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Engpassvermeidung in Übertragungsnetzen durch Online Dynamic Security Assessment

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Presented by Dr. U. Kerin

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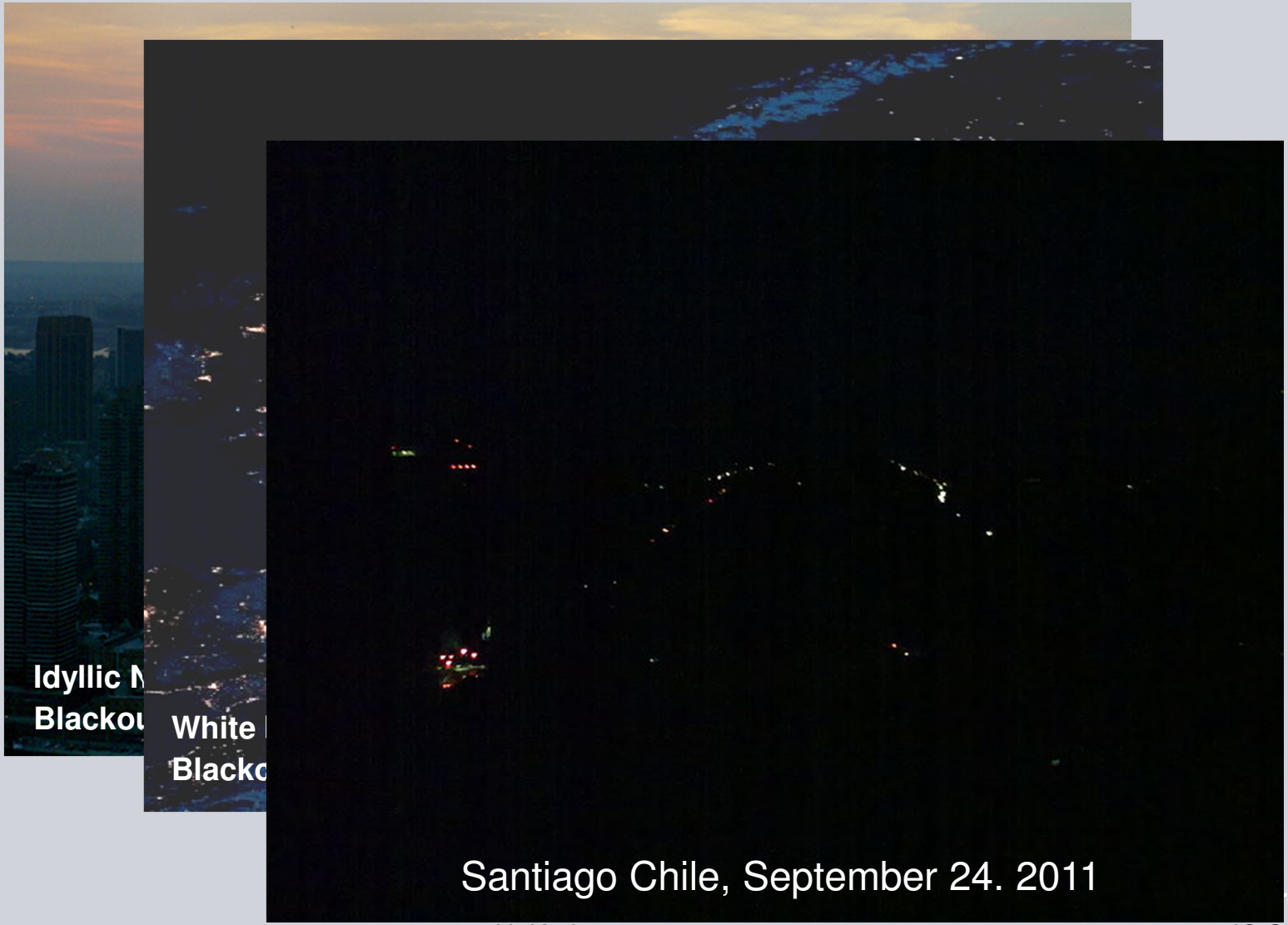
Blackouts



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Features over time

	Past	Present
Network construction	➢ Priority	➢ Subject to severe environmental constraints and public debates
Network	➢ Over-dimensioned	➢ Under-dimensioned
Generation	➢ Close to load	➢ Far from urban areas
	➢ Conventional and controllable	➢ Conventional + Distributed not controllable
Unit commissioning	➢ Long-term plan	➢ Intense DG (government supported)
Interconnections	➢ Increase security	➢ Transit power flows
Market	➢ Regulated	➢ Deregulated
Security	➢ Simple to enforce	➢ Hard to enforce

“New Electricity Age” in Europe
Windfarm-Projects in Northern Waters

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100GW Potential in Northern Waters, thereof today 1.5% installed

… and 3-5GW in the South until 2020.

Site installed with Siemens turbines

Received order for Siemens turbines

Site installed by other turbine manufacturer

Potential site

“New Electricity Age” in Europe
Predictability and Dynamics of Wind Power

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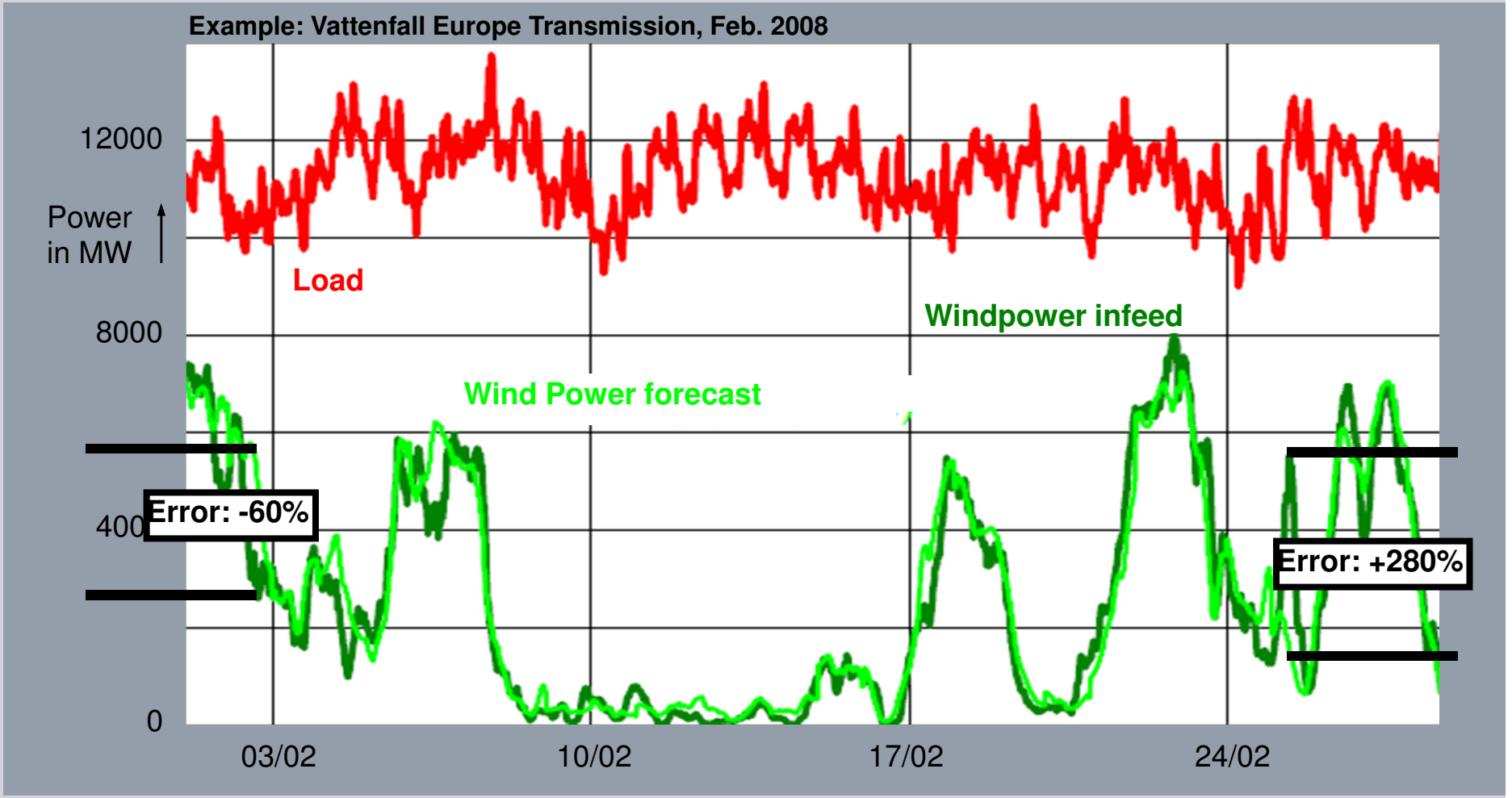

Source: IfR, TU-Braunschweig,
Vattenfall Europe Transmission, Feb. 2008

“New Electricity Age” in Europe
In the South: The “DESERTEC Super-Grid”

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“New Electricity Age” in Europe
Predictability and Dynamics of Solar Power

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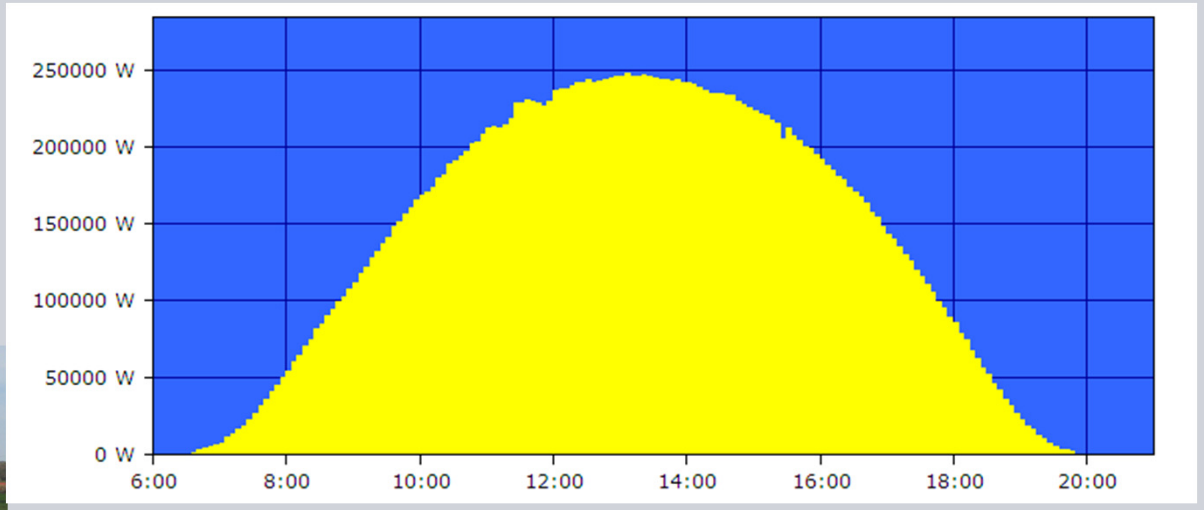
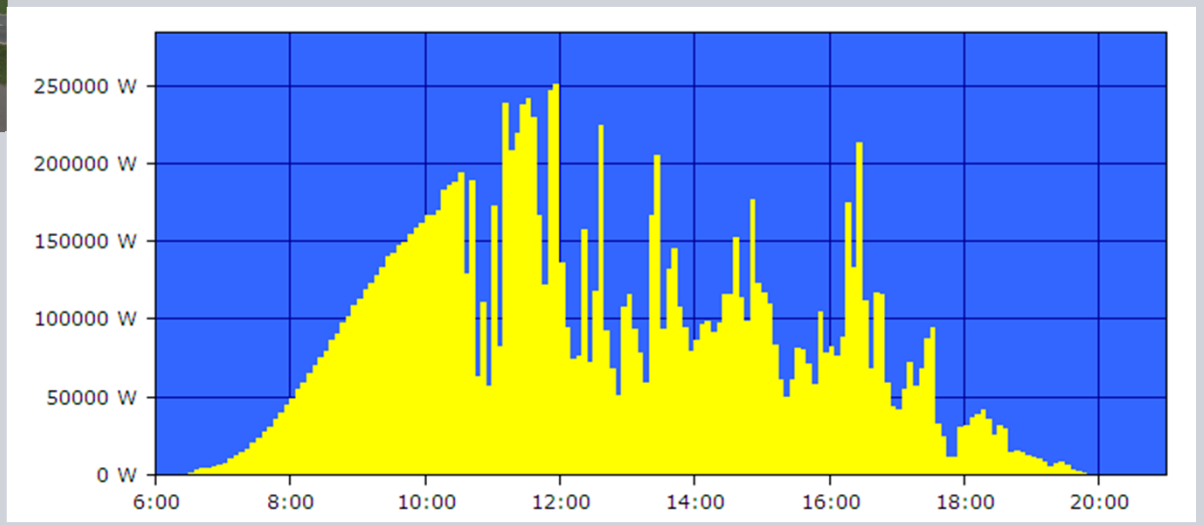
Sunny Day, April: 1,9 MWh



Cloudy Day, April: 1,2 MWh



Source: Michael Weinhold & friends

Security of Electrical Energy Supply Systems
Future Challanges in Germany

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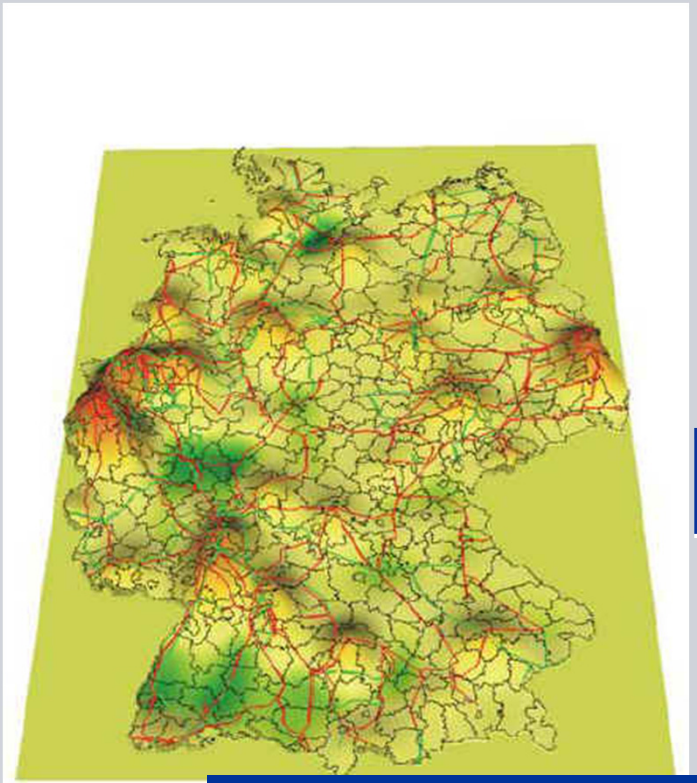
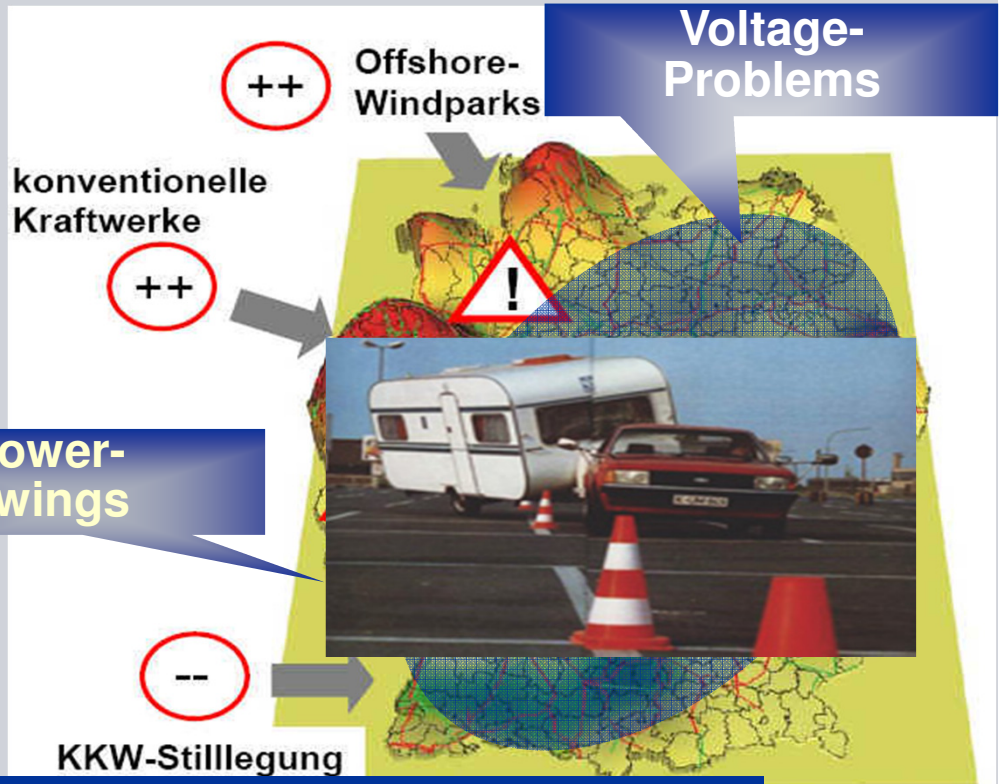
Today: balanced generations and loads



Future: Generations far from loads



REQUIREMENTS:
- **Steady-state and dynamic reactive power compensation**
- **Fast controlled FACTS-Elements for power-swing damping**
- **Overlayed control**
- **Predicting steady-state and dynamic contingency management**

Source: CIGRE SC C2, RWE, 19.11.2008

Solution Overview:
Black-Out Prevention System – Information Flow

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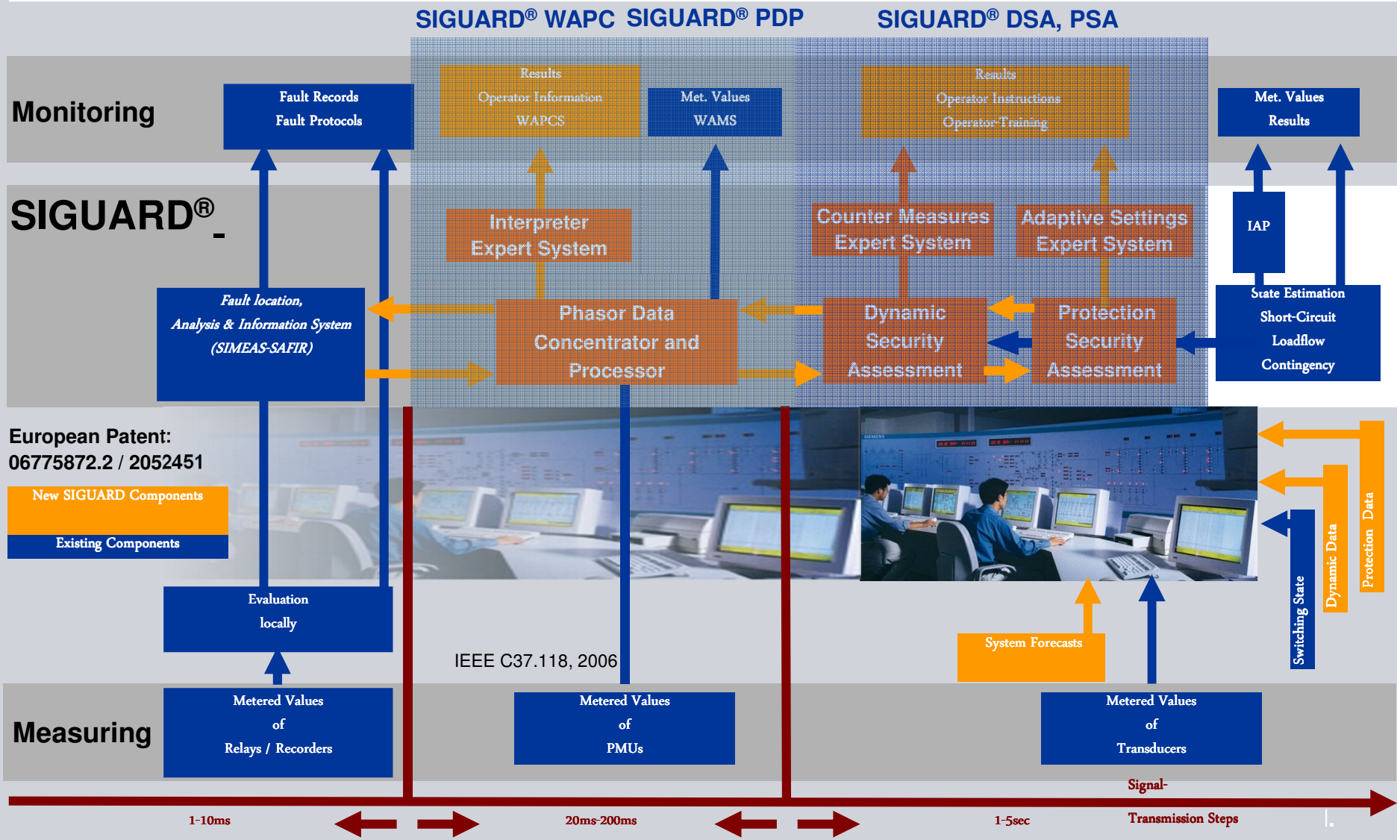

Static and Dynamic Security Assessment System Operations

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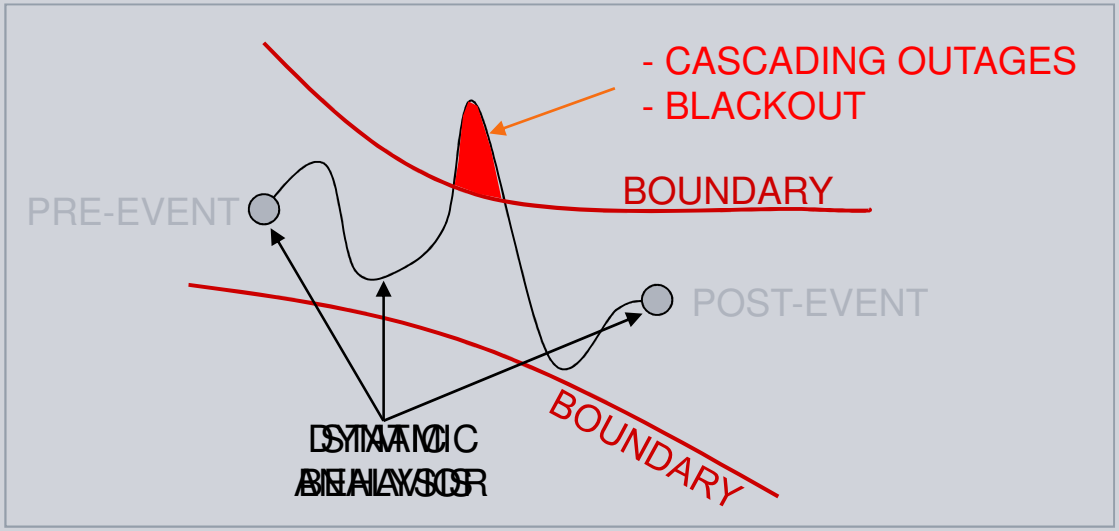

Static Security

- Validation of voltages and power flows
- N-1, N-2-1 etc

Dynamic Security

- multiple faults;
- cascading events;
- switching;
- generator, line outages
- stability issues

FOR CURRENT AND FUTURE OPERATING POINTS

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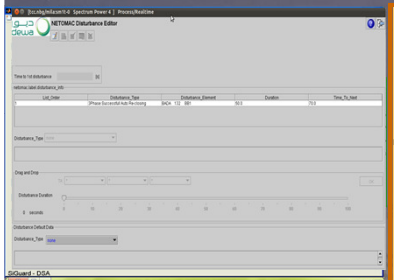
SCADA Snapshot

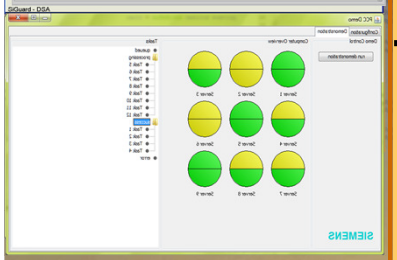
Steady-State Network Database

Energy Trade, Renewable and Load Forecast

Dynamic Network Database

Protection Database





Scenarios

Quickscan with Quickstab®

Automatic Contingencies & Measures

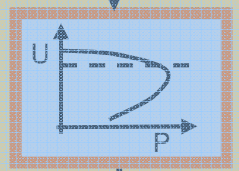
Computation Engine

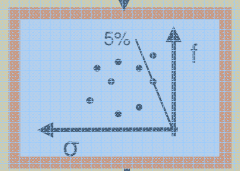
Protection Selector

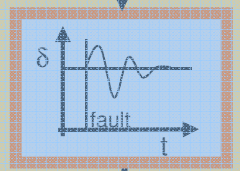
Contingencies, Measures

Interface

SCADA Schedule / Redispatch RDC







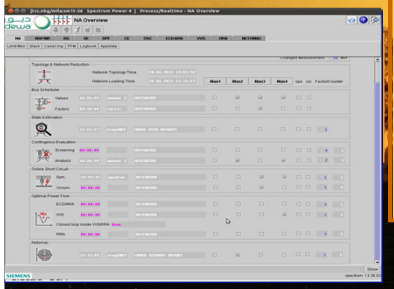
PSS® Suite

Voltage Stability Margin Calculation

Small Signal Stability Margin Calculation

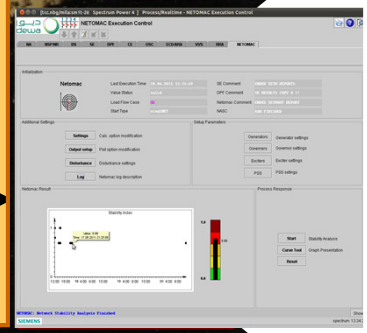
Transient Stability Margin Calculation

Margins & Criteria



Ranking

Application Platform



Visualization & Reporting

SIGUARD® DSA Cockpit

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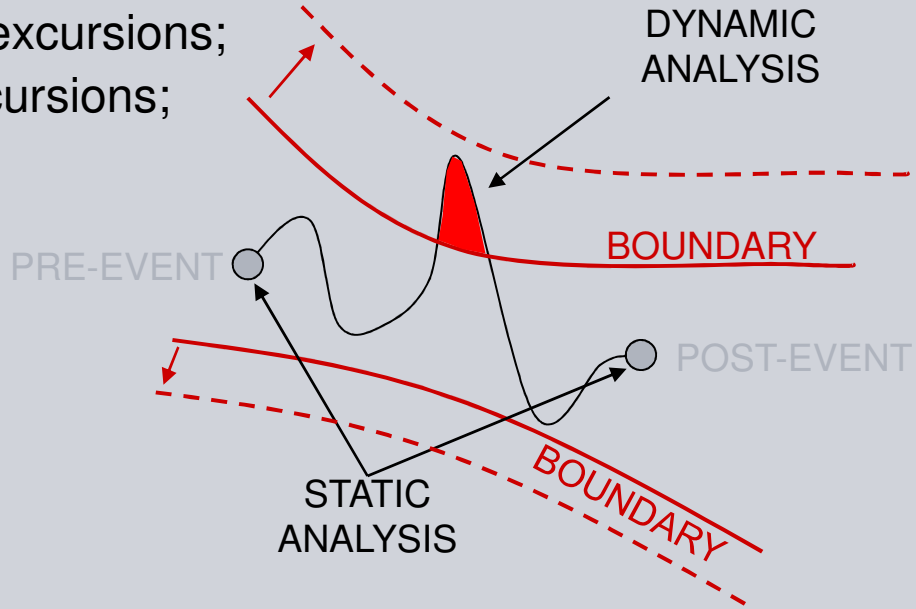
Aim of on-line security assessment

Remove uncertainties related to day-ahead assumptions

- calibration of security margins and limits power flows;
- minimum damping of oscillations;
- transient stability;
- voltage stability
- limits on dynamic frequency excursions;
- limits on dynamic voltage excursions;
- grid code compliance.



SIGUARD® DSA
Stability issues and Grid Code compliance

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Voltage Stability	Results Scaling 0 … 1	**V**oltage **S**tability **I**ndex (VSI)
Small signal stability		**S**mall **S**ignal **S**tability **I**ndex (SSSI)
Angle		**A**ngle **I**ndex (AI)
Energy margin		**E**nergy **M**argin **I**ndex (EMI)
Maximum frequency deviation		**M**aximum **F**requency **D**eviation **I**ndex (MFDI)
Frequency recovery time		**F**requency **R**ecovery **T**ime **I**ndex (FRTI)
Frequency gradient		**F**requency **G**radient **I**ndex (FGI)
Dynamic voltage		**D**ynamic **V**oltage **I**ndex (DVI)
Quasi-steady-state voltage		**Q**uasi-**S**teady-**S**tate **V**oltage **I**ndex (QSVI)
Fault ride through		**Fault R**ide **T**hrough **I**ndex (VRTI)
Line power flow		**L**ine **P**ower **f**low **I**ndex (LPFI)
Load shedding		**L**oad **S**hedding **I**ndex (LSI)
Transformer power flow		**T**ransformer **P**ower **F**low **I**ndex (TPFI)
Nodal loading		**N**odal **L**oading **I**ndex (NLI)

Example:
A realistic network

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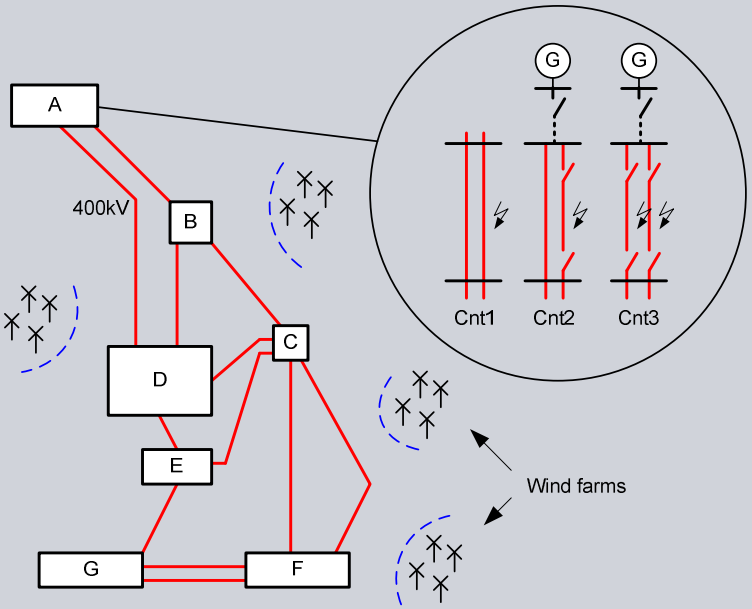
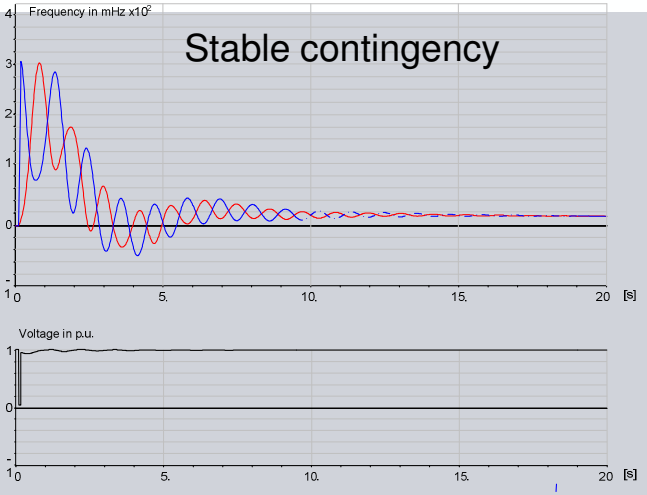
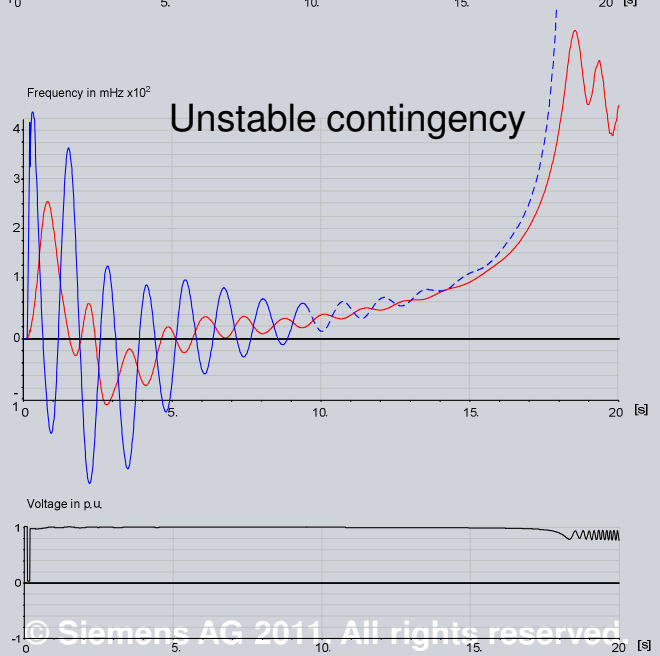


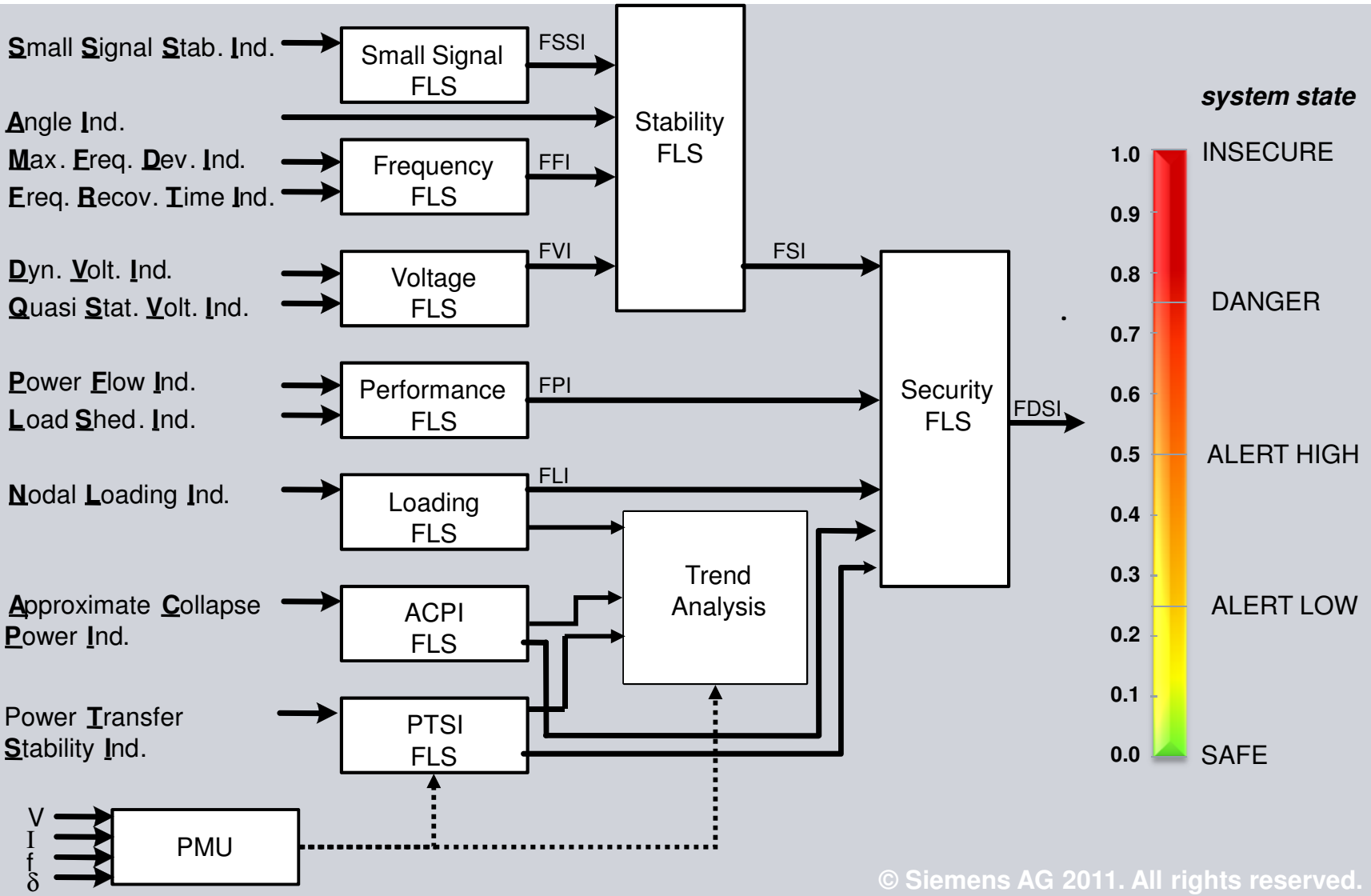




- 400kV, 275kV and 132kV,
- 140 generators,
- 1200 power lines,
- 1700 nodes,
- 650 loads (sum 40.00GW)
- 1200 transformers

More than 4500 observed elements!!!

Information reduction



SIGUARD® DSA
Research and development

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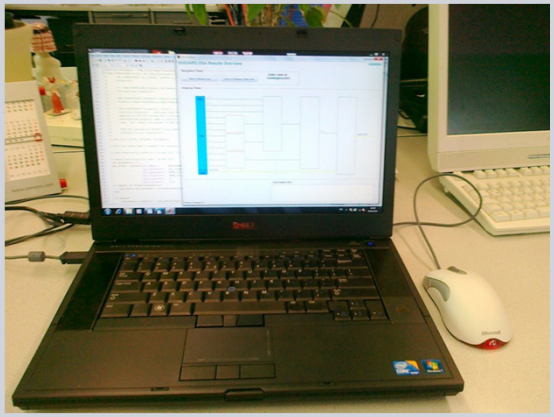
Hardware

- Generic notebook computer
- Intel i7 technology
- Quad-Core
- Clock frequency 1.87GHz
- 8GB RAM



SIGUARD® DSA Prototype in Control Room at Transelectrica

Application

- Testing
- Pilot customers

SIGUARD® DSA Professional

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Hardware

15 Server with each:

- 2 Intel XEON 6 Core
  3.46 GHz = 180 Cores
  - 13 Computation nodes
  - 2 Application server (redundancy)
- 48 GB RAM
- Network
  - 2xGigabit LAN
  - 1x 20 Gigabit Infiniband

Application

- Development tests
- Live Demonstration
- Factory acceptance tests

SiGuard®-DSA
On-line Security visualization

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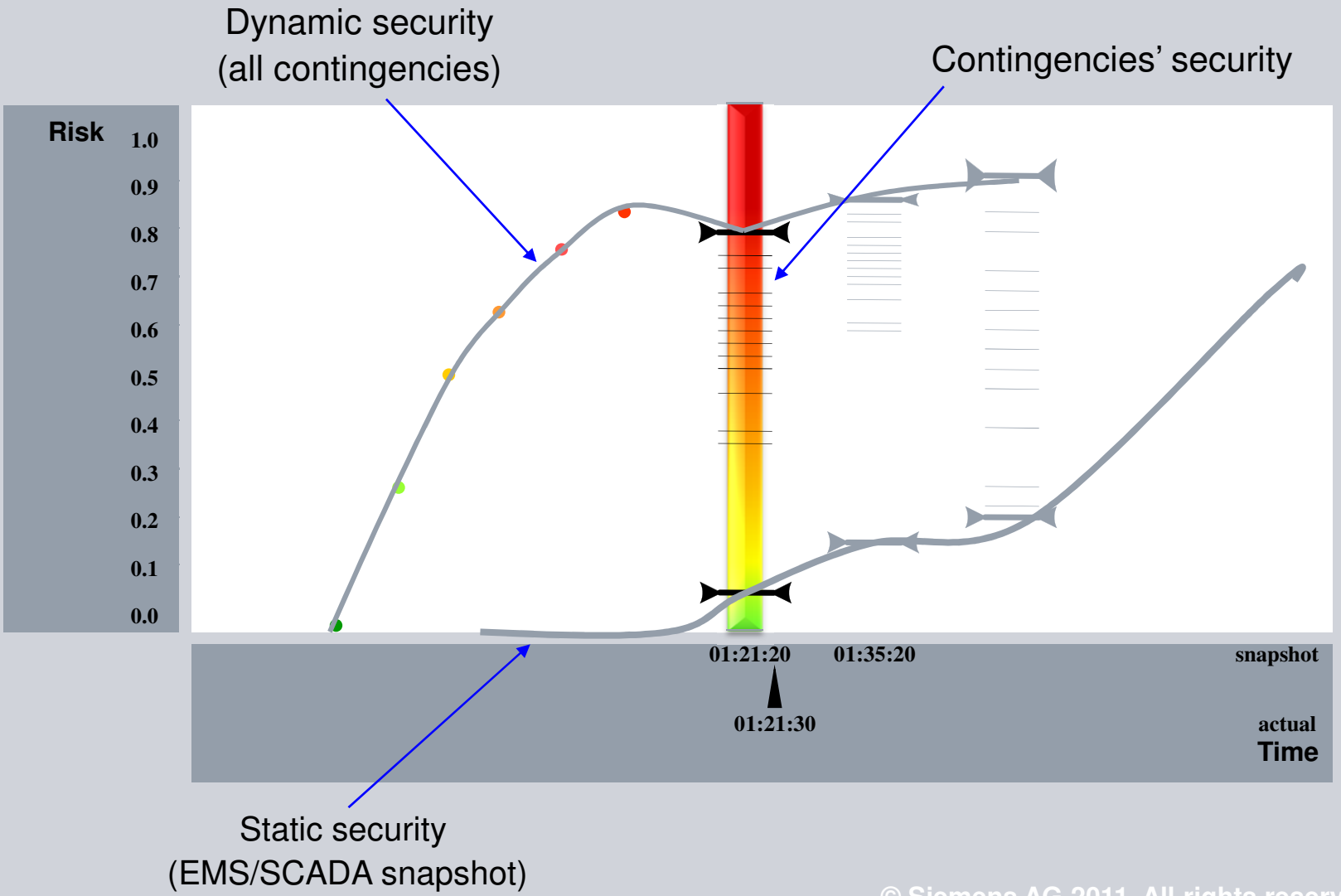

Intelligent Dynamic Power-System Measurement, Analysis, Protection and Control

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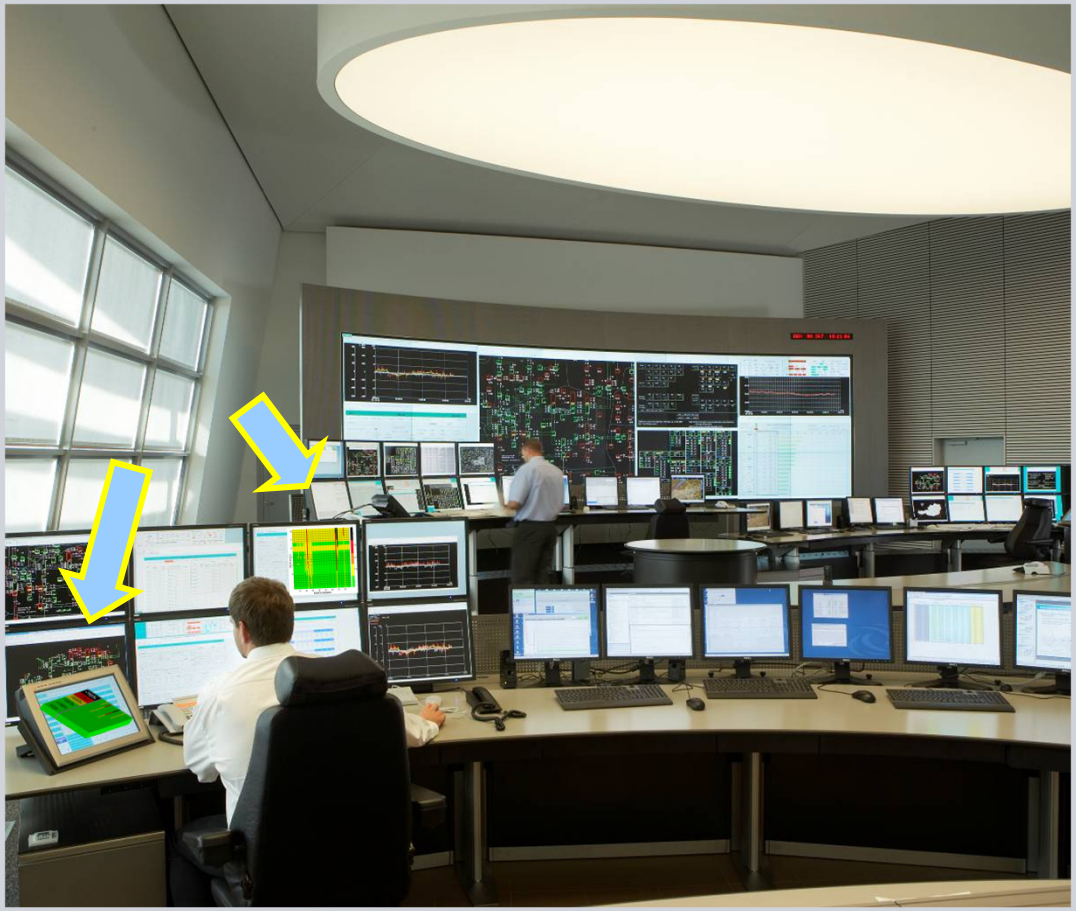

- Combined power system measurement and model based analysis
- Observing dynamics with time-synchronized PMUs
- Predicting critical dynamic system states
- Protection system audits for speed and selectivity
- Autopilot by wide-area protection and control

Customer Value

- Blackout prevention
- Reduction in customer outage costs
- Enhancement of power system utilization
- Decision support for system operator
- Future autopilot for power system control

SIGUARD® Offline and Online
The New Siemens Power-System Security Solution

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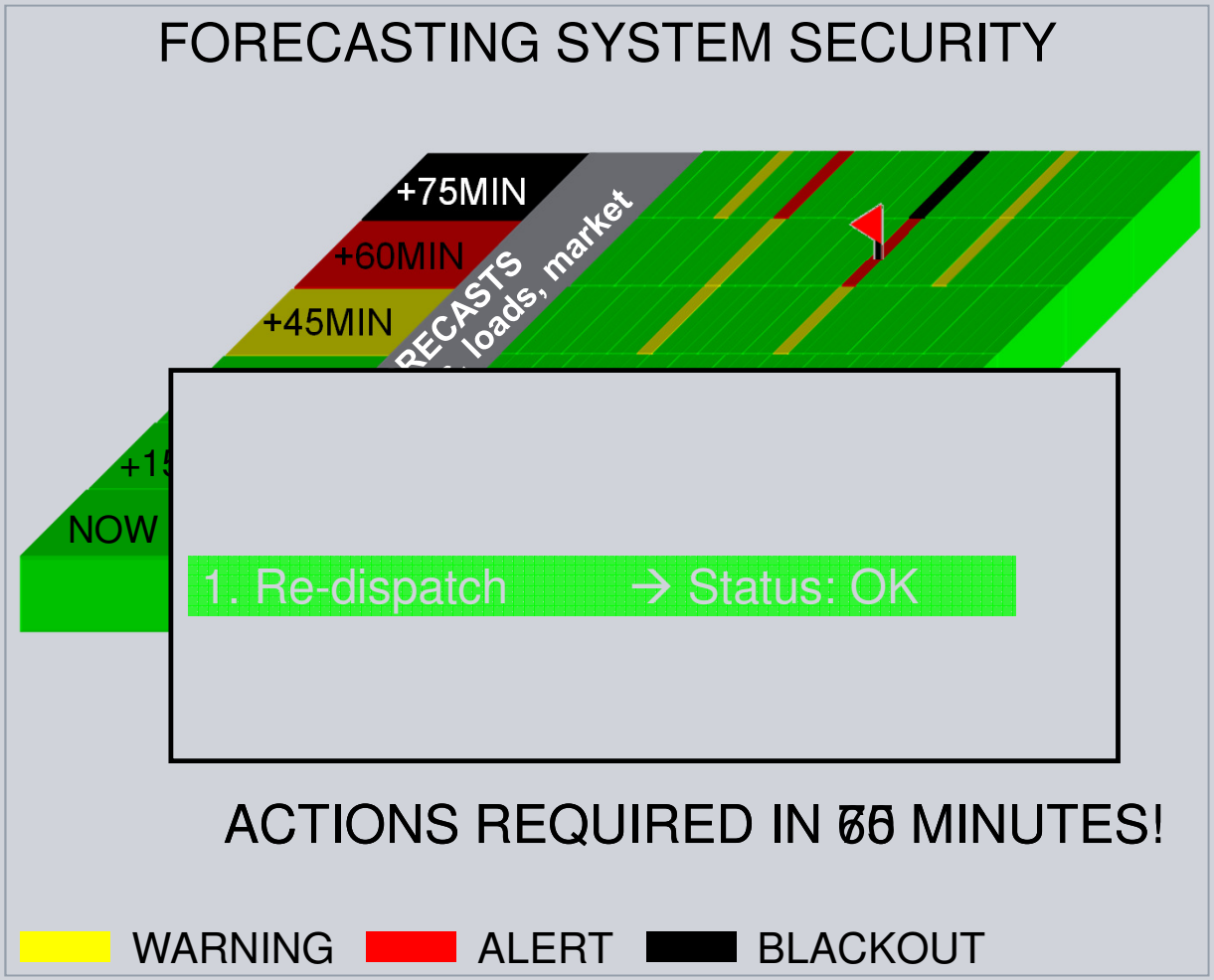

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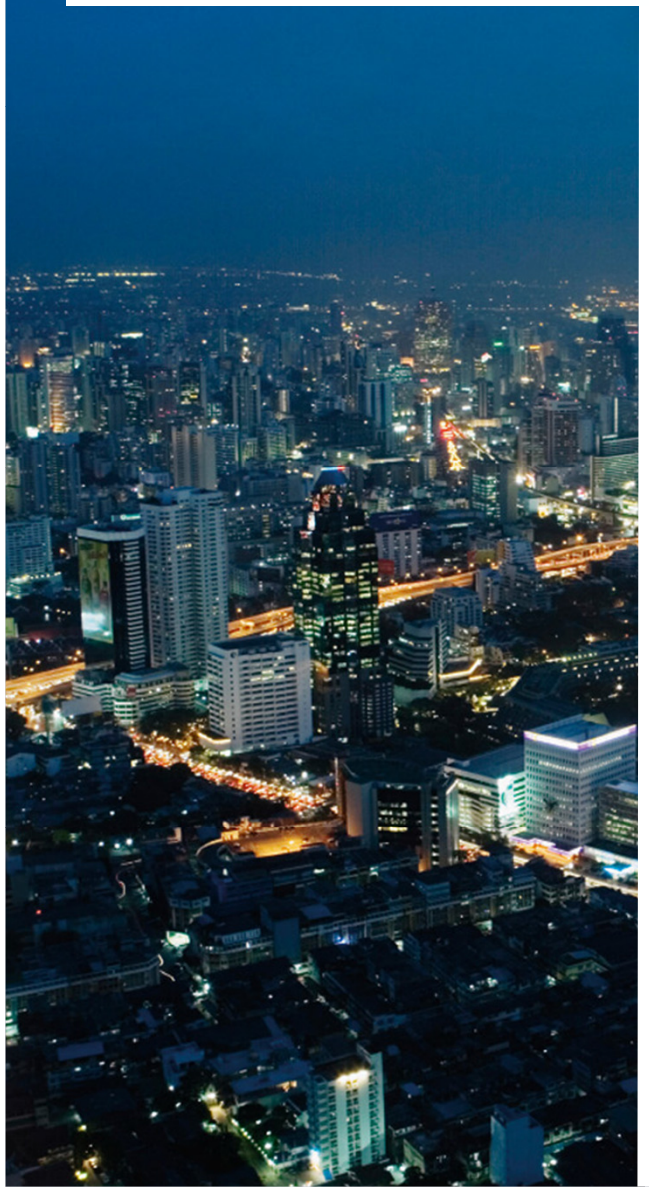
Summary

- Power systems (transmission and distribution) are not being used in a way they were designed for
- Reconsideration of control concepts is required
- On-line security assessment is a suitable solution
- Increase operational awareness
- Proofing of operators' actions and evaluation of remedial measures

Thank you for your attention!



Let‘s keep the lights on!

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Partners, pilot installations, customers
First experience

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