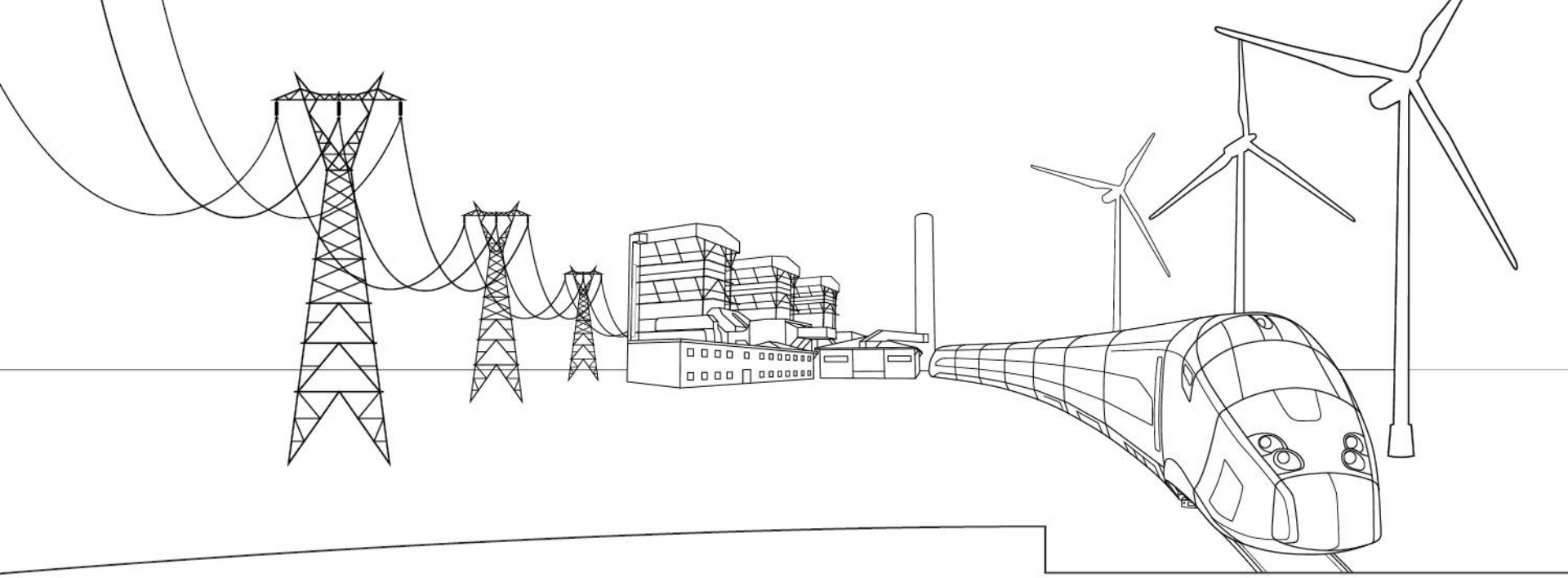

Overview of electricity markets

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Eric GOUTARD – eric.goutard@alstom.com

La Défense

18/07/2014

ALSTOM

Shaping the future

- **Alstom brief overview**
- Alstom’s presence in India
- Strategic view around electricity markets
- Alstom solutions for electricity markets
- Case studies

Three main activities in four sectors

Equipment & services for power generation
Alstom Thermal Power

Equipment & services for power transmission
Alstom Grid

Alstom Renewable Power

Equipment & services for rail transport
Alstom Transport

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Grid: market challenges

Main markets

Utilities

Eco-cities

Industry & infrastructures

Power generation

Oil and gas

Key challenges

- Integrate intermittent renewable energies
- Maximise energy flows with minimum losses
- Bring power to all while preventing outages
- Smarten existing power equipment across networks worldwide

Grid: comprehensive solutions and products

Solutions

Electrical substations, Turnkey solutions & Services

Super Grid technologies

Smart Grid technologies

Products

Air Insulated Switchgears

Gas Insulated Switchgears

Power Transformers

Power Electronics, NMS & Automation

Network Management Solutions

Substation Automation Solutions

Power Electronics

Services

Field services

Asset optimisation

Asset management

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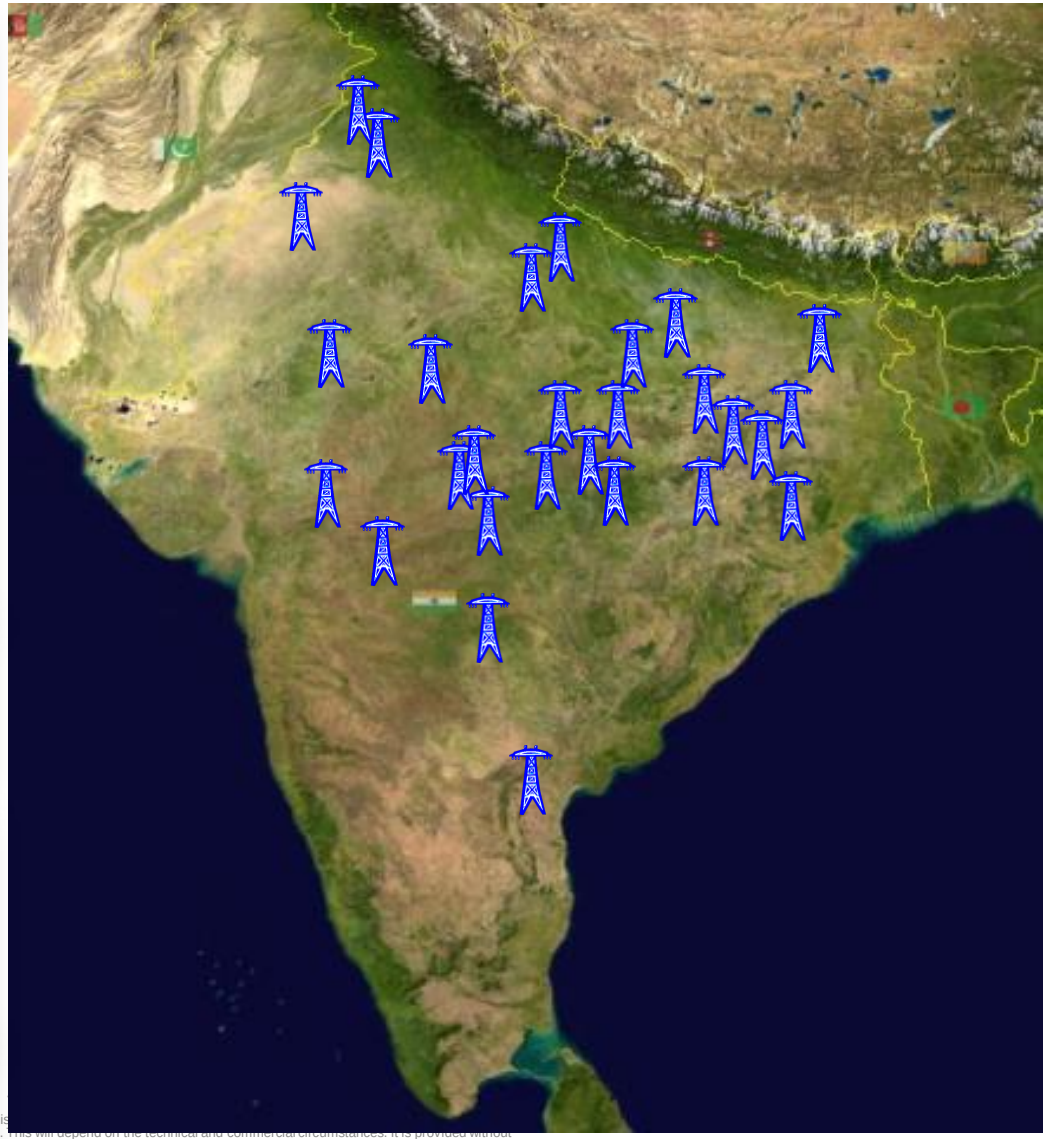
765 kV AC (EHV) substation orders awarded to Alstom Grid

Commissioned 765 kV s/s for PGCIL at Bhiwani in 2012

Commissioned the first fully integrated 765 kV transformer at Vadodara, India for LANCO – Anpara "C" in 2011

India's first 765 kV AIS substation Project for NTPC Sipat (19 Bays) in 2009



Substations with Alstom technology

28 substations with Alstom technology:

- 17 turnkey projects awarded and 11 projects to be equipped with Alstom Grid products
- 9 substations commissioned in 2012/13

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Energy Highways in India

INDIA - Champa Kurukshetra: Alstom Grid UHVDC 800 kV

- LCC point-to-point = 1,300 km
- 3,000 MW
- Voltage level: ±800 kV
- Transformers manufactured in the UK and India
- Award: July 2012
- Completion: August 2015
- Contract: 370 M€

Major NMS References - India

- Establishment of LDC for Uttrakhand SCADA/EMS

- NR SCADA/EMS Project - Powergrid
- NLDC SCADA/EMS Project
- NTAMC SCADA/EMS Project (Under Execution)
- URTDSM Project (Under Execution

- WR ULDC SCADA/EMS Upgrade(Under Execution)
- TATA Power LDC
- TATA Power DMS

- CSPDCL SCADA/DMS Project (Under Execution)

- SR Telecom project – Powergrid
- SR ULDC SCADA/EMS Upgrade(Under Execution)
- TANTRANSCO SCADA/EMS Project (Under Execution)

- Bhutan NLDC Project – BPCL
- SCADA/DMS System to Phuentsholing

- NER EMS/SCADA Project – Powergrid
- SCADA/DMS System to MEECL
- NER ULDC SCADA/EMS Upgrade (Under Execution)

- Bangladesh NLDC SCADA/EMS Project – PGCB

- ER Telecom Project – Powergrid
- ER SCADA/EMS Project – Powergrid

- SCADA/EMS system at JSPL Raigarh
- SCADA/DMS system at JSPL Raigarh

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Power Grid Corp. of India Limited (PGCIL)

Manage the risks of blackouts within constrained grid environment

Client's challenge

In-depth monitoring of the transmission corridors

Alstom's solution

Latest generation grid security technologies
Wide Area Monitoring System (WAMS), incl. Phasor Measurement Units (PMUs) measuring the electrical oscillations in electrical power flows

Noteworthy

World's largest PMUs roll-out
1100 PMUs, 18,000 phasors, in 351 substations across the country and establishment of 34 new control centres

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Foreword on market designs

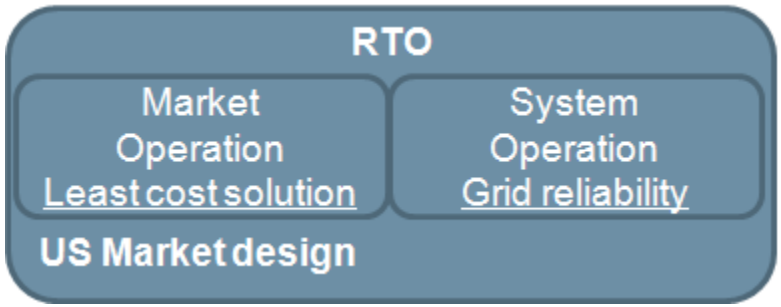
US Market design

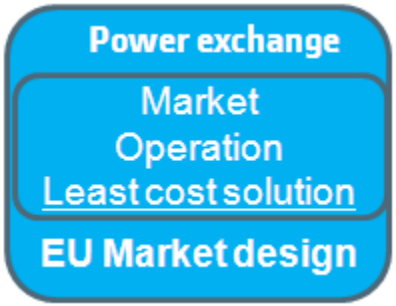
- Responsibility for Market operation (least cost solution) and System operation (Grid reliability) are under the same organization

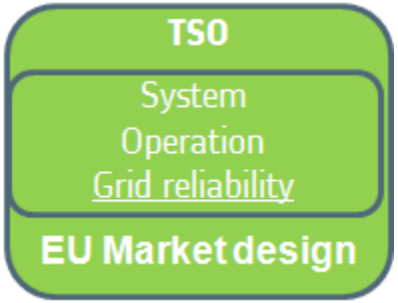
European Market design

- Responsibility for Market operation (least cost solution) and System operation (Grid reliability) are under two separate organizations:

Power exchange and TSO







Network codes in Europe

A set of rules applying to one aspect of the energy sector

Which are developed by ACER, ENTSO-E and market participants

And become legally binding after the comitology process

Hence network codes will have the same status as any other regulation

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Overview of Network Codes

Grid connection related codes	• Requirements for Generators	(RfG)
	• Demand Connection	(DCC)
	• HVDC Connection	(HVDC)
System Operation related codes	• Operational Security	(OS)
	• Operational Planning and Scheduling	(OPS)
	• Load Frequency Control and Reserves	(LFCR)
	• Operational Procedures in an Emergency	(EP)
Market Related codes	• Capacity Allocation and Congestion Management	(CACM)
	• Forward Capacity Allocation	(FCA)
	• Electricity Balancing	(EB)

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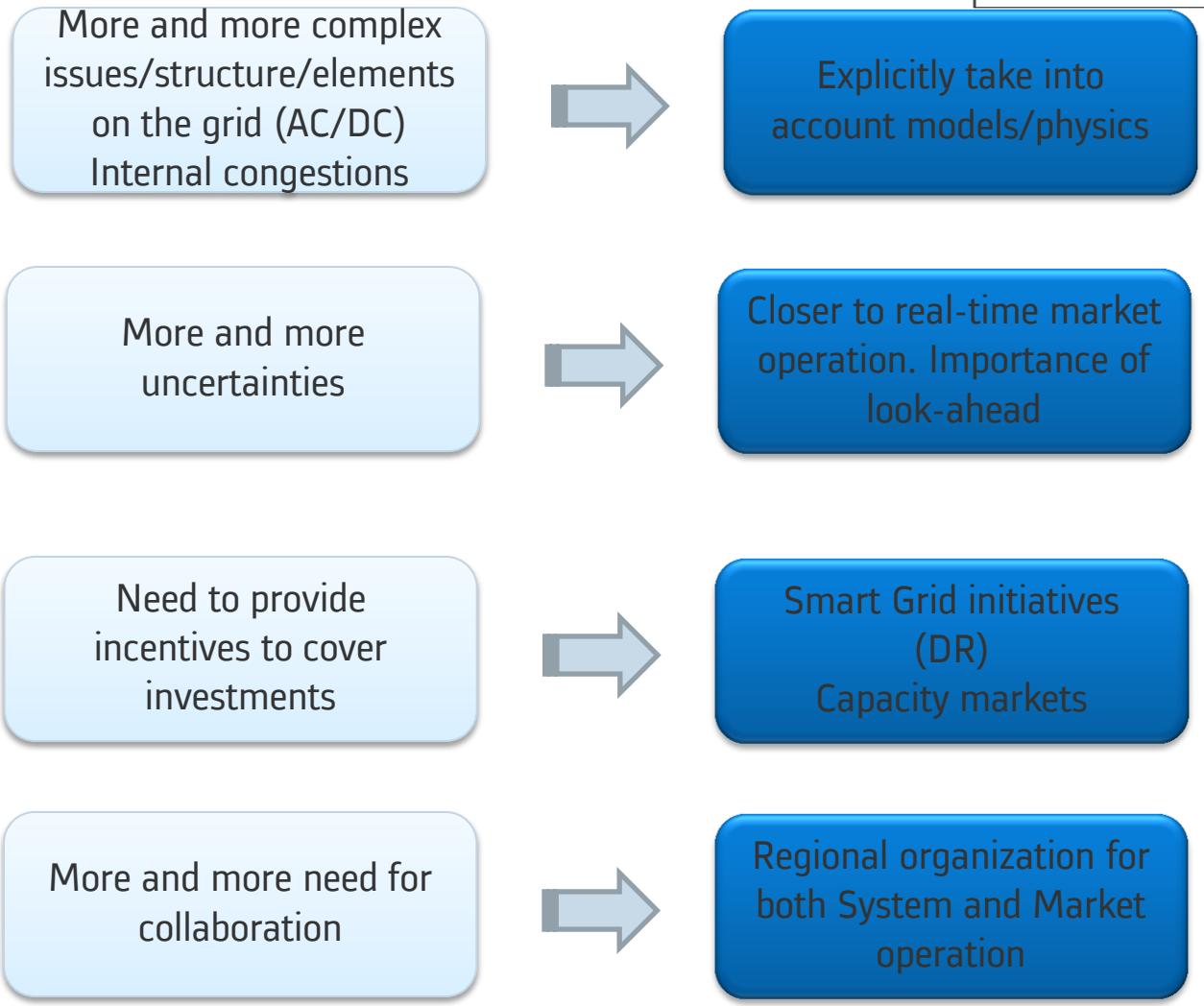
Observations based on customer interactions



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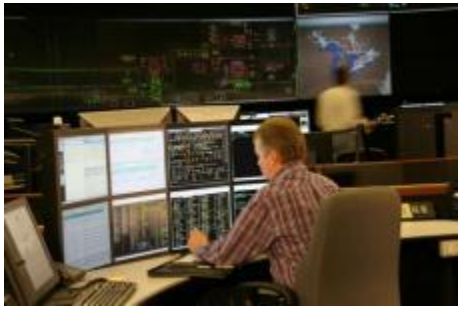
Grid Control Room Solutions

Mission critical (365 x 24 x 7) software solutions

Alstom Grid control room oversees, monitors, controls, operates and protects the grid

e-terra 3.0

- Answers to **40%** of the electricity global demand
- Runs **the largest distribution system in operation in the US**: 500 users clients, 1 million transformers, 5 million customers
- **60+ countries** running an energy management system based on e-terra



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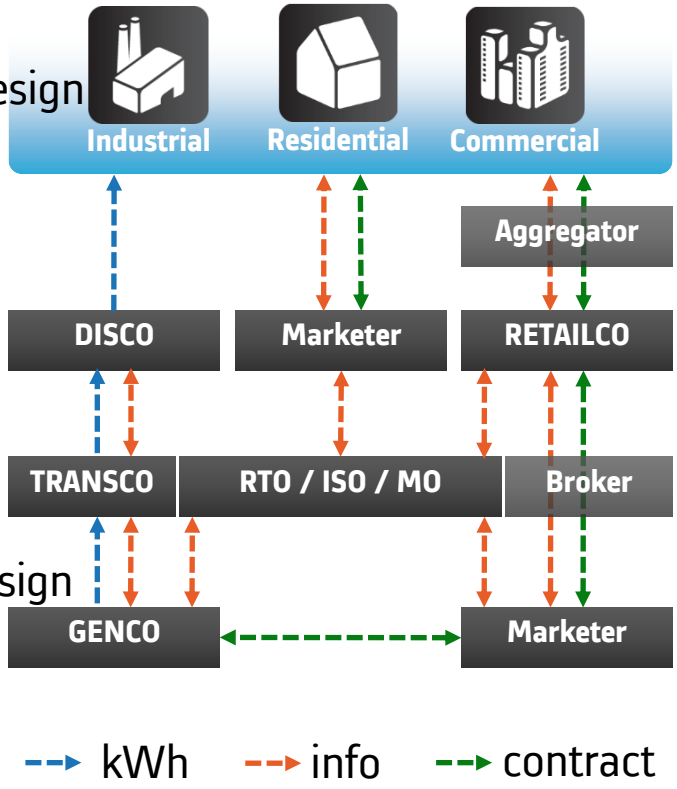
Control Center Solutions for Market Management

ALSTOM is a Full Service Provider of Market Solutions

- Energy Management System (EMS)
- Market Management System (MMS) – US market design
  - Day-Ahead Market (SCUC)
  - Real-time Market (SCED)
  - Look Ahead Scheduling and Dispatch
  - Capacity market (RPM)
  - Financial Transmission Rights (FTR)
- Market Management System (MMS) – EU market design
  - Capacity Allocation
  - Scheduling
  - Balancing market
- Settlements System



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- **Case studies**

TenneT – Markets and Settlements – 2014

Customer: TenneT Taking power further
Country: Nederland 
Installed capacity: 15 GW
Peak Load: -
Transmission: 20,000 km
Market Participants: 150+
# of customers served: 36 Millions
Network model size: 1200 buses
# of generating Units: 550

Challenges & Goals:

Reorganize and prepare the IT and MMS landscape for upcoming challenges:

- Lead the integration of EU market with the most advanced IT infrastructure
- Establish a solution aligned to key-business needs and allowing quick adaptation to market, regulatory and technical changes
- Integrate and harmonize processes within the organization
- Reduce IT cost and rationalize the infrastructure thanks to a COTS approach

Solution:

e-terra*market* and **e-terra***settlements*

- Balancing Market
- Congestion Management
- Settlements

ALSTOM

Tennet press release

The modular infrastructure will support the entire market management operation from scheduling processes, to imbalance management, to settlement – all while maintaining optimal service and adaptability to future market conditions.

“As part of the tendering process, Alstom and Unicorn Systems demonstrated that their joint solution is well in line with our business needs, and their energy IT technologies and domain expertise well-suited in the realm of an active European electricity market,” said Peter Hoffmann, Senior Manager System Operations of TenneT.

http://www.alstom.com/press-centre/2014/4/alstom-and-unicorn-systems-win-tennet-contract-for-major-electricity-market-management-solution/

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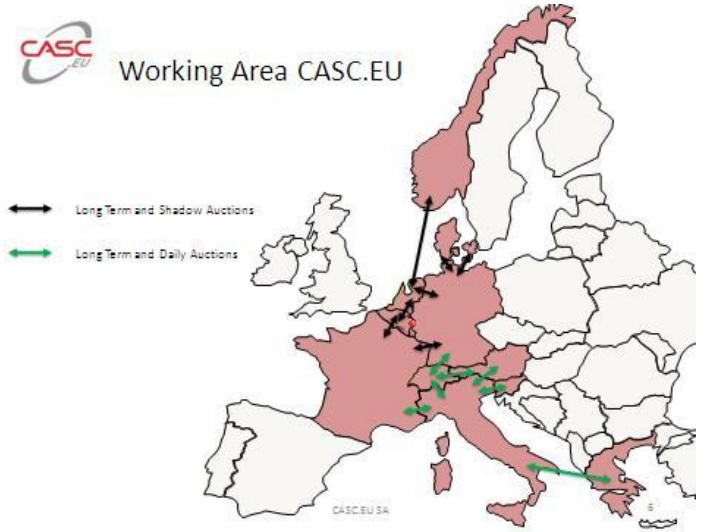
CASC – Transmission capacity allocation – 2008-2014

Customer: CASC.EU
Country: Luxembourg
Installed capacity: N/A
Peak Load: N/A
Transmission: 30 oriented borders
Market Participants: 150+
# of customers served: N/A
Network model size: N/A
# of generating Units: N/A

Challenges:

- Go-Live for first explicit transmission capacity auction in 3 months after contract signing
- Quickly integrate new borders with different allocation rules
- Propose an attractive platform for market participants with advanced functions such as curtailment and secondary market
- Comply with ENTSO-E ECAN



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Transmission: 30 oriented borders
Market Participants: 150+
# of customers served: N/A
Network model size: N/A
# of generating Units: N/A

Benefits:

- Fast addition of new borders with possibility of having different logic per border
- Uniform interface for participants across multiple countries and borders
- Product-based solution, compliant with ENTSO-E ECAN

Solution:

- **e-terra***market* ENTSO-E
  - Yearly, Monthly, daily, intra-day auctions
  - Settlements
  - Interfaces with banks and accounting system

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NOIS – Nordic Operation Information System – since 2008

Customer:
Statnett
SVENSKA KRAFTNÄT
ENERGINET.DK
FINGRID

Country: Denmark, Finland, Norway, S...

Installed capacity:
100 GW

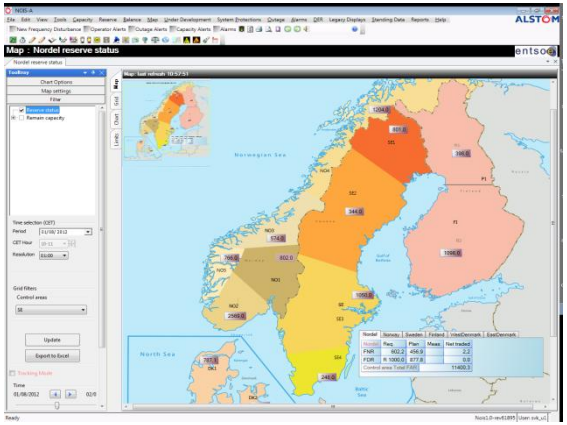
Peak load:
60 GW

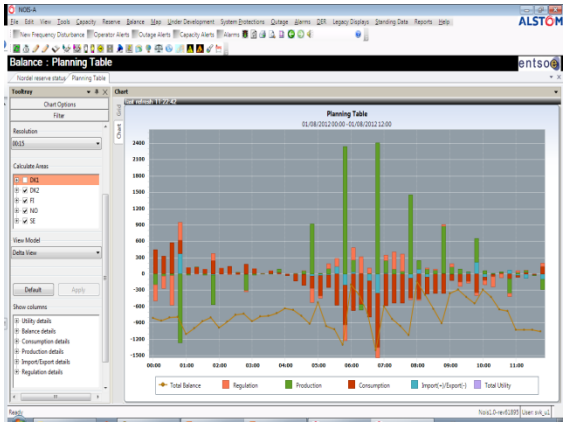
# of customers served:
25 Millions

Transmission:
45,000 km

Challenges:

- 4 TSOs with
  - 4 set of business processes to be unified
  - 4 grids with different characteristics
- Balance Management Integration with Nordic Market
- Comply with fast-track market changes (e.g. split of Sweden in 4 bidding zones)





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Country: Denmark, Finland, Norway, Sweden

Installed capacity:
100 GW

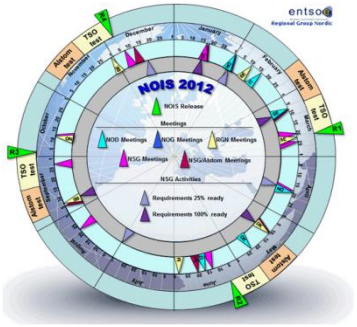
Peak load:
60 GW

# of customers served:
25 Millions

Transmission:
45,000 km

Benefits:

- Improved TSOs co-ordination for operational planning and balance management thanks to a unified platform
- Better co-ordination of the data exchange with the Power Exchange
- Supplier partnership



Solution:

- Common platform for TSO coordination and co-operation
  - Capacity Management
  - Reserve management and Power Balance
  - Outage management

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CWE – Flow-based market coupling - 2013

Customers

amprion

creos

elia

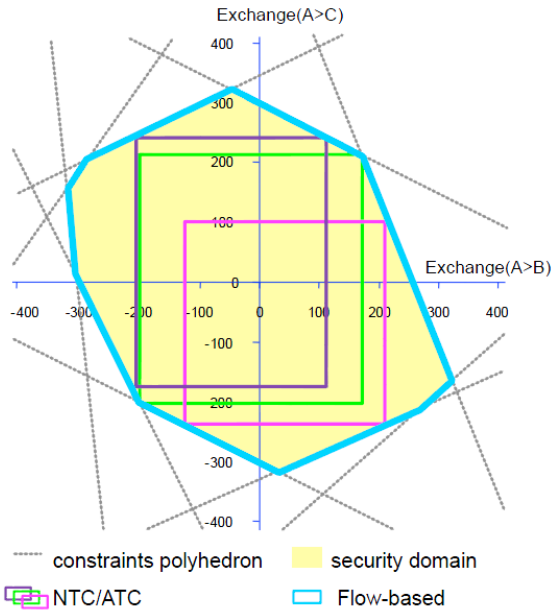
Rte Réseau de transport d'électricité

TenneT Taking power further

TRANSNET BW

Challenges:

- Industrialize FB market coupling algorithm using COTS solution
- High performance calculation
- High accuracy calculation (impact on coupling)
- IT integration with the CWE common platform



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CWE – Flow-based market coupling - 2013

Customers

amprion

creos

elia

RTE Réseau de transport d'électricité

TenneT Taking power further

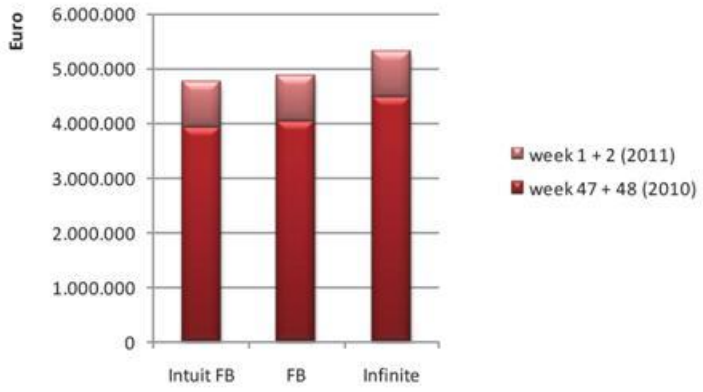
TRANSNET BW

Benefits:

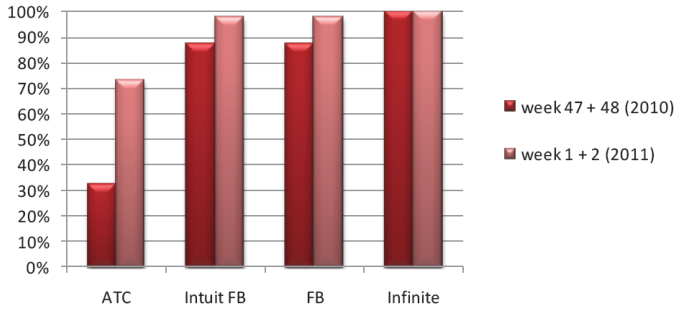
- Increase of transmission capacity offered to the market => higher welfare
- In FB, capacity split is not a choice of the TSO, but is market driven

Solution:

- **e-terra***market* SFT and market control



CWE D-1 MC social welfare increase relative to ATC



CWE D-1 full convergence 'copper plate'

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PJM – Markets and Settlements – 2004 - 2014

Customer: PJM
Country: US
Installed capacity: 180 GW
Peak Load: 163 GW
Transmission: 61,200 miles
Market Participants: 700+
# of customers served: 58 Millions
Network model size: 15,000 buses
# of generating Units: 1,300+

Challenges:

- Complex and very large optimization problem
- Comply with FERC
- Integrate 15 GW of DR
- Settlements on a weekly basi
- Capacity market also includin various DR products and network expansion
- FTR with time coupled solutions
- SOA-based architecture

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Installed capacity: 180 GW
Peak Load: 163 GW
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Market Participants: 700+
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# of generating Units: 1,300+

Benefits:

"PJM Interconnection saved $199 million last year—an amount almost equal to its operating costs—by increasing efficiency in how generation is scheduled to meet electric demand requirements, particularly, the scheduling of more costly combustion turbines used to meet demand shortfalls. Accumulated savings since 2008 are $455 million.

PJM Press Release, Valley Forge, Pa. – Jan. 19, 2012

Solution:

- **e-terra***market* and **e-terra***settlements*
  - Capacity market, FTR
  - Day-ahead, real-time, look-ahead, DR
  - Settlements

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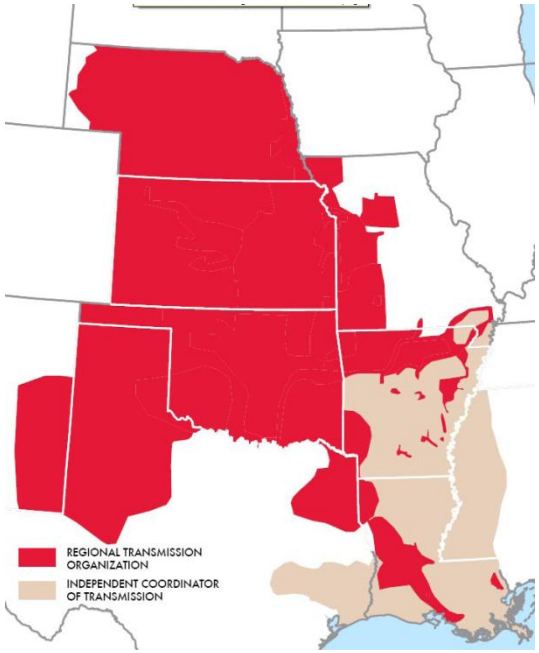
SPP – Southwest Power Pool IEM – 2011 - 2014

Customer: SPP
Country: US
Installed capacity: 66 GW
Peak Load: 49 GW
Transmission: 50,575 miles
Market Participants: 100+
# of customers served: 15 Million
Network model size: several thousands buses
# of generating Units: 850+

Challenges:

- Move from Zonal energy imbalance market to full-blown zonal LMP market
- Less than 3 years from contract signature to Go-Live
- With implementation of the Integrated Marketplace, SPP will settle a ten fold increase over the existing EIS Market, including 5 min nodal Settlements
- Change management for participants, parallel tests and operation



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Transmission: 50,575 miles
Market Participants: 100+
# of customers served: 15 Million
Network model size: several thousands buses
# of generating Units: 850+

Benefits:

- Projected savings around $100 Million/Year
- Reduce total energy costs through centralized unit commitment while maintaining reliable operations
- Day-Ahead Market allows additional price assurance capability prior to real-time
- Includes new markets for Operating Reserve to support implementation of Consolidated Balancing Authority (CBA) and facilitate reserve sharing

Solution:

- **e-terra***market* and **e-terra***settlements*
  - Day-ahead SCUC and RUC, real-time SCED, look-ahead, Settlements

Worldwide MMS and Settlements reference list

And 2 new more recently signed !

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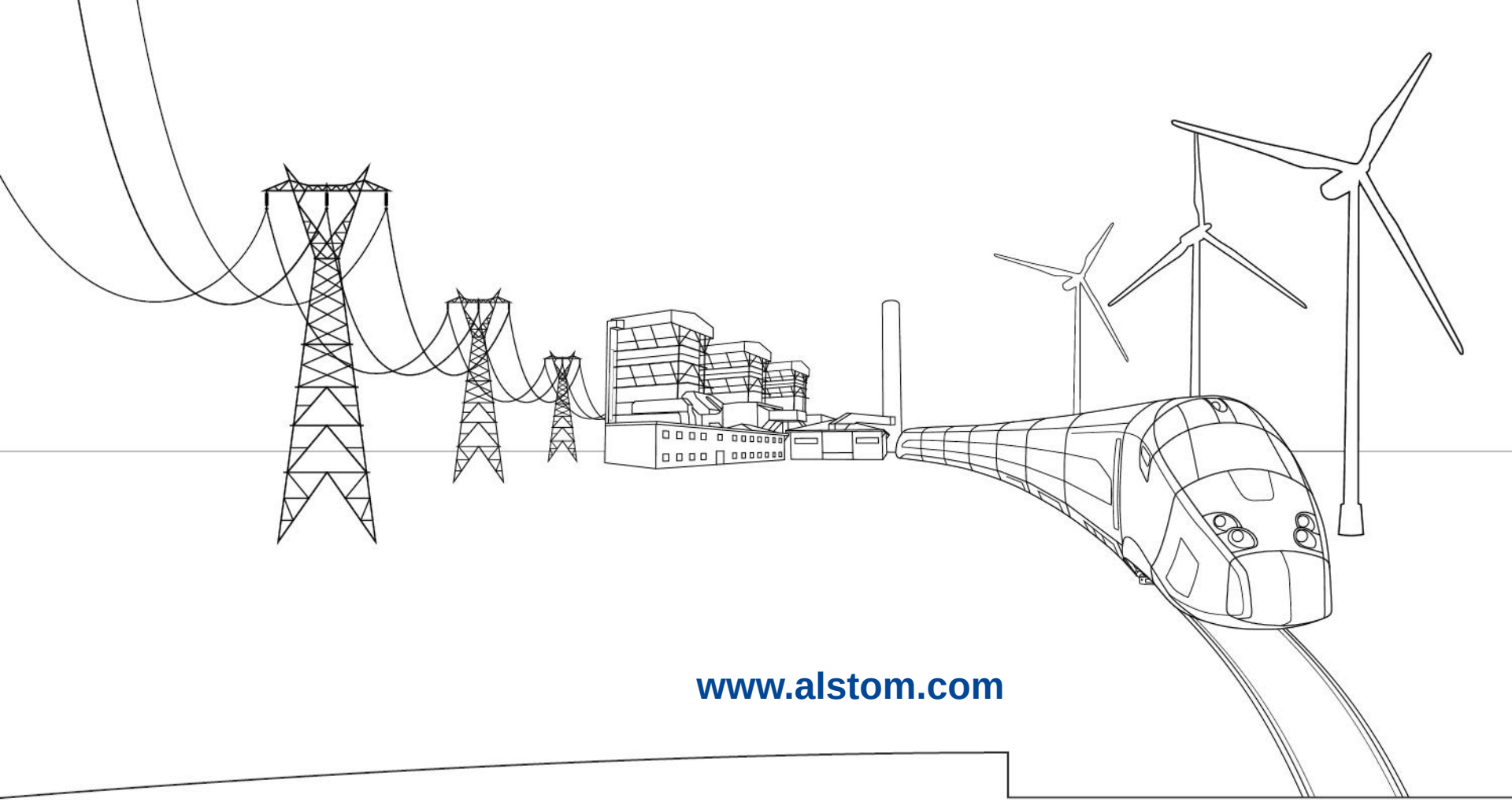

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