by end of March 2009)
- High level feasibility studies considering the existing ESKOM transmission grid (excluding subtransmission, <=132kV)
- Constraints:
  - No major network upgrades (such as new lines)
  - Minor network upgrade, such as additional var-compensation is allowed.
- System 2009 (without the new 765kV line running into the Cape)

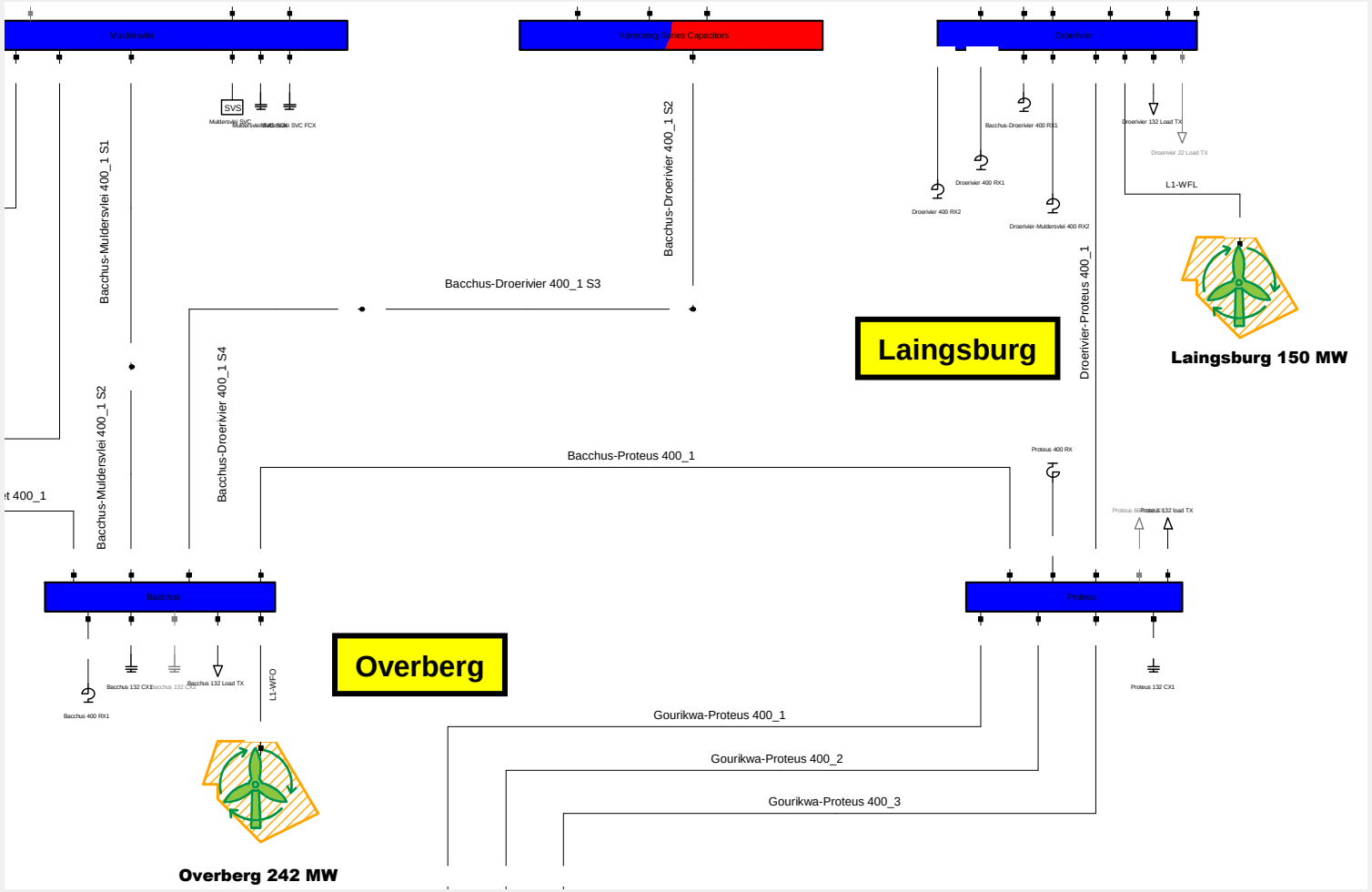
Stage 3 - 2800 MW of Wind Generation in the Western Cape



Stage 3: 2800 MW of Wind Generation in the Western Cape



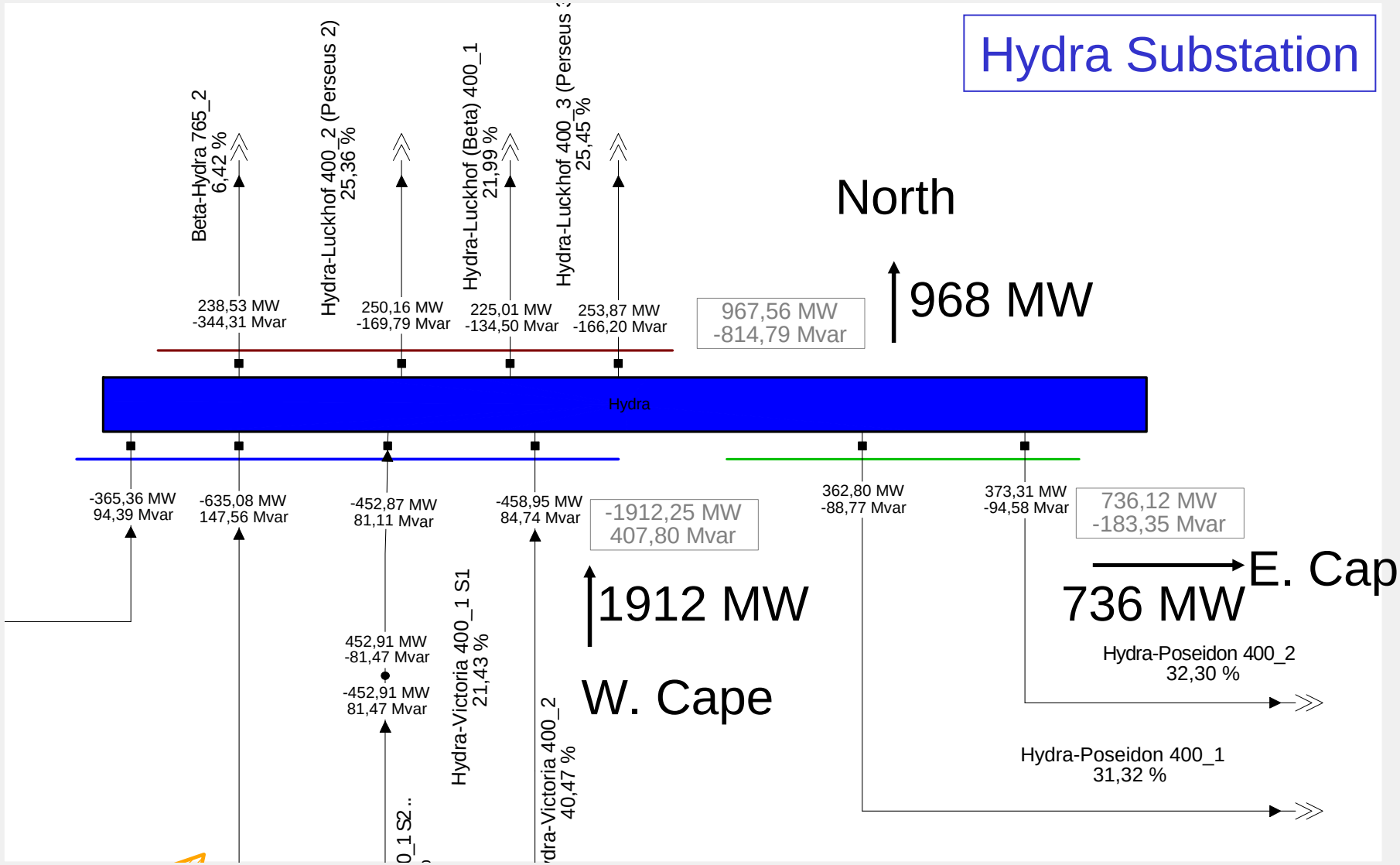
Stage 3: 2800 MW of Wind Generation in the Western Cape



Stage 3 – 2800MW – Scenarios for Studies

- Consideration of all wind farms in the Western Cape, for which application exist (2798MW by end of March 2009)
- Assumption: Max. wind generation = installed generation -> overestimates max wind generation by 10..20%, leaving some margins.
- Analysed cases:
  - High load, 1Koeberg units in
  - High load, 2 Koeberg units in
  - Low load, 1 Koeberg unit in
  - Low load, 2 Koeberg units in
- Generation Balancing – High Wind Scenarios:
  - Reduction of Gas Turbine Generators (running in SCO mode where possible)
  - Reduction of pump storage generation at Palmiet
  - Reduction of coal power plants outside the Cape

Stage 3 – 2800MW of Wind – Example: LL+HW, 2KB-Units



Stage 3 – 2800MW in the Western Cape – Summary of Results

- Up to 1000MW of export from the Cape to the North under Low load – High Wind conditions.
- No violation of thermal limits under n-1 conditions in all scenarios.
- Voltages can be maintained within appropriate limits, without any additional reactive power compensation in the Western Cape.
- The general feasibility of the integration of up to 2800MW of wind generation in the Western Cape, with regard to the impact on the transmission grid, could be demonstrated.
- However:
  - Operation of the system with considerable export from the Cape to the North must be studied in further detail.
  - Size of Komsberg series compensation must be verified/redefined (see stage 2 studies)
  - More detailed studies are required for confirming these results.

Integration of Wind Energy into the Western Cape System - Summary

Western Cape transmission system – excellent for wind integration:

- Cape system currently has an import problem (no export problem). Power import will be reduced during times of high wind generation.
- Large number of fast acting peak load units available that can be used for balancing wind variations.
- Pump storage can be used for supporting the balancing of wind variations.
- Some GTGs allow for SCO-operation – no need for additional dynamic reactive power compensation (SVC).

At subtransmission levels (<=132kV), transmission capacity will be limited in some cases.

What else needs to be done

- Additional, more detailed studies at transmission levels, including additional generation-load scenarios and alternative wind generation scenarios.
- Stability studies under various operating scenarios.
- Wind farm connection studies for every wind farm application.
- Studies related to transmission system operation under situations, in which the Cape exports power to the rest of the system
- Studies related to the expected total power variations of wind generation (variations, ramp-up and ramp-down speeds) for identifying additional reserve requirements have to be carried out.

Thank You

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