CLEEN
Cluster for Energy and Environment

sgem
Smart Grids and Energy Markets

Distributed generation interconnection and power quality improvement by smart control

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Cleen Summit 7.4.2011

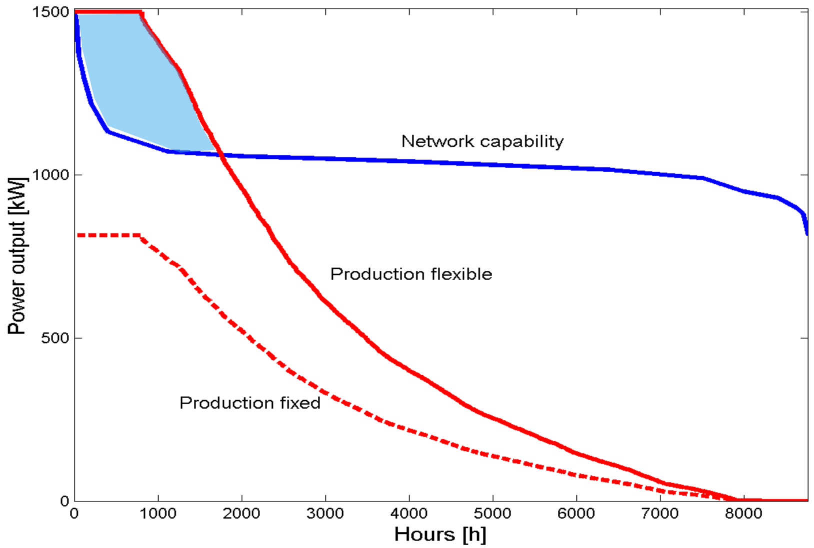
Contents

DG technology trends

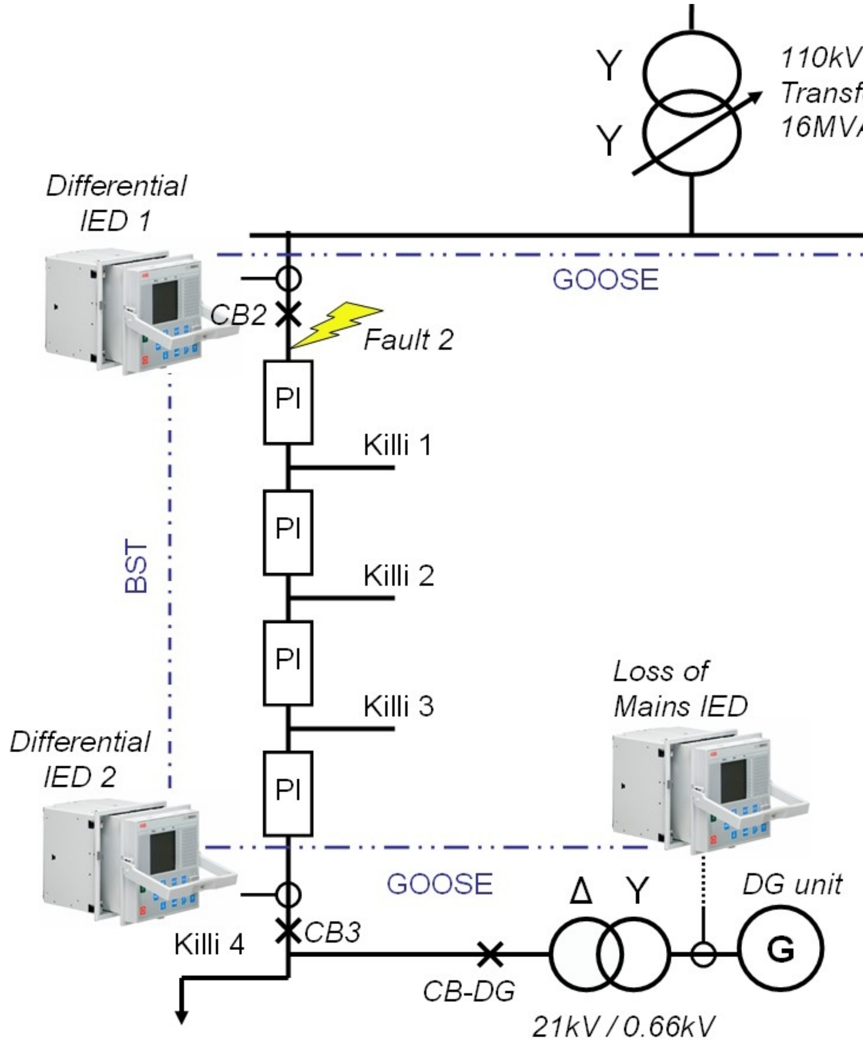


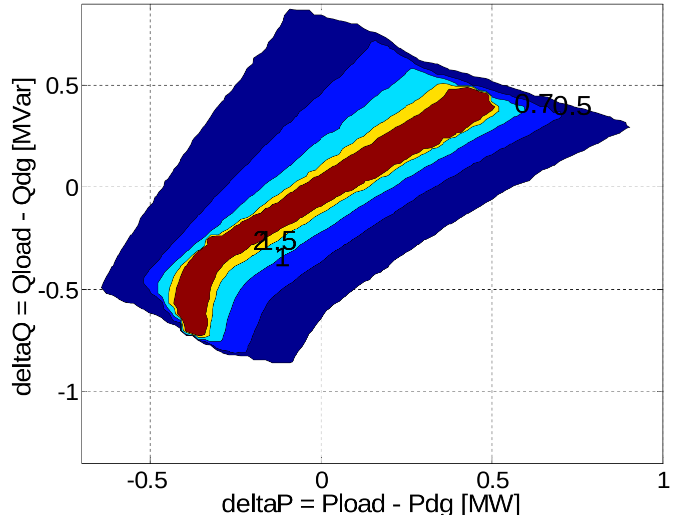

Distributed generation interconnection

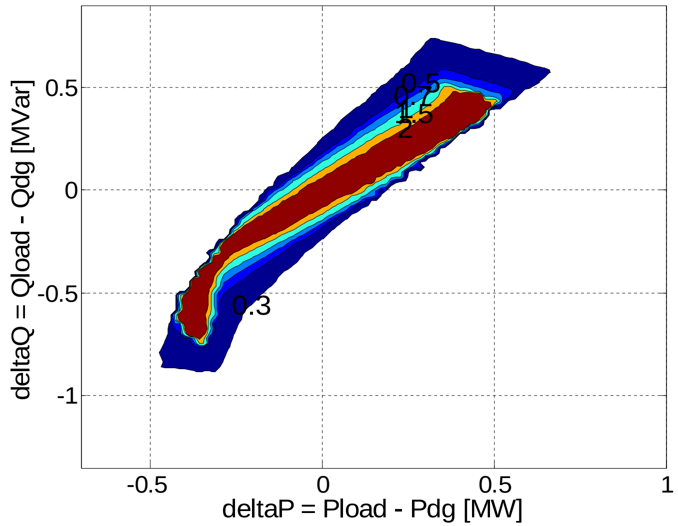
- Connection principle
  - Normally network customers have firm network capacity available
  - Non-firm network capacity >> firm capacity
    - The amount of DG to be connected and operated under normal network conditions will be increased
    - Production curtailment or constraints in extreme conditions
    - The probability of extreme conditions should be low enough



Loss-of-Mains protection







Island operation

Protection

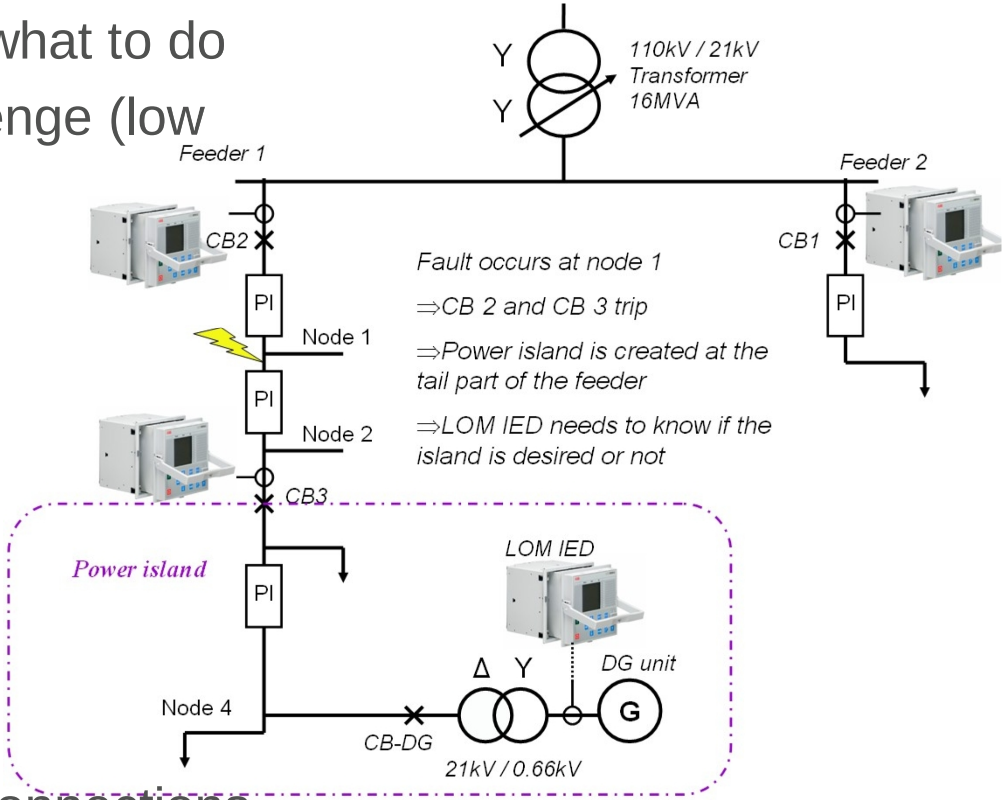
- In automatic islanding LOM need to know what to do
- Protection in island mode might be a challenge (low fault currents)

Control and automation

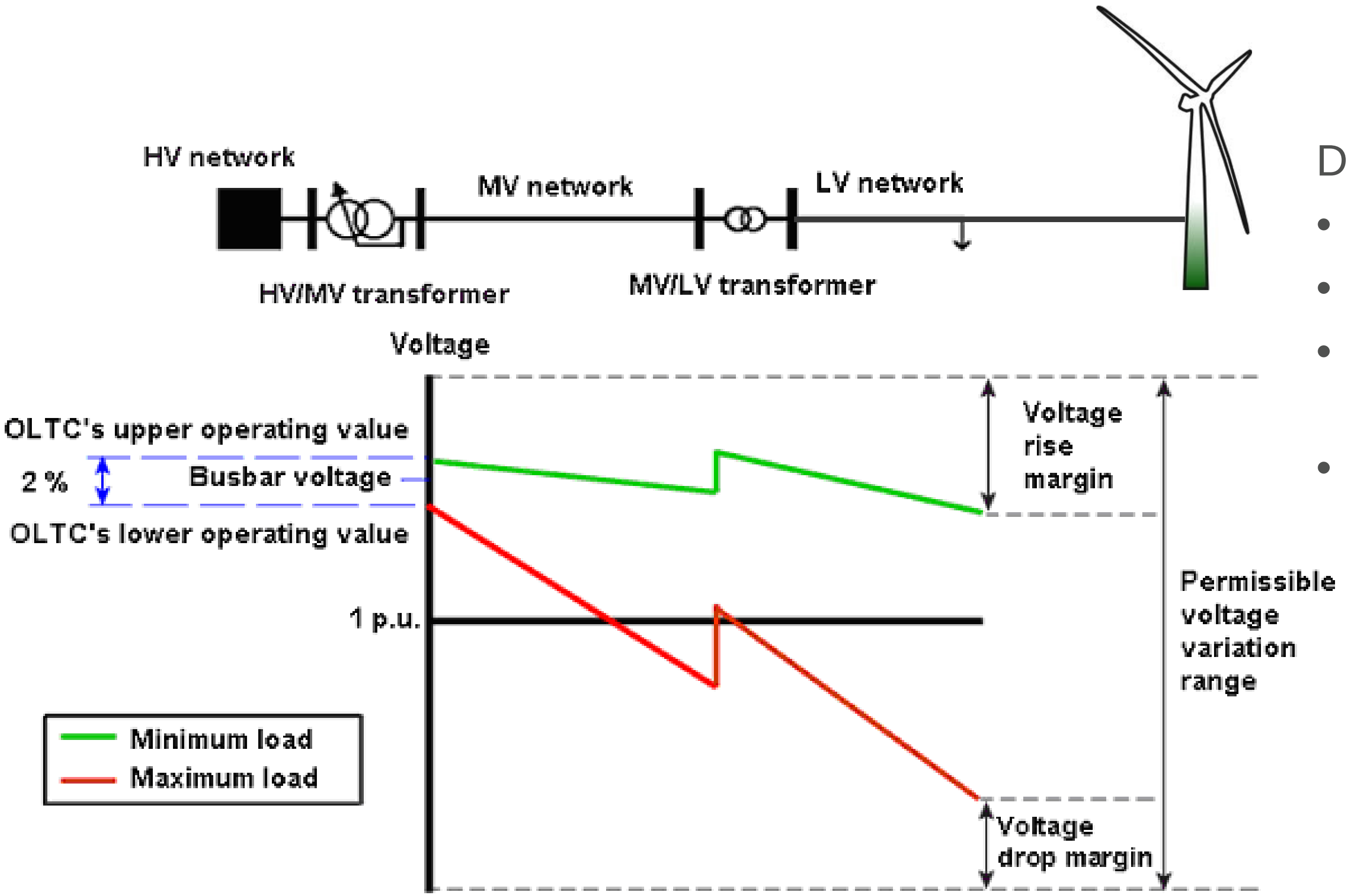
- Black starting
- Frequency and voltage
- Resynchronization

Network planning

- Adequate DG capacity and controllability
- SAIDI improves
  - Island operation may replace backup connections
  - Permanent islands may allow to remove lightly loaded frequently faulted MV branches



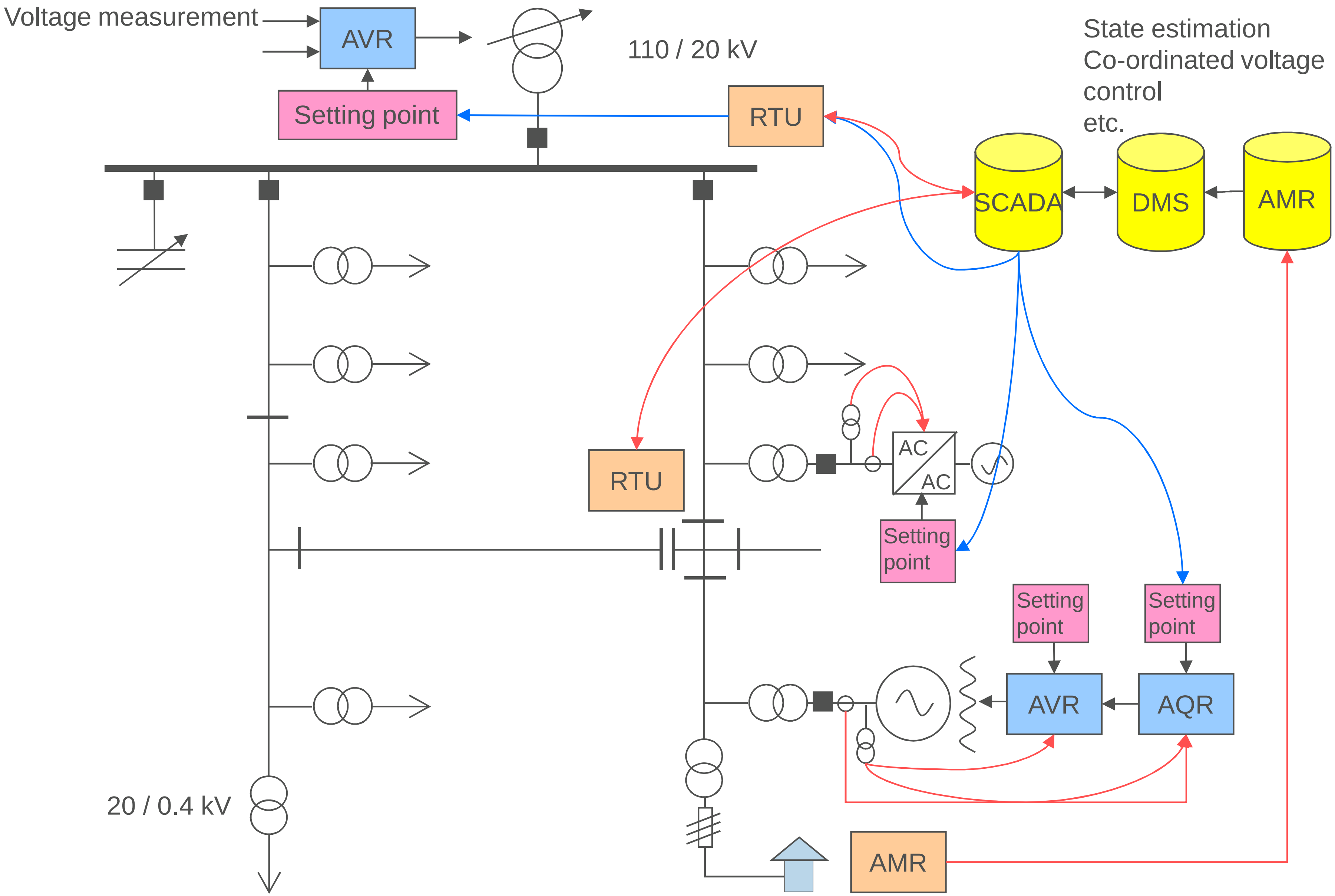
Voltage control – Voltage rise



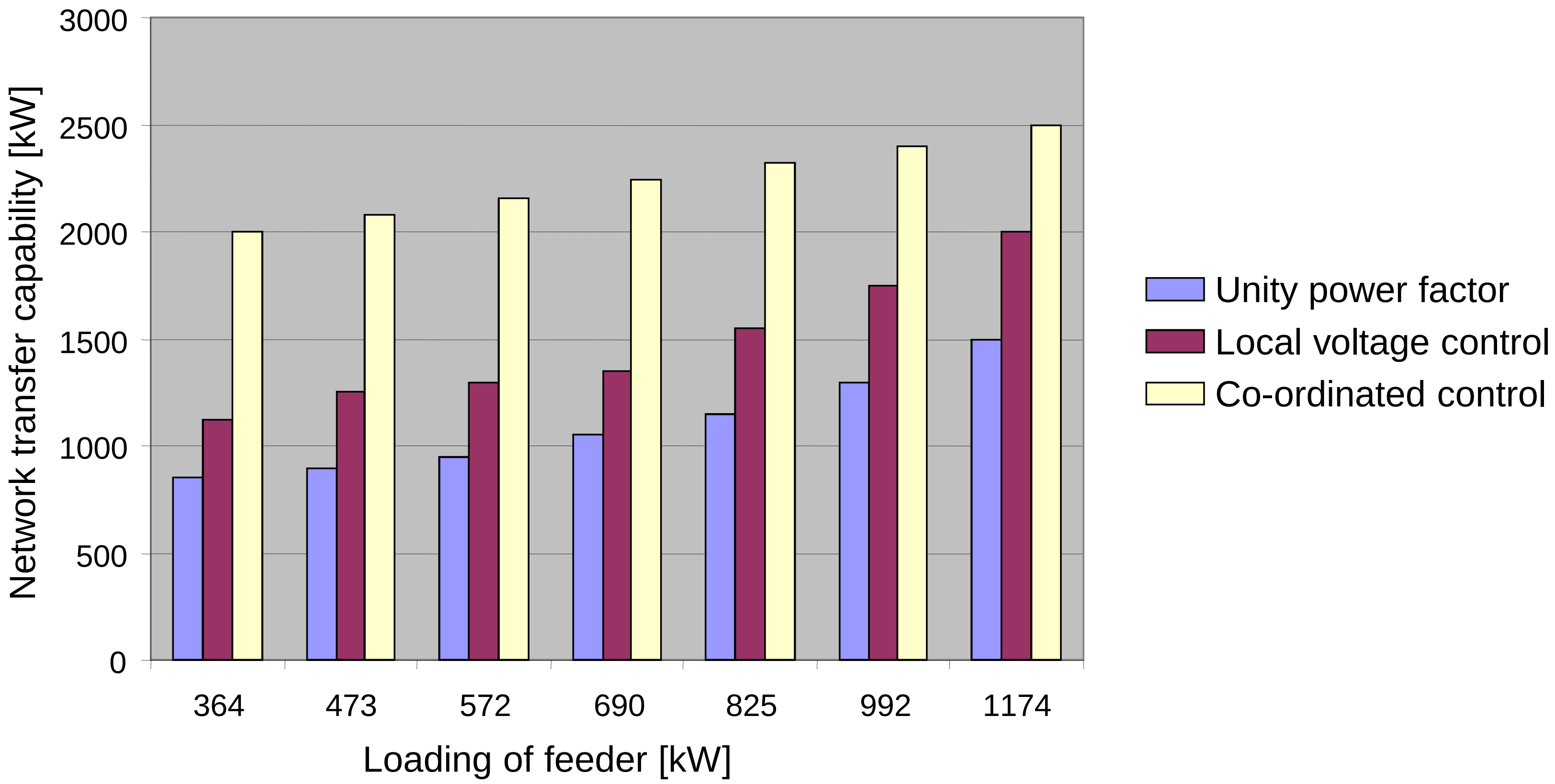
DG unit may contribute to control

- Power factor control
- Local voltage control
- Co-ordinated control (controller parameter resetting)
- Production curtailment

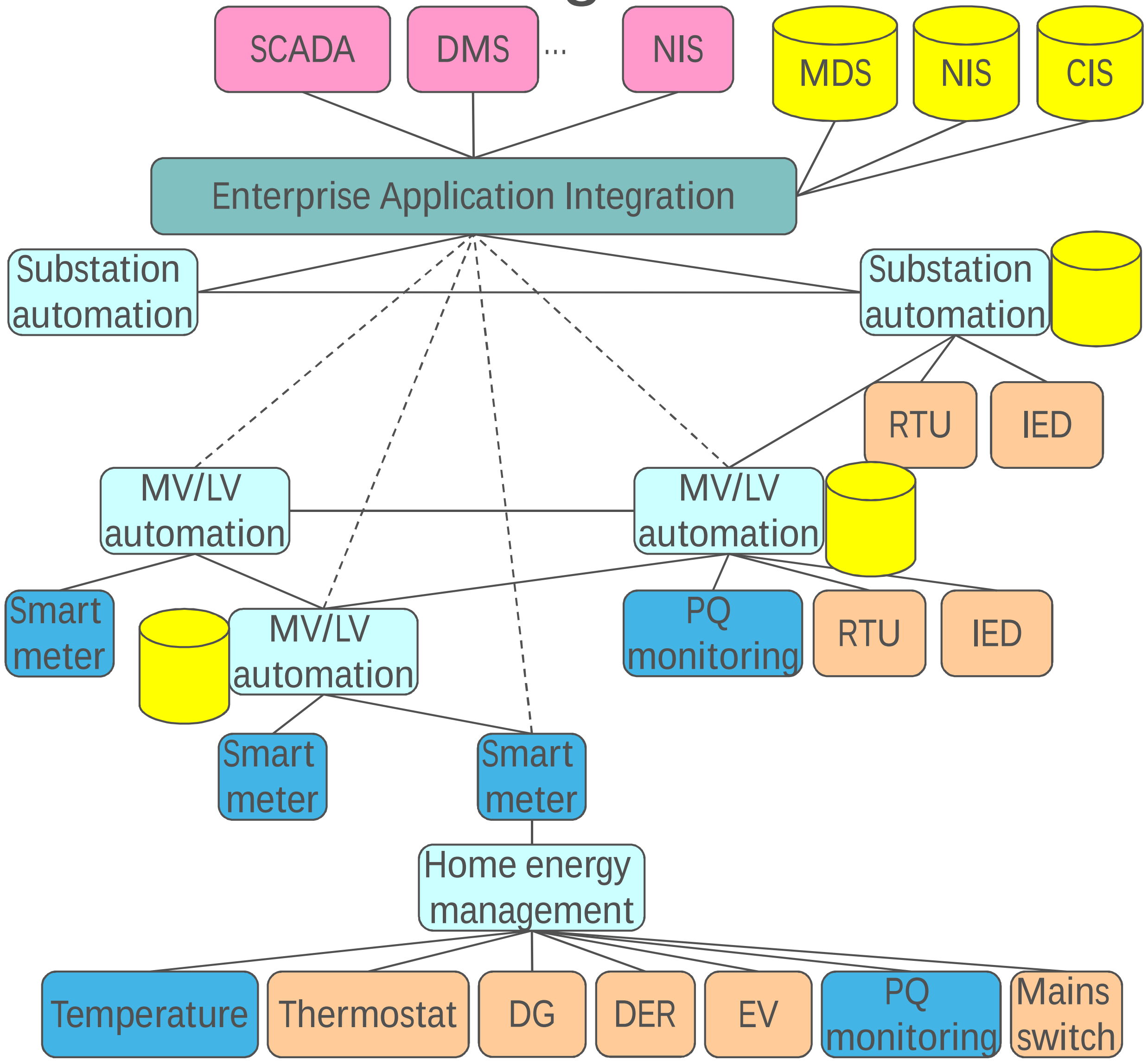
Co-ordinated voltage control



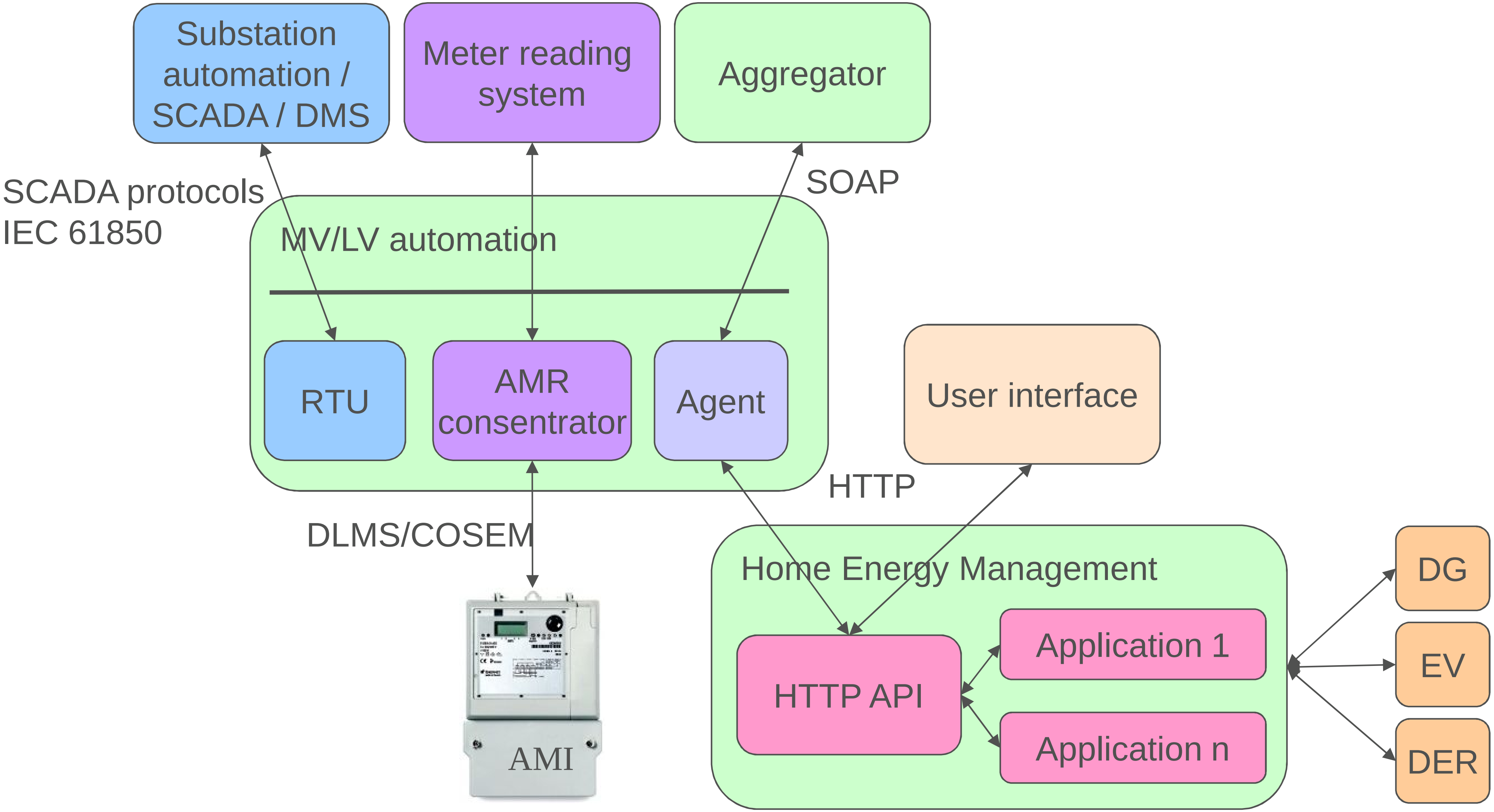
Benefits of co-ordination



Active network management



Active network management



Introduction to STATCOM development

A number of different multilevel VSC topologies for high-power medium voltage applications has emerged as results of development work related to power semiconductors.

Multilevel converters include in general an array of power semiconductors which are arranged in such a way that they are able to add capacitor voltages stepwise to the output of the converter.

The 3-level converter topology (3L-NPC-VSC) described in this paper offers a good compromise in terms of:

- Performance,
- Efficiency,
- Quality of harmonics spectrum,
- Complexity,
- Costs.

Three-Level, Neutral Point Clamped, Voltage Source Converter

The bus voltage is split in two by the connection of equal series-connected bus capacitors.

Diodes are connected to the mid-point of the dc bus to insure that the voltage across any single IGBT never exceeds one half of the total dc bus voltage.

Each phase leg contains four IGBT and additionally two so called clamp diodes.

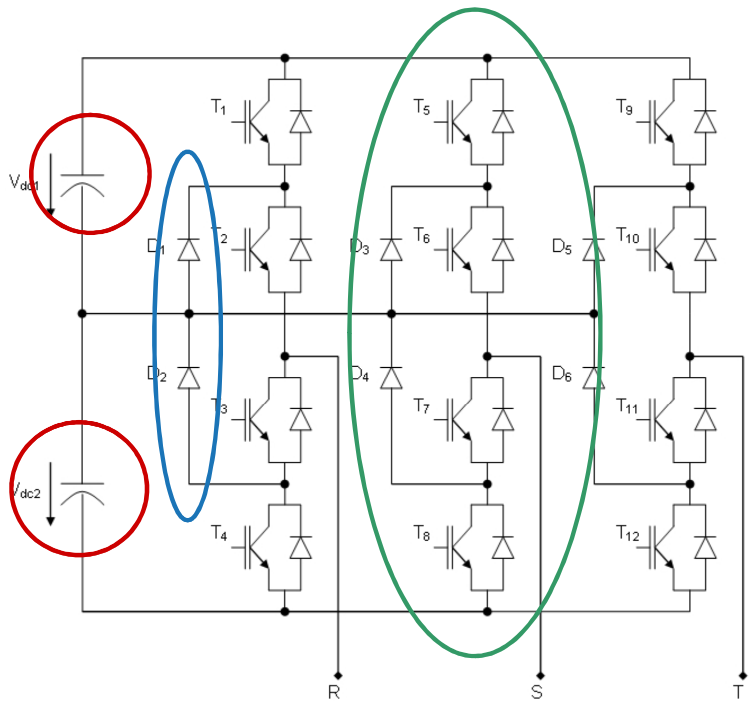


Figure 1. 3-level neutral point clamped voltage source converter schematics.

STATCOM system

The STATCOM system consists of a Master Controller and one or several parallel Power Modules.

The Master Controller captures the measurements from the network and calculates the required reference values for the compensation currents.

These values are transformed into a serial data stream and transmitted via fiber optic links to the Slave Controllers of the Power Modules.

The Master Controller communicates also with a common user interface (HMI, SCADA or Web server).

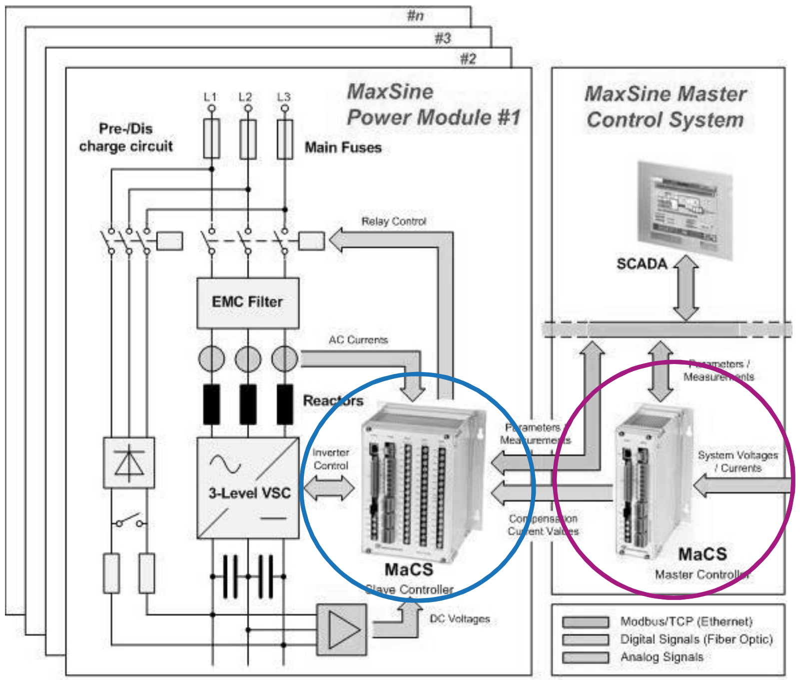


Figure 2: STATCOM block and communication diagram

STATCOM system

- 3L-NPC-VSC with IGBTs
- DC capacitor bank
- LCL-Filter for AC currents

STATCOM modules can be switche in parallel and connected to the power system via a step up transformer to any voltage level.

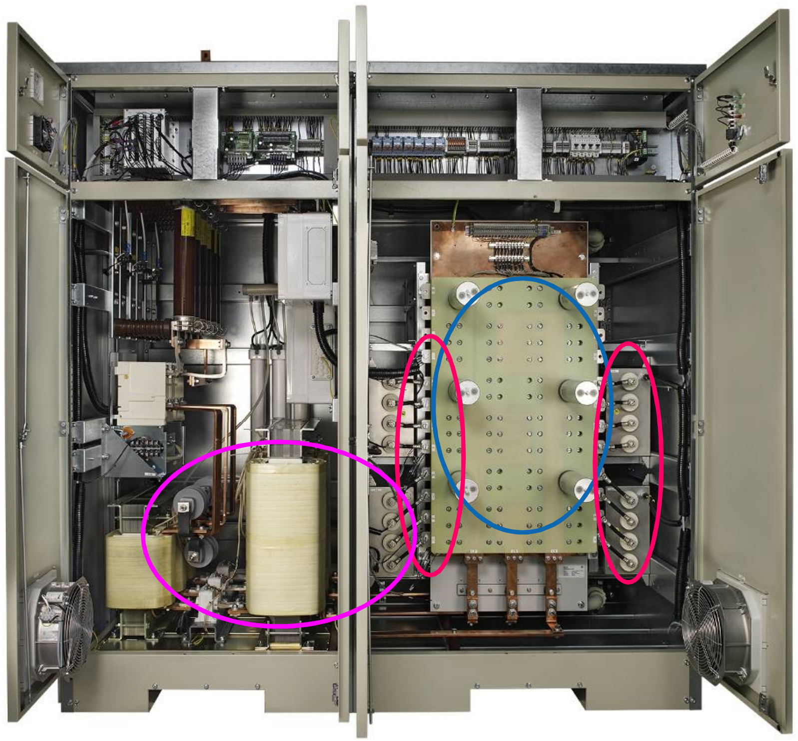


Figure 4 STATCOM Power Module

STATCOM system (cont.)

The efficiency and the power quality in the distribution network can be improved using STATCOM by:

- Compensating harmonics and reactive power,
- Eliminating negative sequence currents,
- Reducing voltage flicker,
- Stabilizing the voltage level,
- Improving the network recovery during line fault.

Demonstrator: STATCOM for Dunneill Windfarm

Alstom Grid delivered a 6Mvar STATCOM to Dunneill windfarm in Ireland as demonstrating system related to ADINE project. The STATCOM is installed in a container and commissioned in september 2010.

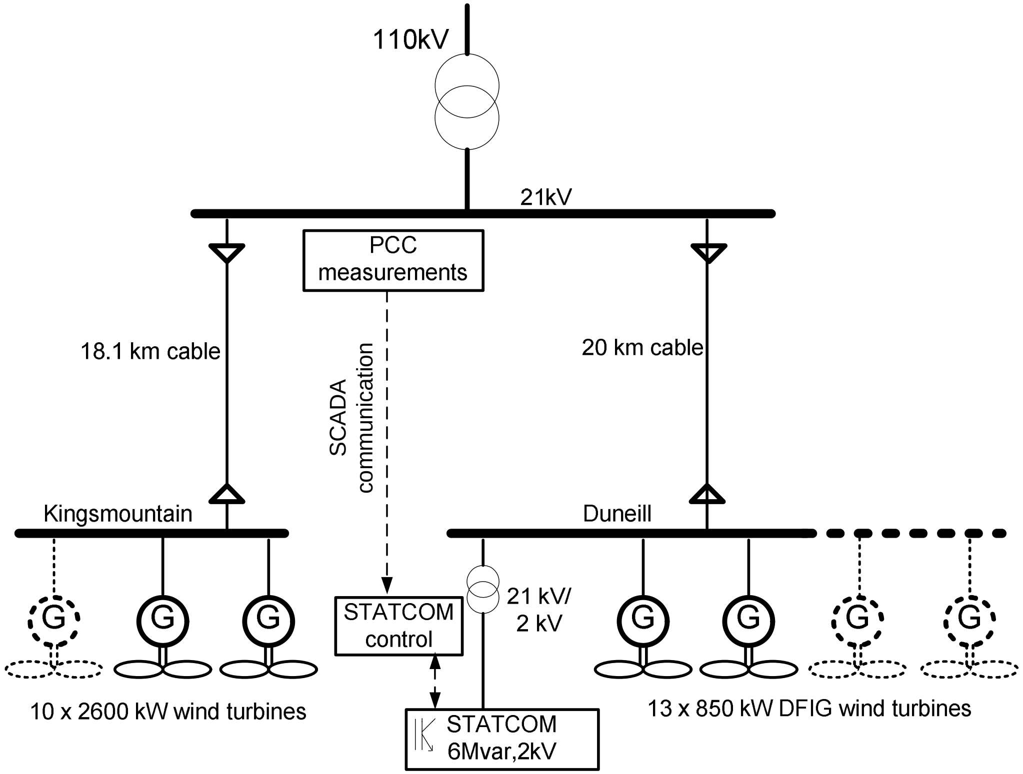
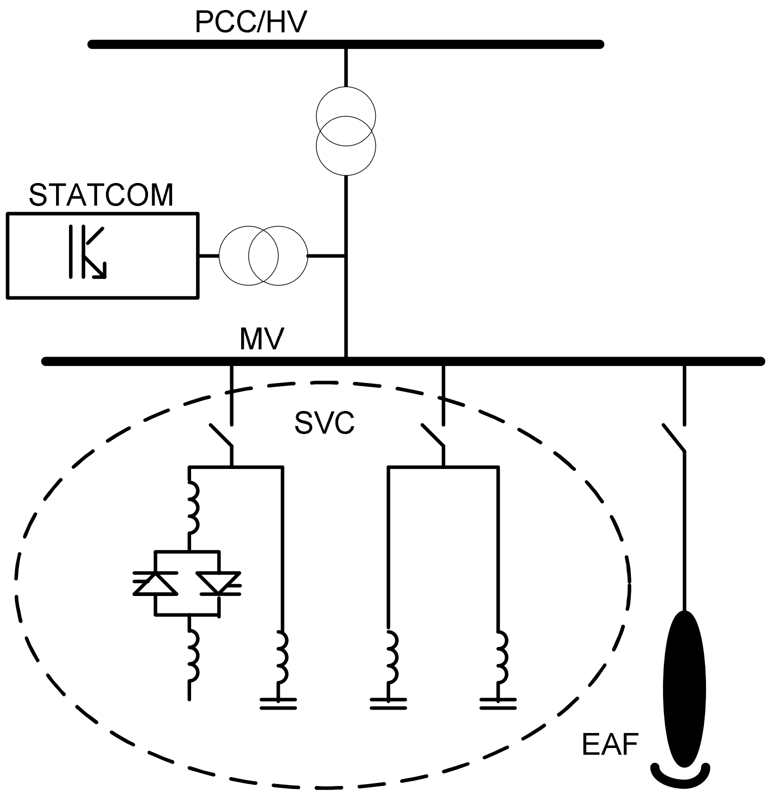


Figure 3: Single line diagram of the power grid

Figure 4: STATCOM in a container

Single line diagram and block diagram for RTDS simulations in hybrid SVC simulations for SGEM



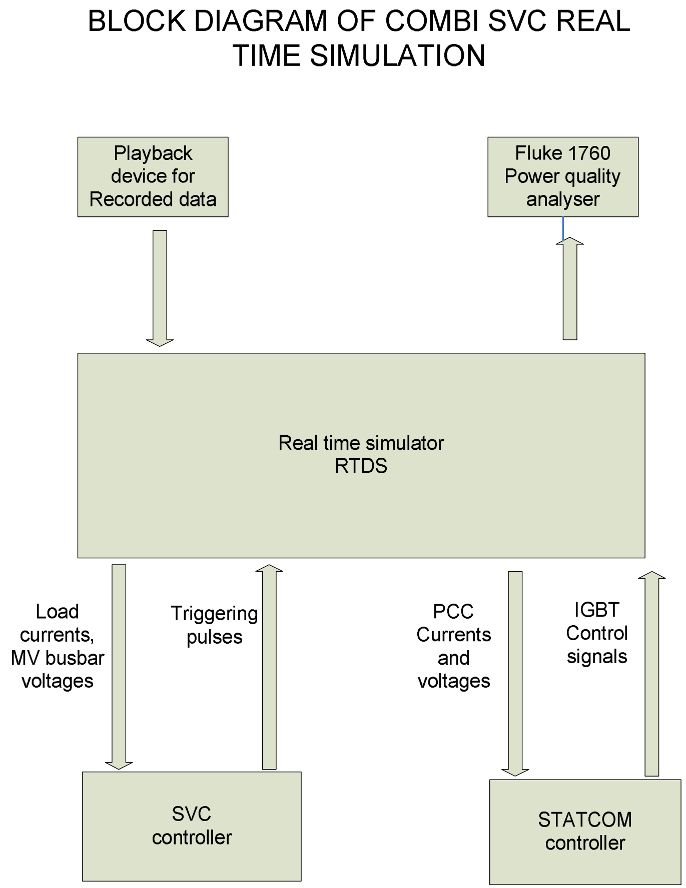


Figure 5: Single line diagram

Figure 6: Signalisation block diagram of RTDS simulation

Flicker value improvement using hybrid SVC

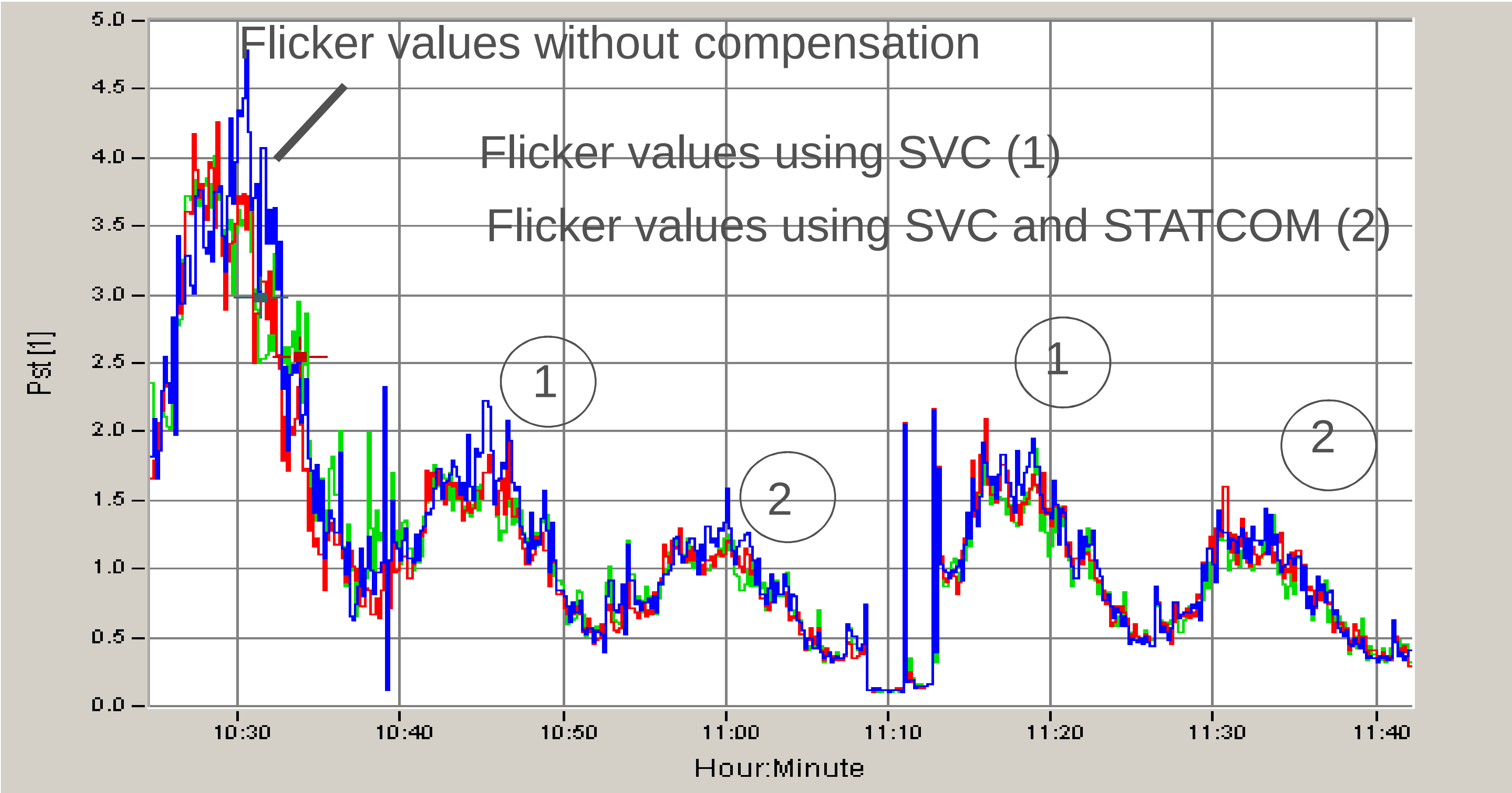


Figure 7: Flicker reduction for different reactive power comp. topologies

ADINE is a project co-funded by the European Commission

Thank you!

www.adine.fi