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WAMS and WACS Enabling the Smart Grid at Statnett

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Stockholm, Sweden

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Outline

- Statnett in brief
- Statnett's challenges – modernization of the Main Grid
- Statnett & Smart Grid
  - Our view
  - Vision
- PMU Technologies - Running R&D Projects
  - WAMS
  - WACS (WAPS)
- New applications to facilitate Smart Grid
- Conclusions

STATNETT IN BRIEF

Statnett SF – The Owner

Statnett SF is a state-owned enterprise administrated by the Ministry of Petroleum and Energy

Stanett's Vision

Statnett shall be recognized as Europe's most innovative and environmental responsible grid operator.

Business idea

- Statnett aims to create conditions conducive to a well functioning electricity market and a satisfactory quality of supply in the power system

Areas of responsibility

- To contribute to the efficient utilisation of the total power system
- To ensure quality
  - in the short term: to coordinate supply and demand
  - in the long term: to develop the Main Grid
- To ensure equal access for all players
- To secure electricity transmission
  - the Main Grid: power highways
  - interconnections

STATNETT'S CHALLENGES

Energy balance in the Nordic countries 2010

- With normal precipitation
  - Norway -4 TWh
  - Sweden 3 TWh
  - Finland -16 TWh
  - Denmark-West 5 TWh
  - Denmark-East 1TWh
  - Nordic region imbalance - 11

Source: Nordel

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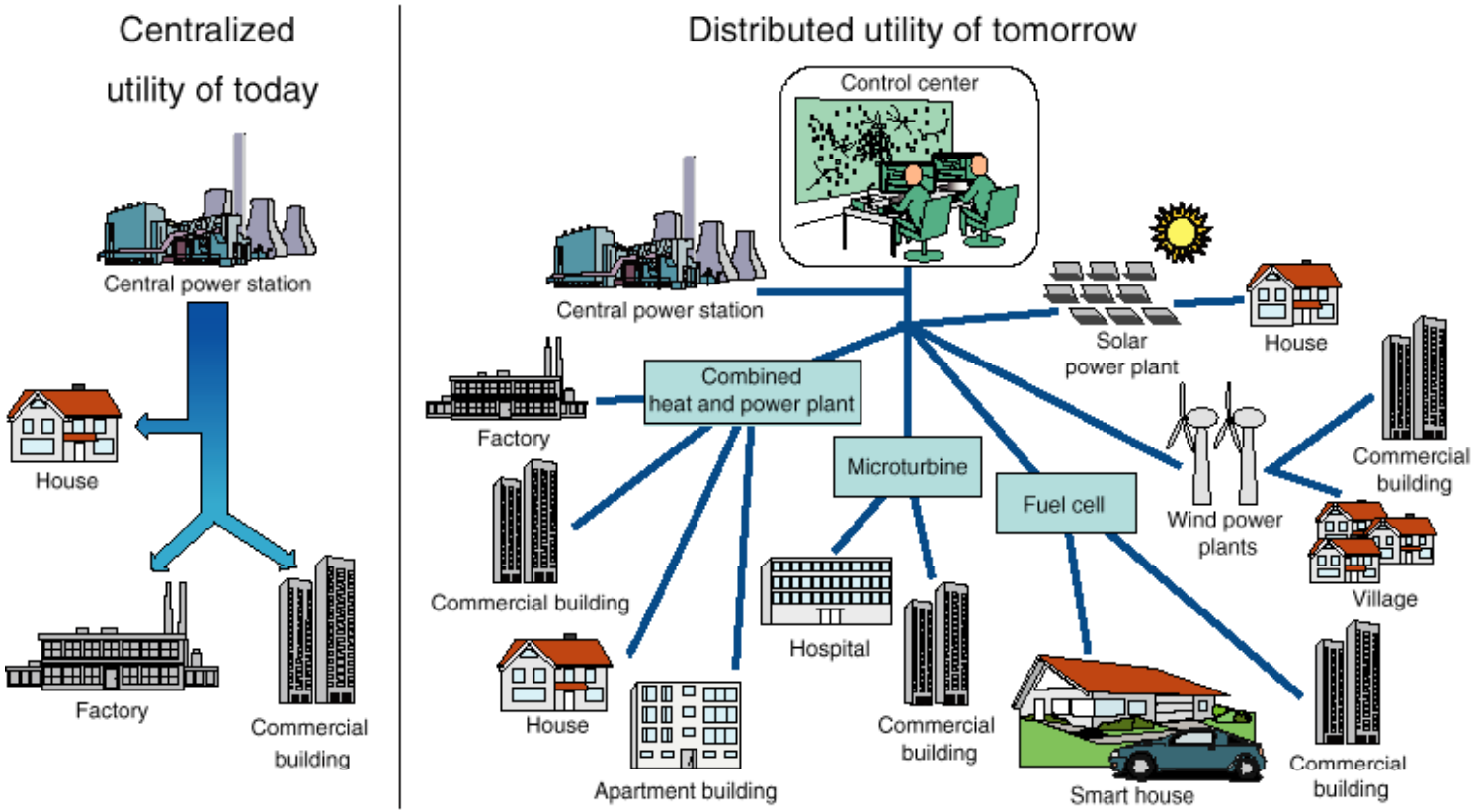
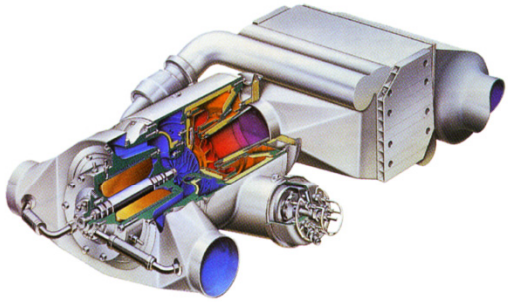
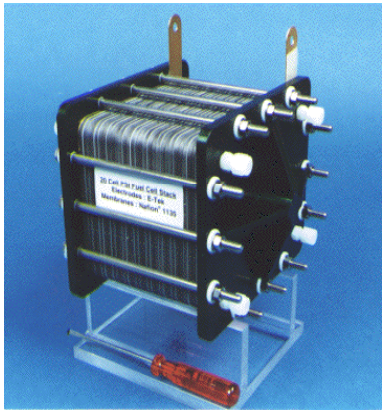
The Future Energy System

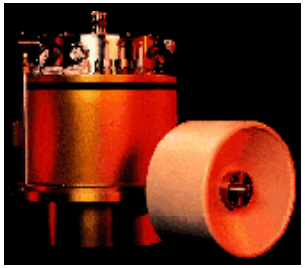
- Central production to a energy source mix



New and remote generation capacity



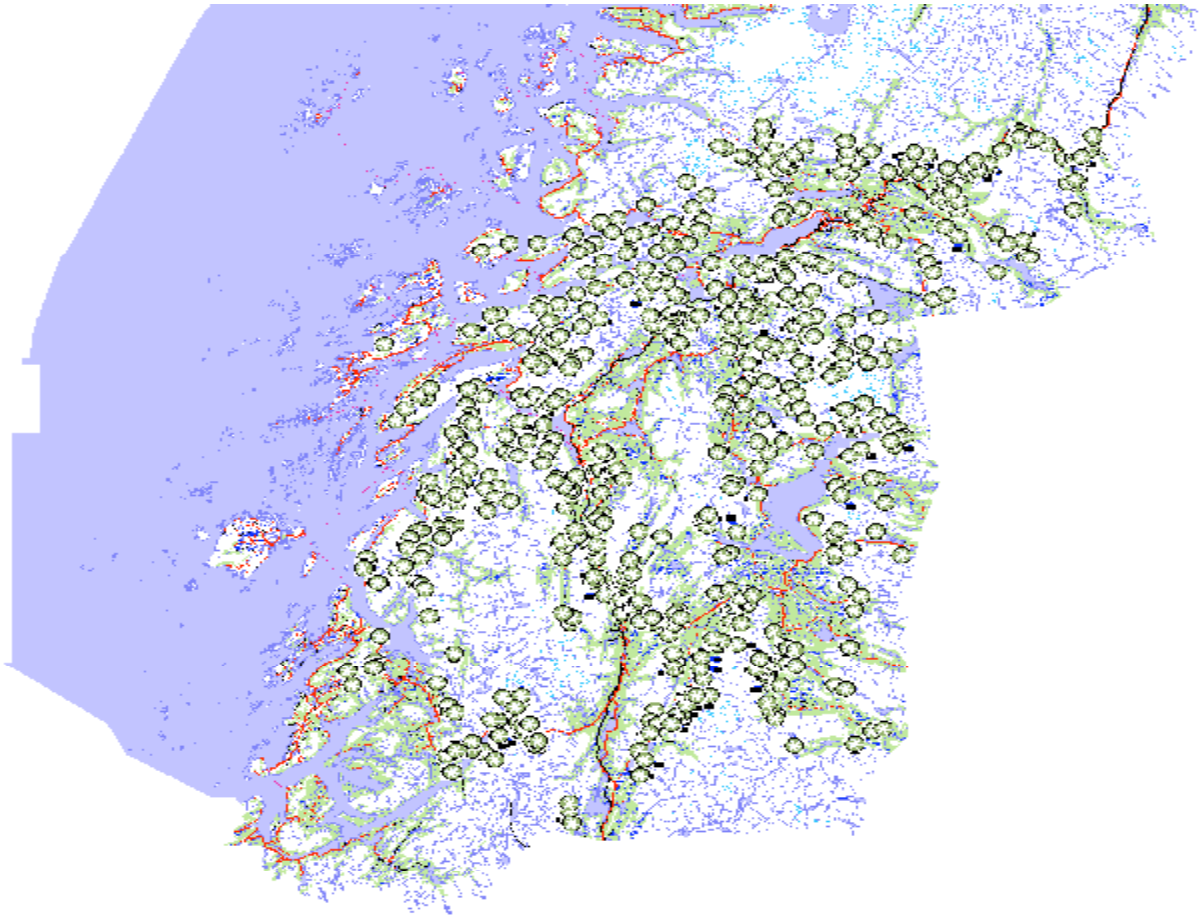




- Production of electricity (energy) – Large wind farms to small units
- In Norway – great potential for micro hydro plants
- The production sources are sited ”closer” to the customer – on all voltage levels

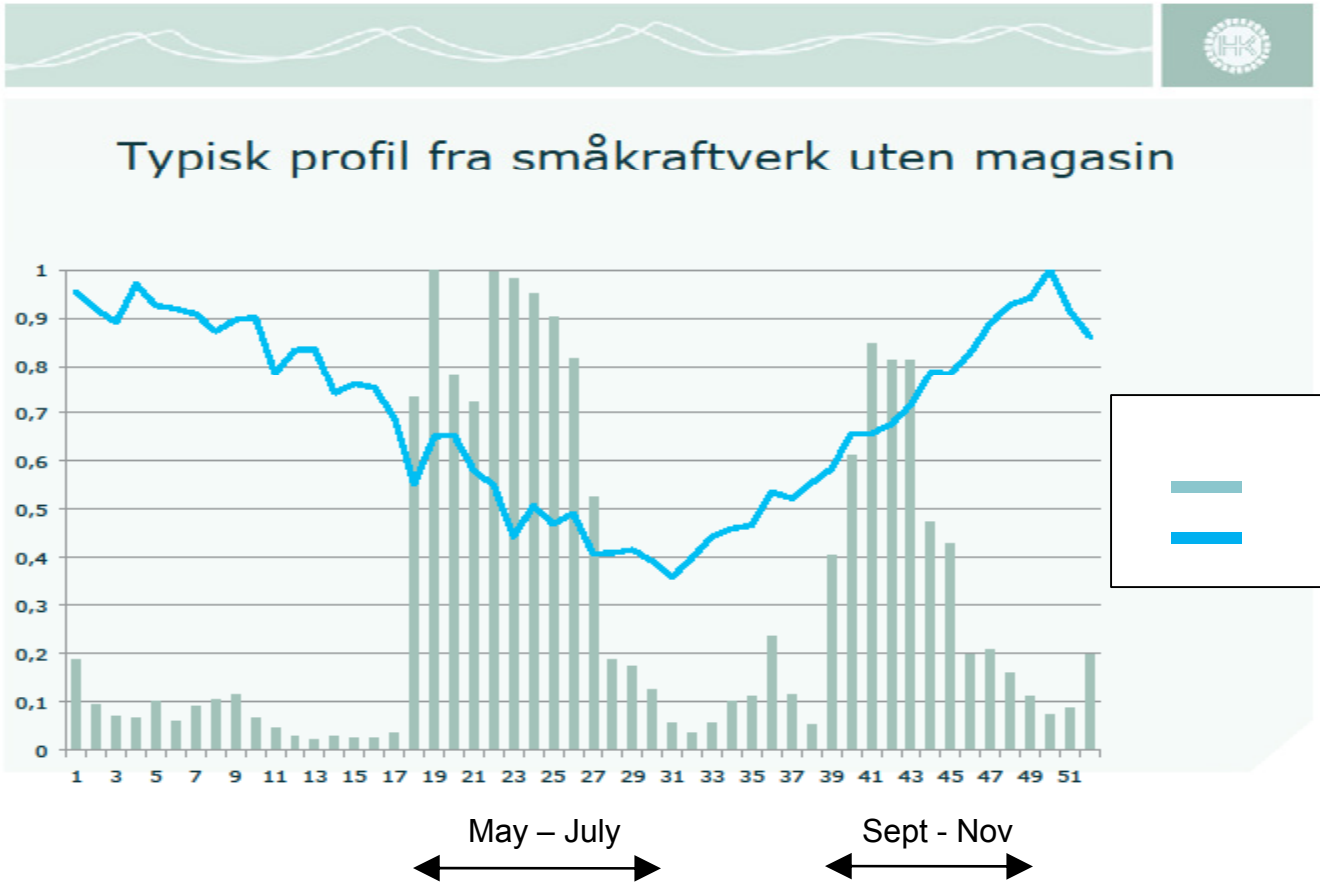
North of Norway – Helgeland coast

- Potential for many small micro hydro generators



Small Hydro plant (1-10 MW)

- Production in the ”wrong season”



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Fundamental changes in the power system

- Challenges for everybody

Future challenges for electricity supply

- Increasing demand
- Environmental concerns
- Security of supply – less sourcing from sensitive regions

More *renewable power* generation

Distributed and intermittent generation

Energy efficiency

Customer pricing expected to foster ***demand responses***

***Reliability* of supply**

- Ageing infra-structure
- Ageing workforce
- IT security

Impact on grid stability and efficiency

Future grids will be different

- **Open for all types and sizes of generation technologies**
- **Integrating demand side in system operation**

Creating a future-proof power grid

- Voltage upgrading

- Current main grid
  - 2600 km 420 kV
  - 5200 km 300 kV (1500 km duplex and 3800 km simplex)

- Voltage upgrading is strategically important for Statnett
  - Environment / licenses
  - Costs

- Challenges:
  - Cost and time efficient solutions for upgrading simplex lines
  - Upgrading of 300 kV stations to 420 kV

Creating a future-proof power grid

- Integration of new renewable energy

- Large potentials in Norway
  - Small scale hydro
  - Wind power: On-shore and off-shore
- Pro
  - Low costs for small hydro, interaction with regulated hydro
- Con
  - Medium cost onshore wind, interaction with regulated hydro
  - High cost offshore
  - Surplus in the Nordic countries, long transport to consumption
- Challenges:
  - Market and operational innovations related to regulated/unregulated production
  - Cost efficient solutions for very long range transportation of electricity

Total investments in the Norwegian main grid

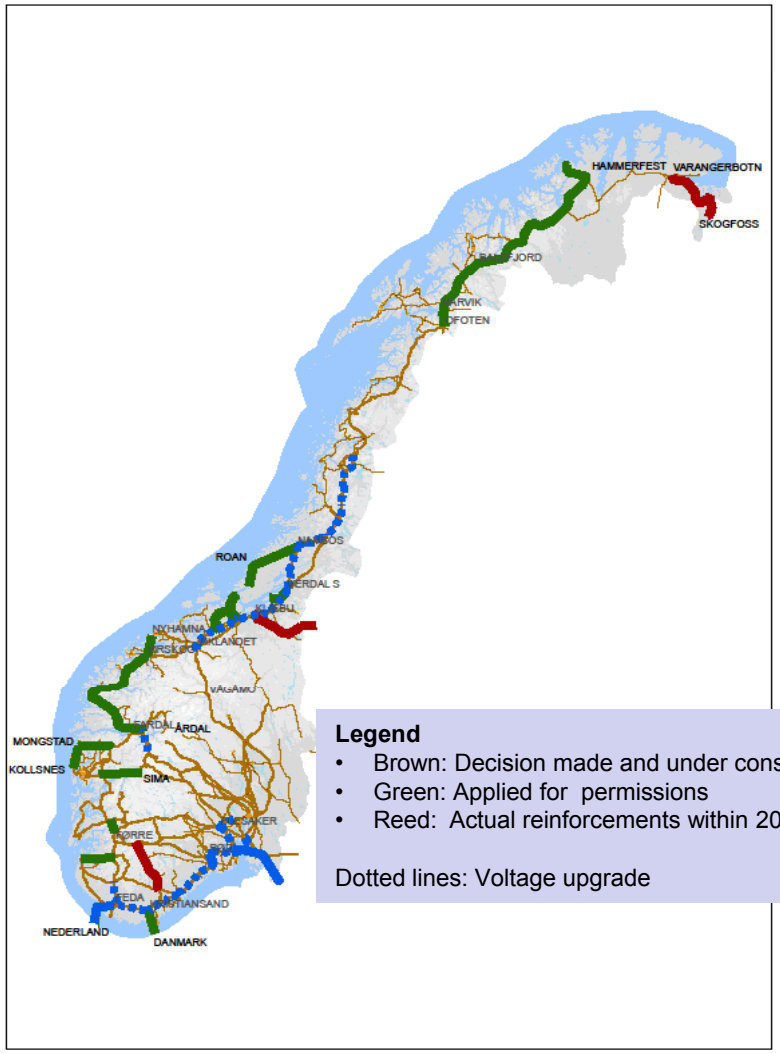
- Statnett's scenarios

This is a general trend globally – tremendous investment in infrastructure

- Challenges:
  - Licensing processes
  - Supply side capacity ??

Creating a future-proof power grid

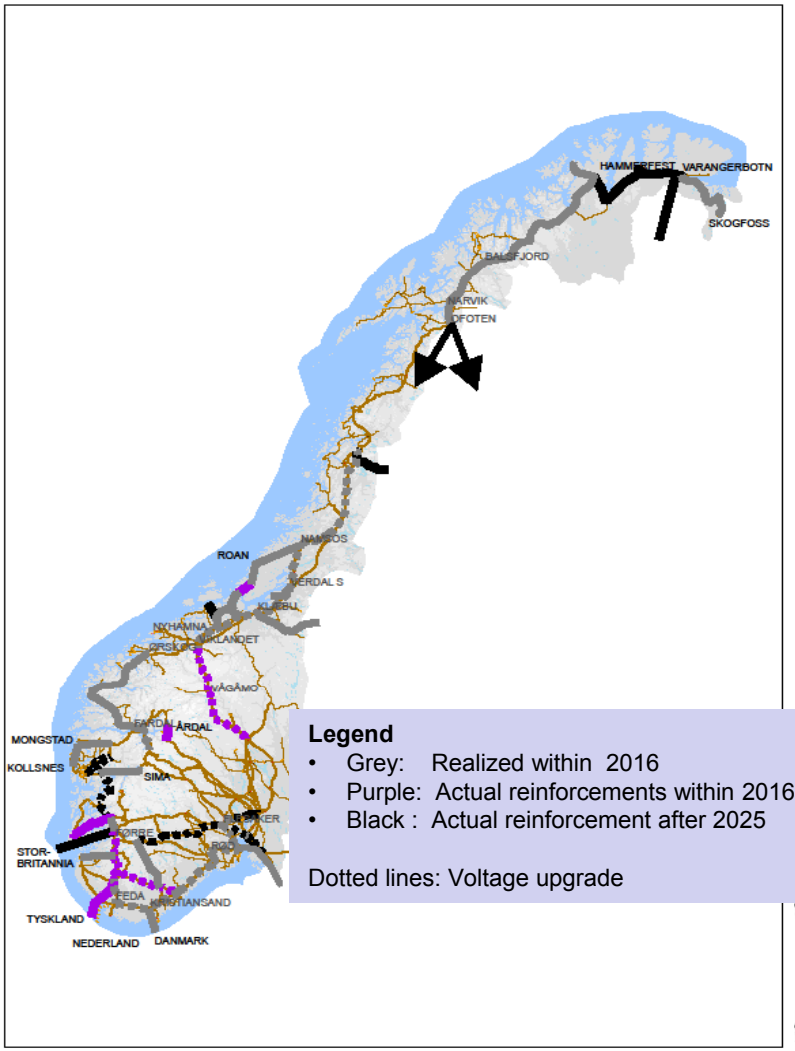
- Summary of Statnett's plans, 2016 and 2025



Legend

- Brown: Decision made and under construction
- Green: Applied for permissions
- Reed: Actual reinforcements within 2016

Dotted lines: Voltage upgrade



Legend

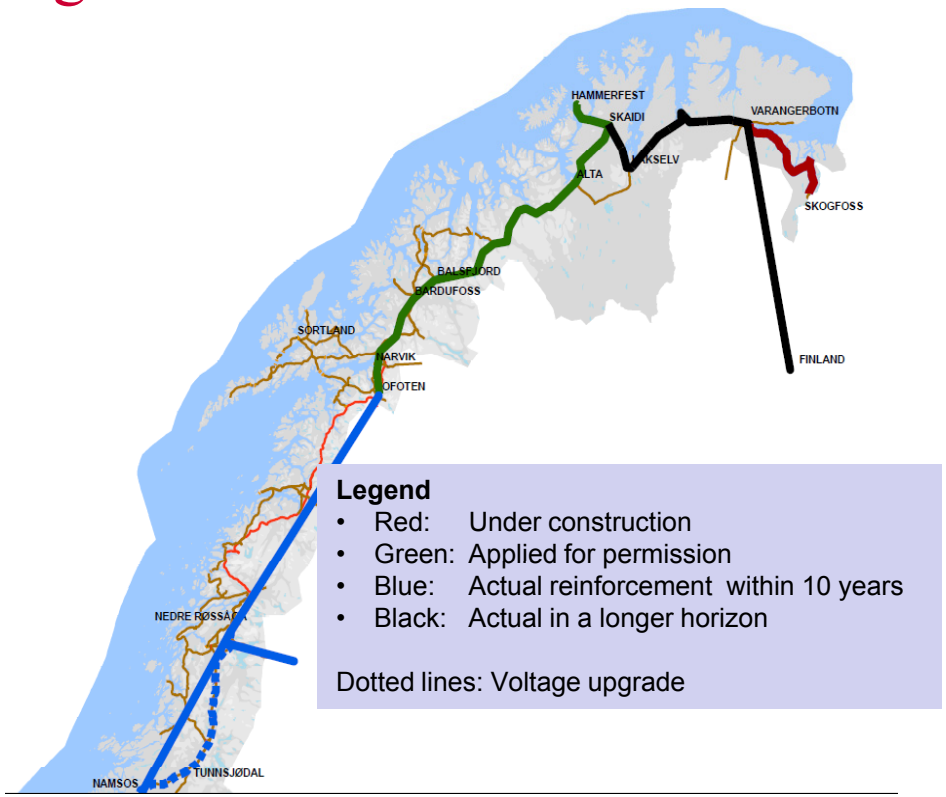
- Grey: Realized within 2016
- Purple: Actual reinforcements within 2016 - 2019
- Black : Actual reinforcement after 2025

Dotted lines: Voltage upgrade

Creating a future-proof power grid

- Extension to the north

- ”Arctic Circle” to support new industrial activity (petroleum) and integration of wind power



- Challenges:
  - Security of supply under extreme weather conditions

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Creating a future-proof power grid

- Interconnectors

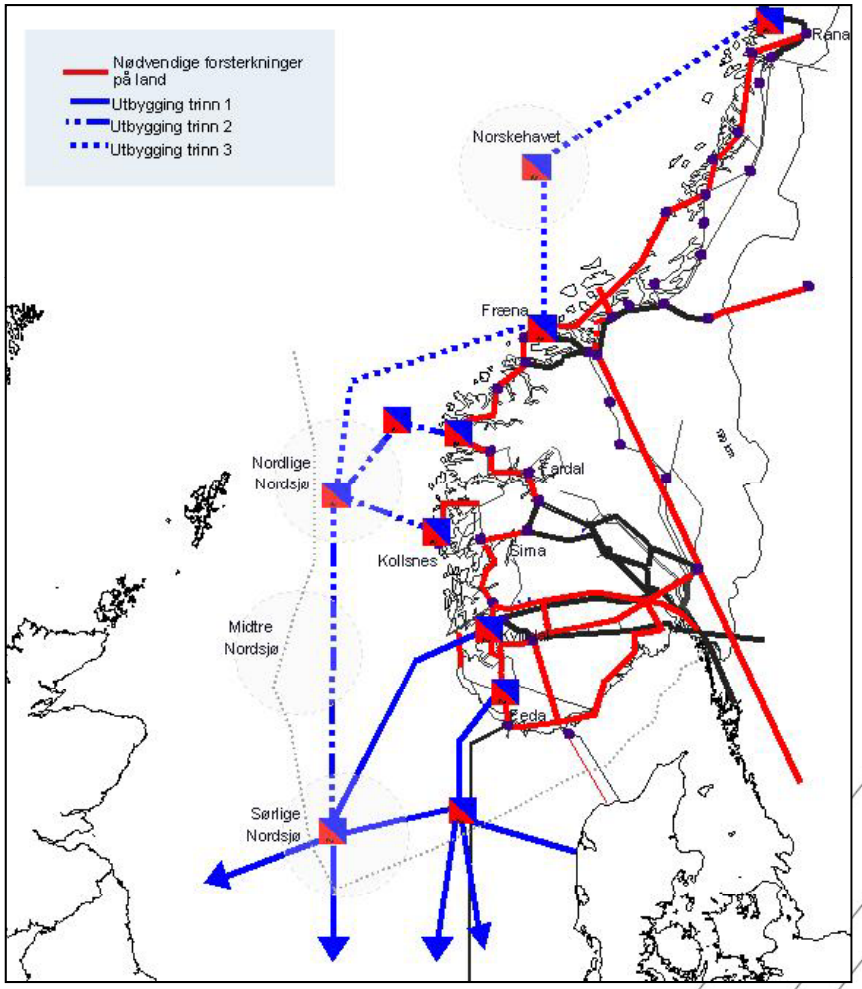
- New interconnectors between Norway and the Continent/Great Britain will be environmentally and economically beneficial for Norway and for Europe

- Challenges:
  - VSC technology: Need for larger capacities and less losses
  - Do suppliers of HVDC technology have sufficient capacity to satisfy the market?

Creating a future-proof power grid

- Offshore consumption and production

- Off-shore wind power
- Petroleum sector consumption
- Interconnectors
- Super grids – “Smart Grids”



- Challenges:
  - Multi terminal HVDC
  - Market and regulatory innovations (ref Kriegers Flak)

Statnett's challenges as the Norwegian TSO

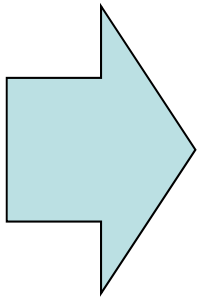
Traditional - as usual

New solutions – Smart Grids - Smart Operation

New Infrastructure - Smart Grid

To Solve:

- Long term planning - Scenarios
- Develop
- Build



Requires Smart Operation

To develop and deploy:

- Operational Planning
- On-line operation
- Monitoring & Control
- Balancing

A combination in the short term and long term development

Focus to develop new Smart Grid applications

STATNETT'S VISION ABOUT SMART GRID

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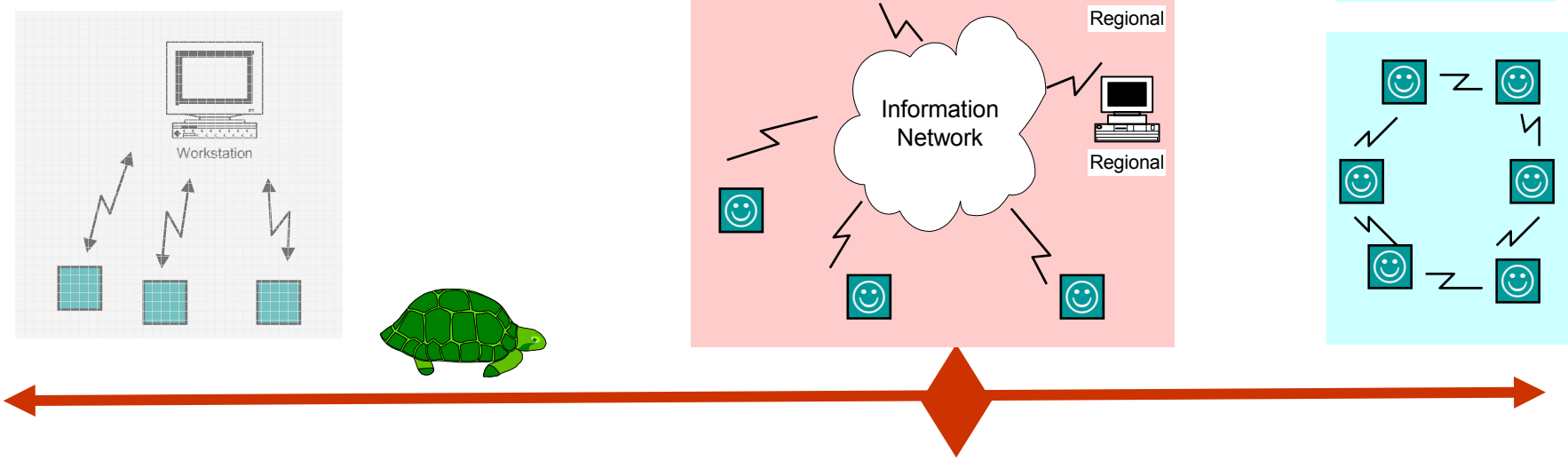
System Monitoring, Control & Protection

- State of the Art in architecture

Statnett's vision

Status quo

Academic Research



Centralized

- Heavy on control-center apps
- Light on device apps
- Strongly dependent on communications links

De-centralized

- Light (or no) control-center apps
- Heavy on device intelligence
- Less dependent on communications

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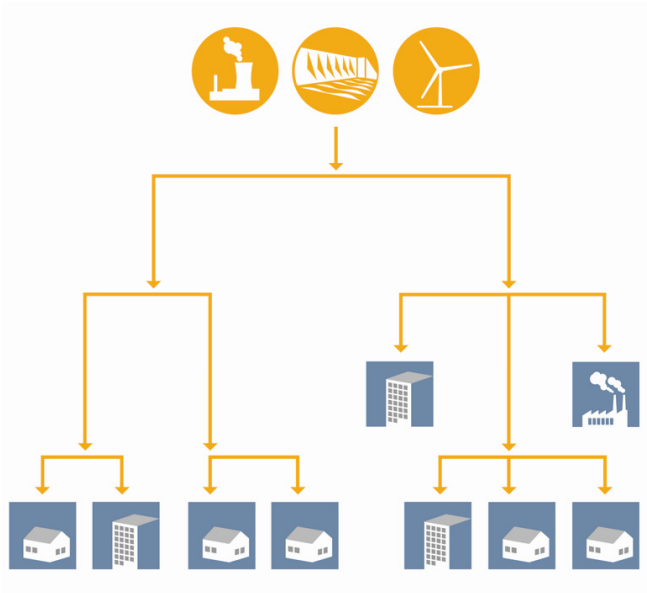
Smart Grids – A transition over time

Traditional grid



Smart Grid

- Centralized power generation
- One-directional power flow
- Operation based on historical experience

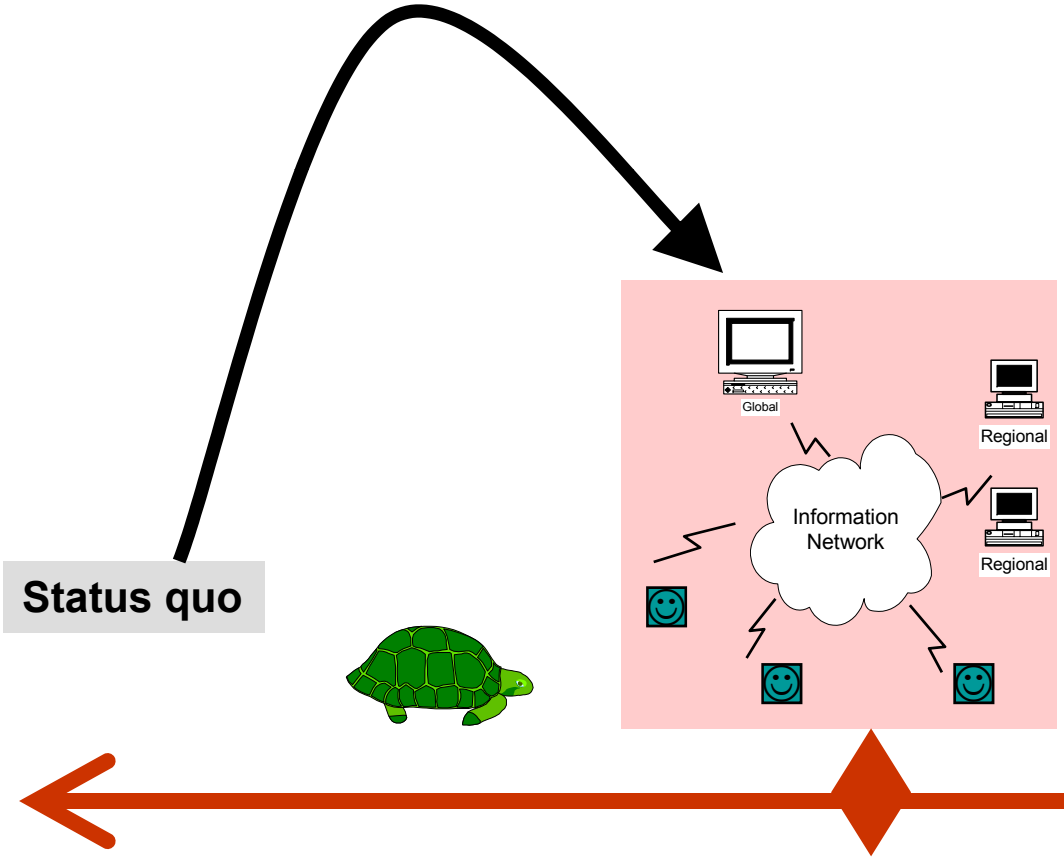
- Centralized and distributed power generation (renewable)
- Multi-directional power flow
- Operation based on real time data

Smart Grid

- What is Smart – The power grid or how we operate the grid

How do we get there?

- A Smart Grid Operation?



Philosophy:

Use local and global measurements to ensure a cost effective planning and operation of the power system

Knowledge:

Statnett has good knowledge of power systems and data processing.
Need to corporate with DSO & End-users
Close corporation with academia, vendors & other TSO's

Implementation:

Software codes can be downloaded to boxes or control centers and tested in the power systems

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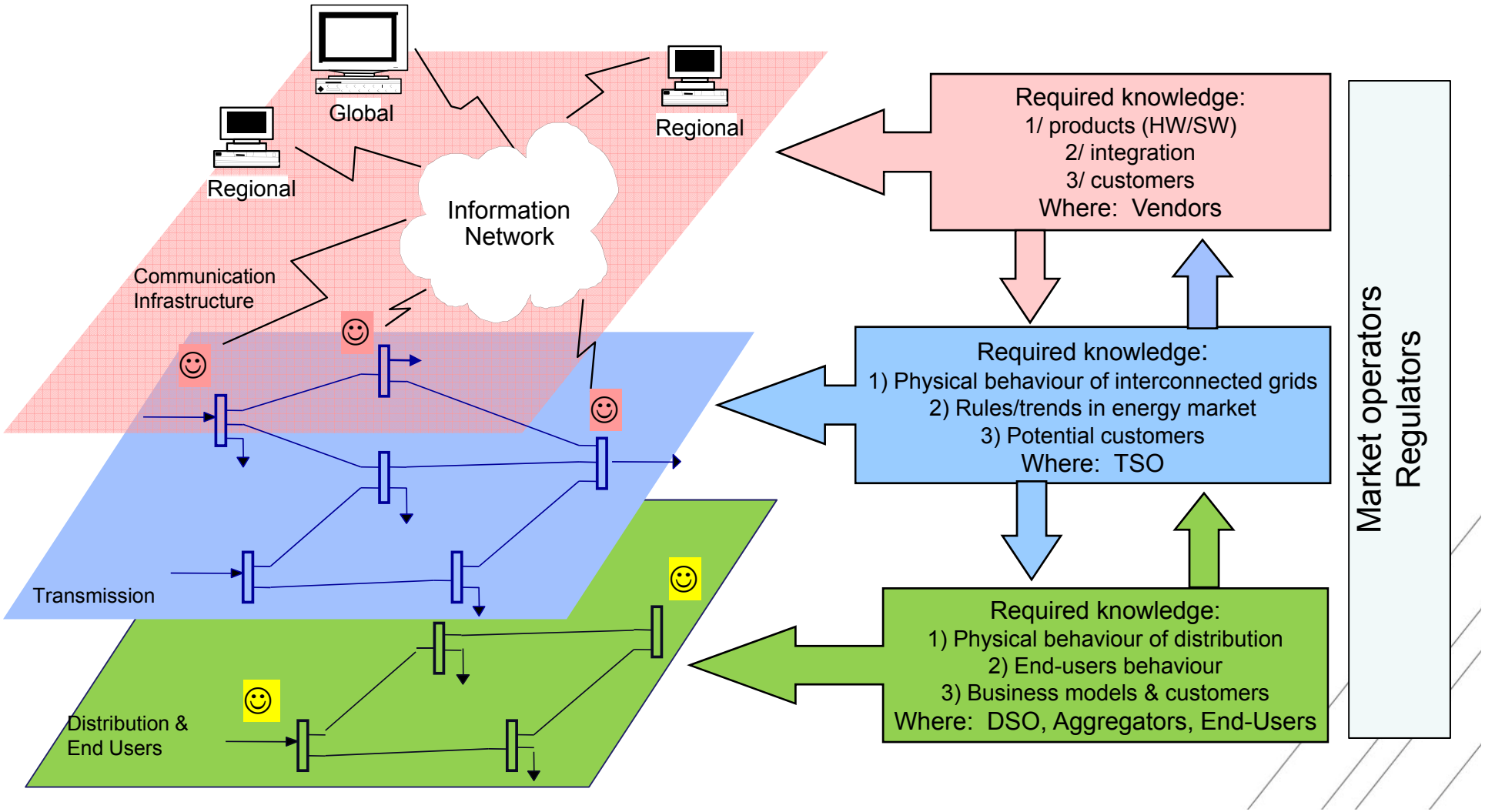
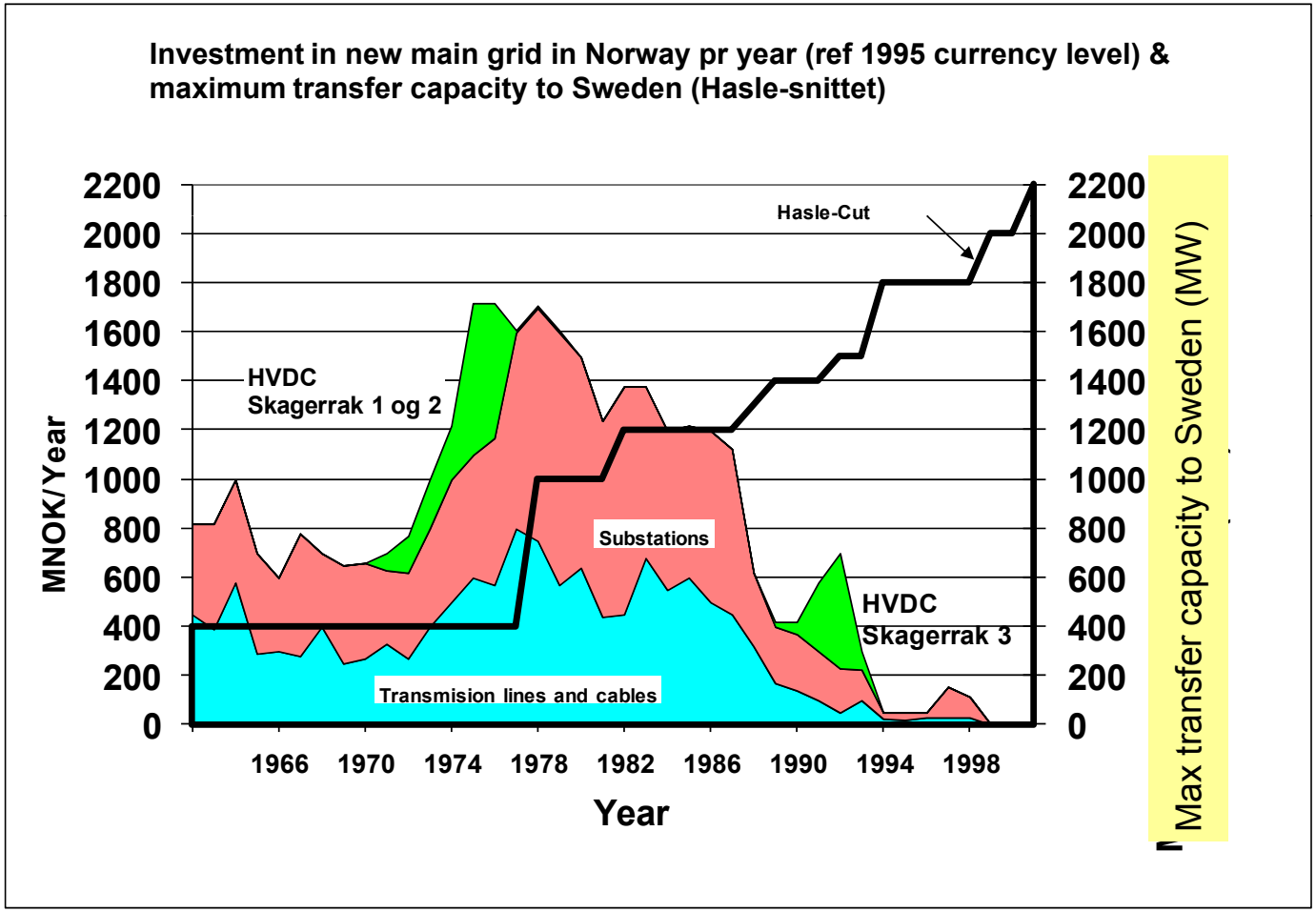
To design "Grid Monitoring, Control, Protection"

- in line with the Smart Grid ideas



The Hasle Corridor - Connection to Sweden

- Increased power transfer – Smart Grid solutions with System Protection
- First Smart Grid Application in Norway



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WAMS & WACS (WAPS) AT STATNETT

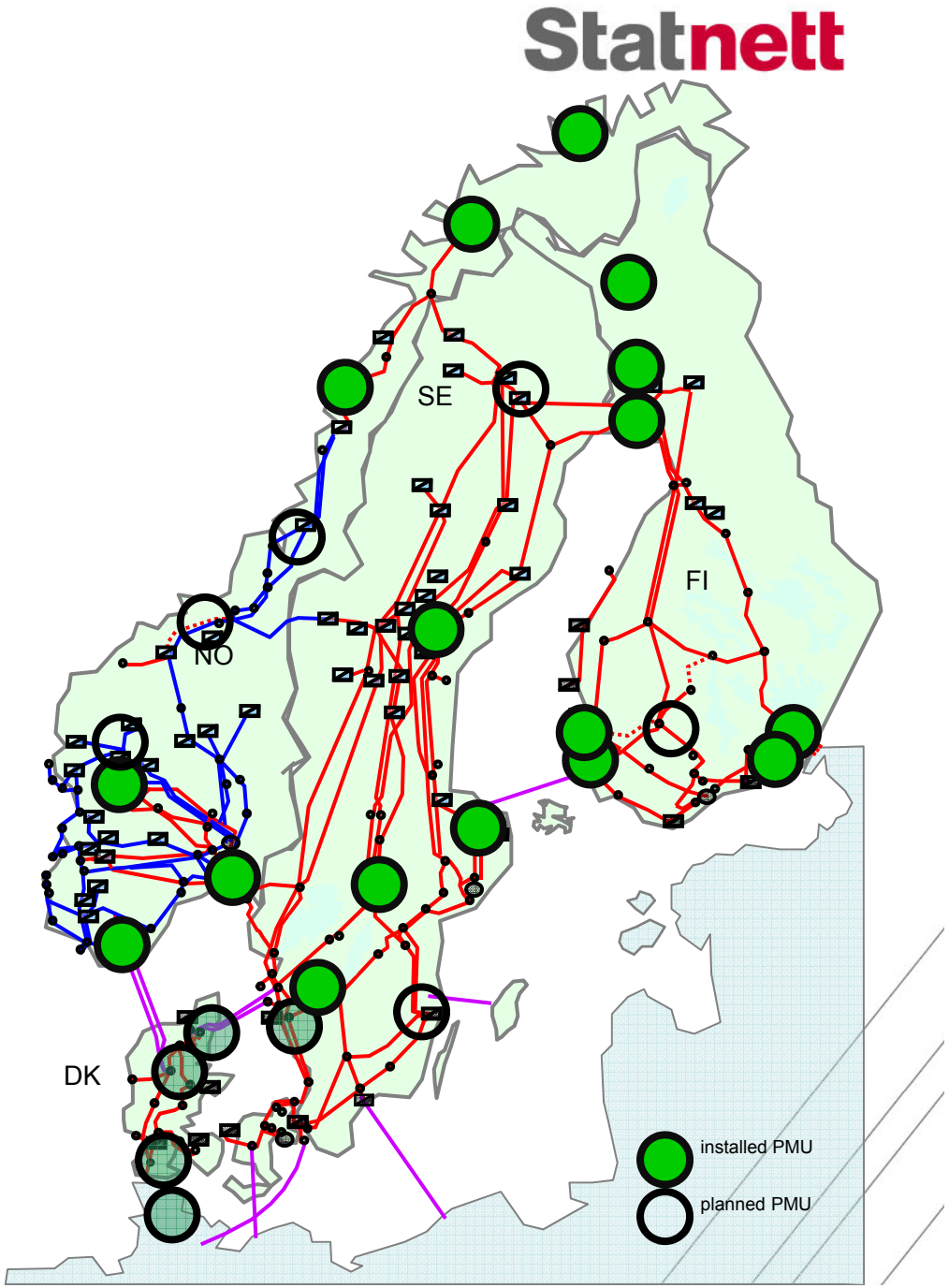
WAMS & WACS (WAPS)

-joint R&D project between ABB, Sintef and Statnett

- Project duration 2006-2011, unded by ABB, Statnett and NFR
- Objectives
  - Deploy 4 (6) PMUs
  - Develop and deploy a ”new” integrated WAMS pilot
  - Demonstrate power oscillation monitoring
  - Study possible WACS control applications
  - Develop a WAPOD – general methodology and concept
  - Install at a SVC – the 400 kV Hasle substation was chosen
  - Concepts for WAPS
    - System protection Schemes
    - Handling islanding – large amount of DG

Status

- Several PMU's installed
- Three Phasor Data Concentrators (PDC) in operation
- Data streaming between PDC's in Norway and Finland via Electronic Highway
- Sweden – data streaming to SvK – preparing for data streaming
- IEEE 1344-1995 and IEEE C37.118 protocols in use



WAMS pilot at Statnett

- First version

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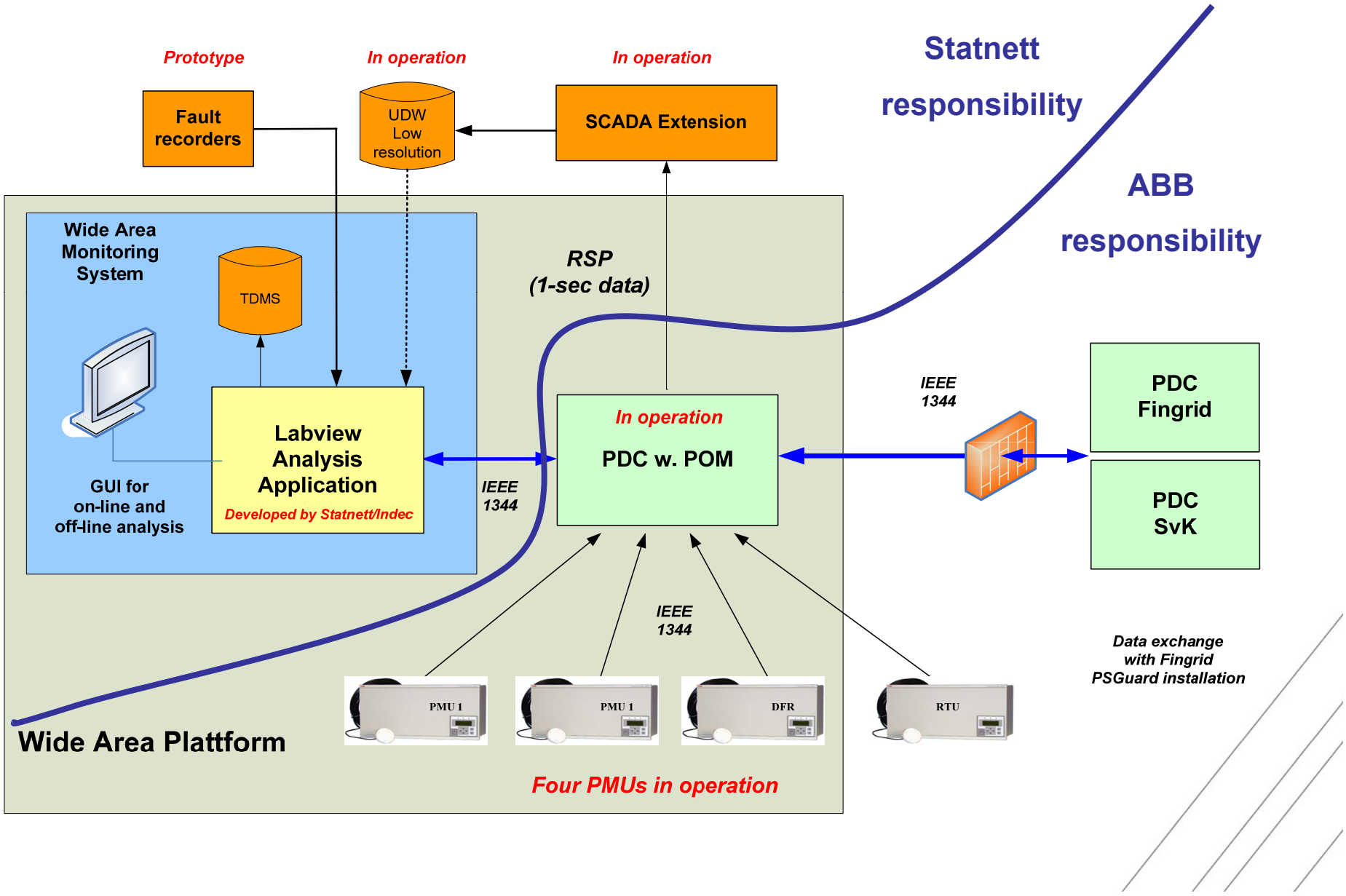

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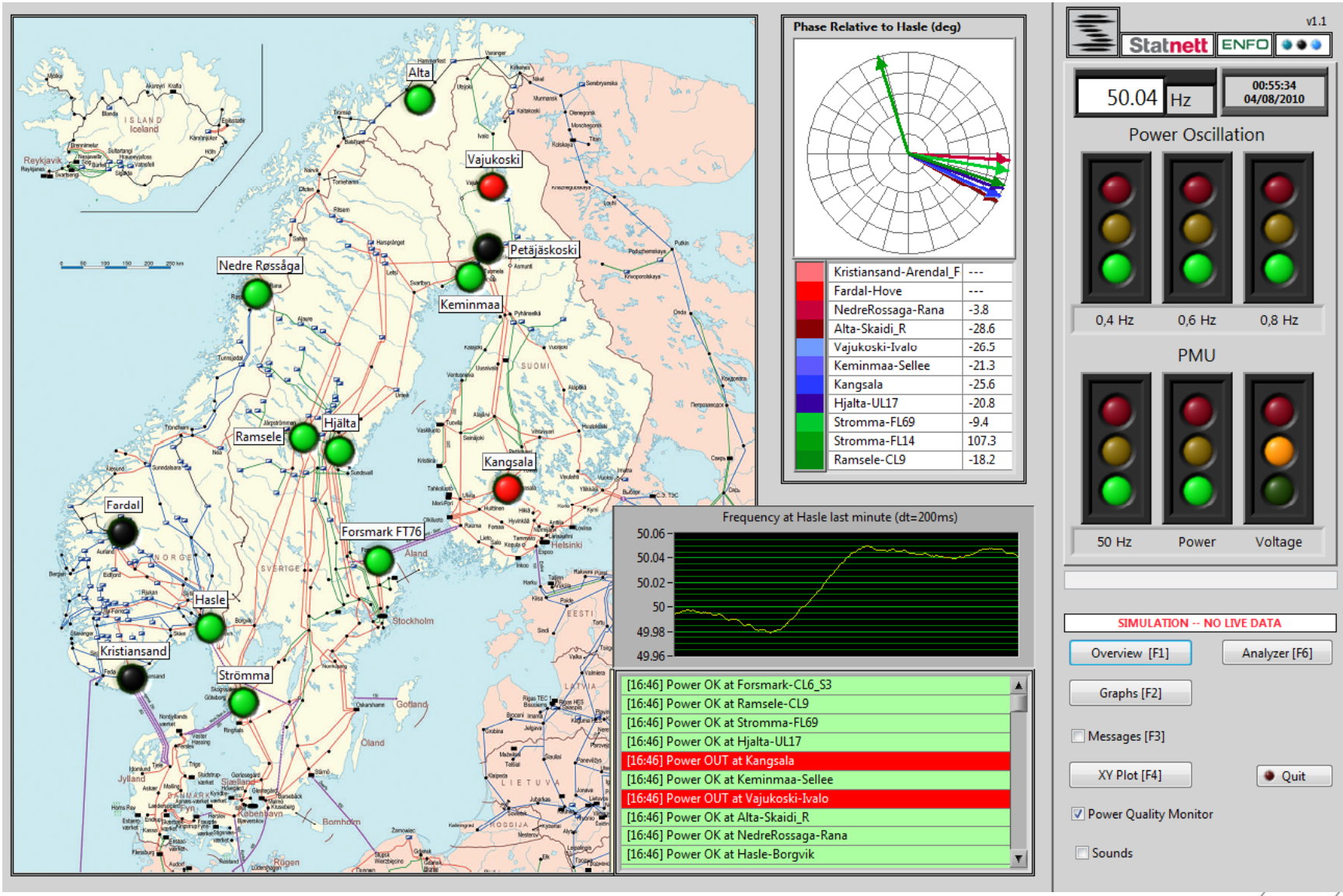
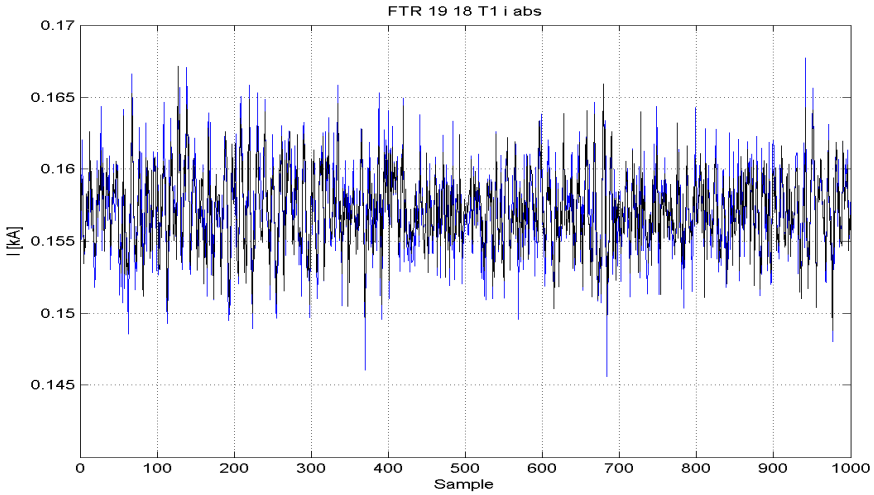

Alta
Vajukoski
Petäjäskoski
Nedre Røssåga
Keminmaa
Hjälta
Ramsele
Kangsala
Fardal
Forsmark FT76
Hasle
Kristiansand
Strömma
Phase Relative to Hasle (deg)
Kristiansand-Arendal_F ---
Fardal-Hove ---
NedreRossaga-Rana -3.8
Alta-Skaidi_R -28.6
Vajukoski-Ivalo -26.5
Keminmaa-Sellee -21.3
Kangsala -25.6
Hjalta-UL17 -20.8
Stromma-FL69 -9.4
Stromma-FL14 107.3
Ramsele-CL9 -18.2
Frequency at Hasle last minute (dt=200ms)
50.06
50.04
50.02
50
49.98
49.96
[16:46] Power OK at Forsmark-CL6_S3
[16:46] Power OK at Ramsele-CL9
[16:46] Power OK at Stromma-FL69
[16:46] Power OK at Hjalta-UL17
[16:46] Power OUT at Kangsala
[16:46] Power OK at Keminmaa-Sellee
[16:46] Power OUT at Vajukoski-Ivalo
[16:46] Power OK at Alta-Skaidi_R
[16:46] Power OK at NedreRossaga-Rana
[16:46] Power OK at Hasle-Borgvik
v1.1
Statnett
ENFO
50.04 Hz
00:55:34
04/08/2010
Power Oscillation
0,4 Hz
0,6 Hz
0,8 Hz
PMU
50 Hz
Power
Voltage
SIMULATION -- NO LIVE DATA
Overview [F1]
Analyzer [F6]
Graphs [F2]
Messages [F3]
XY Plot [F4]
Quit
Power Quality Monitor
Sounds

POM - Power Oscillation Monitoring

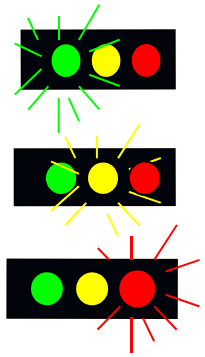
- Smart monitoring – a basis for decision in on-line operation

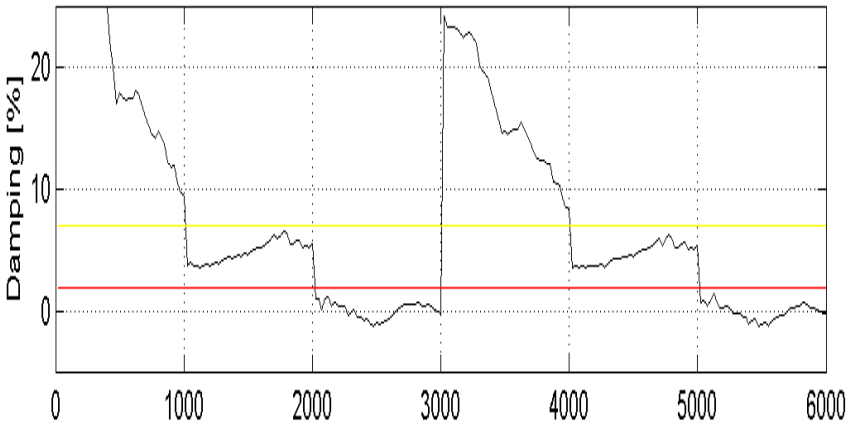
- How to utilize information

- A way to present information ?



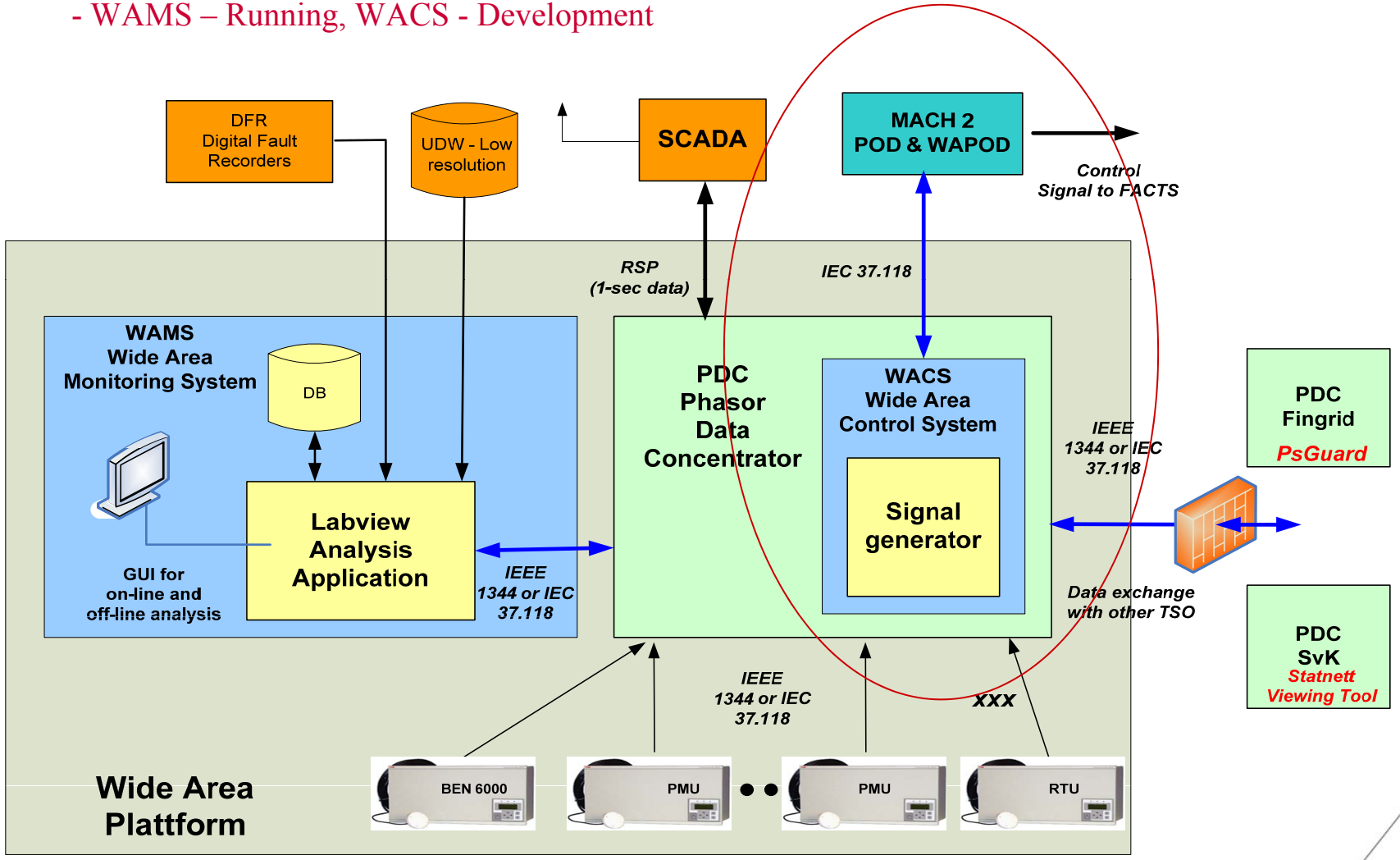
Signalisering





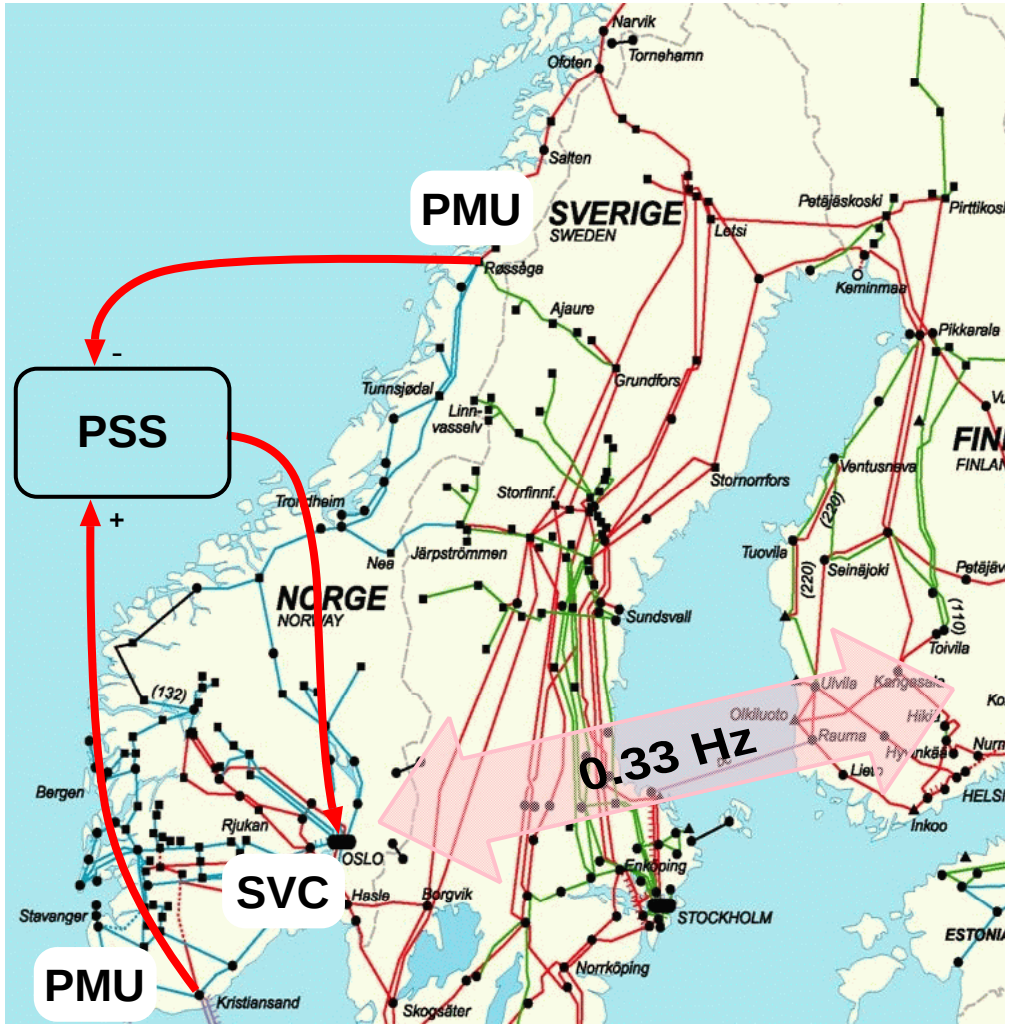
Wide Area Platform

- WAMS – Running, WACS - Development

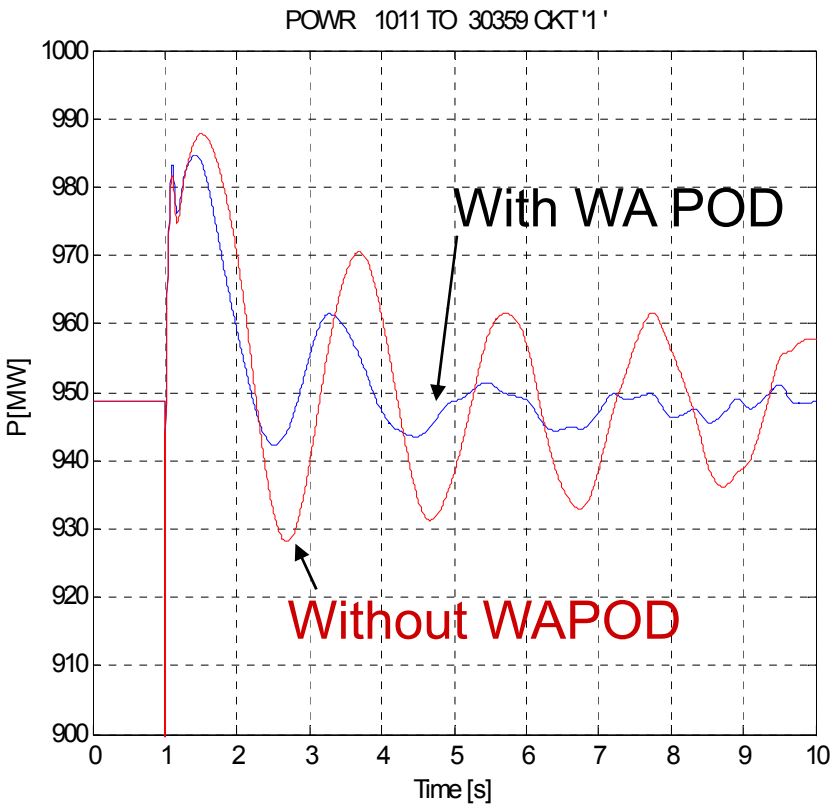


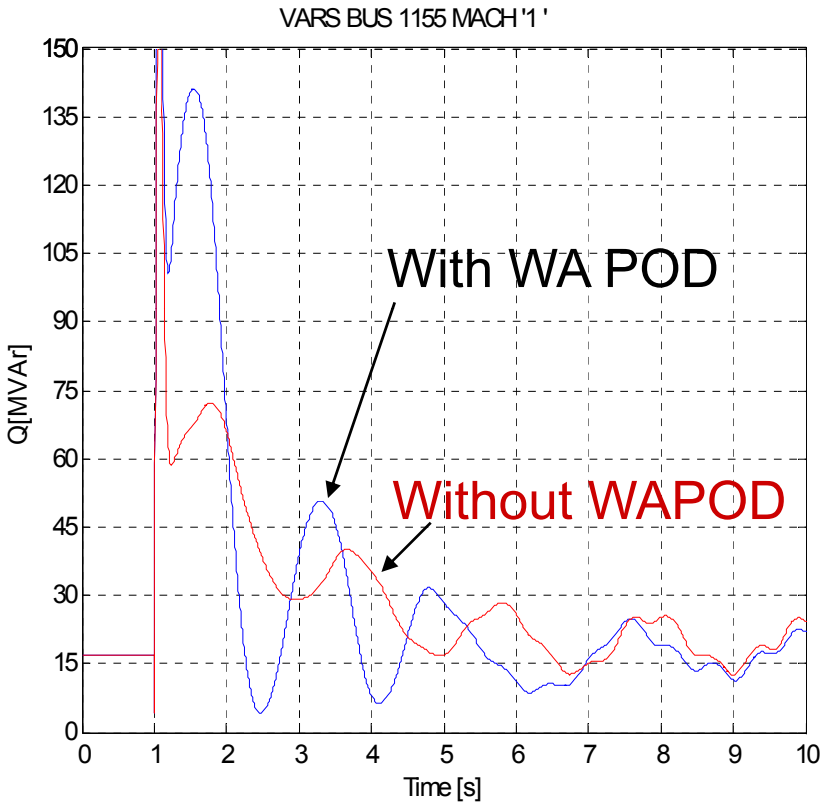
From WAMS to WACS..

- A demanding step



Results from a Nordic simulation model (PSS/E)





Active Power transfer:

Norway → Sweden

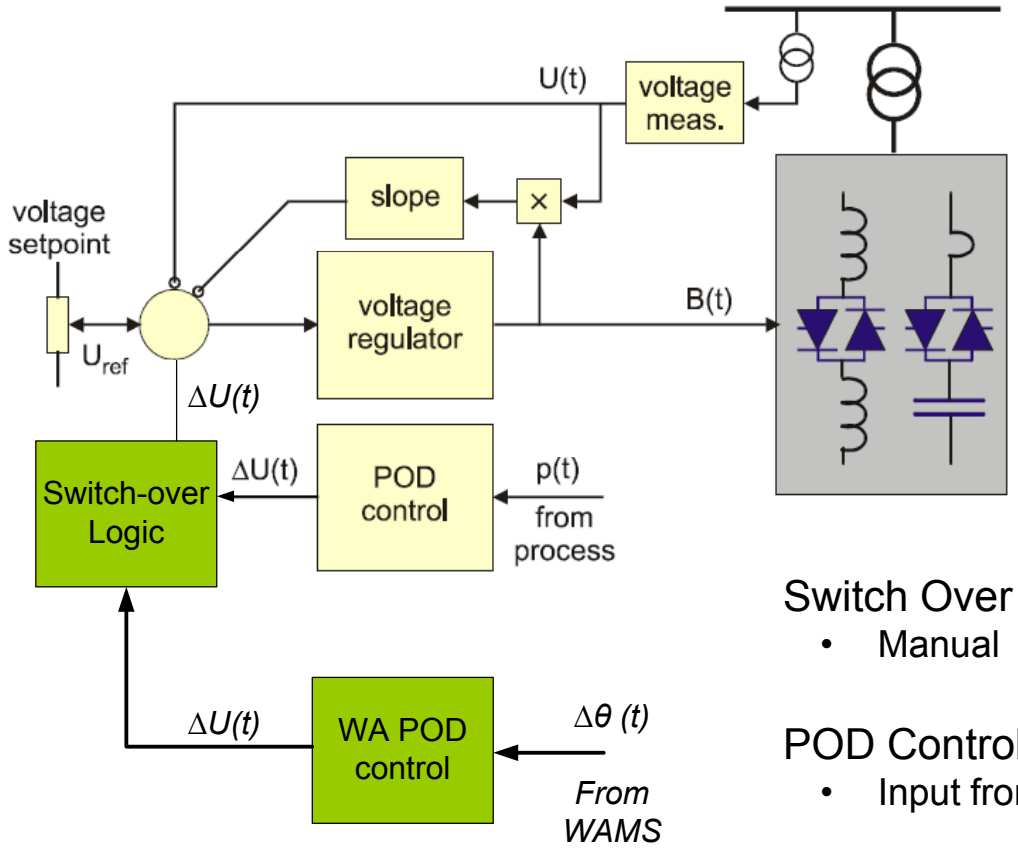
(Halden-Skogsäter)

Reactive power transfer:

SVC Sylling

Power Oscillation Damper

- Local POD & WA POD



Switch Over Logic

- Manual or automatic change of damping signal to SVC

POD Control

- Input from power transfer on Hasle corridor

WAPOD Control

- Input to WAPOD from Røssåga + Kristiansand
- Input from Norway and Sweden and Finland

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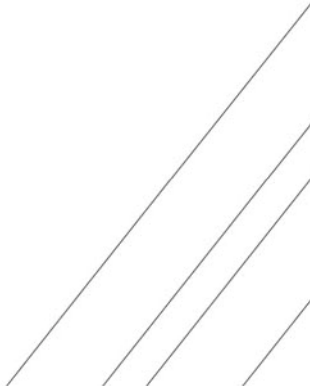
WAMS & WACS Activities - Ongoing

- WAPOD in pilot phase
  - Verification of WAPOD performance
    - Simulation vs. measurements
    - Compare POD and WAPOD
  - Synchronization of measurements in Sweden, Finland, Norway
- Write and Present Paper of measurements
  - Local POD
  - WAPOD – Norway case
- Design of “new” WAPOD Nordic
  - Simulation of Nordic model
  - Use measurements from Finland and Sweden
  - New WAPOD
- New initiative
  - Real Smart – EU project
  - Nordic PMU project
  - EU - projects



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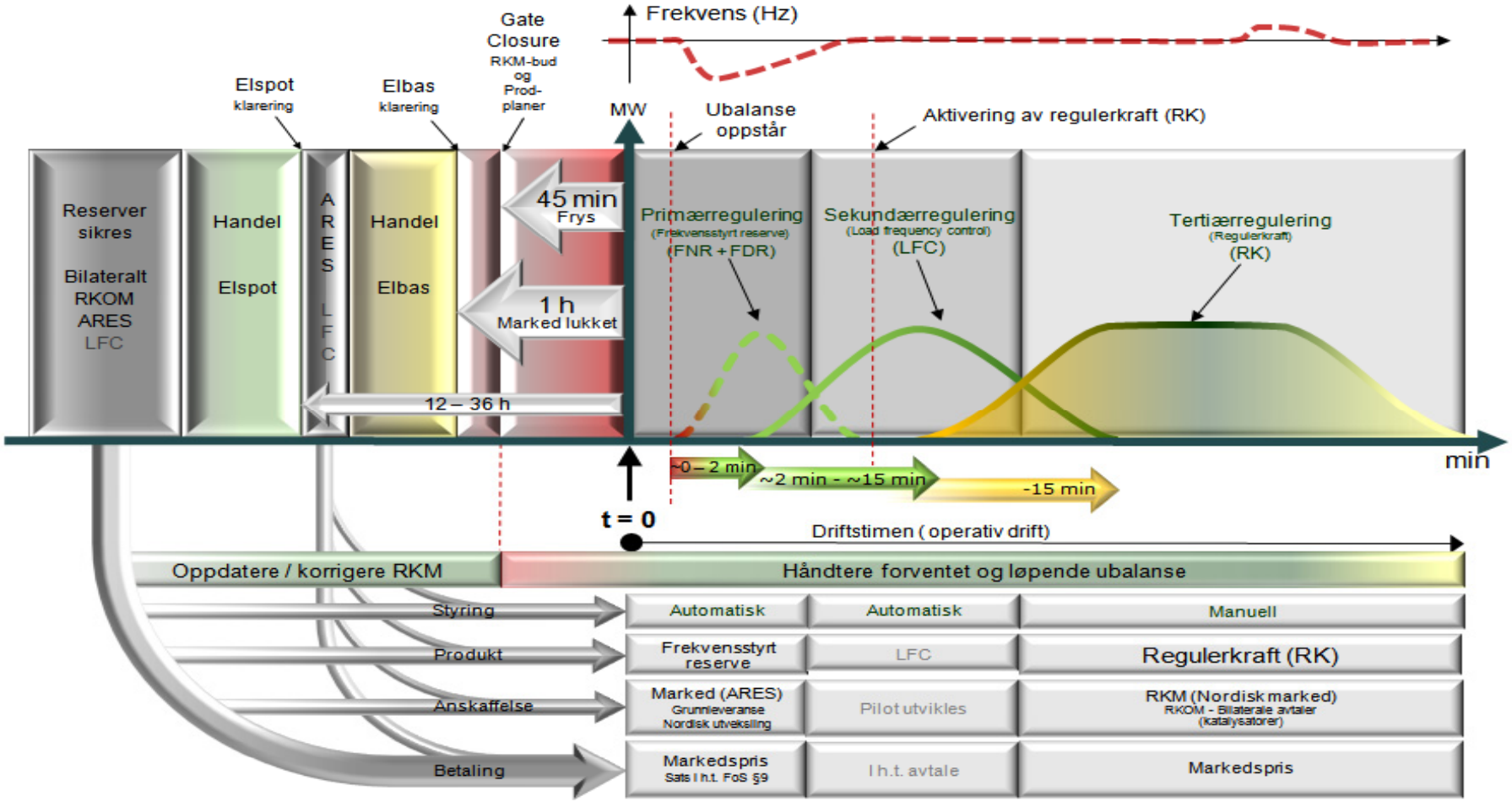
NEW APPLICATIONS TO FACILITATE SMART GRID

Flexibility is crucial …

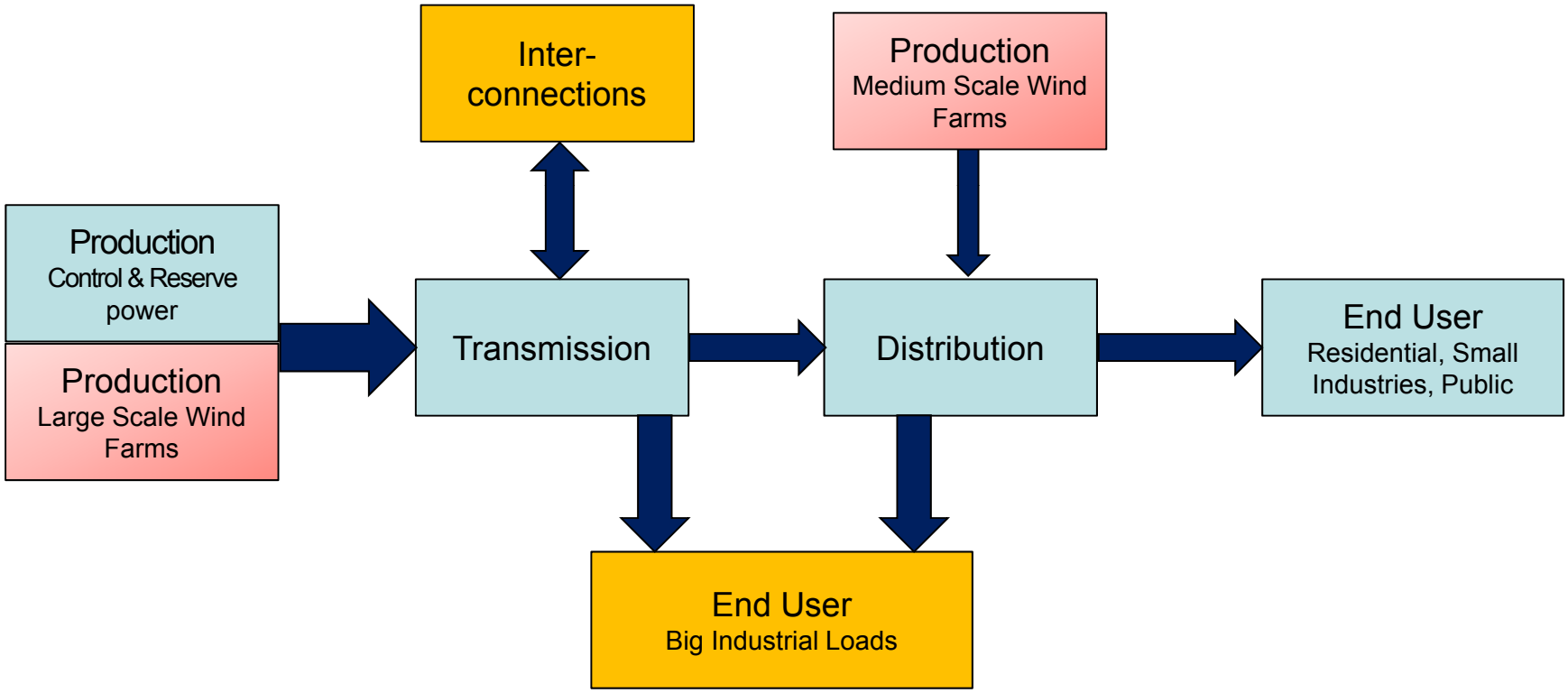
- To have access to flexibility is a need in the future power system

- Design and long term planning
- Operational Planning
- On-line operation

New time horizons

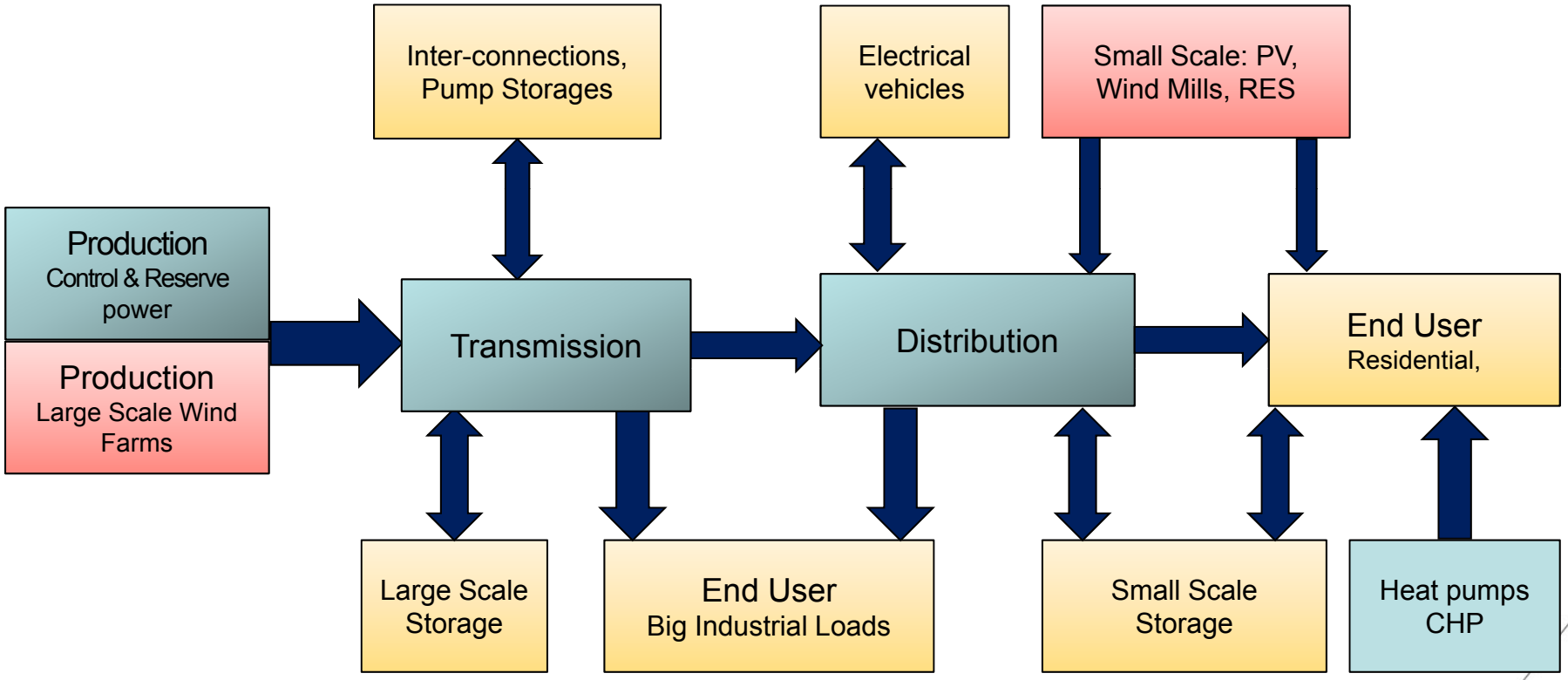


Flexibility in balancing - today



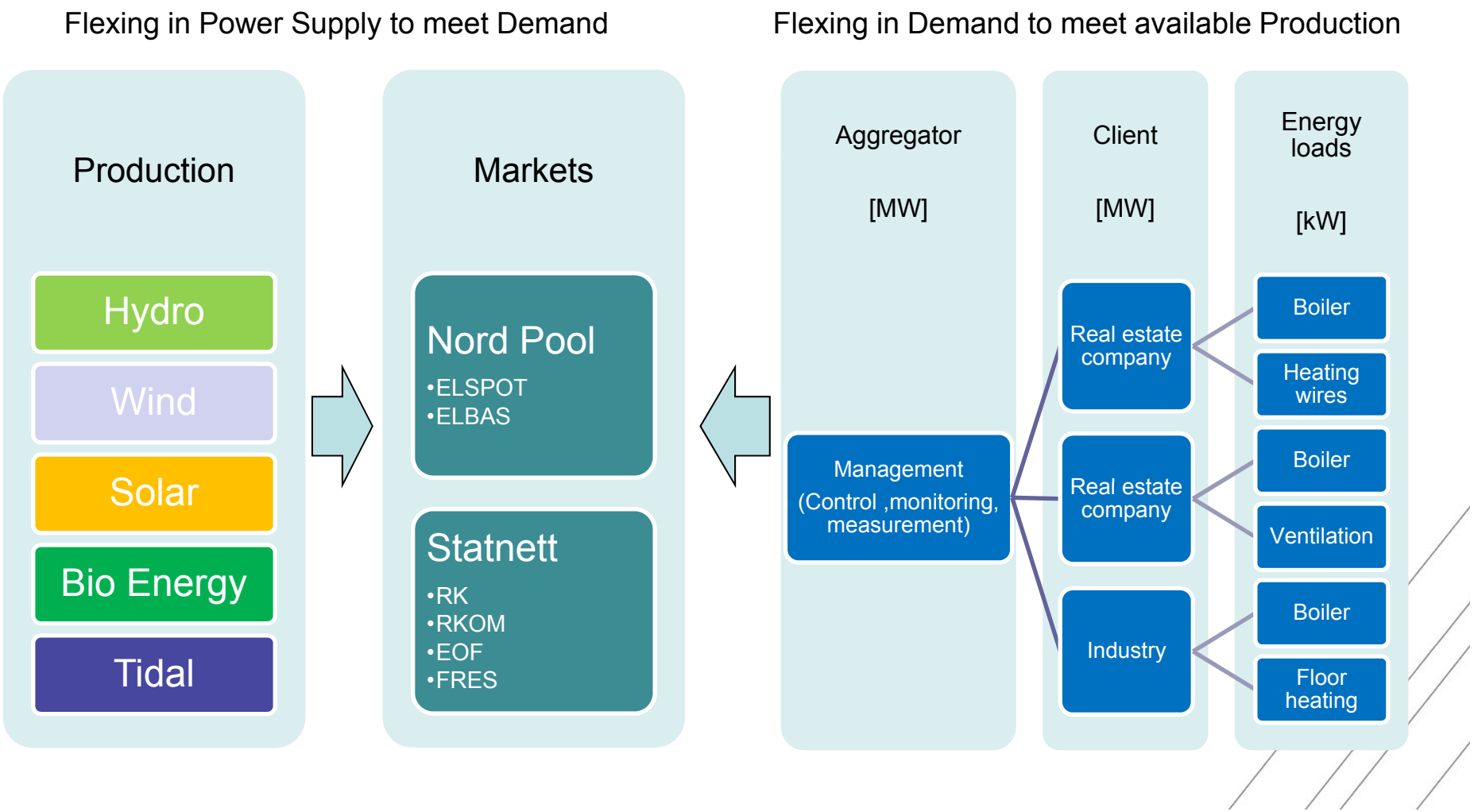
Paradigm shift

– New opportunities & Challenges with respect to Balancing



Consumption as an alternative to production

- a considerable resource for both society and environment



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NG - Strategisk plan for å møte EU sine 20/20/20 mål

Transmission Reinforcement Alone is Insufficient

Maximising capacity with smart..

..Meters

An informative display showing energy utilisation and cost

Increases consumers' sensitivity to energy prices and thus reduces demand.

..Grids

Automation and efficient use of network systems

Facilitates network flexibility in a complex generation pattern

..Homes

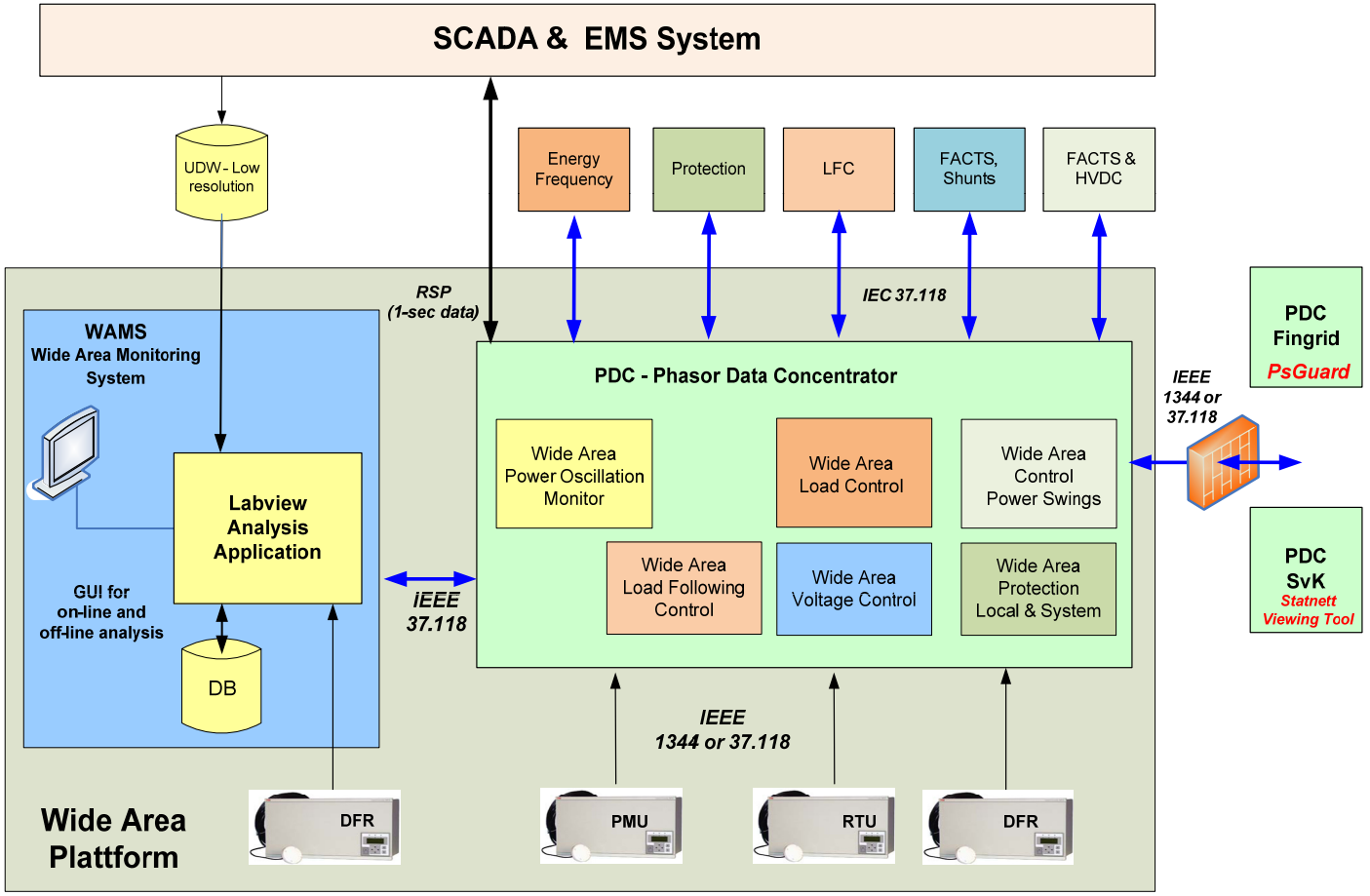
Automation of energy loads in the home

Facilitates demand side response in a world of more inflexible generation

Flexing generation to meet demand → Flexing demand to meet generation

Wide Area Platform – Enables Smart Grid Operation

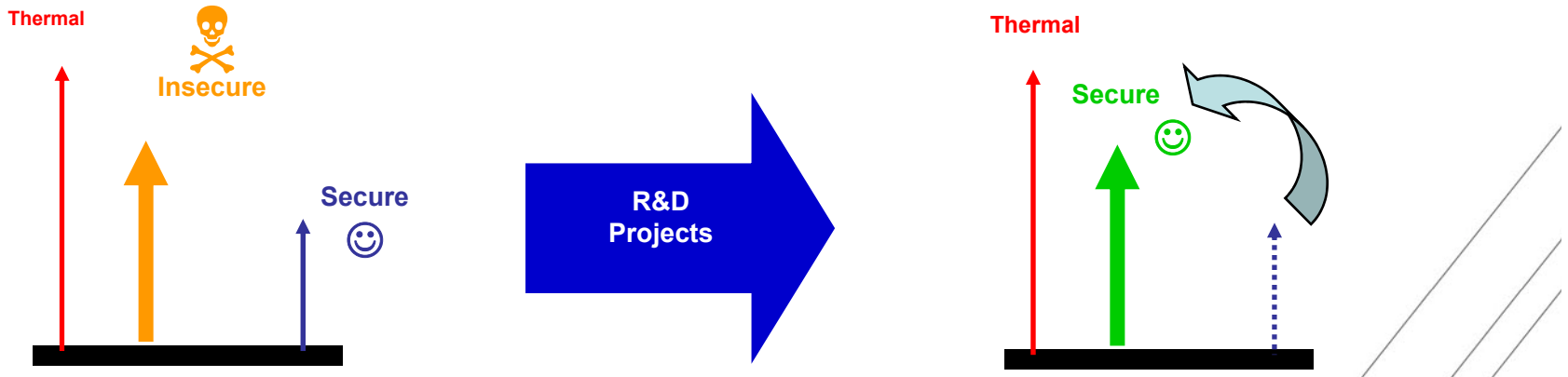
- Conceptual approach with applications



What have the R&D Project achieved so far

- Benefits for Statnett

- On the edge competence within this field
- WAMS/ WACS benefits for Statnett
  - Increased knowledge about own power grid
  - Easier to see where to utilize the system harder
  - A tool for better operational planning and fault analysis
  - Metods and sollutions for damping of power ocillations by using FACTS



Limits w/ existing technologies

Limits w/ new technology

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Thank You for Your Attention !

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