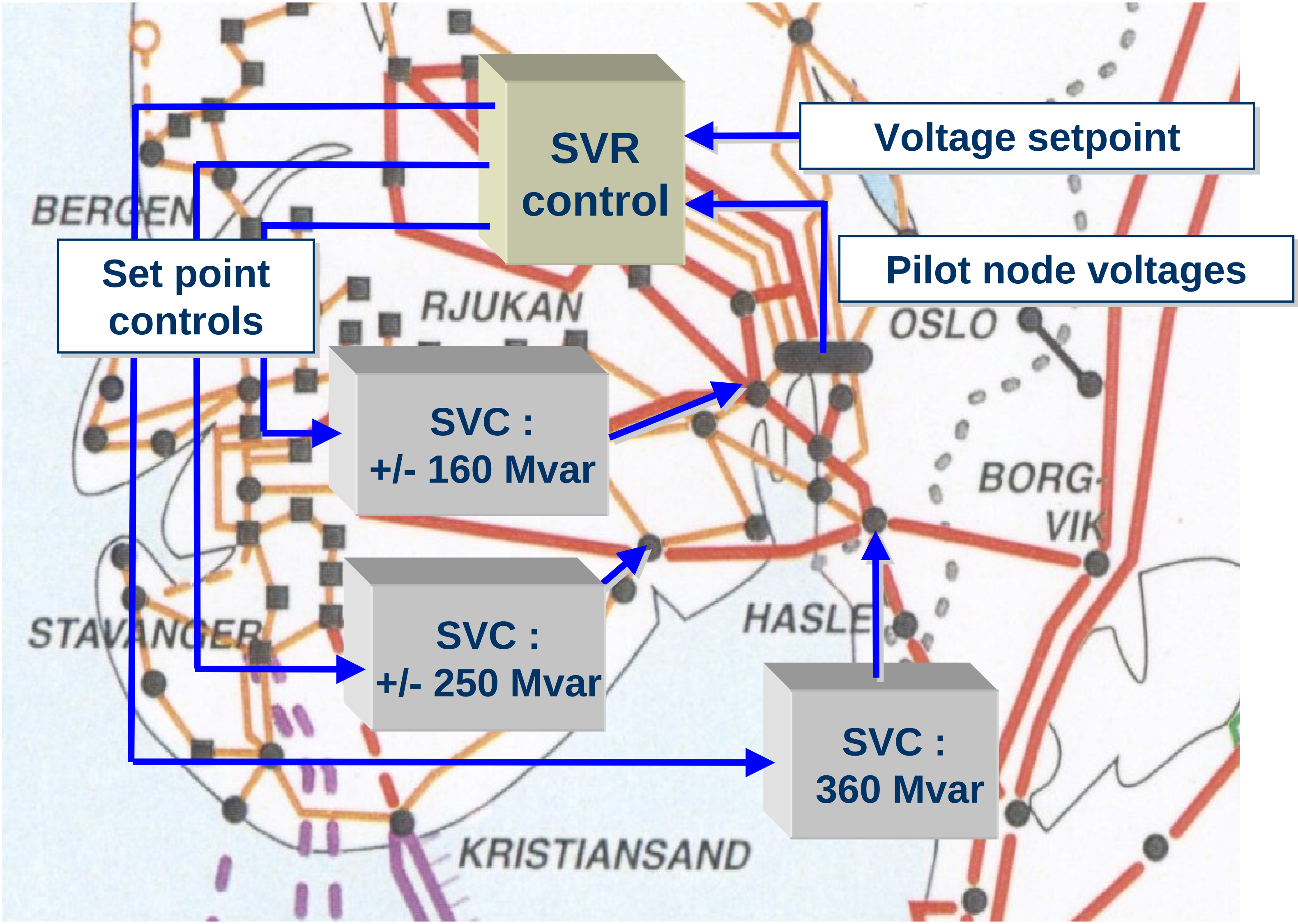
Coordinated Secondary Voltage control (SVR scheme)

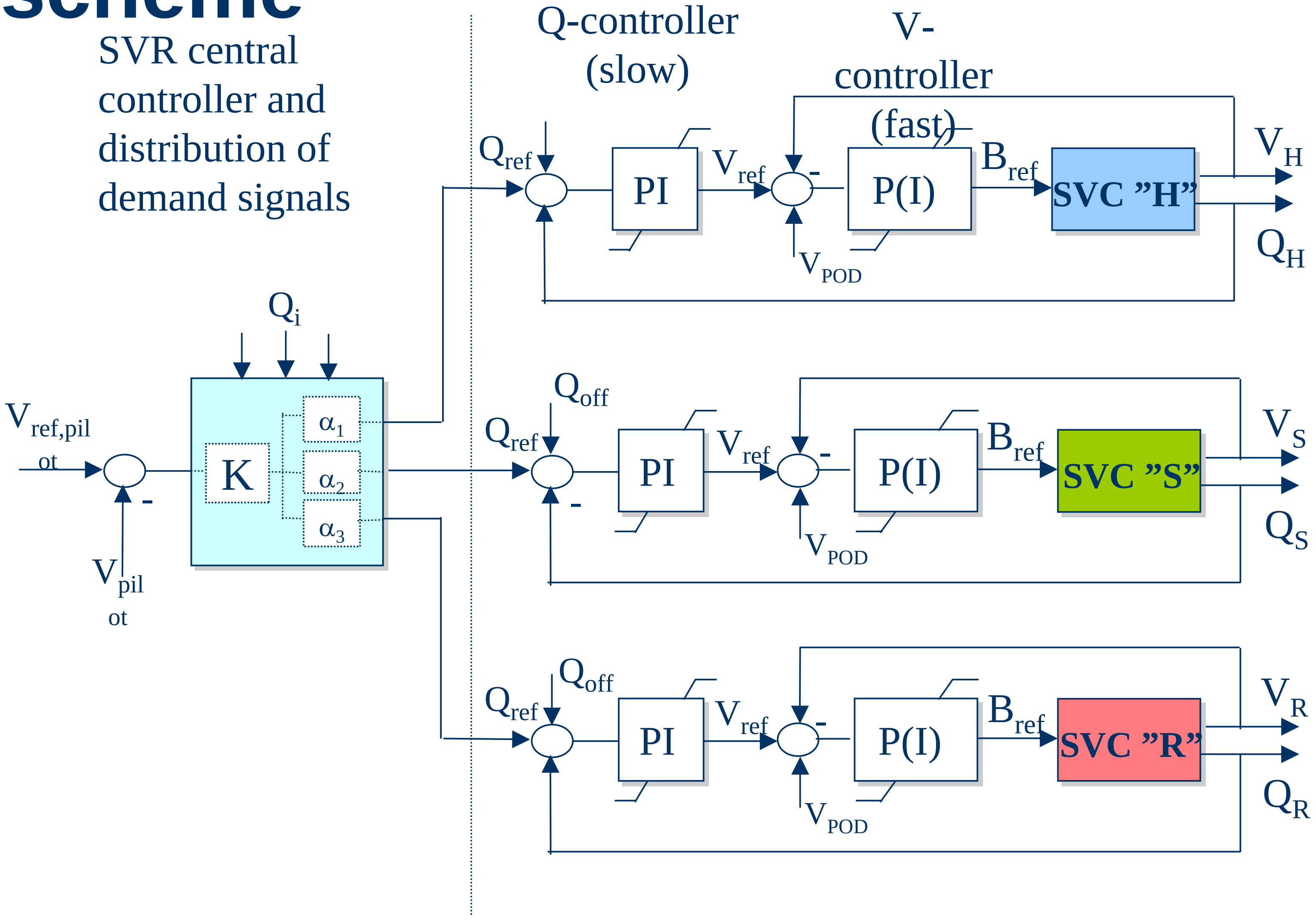
Transfer limits are normally determined from the ”N-1” security criterion. Sufficient on-line reactive reserves are important in order to reduce the consequences of critical contingencies.

- Overall objective of the SVR scheme is:
  - To maintain a sufficient and balanced reactive reserve in the SVC units during normal operation.
  - To keep the pilot node voltages within specified limits.

- Benefits:
  - Desired voltage profiles are maintained automatically.
  - By having automatic and coordinated control of the SVCs, the operators can concentrate on the total reactive reserves (by switching of capacitor banks or other equipment with discrete control).


SVR
control
Voltage setpoint
Pilot node voltages
Set point
controls
BERGEN
RJUKAN
OSLO
SVC :
+/- 160 Mvar
SVC :
+/- 250 Mvar
SVC :
360 Mvar
BORG-
VIK
STAVANGER
HASLE
KRISTIANSAND

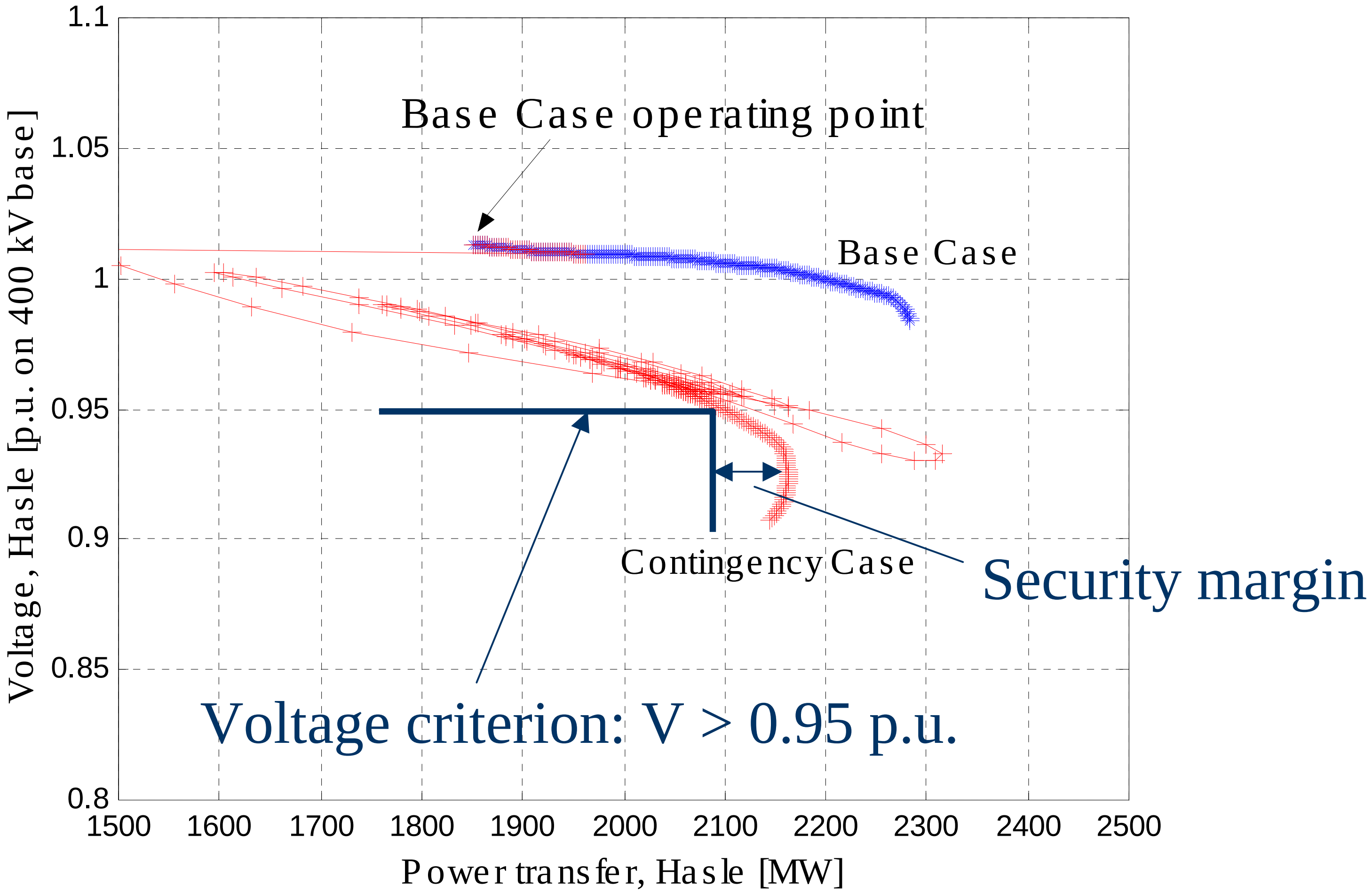
Control structure of the SVR scheme



Models and analysis

- Dynamic simulations are performed by using a recent updated and validated Nordel transmission system model.
- Detailed SVC models regarding controls and limit handling.
- Purpose of analysis:
  - Demonstrate potential of raising power transfer limit with use of the SVR scheme.
  - Simple criterion adopted from operating experience: Steady state pilot node voltage must be above 0.95 p.u. = 380 kV (10% below nominal 420 kV)

Assessing voltage stability limits
P-V curves from dynamic simulations

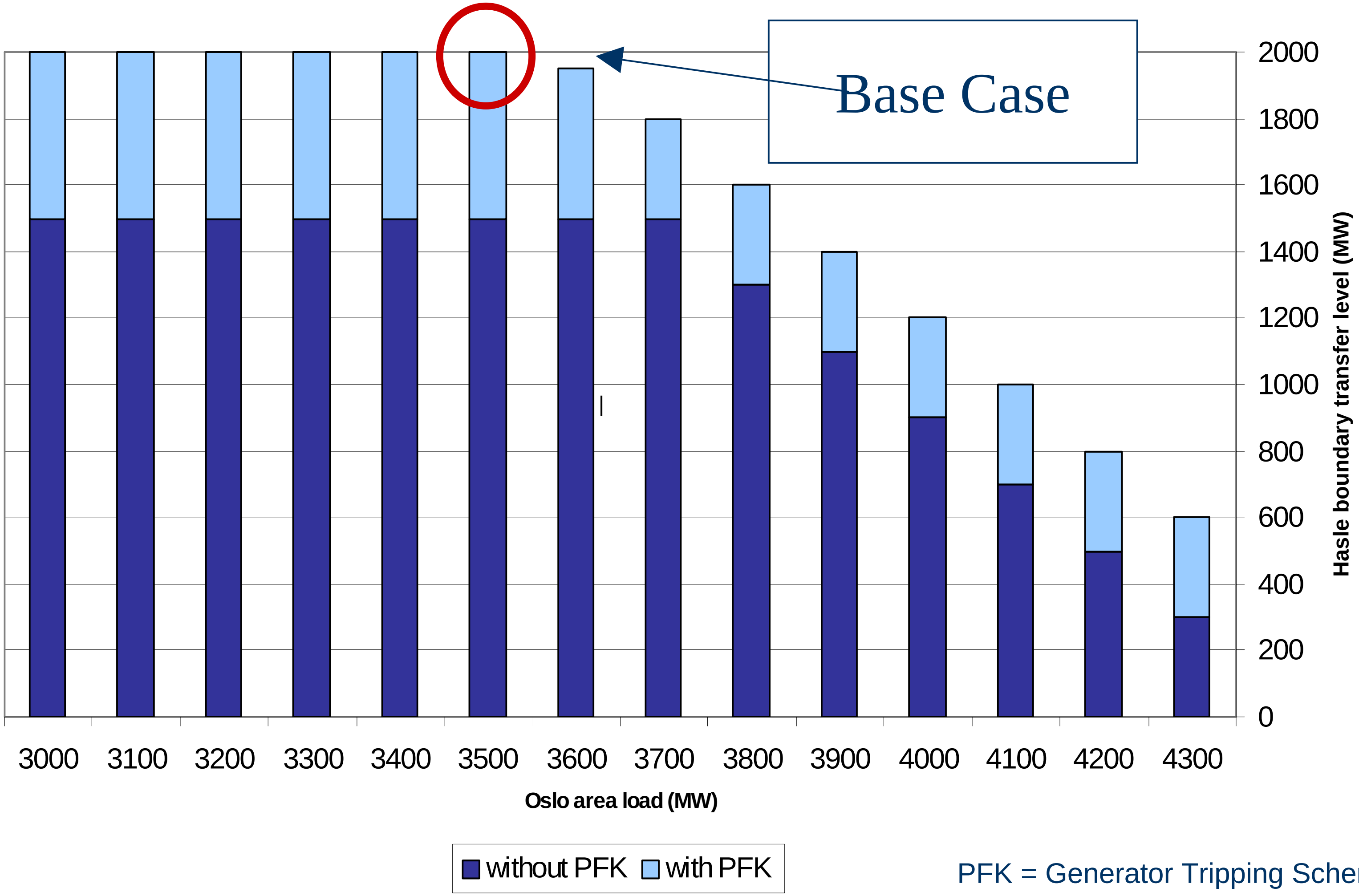


Simulation study

- Base case: System operating at the present maximum power transfer limit = 2000 MW.
- Most critical contingency applied: Loss of 420 kV “Rød-Hasle” (line/cable).
- System responses with and without the SVR scheme are simulated.

- Study repeated at 2400 MW power transfer to demonstrate the benefit of SVR scheme.

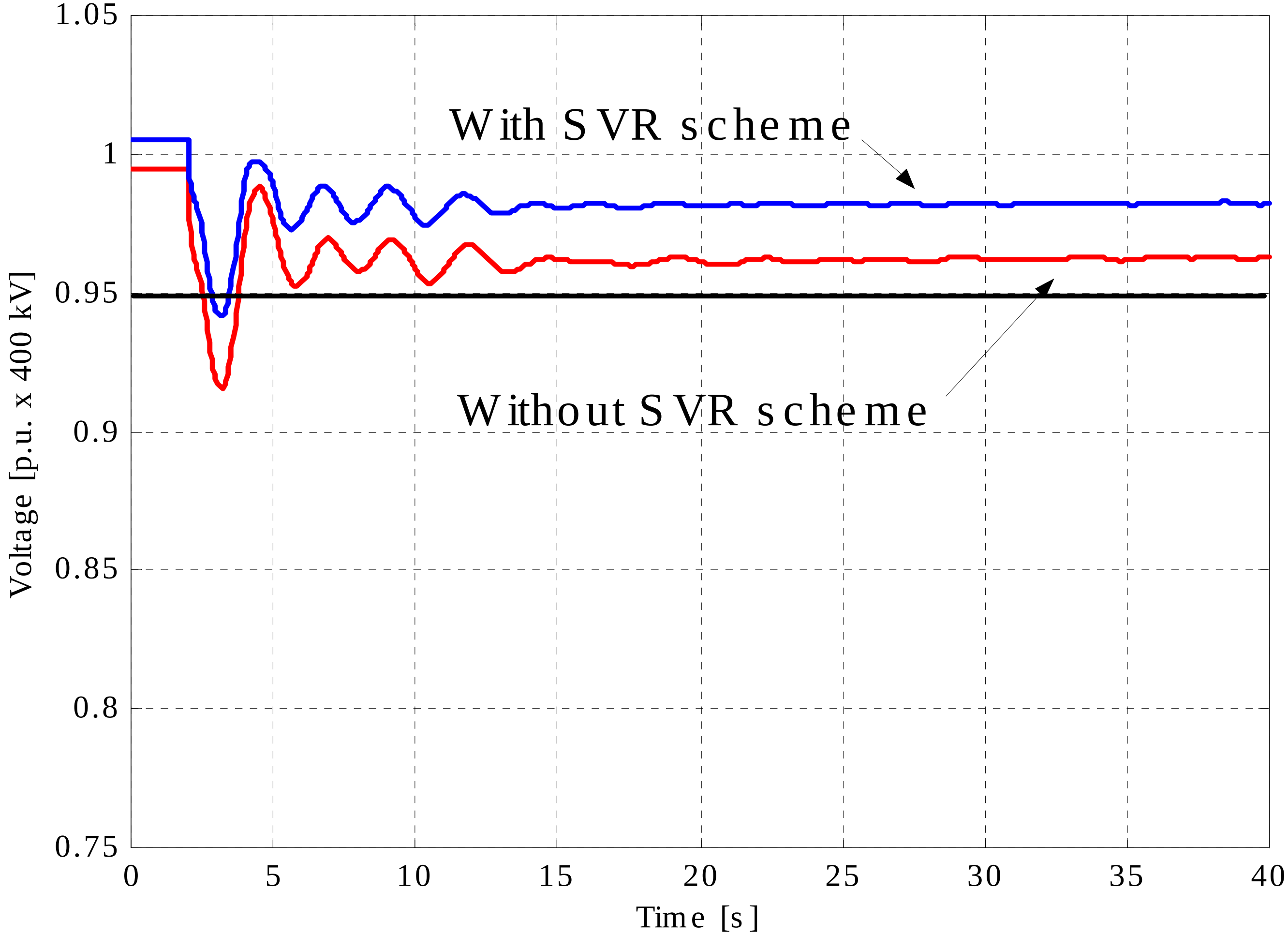
The Hasle transfer level is affected by the load in the Oslo area



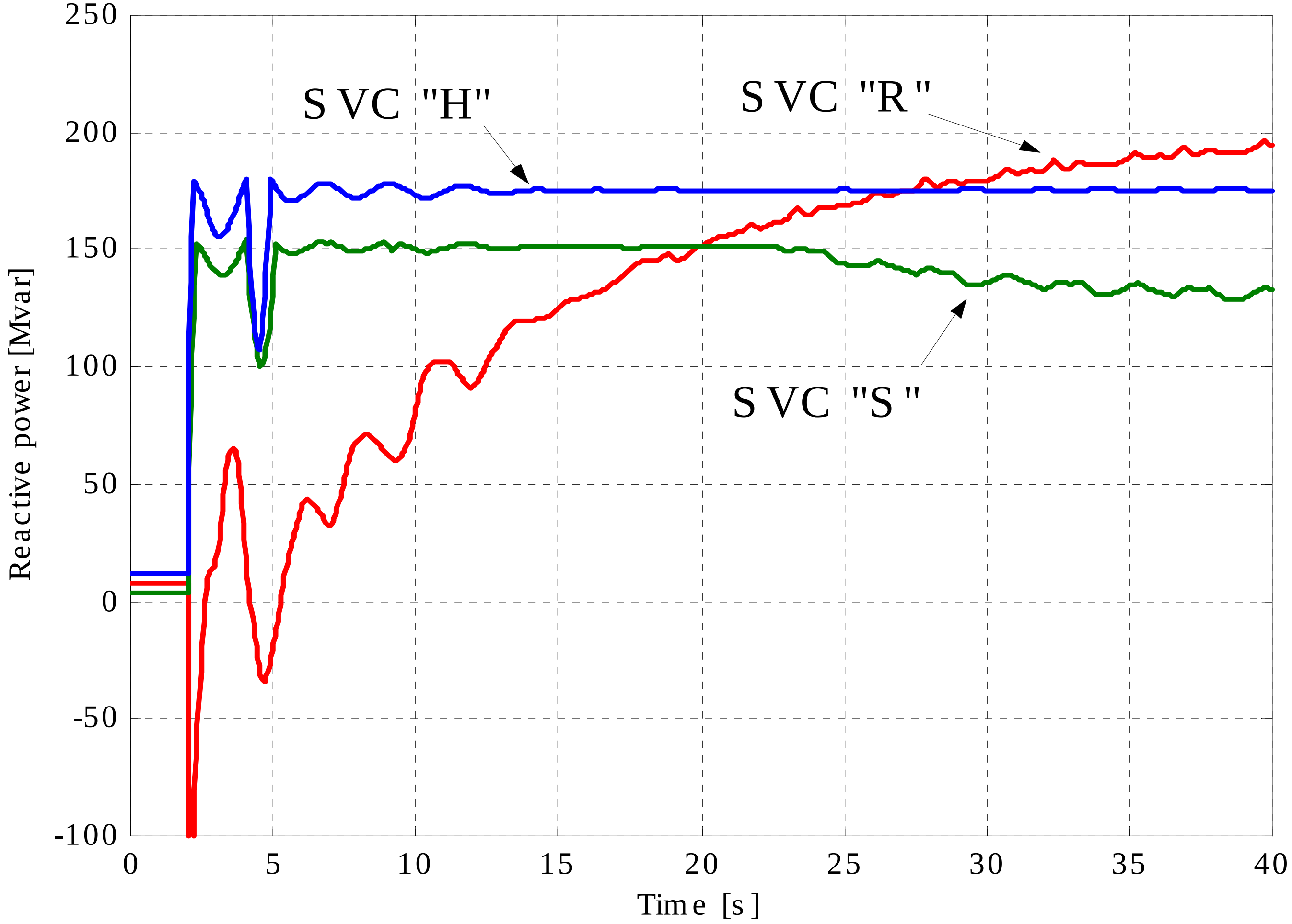
PFK = Generator Tripping Scheme

Power Transfer 2000 MW

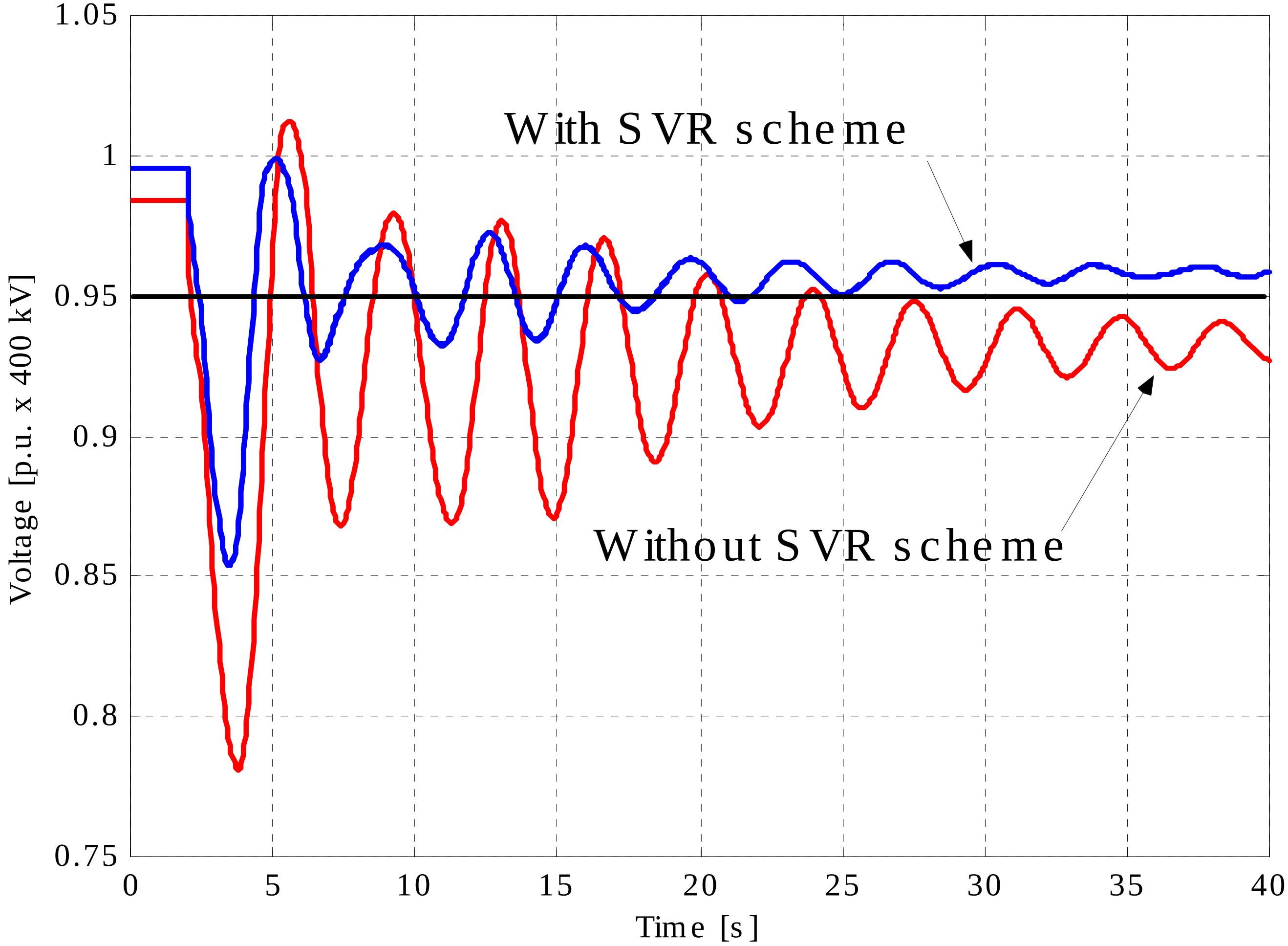
Pilot node voltage



Power Transfer 2000 MW
SVC outputs with SVR scheme

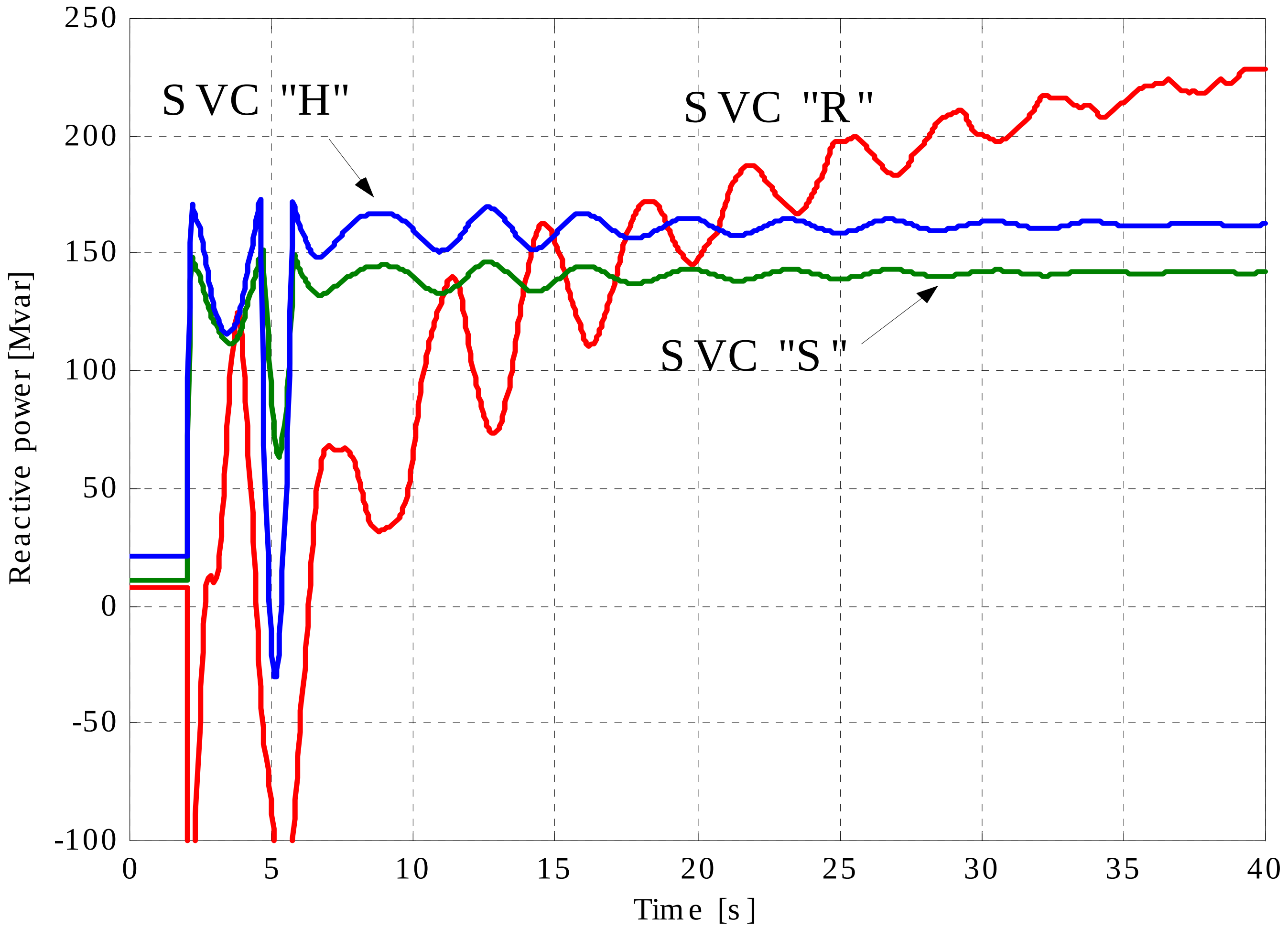


Power Transfer 2400 MW
Pilot node voltage



Power Transfer 2400 MW

SVC outputs with SVR scheme

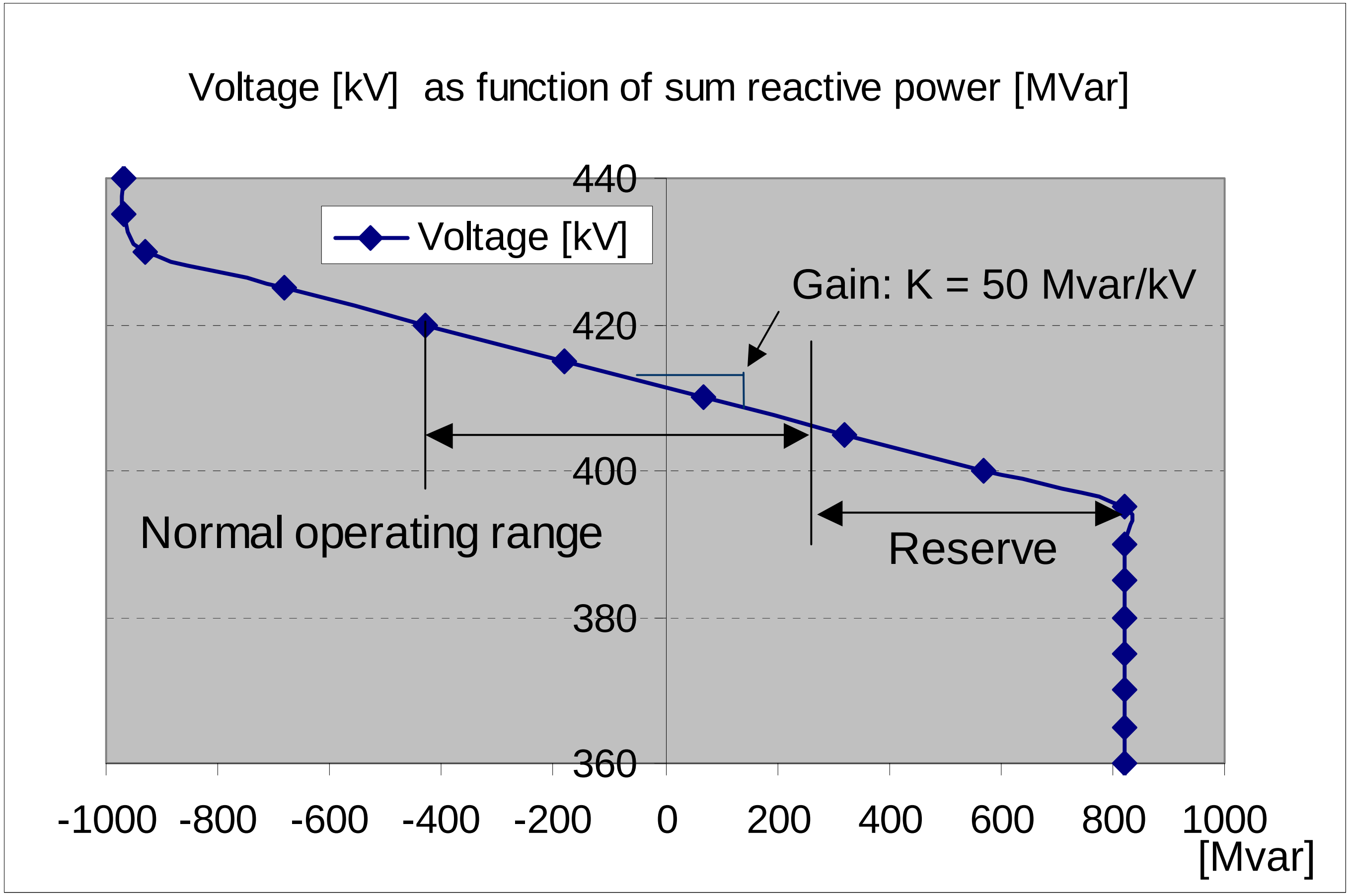


Control centre implementation

Participating units:

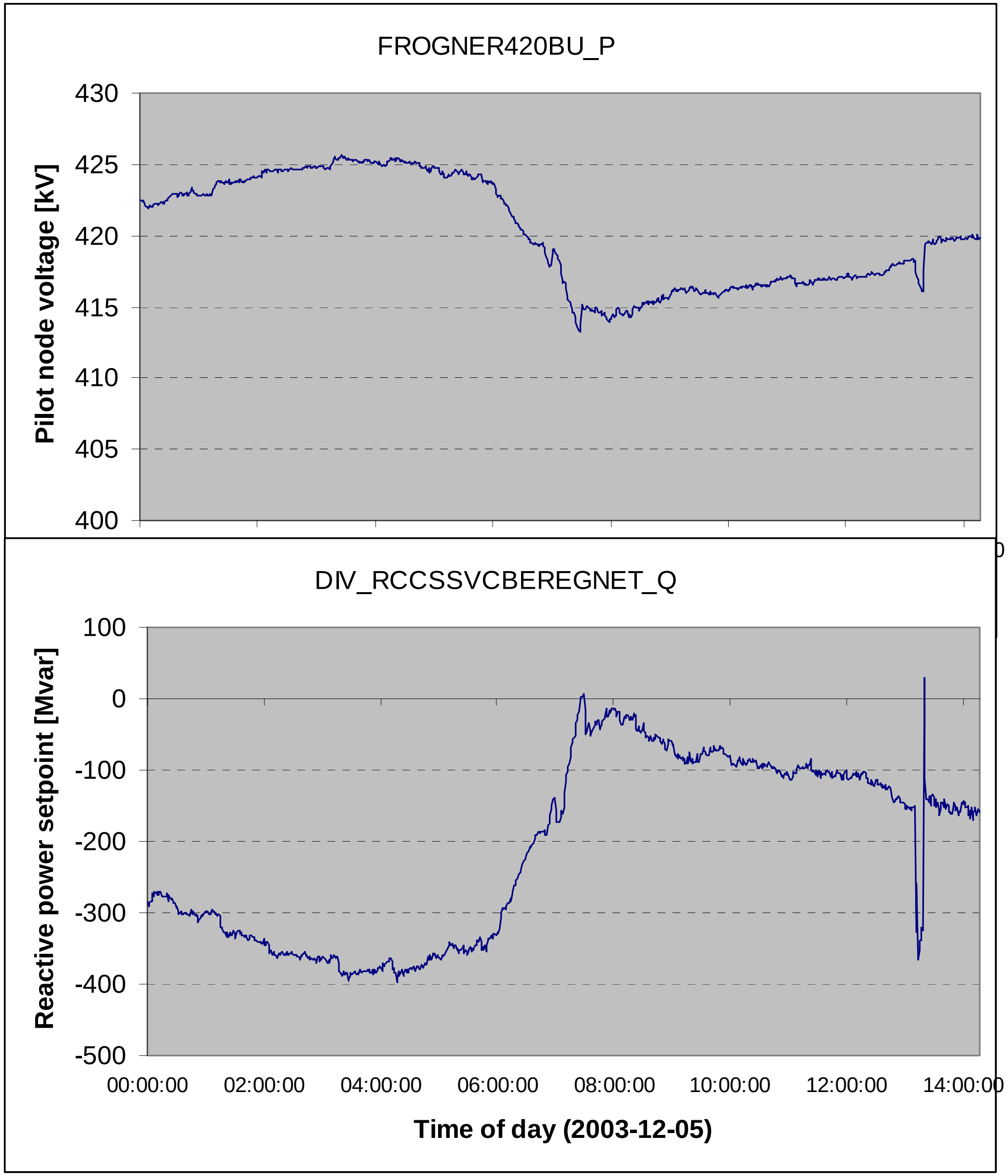
NAME	TYPE	Capacity, inductive	Capacity, capacitive	Comments
Sylling F1	Rotating condenser	-90 Mvar	+160 Mvar	Controllable in steps of 20 Mvar
Sylling SVC	SVC	-160 Mvar	+160 Mvar	Controllable in steps of 40 Mvar
Frogner F1	Rotating condenser	-90 Mvar	+250 Mvar	Controllable in steps of 10 Mvar
Rød SVC	SVC	-250 Mvar	+250 Mvar	Controllable in steps of 15 Mvar
Hasle TCR 1&2	TCR	-360 Mvar	0 Mvar	Controllable in steps of 50 Mvar

Operation:
Principles and characteristic



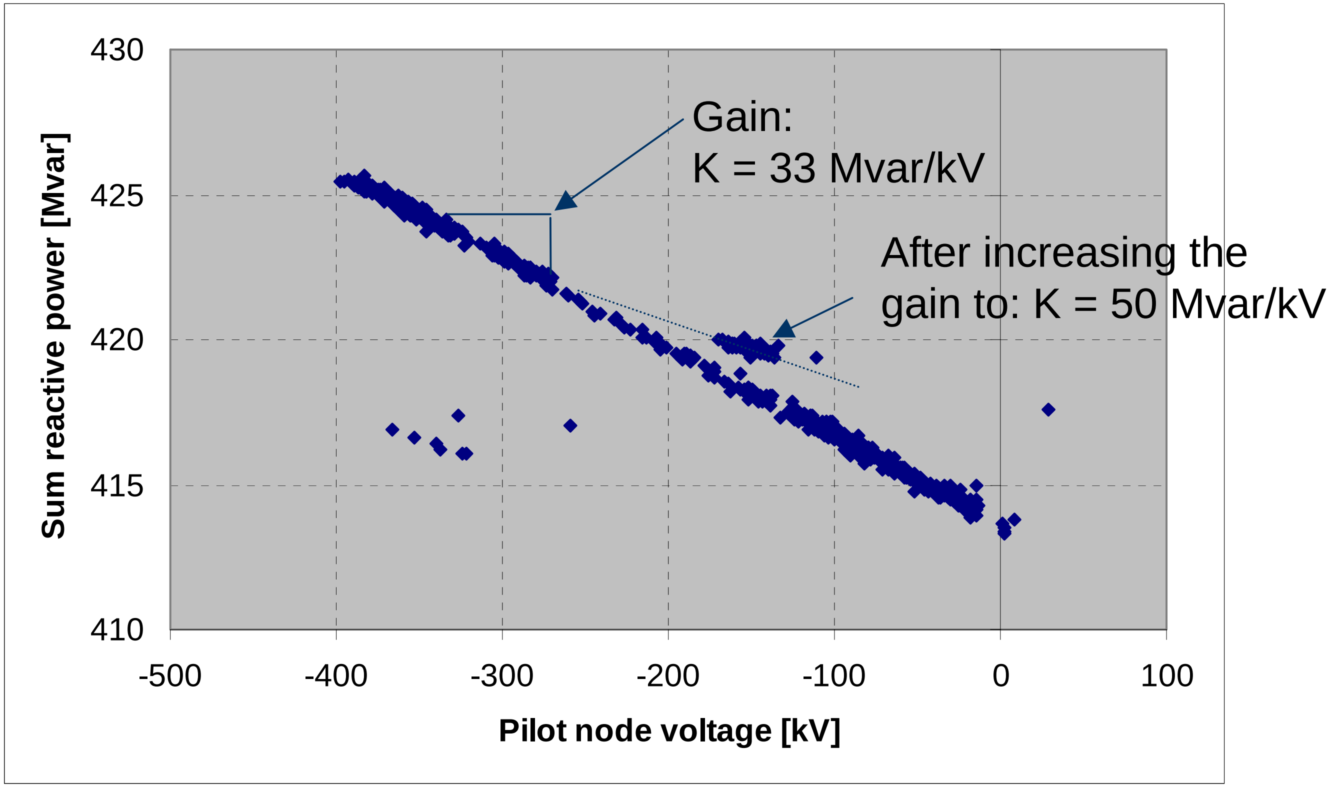
First day operational results

- Trend curves of pilot node voltage (420 kV Frogner) and total Mvar setpoint.
- 14 hours of operation



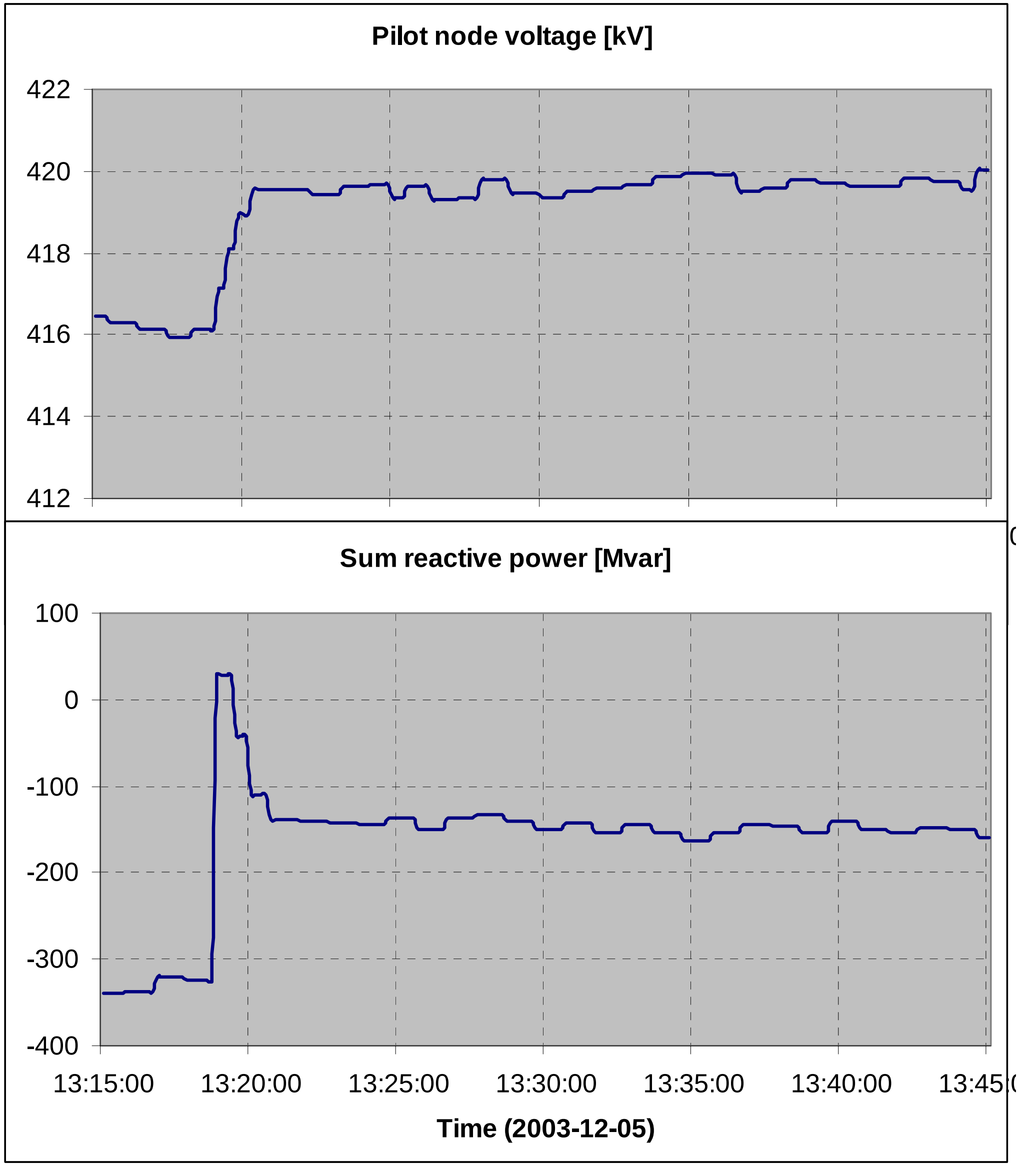
First day operational results

- Measured pilot node voltage versus reactive power setpoint



Testing dynamic response

- Step change in voltage setpoint: 415 → 420 kV
- Gain: K = 50 Mvar / kV
- Response time (time constant): ~1-2 minutes



Preliminary conclusions

- Power transfer on the important ”Hasle” corridor is limited by both thermal and stability constraints.
- Thermal limits are raised by use of system protection schemes.
- Important also to raise the angle stability (damping) and voltage stability limits.
- SVR scheme can help to raise the voltage stability limit.
- Preliminary results from SCADA implementation are promising