Steps toward a wide-area protection system

Khoi Vu

ABB Corporate Research

Raleigh, North Carolina

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Agenda

- ABB?

- Wide-area control/protection systems – Philosophies

- Wide-area systems – Field deployment and the Norwegian experience
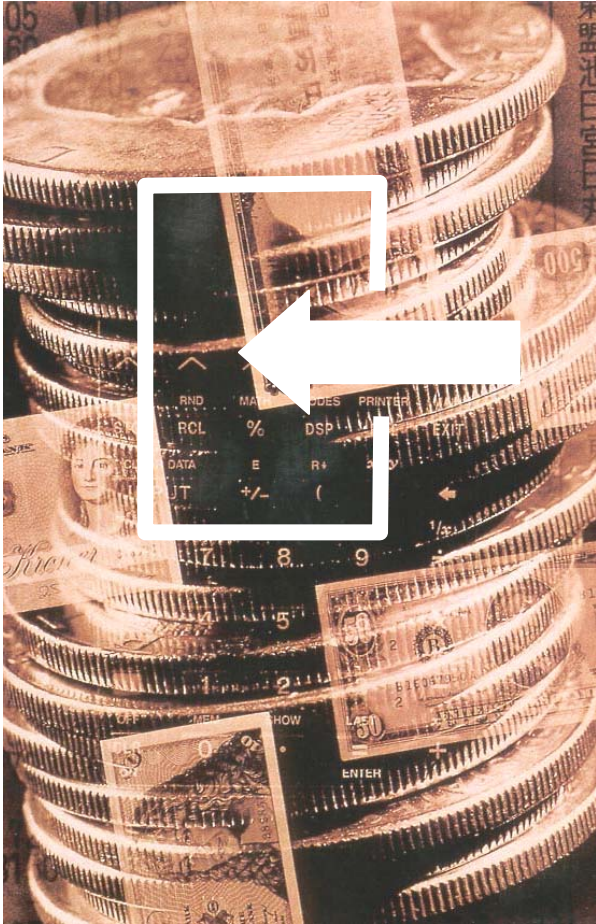
- The missing link…

Facts about ABB

- **Headquarters: Zurich, Switzerland**

- **About 103,000 employees in around 100 countries**

- **Revenues : $20+/- billion**

- **Listed on stock exchanges in Zurich/London, Stockholm, Frankfurt and New York**

- A leading power and automation technology company with strong market positions in its core businesses

- Two divisions: Power Technologies, Automation Technologies

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R&D investment: $ 907 million in 2004

Order-related development

317

Product development

490

Research

100

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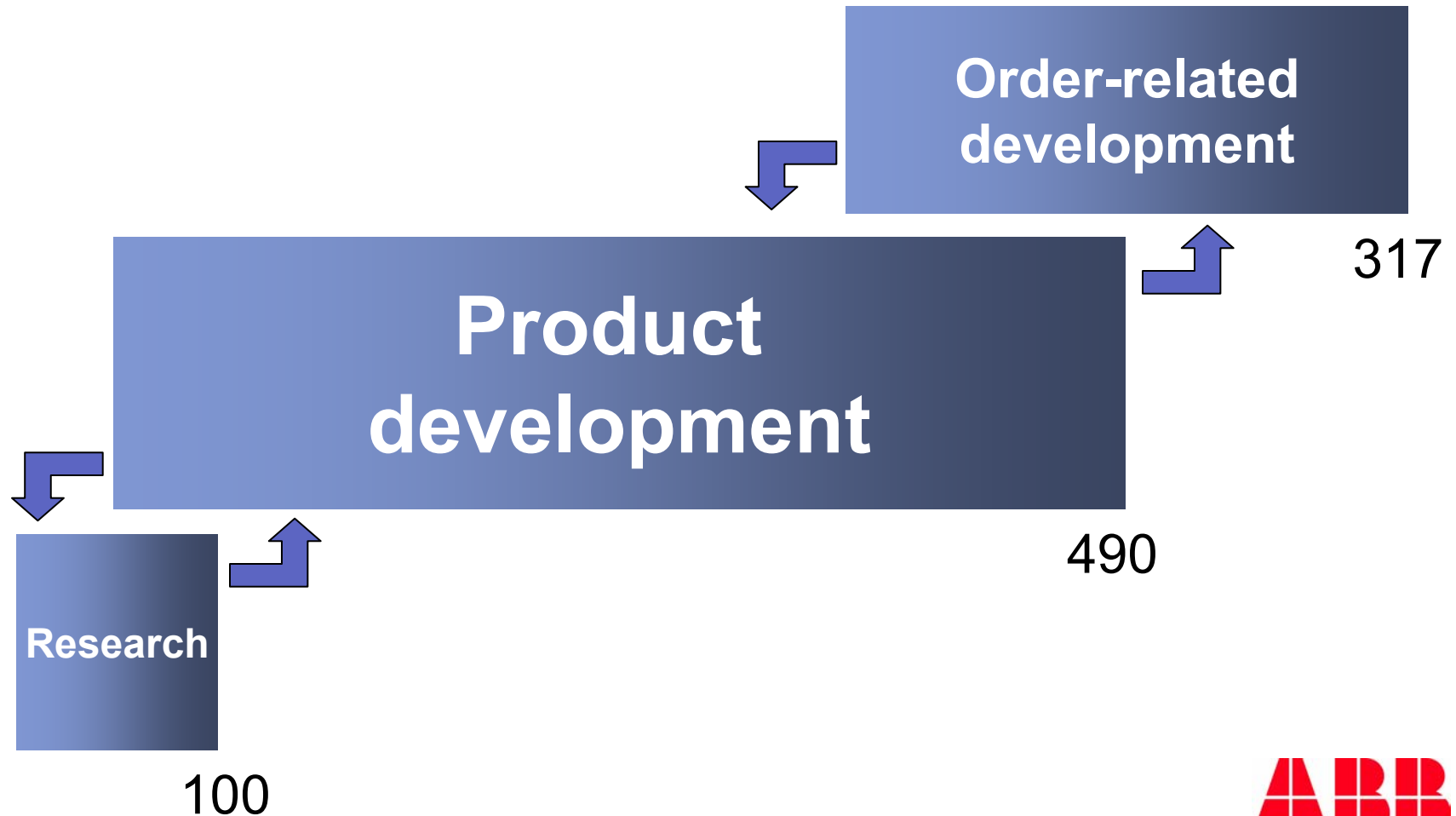
R&D priorities

- Create more value through technology

- Be responsive to external world

- Build partnerships with customers and universities

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Universities: partnership for technical excellence

- Massachusetts Institute of Technology U.S.
- Carnegie Mellon University U.S.
- Stanford University U.S.
- Cambridge University U.K.
- Imperial College U.K.
- Federal Institute of Technology CH
- Chalmers University SE
- Royal Institute of Technology SE
- RWTH Aachen DE
- Technical University Berlin DE
- Karlsruhe University DE
- Tsing Hua University CN

and more than 50 other partners

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Research close to customers and universities

Global labs for power and automation technologies

Raleigh U.S.
Wickliffe U.S.

Västeras SE
Baden CH
Ladenburg DE
Krakow PL
Oslo NO
Vaasa FI

Beijing CN
Shanghai CN
Bangalore IN

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600 people in 11 Research Centers

Current research programs

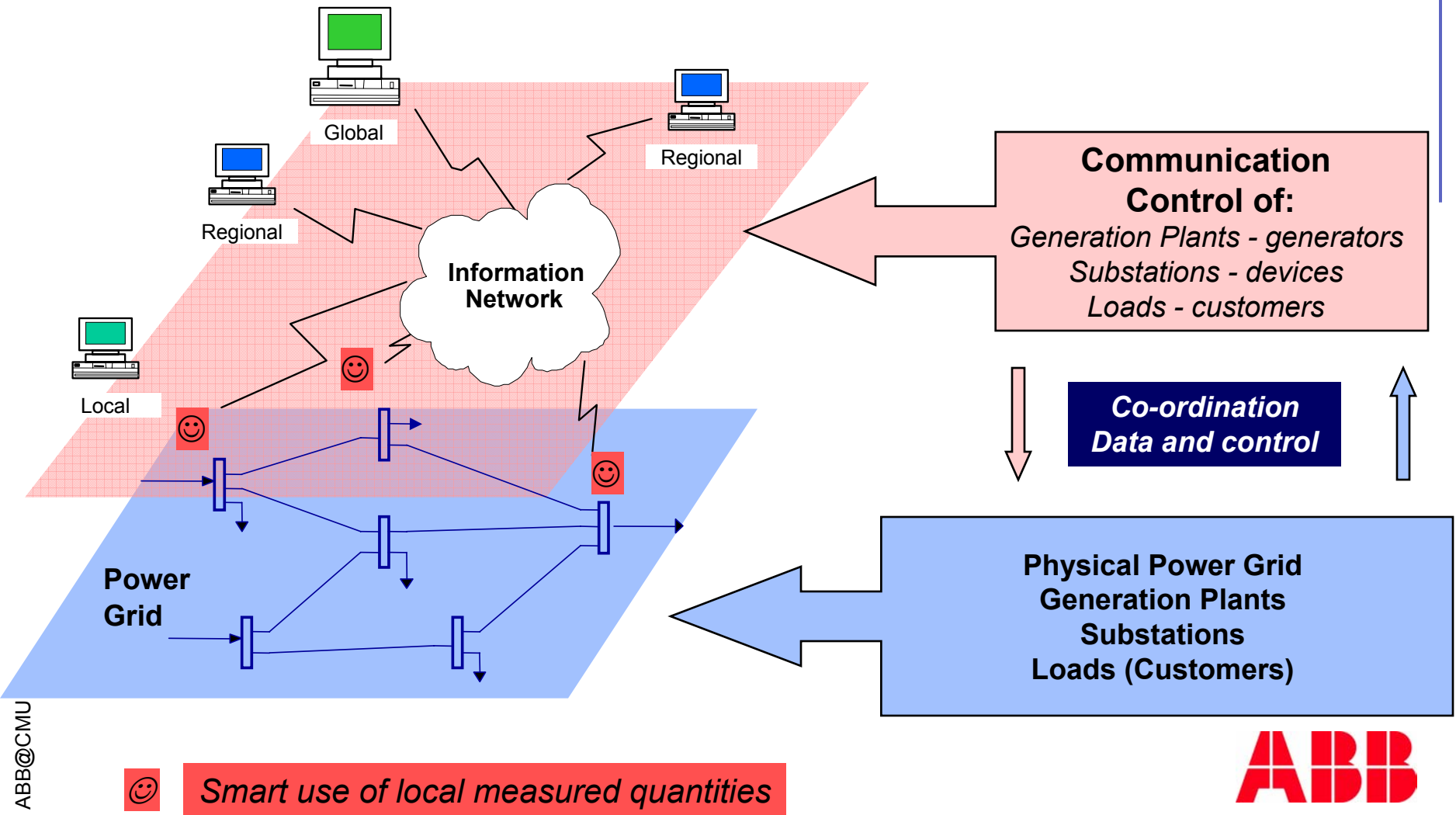**Securing and developing ABB´s core competence**

- Power device technology
- Power transmission and distribution applications
- Power electronics
- Mechatronics and robotics application
- Control and optimization
- Automation networks and devices
- Software architecture and processes
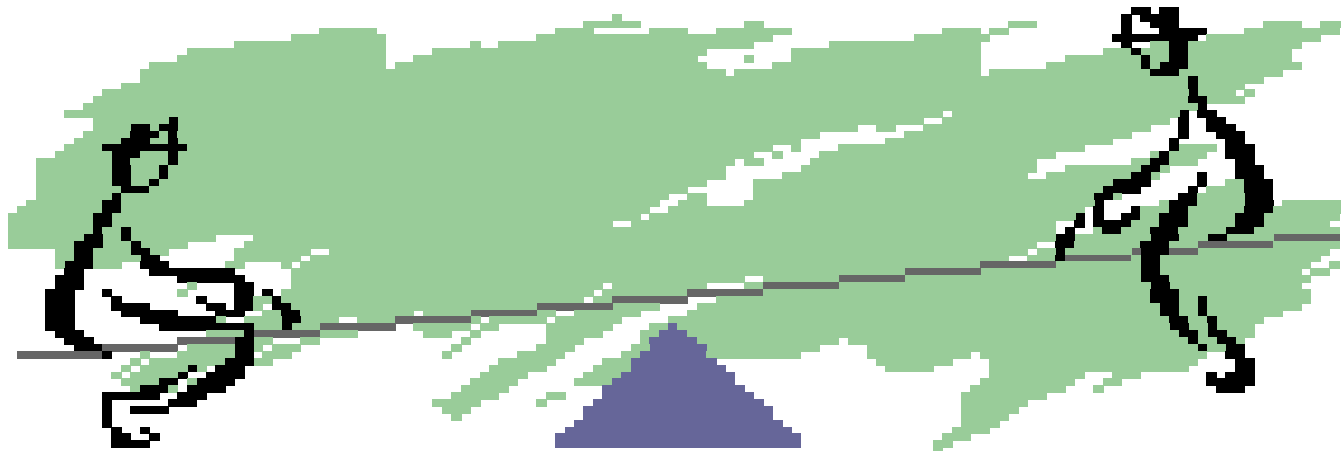- Advanced material
- Manufacturing technologies

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Wide-area control/protection systems - Philosophies

Electrical Network and Automation

Global

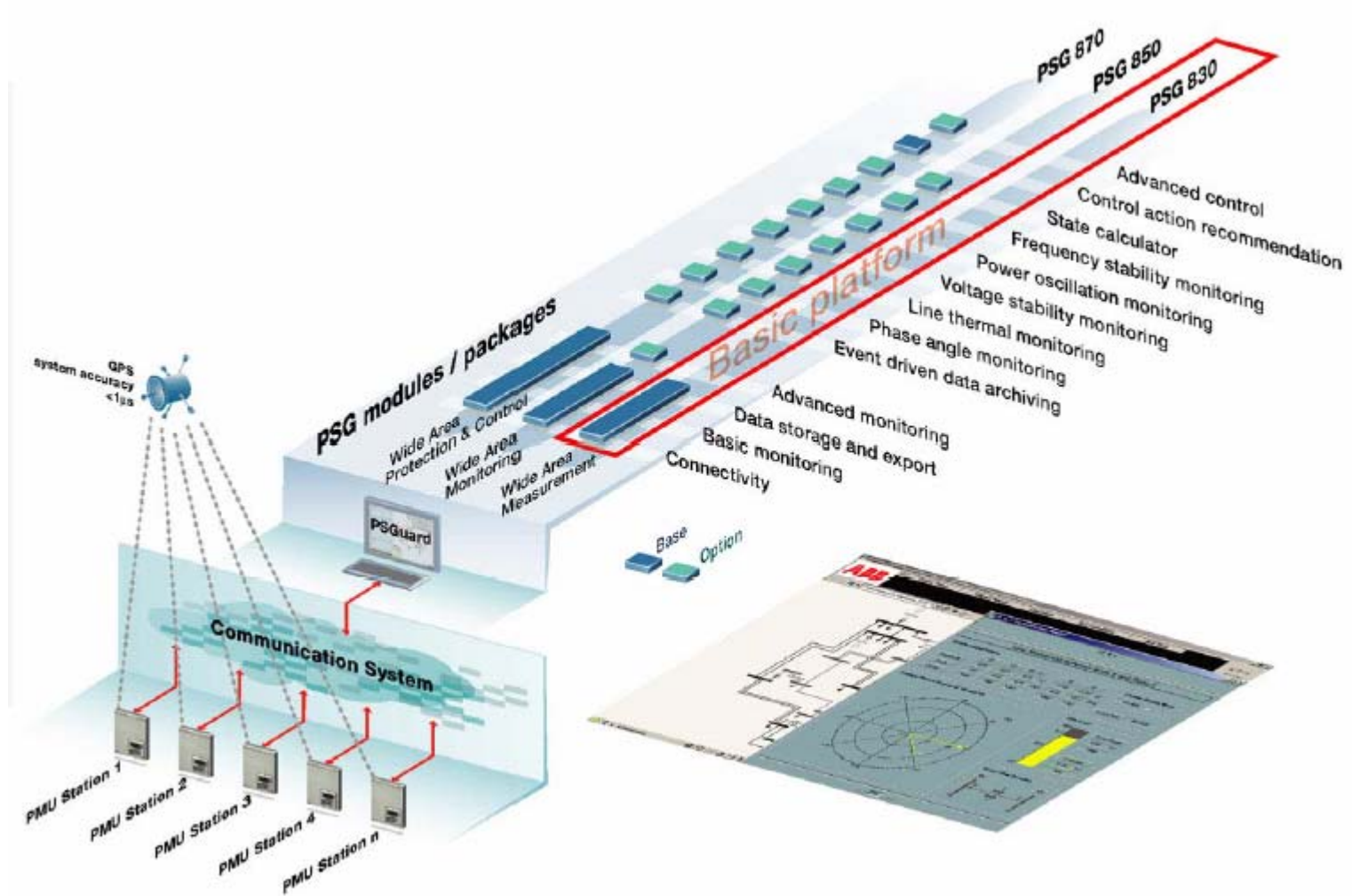Regional

Regional

Local

Information Network

Power Grid

☺

☺

☺

Communication Control of:
Generation Plants - generators
Substations - devices
Loads - customers

Co-ordination Data and control

Physical Power Grid Generation Plants Substations Loads (Customers)

☺ *Smart use of local measured quantities*

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Technology Solution: G vs. L

■ GLOBAL solution   ■ MIXed solution   ■ LOCAL solution

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VIP (Voltage Instability Predictor) – example of local solution

E_{NET}

Z_{NET}

Source Network

V

I

Z_{app}

Load / Sink
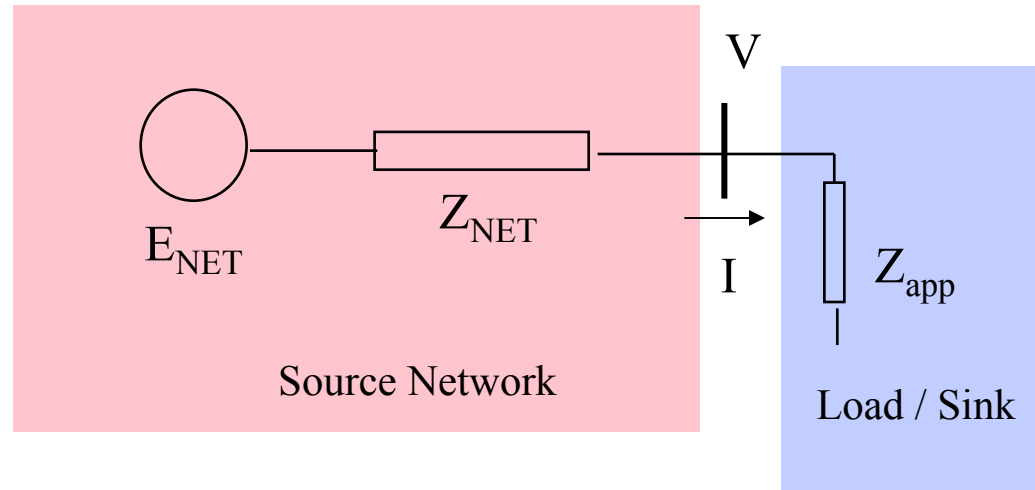
Maximal power transfer

<=> $|Z_{NET}| = |Z_{app}|$

Algorithm tracks system strength based on local V & I

$\overline{Z}_{app}$

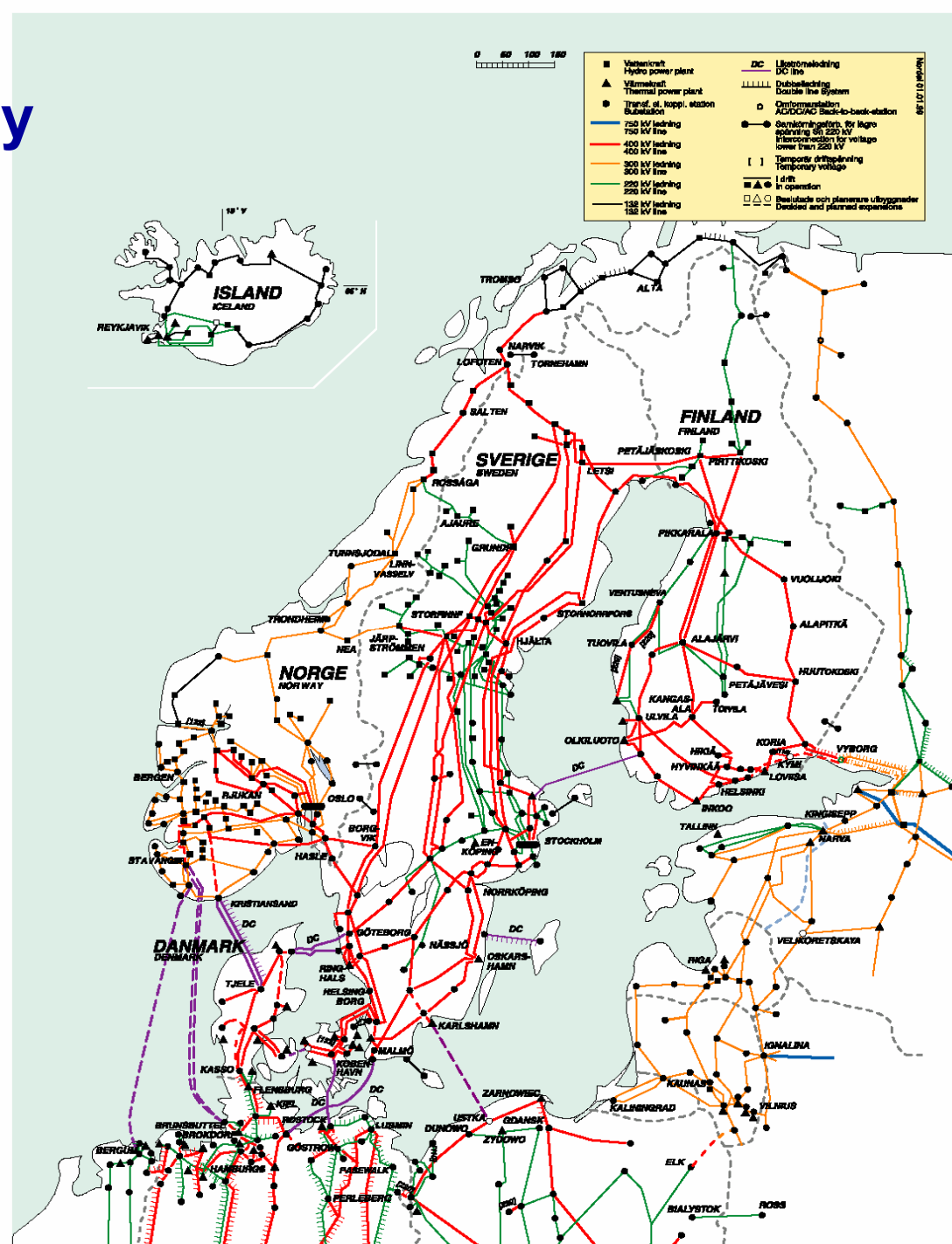Circle of radius $|\overline{Z}_{NET}|$
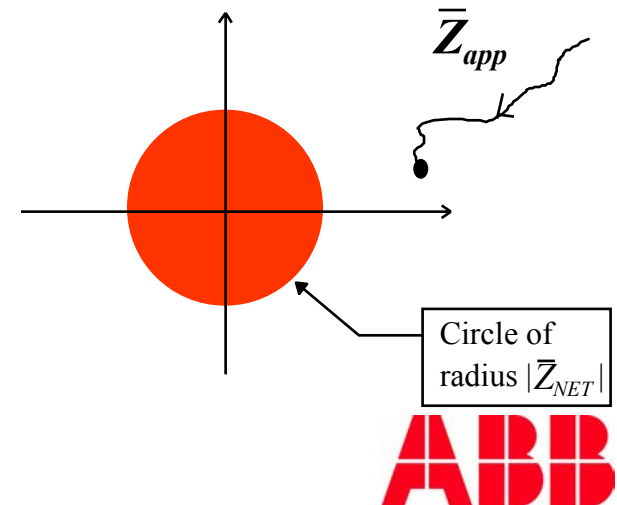
The Norwegian Intellectric Project (NiP)
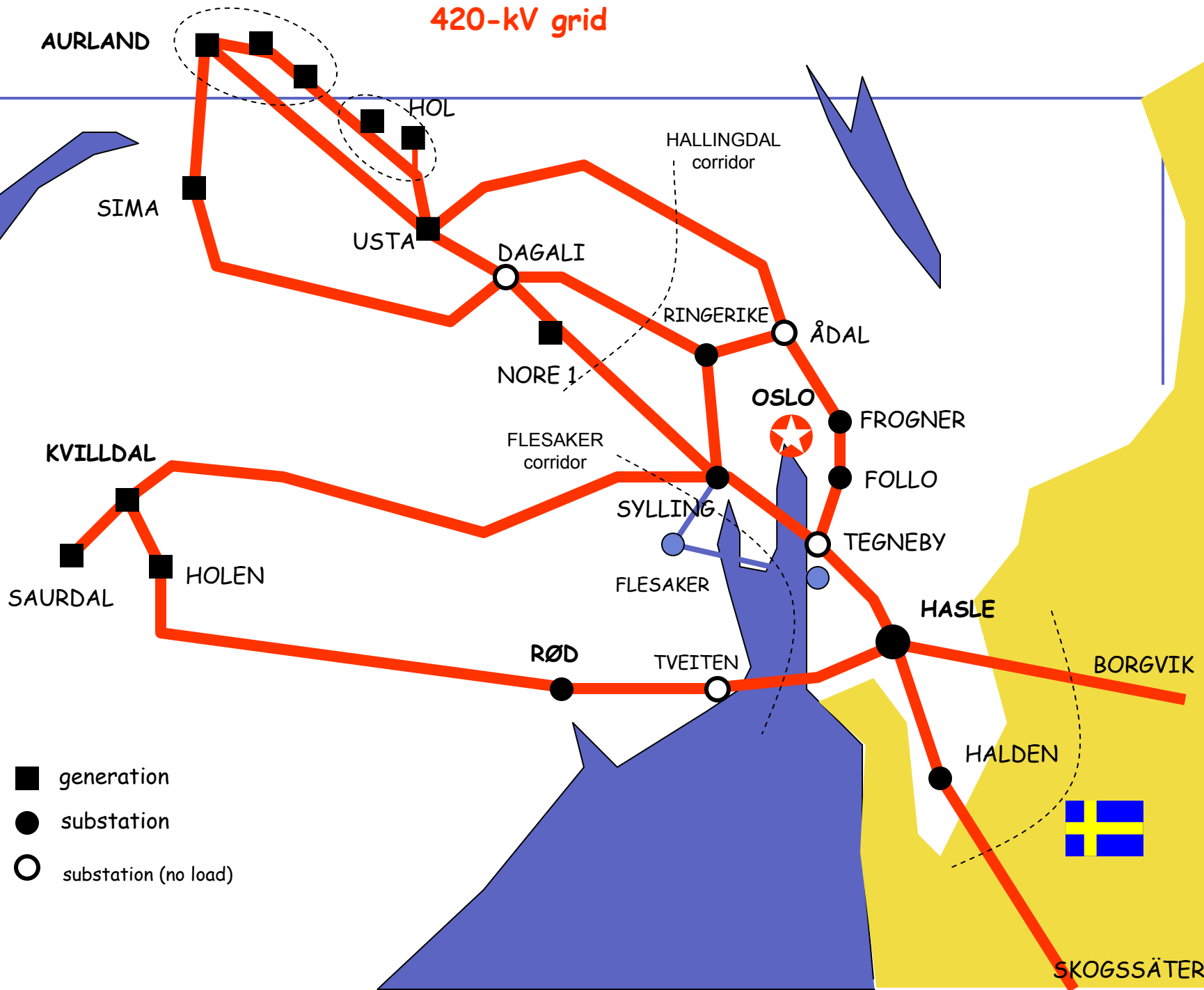
An example of field deployment

Nordic grid and Norway

- 5 Nordic TSOs in close collaboration.

- Deregulated market since 1991.

- Norway:
  - TSO = Statnett
  - Hydropower ~ 100%
  - Hasle as the most critical bottleneck for energy transfer

420-kV grid

AURLAND

HOL

HALLINGDAL
corridor

SIMA

USTA

DAGALI

RINGERIKE

ÅDAL

NORE 1

OSLO

FROGNER

FLESAKER
corridor

KVILLDAL

FOLLO

SYLLING

TEGNEBY

HOLEN

FLESAKER

SAURDAL

HASLE

RØD

TVEITEN

BORGVIK

HALDEN

■ generation

● substation

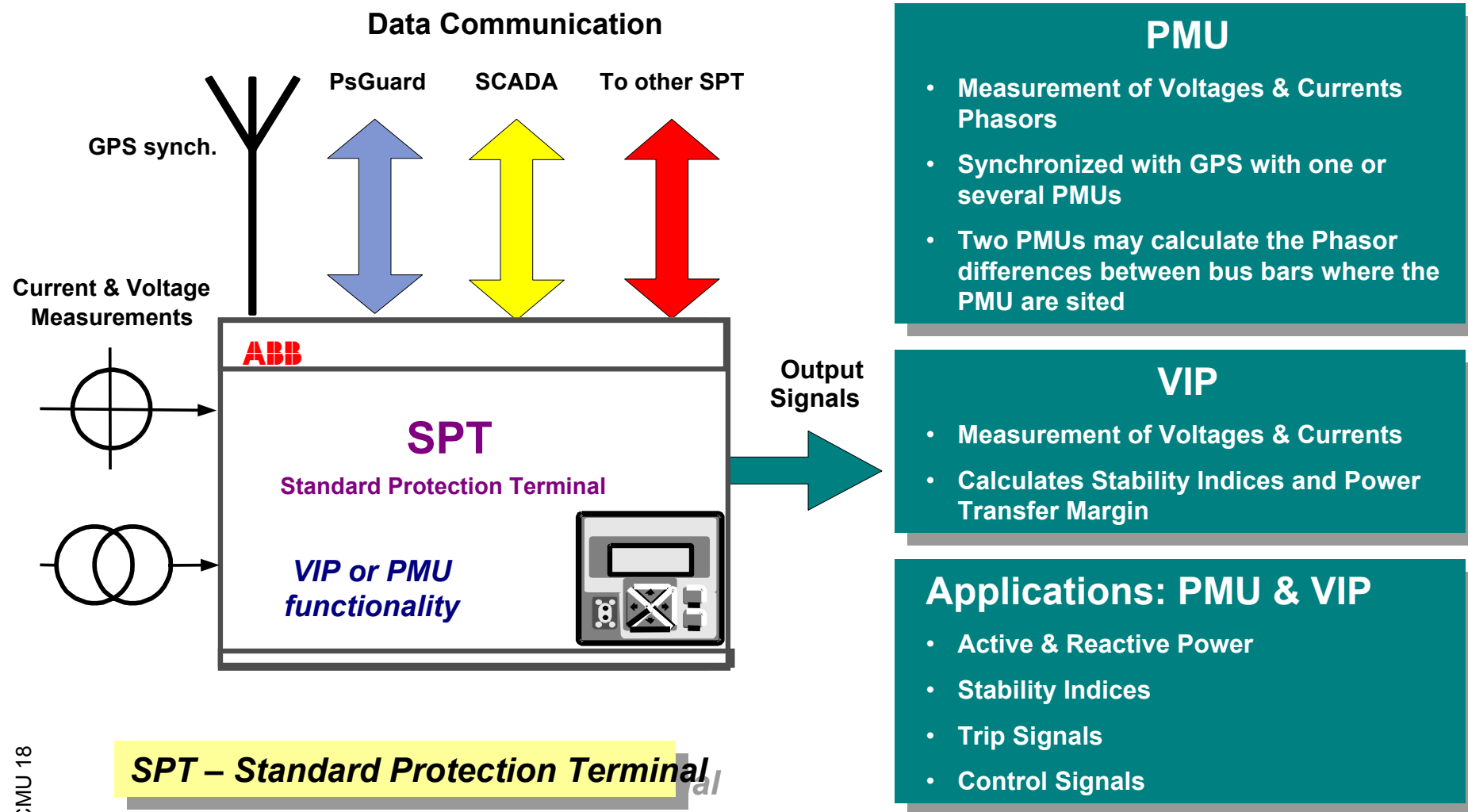○ substation (no load)

SKOGSSÄTER

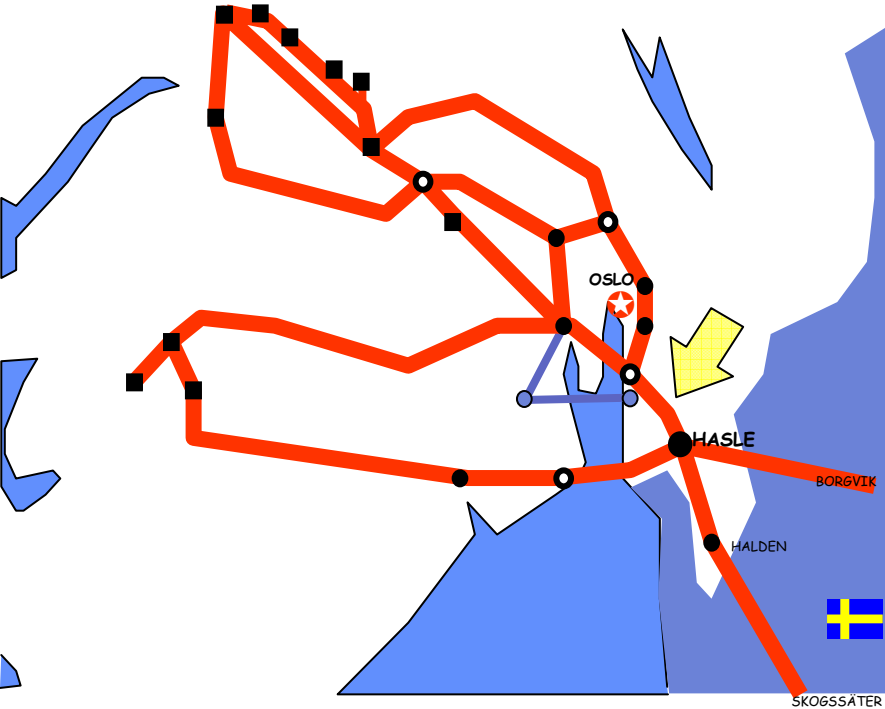© ABB@CMU 16

Issues pondered by Statnett

- 19xx-1999: New grid asset or new information system?

- 2000: launched the Norwegian Intellectric Project.

- 12/2000: installed 3 PMUs and 1 VIP.

- 2000-2003: data analysis, field tests; also, wide-area monitoring. Confidence in VIP grew.

- 2004: first commercial order of VIP for an industrial site in Western Norway; VIP box is linked to SCADA and load shedding.

- 2005+: New R&D project to deploy more IEDs; bring in other TSOs.

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General VIP/PMU terminal

Data Communication

GPS synch.

PsGuard   SCADA   To other SPT

Current & Voltage Measurements

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SPT

Standard Protection Terminal

VIP or PMU functionality

Output Signals

PMU

- **Measurement of Voltages & Currents Phasors**
- **Synchronized with GPS with one or several PMUs**
- **Two PMUs may calculate the Phasor differences between bus bars where the PMU are sited**

VIP

- **Measurement of Voltages & Currents**
- **Calculates Stability Indices and Power Transfer Margin**

Applications: PMU & VIP

- **Active & Reactive Power**
- **Stability Indices**
- **Trip Signals**
- **Control Signals**

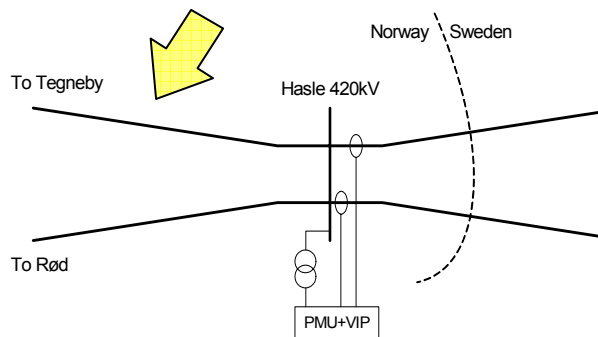*SPT – Standard Protection Terminal*

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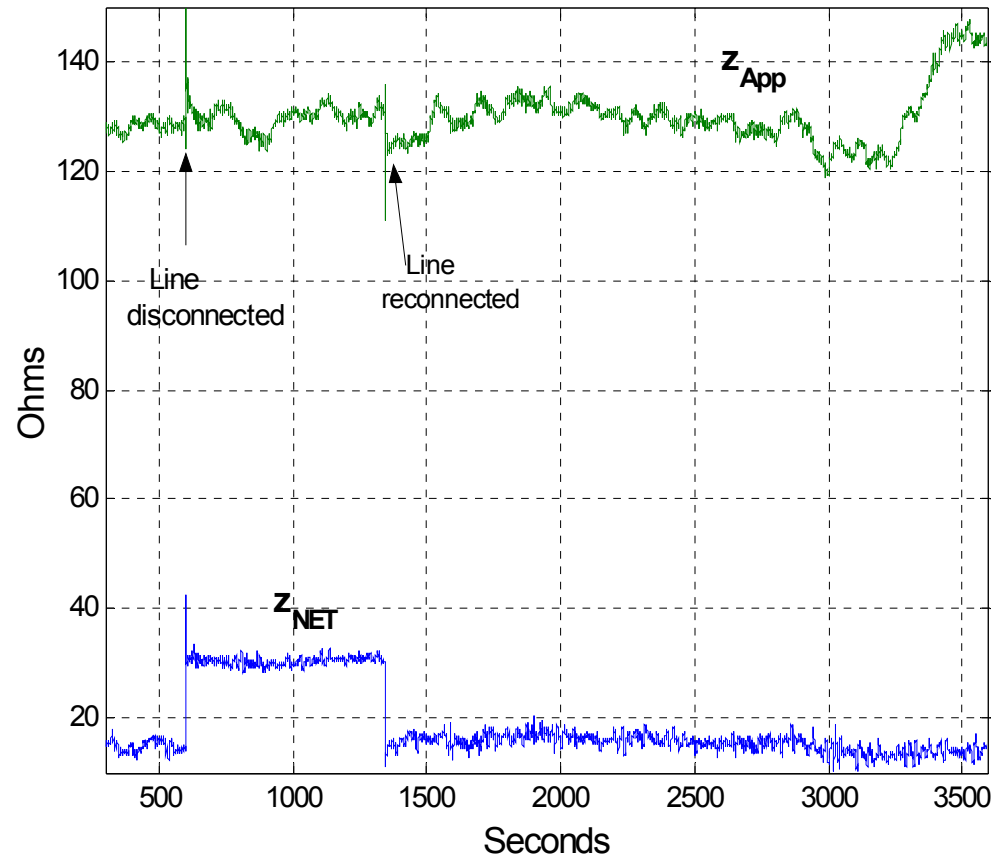
Performance verification of VIP (1)

REAL-LIFE TEST:

- Date: Jan-18-2002, ~noon.

- Transfer of 1300MW to Sweden through the Hasle corridor.

- Line Tegneby-Hasle was disconnected at 1210 and reconnected at 1220.
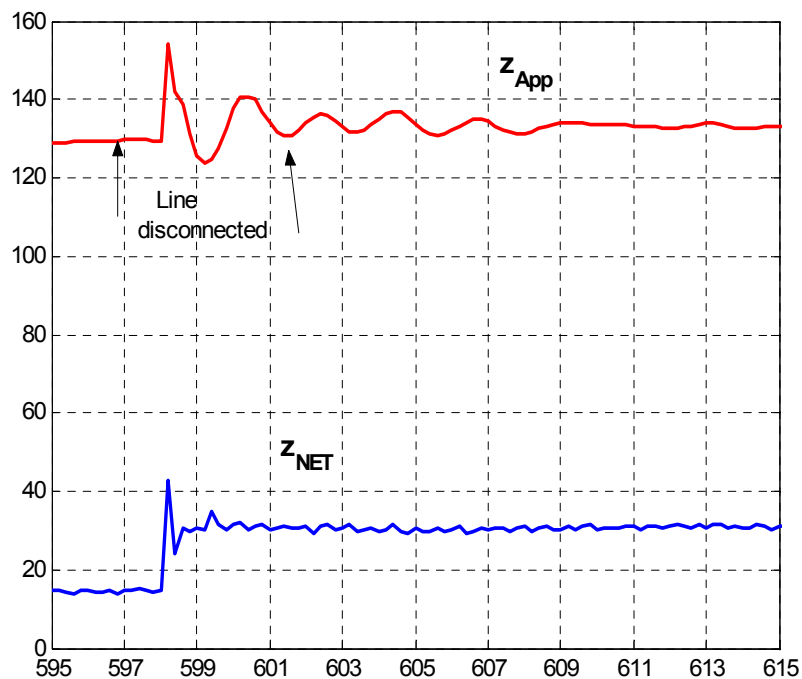
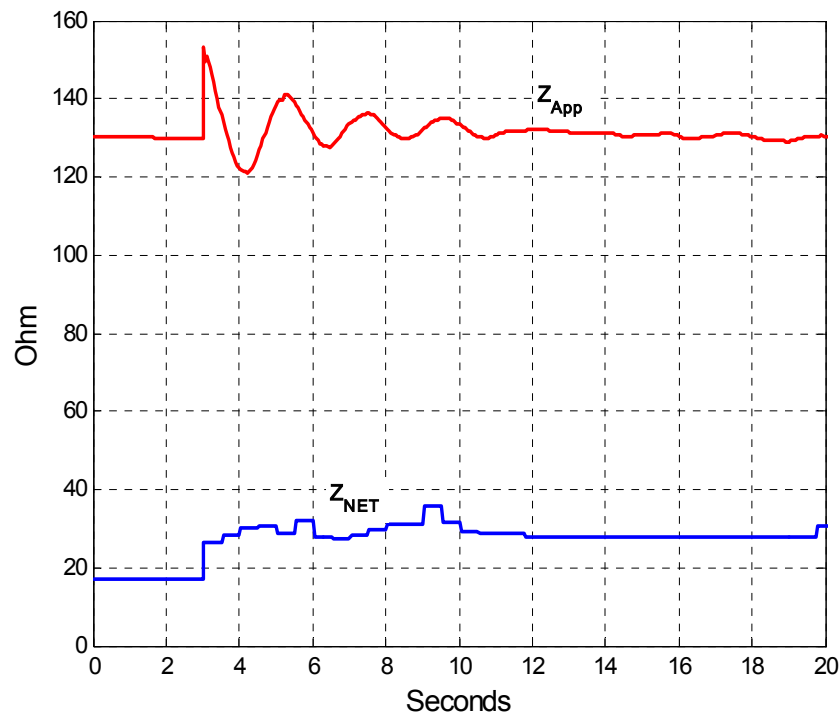- Issue: how did the VIP box respond?

Performance verification (2)

- This was how the VIP box responded.

- Yeah… but how can one be sure that the values were correct?

Performance verification (3)

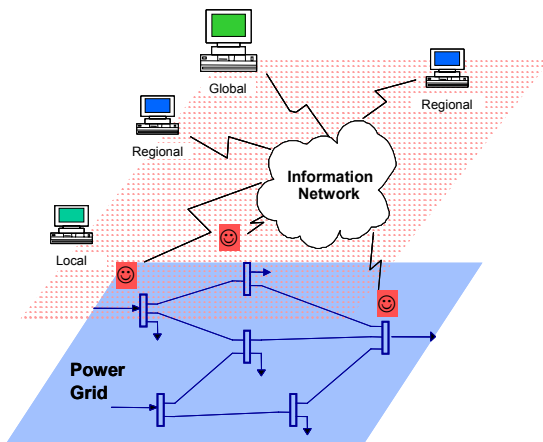**Response from the VIP box (during the event)**

**Network Simulation by SINTEF and Statnett (after-the-fact)**

# The missing link in wide-area systems

Building the "last 10 meters"

Load Shedding vs. Load Rationing

- Load shedding is a very economical and effective control.

- But how is it done today?

Distribution Substation

Primary Distribution Feeders

DG

Secondary Substation

Residential Consumers

DG

- Would it be nice if one can do "load rationing" instead of "load shedding"?

  - If each customer cuts back kWH by 10%, the burden on the substation is reduced by ~10%.

  - 10% is approximately 1 light bulb per customer.

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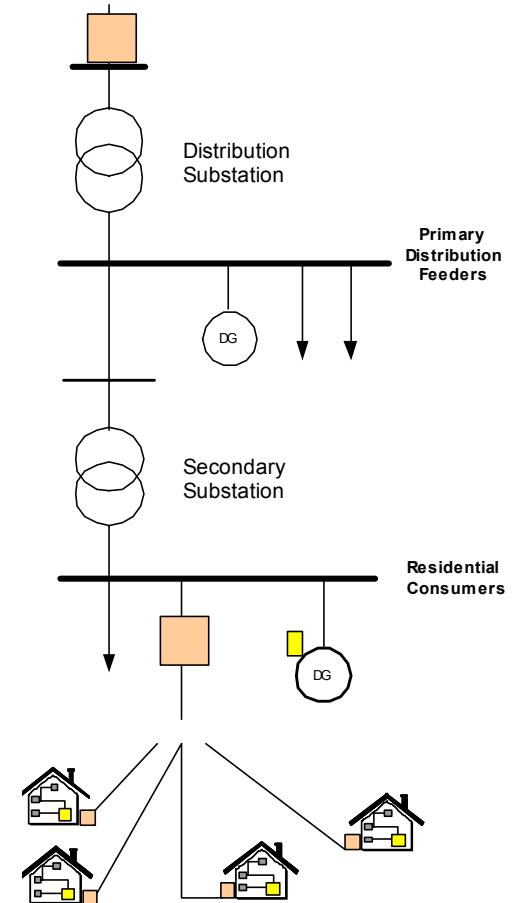
Enabling technology for the last 10 meters
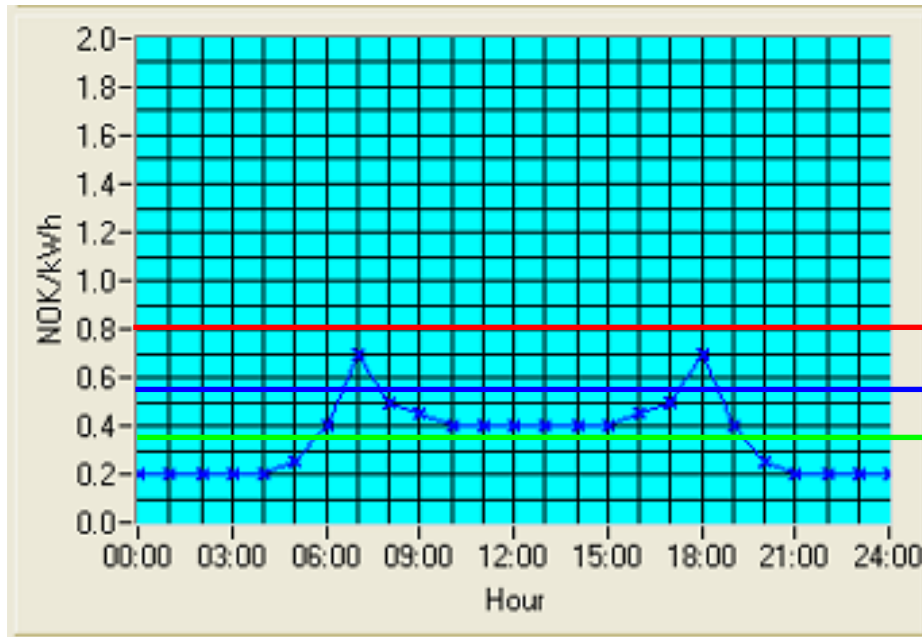
- **Normal operation, user control;** **99.999% of the time**
  - Features and functionality
  - Value for user
- **Emergency operation;** **0.001% of the time**
  - Features and functionality, including response time
  - Value for Utility