Document number

E-Price as smart grid enabler

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Introduction

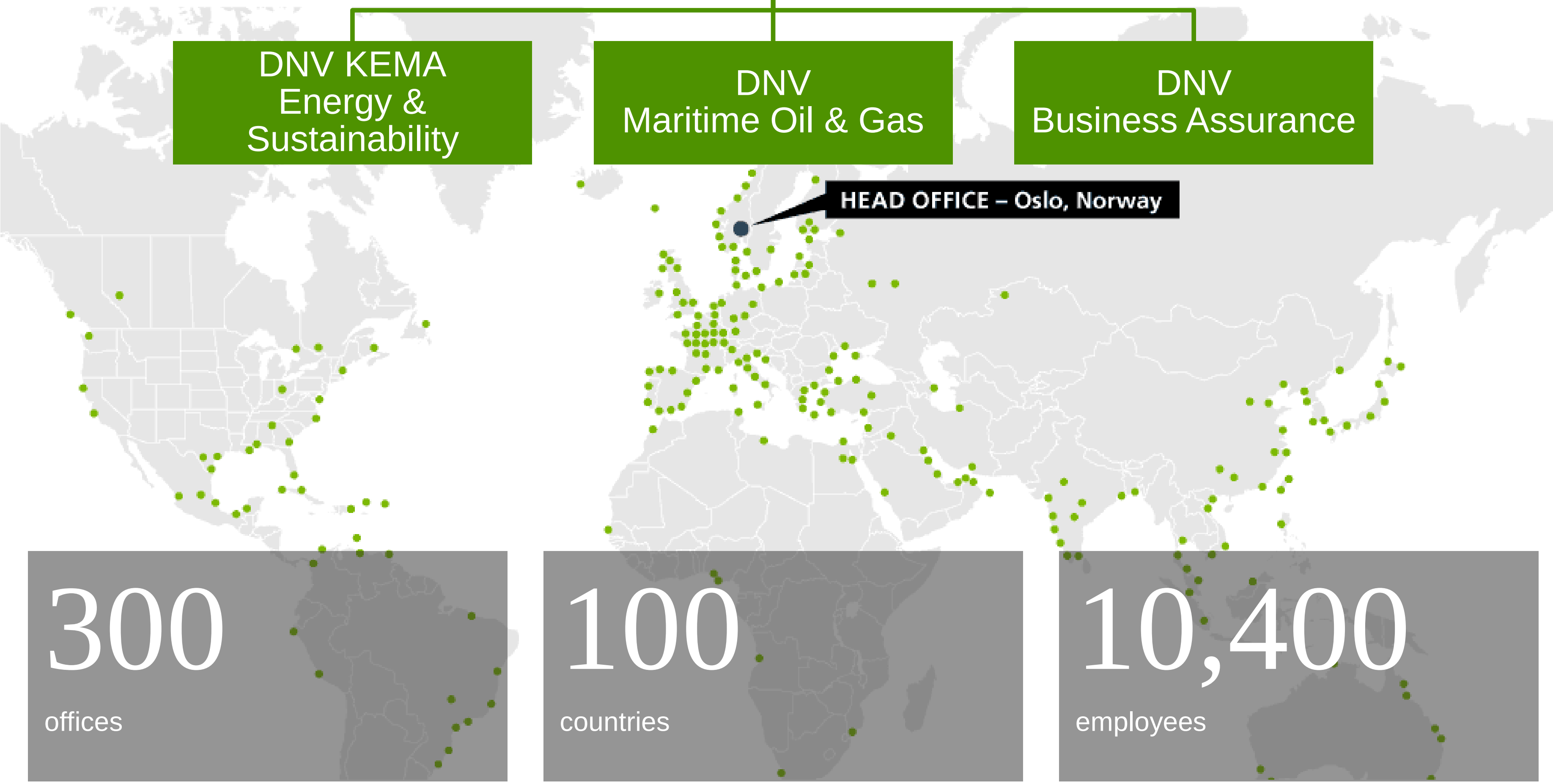
DNV KEMA Energy & Sustainability

- DNV KEMA Energy & Sustainability offers innovative solutions to customers across the energy value chain, ensuring reliable, efficient and sustainable energy supply, now and in the future.
- 2,300+ experts across all continents
- KEMA and DNV combined: a heritage of nearly 150 years
- Headquartered in Arnhem, the Netherlands
- Offices and agents in over 30 countries around the globe

The DNV Group

DNV Group

- DNV KEMA Energy & Sustainability
- DNV Maritime Oil & Gas
- DNV Business Assurance



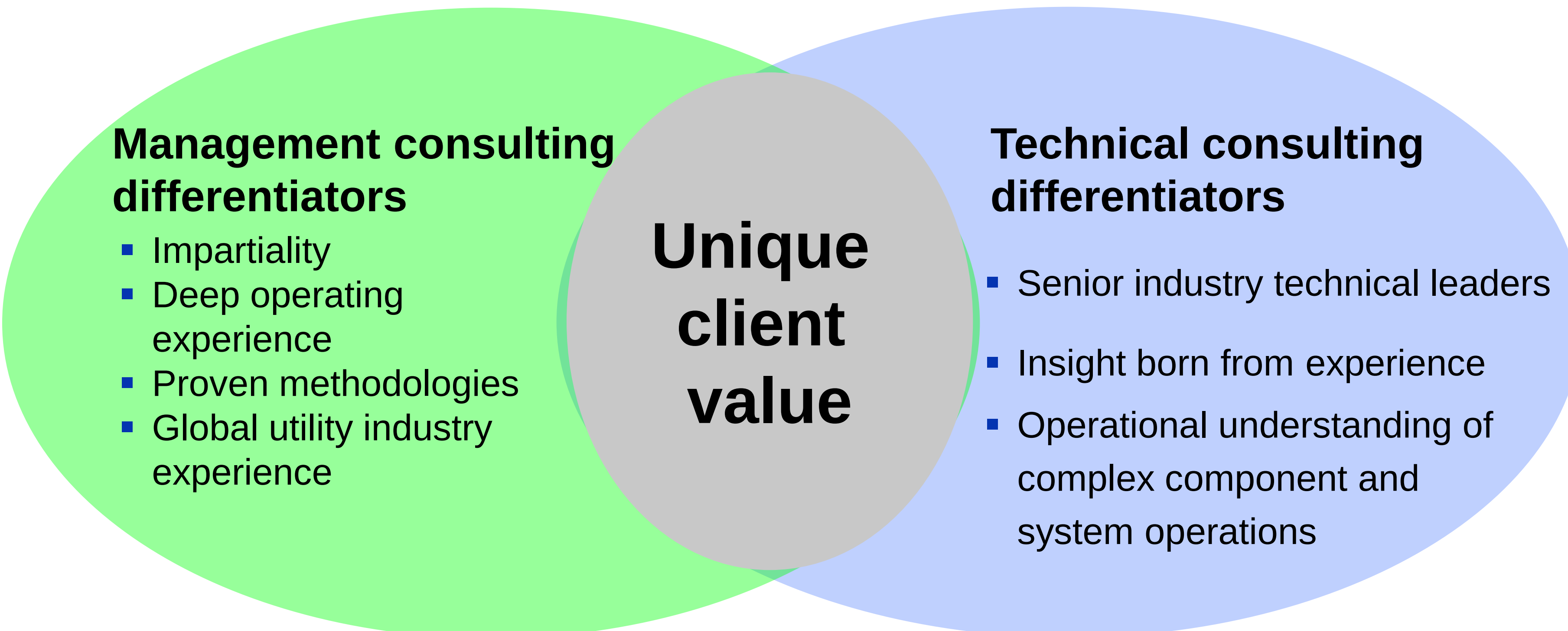
300 offices

100 countries

10,400 employees

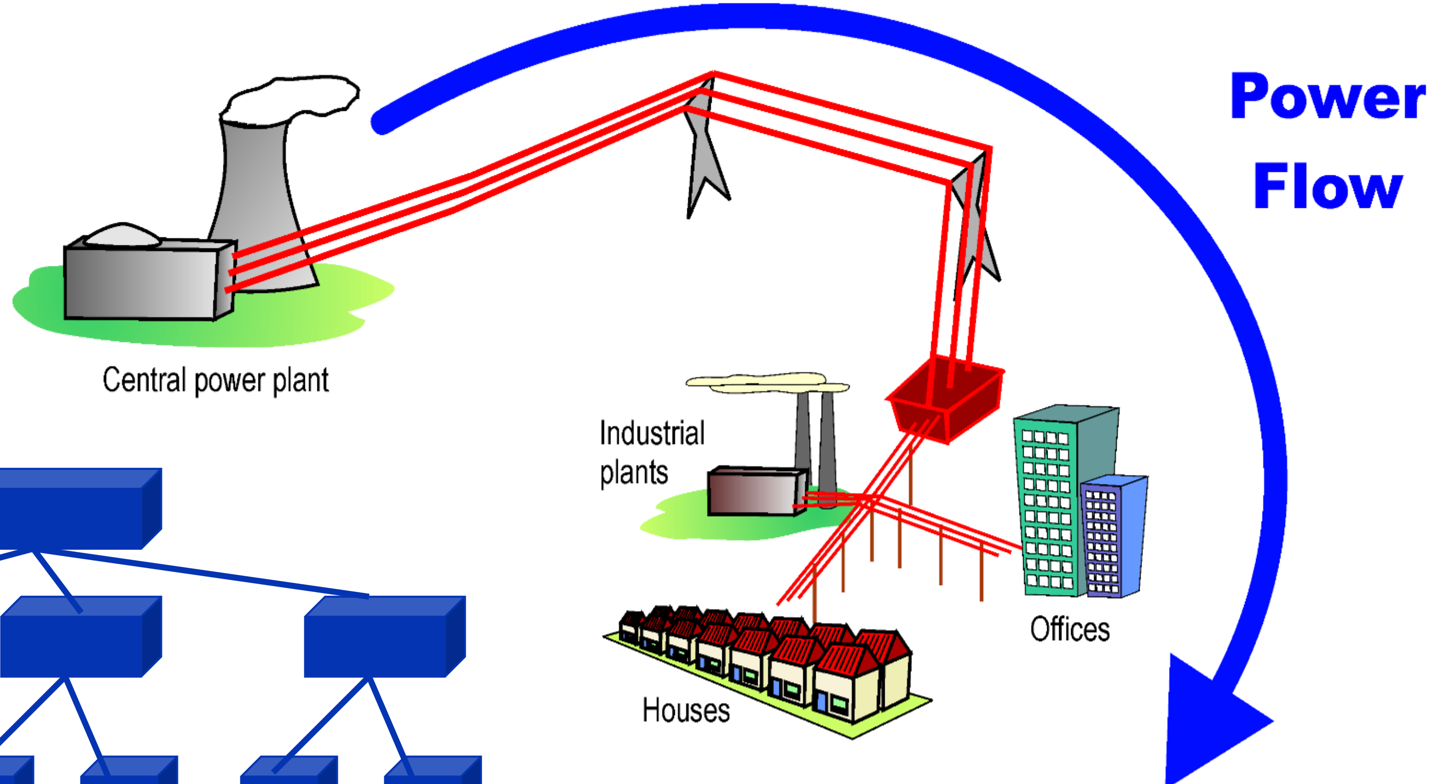
We understand:

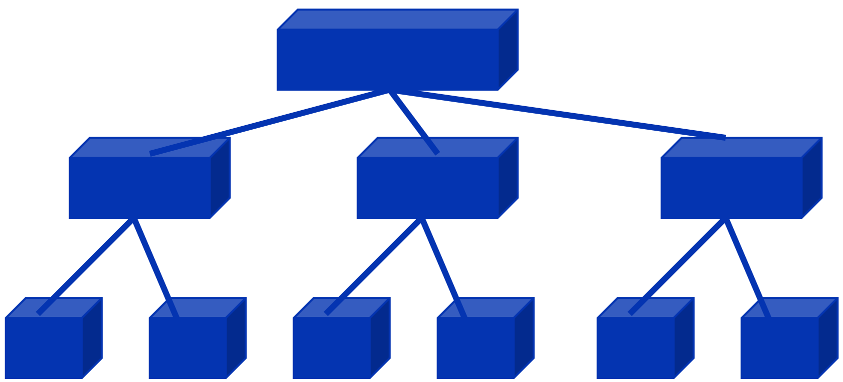
The business consequences of a technical decision,
and the technical consequences of a business decision.



Our customers span the energy value chain

Recources →





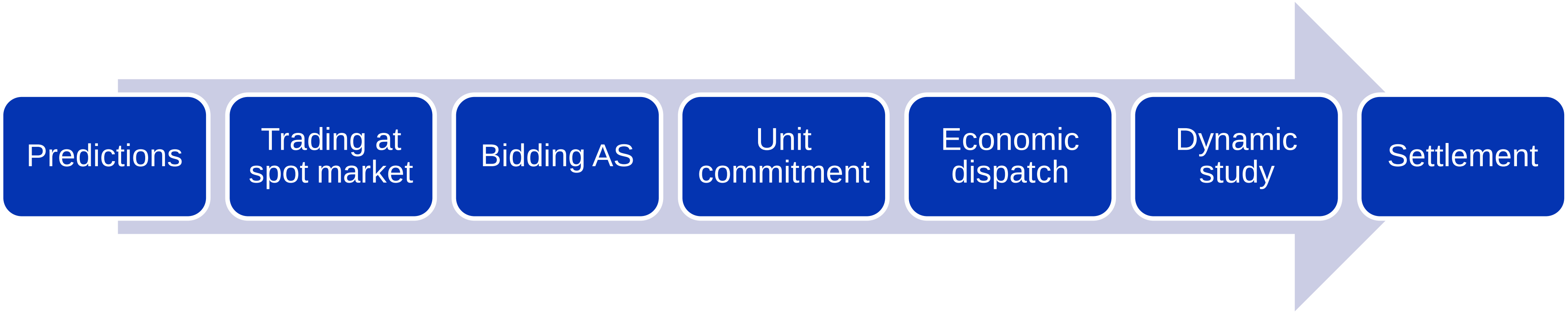
'1985 - '20?? - De-central sys-tem, Hierarchical communication

Production → Transport & Distribution → Use

How does the E-Price system function?

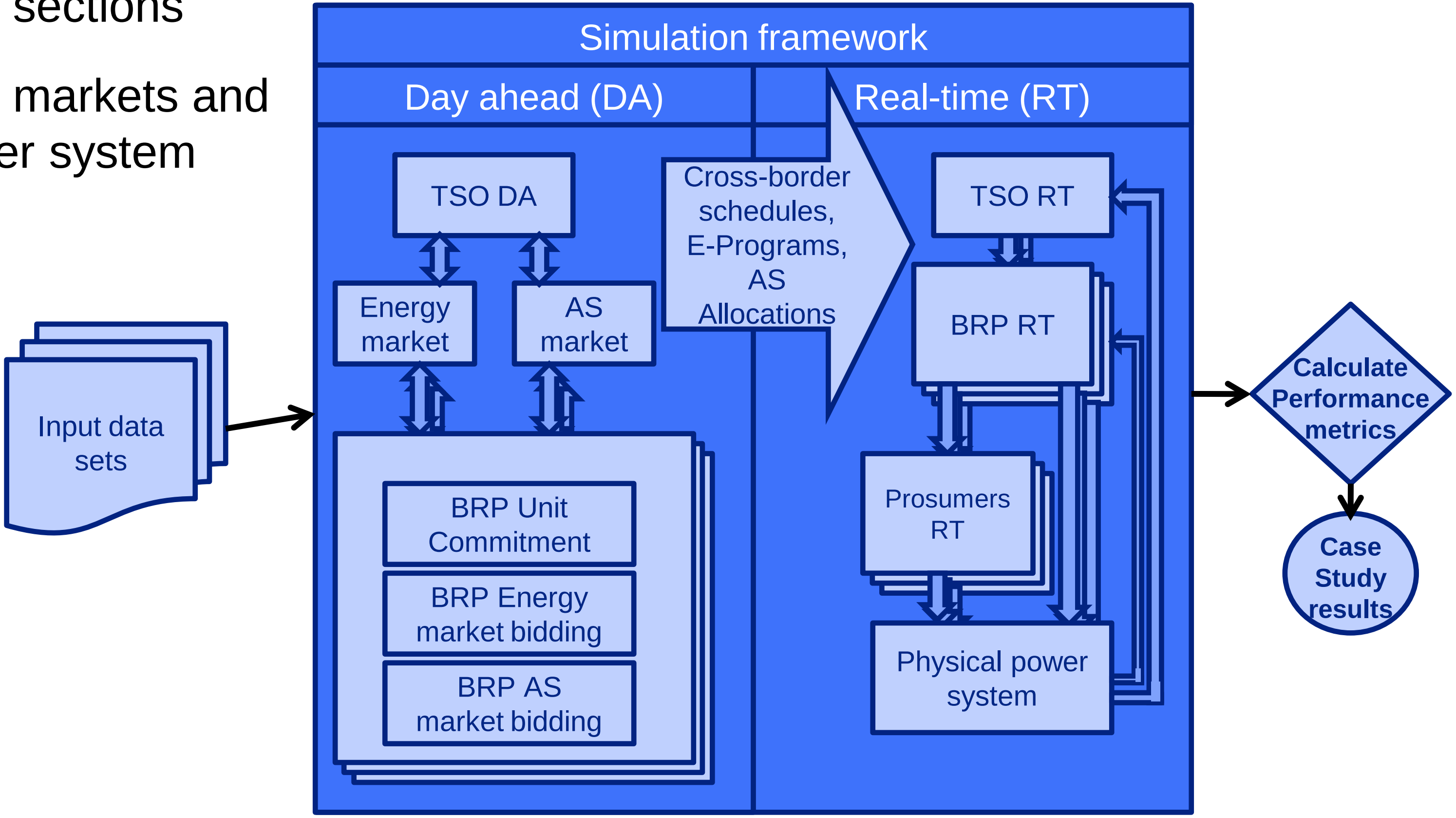
Model description

- Includes both day ahead and real-time behavior of
  - Transmission System Operator, and
  - Balance Responsible Parties
- DA market operation based on APX DA spot market algorithm
- Model of the Netherlands in European power system and includes cross-border interconnections with their limitations
- Physical model is based on active power balance and includes dynamics of power plants (ramp rates, delays, etc.) and grid



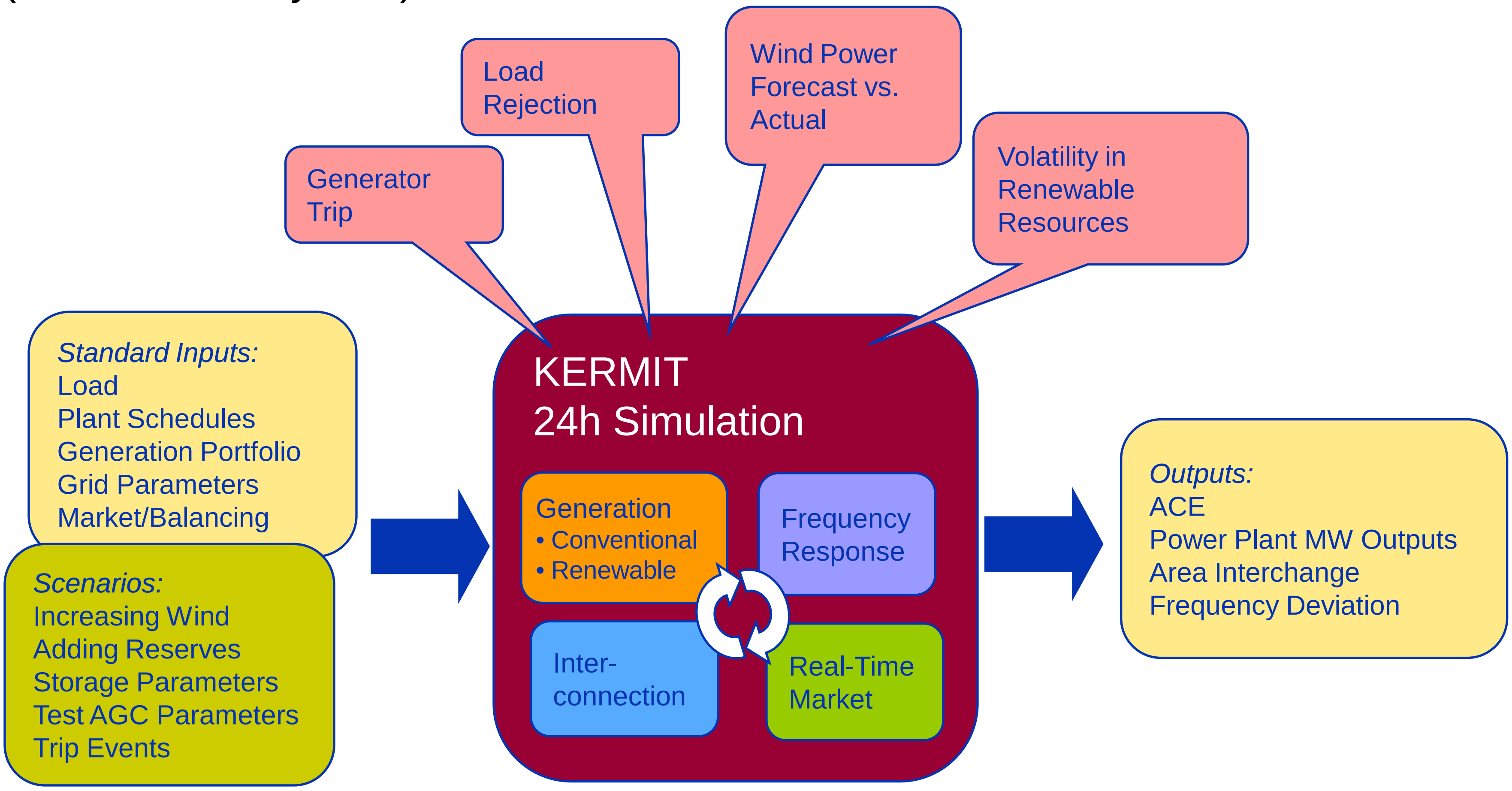
Integration of day ahead and real-time models

- Integration of day ahead and real-time sections
- Integration of markets and physical power system



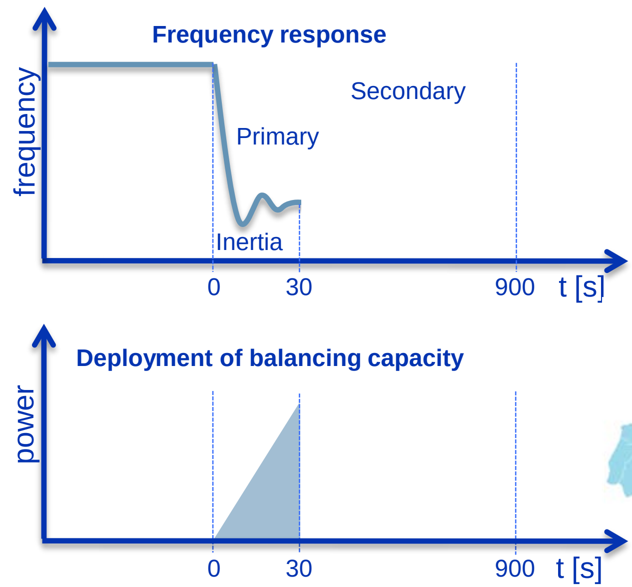
Physical model

- Based on DNV KEMA's KERMIT model which is fine tuned and verified on real-life (Dutch Power System) measurements



Physical model and power balance

System response during unit trip

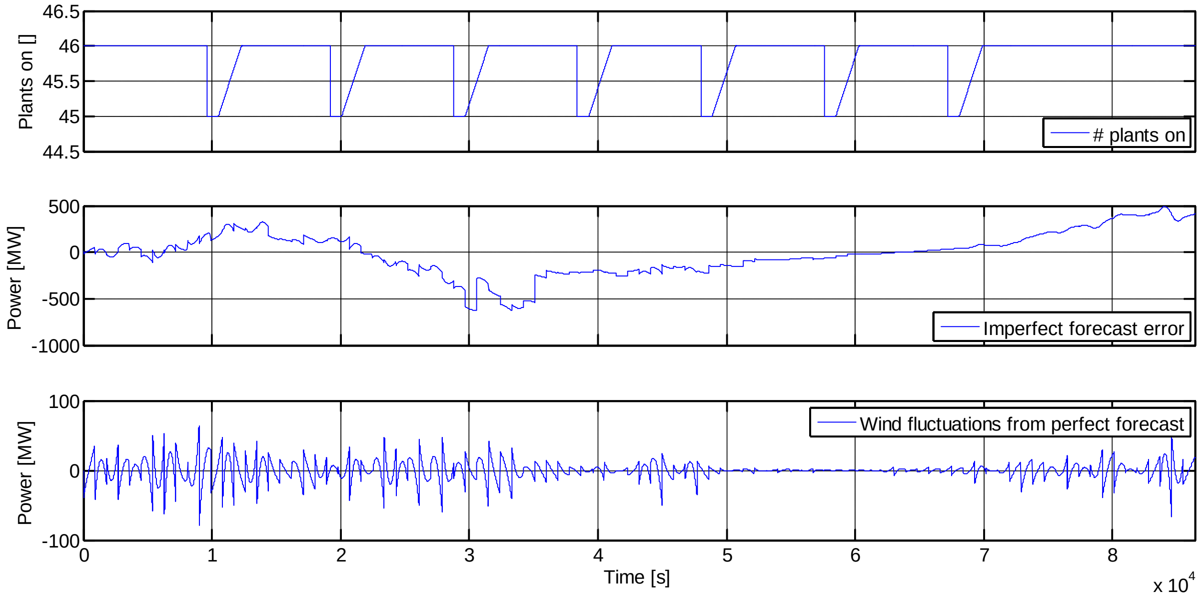


- Imbalance caused by
  - Trip of generation or load, or separation of areas.
  - Control strategy
  - Prediction errors in load or generation
- Balance should always be restored

Imbalance definitions

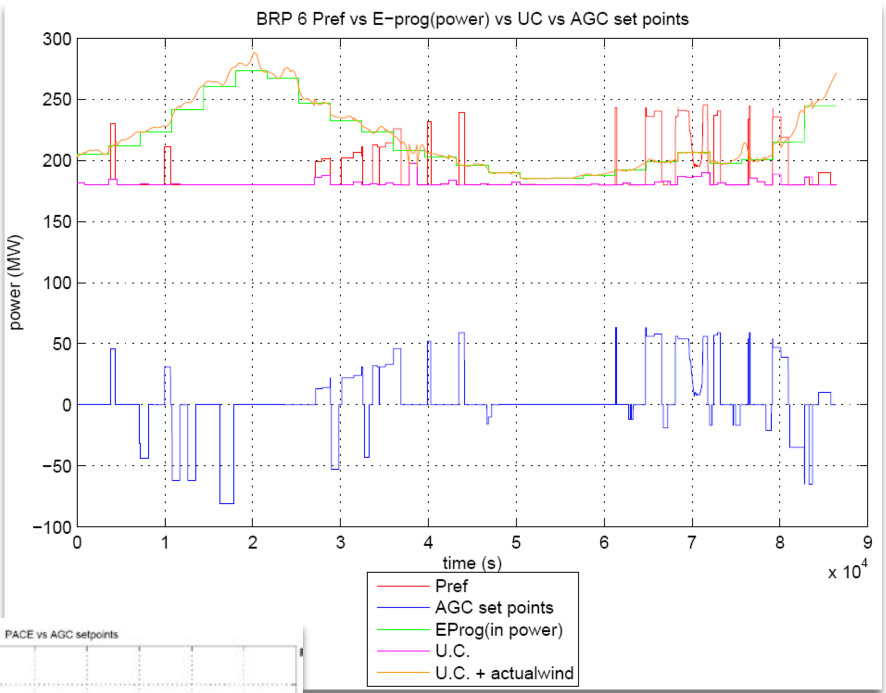
- Imbalances have been defined to validate the algorithms

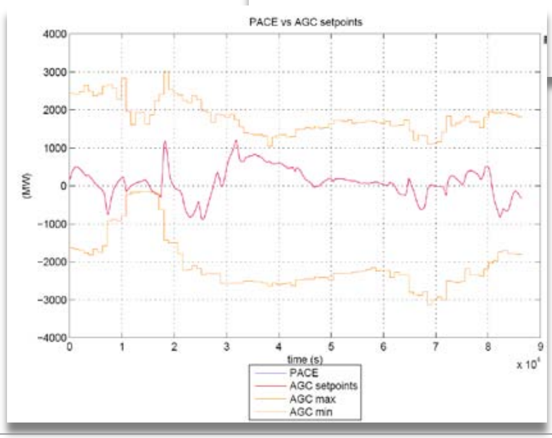
  - Power plant trips
  - Wind power forecast errors
  - Wind power fluctuations



Model outputs

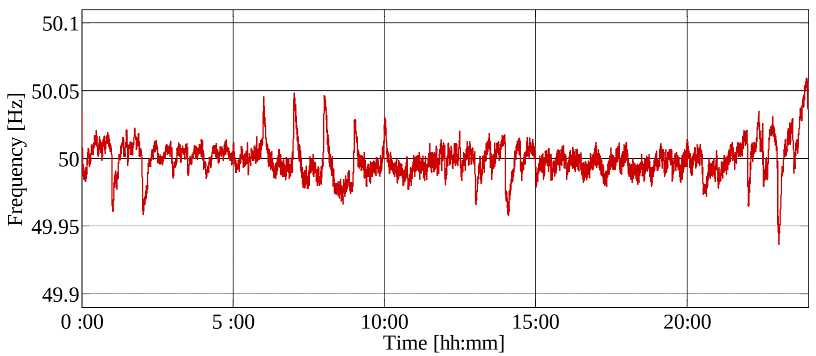
- Delta frequency
- Power realized vs. scheduled on cross-border interconnection
- BRPs reference power vs. E-program vs. AGC set points
- BRPs reference power vs. realized
- ACE and PACE, action TSO
- Load
- Etc…

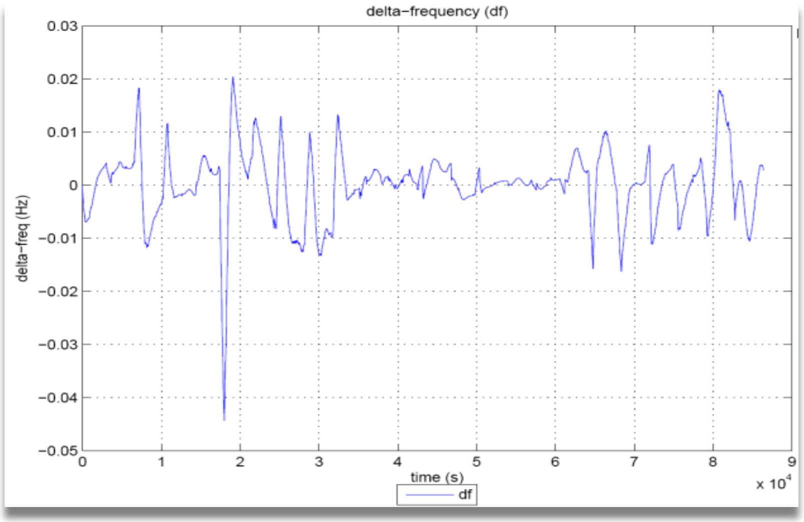


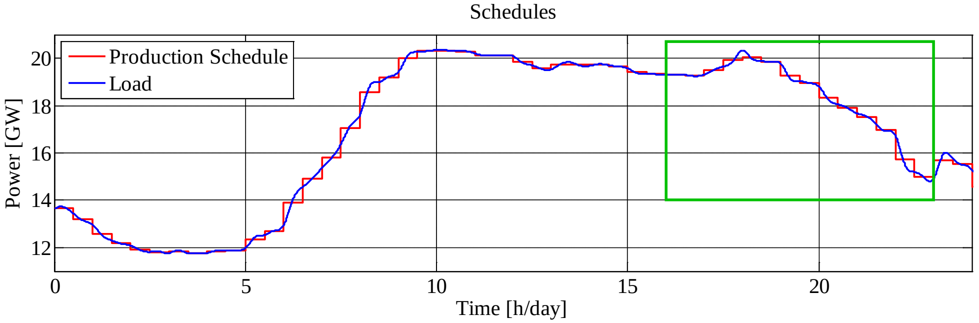


Observations – hourly frequency excursions

- Generator dispatch
- Observations of the current model:
  - Frequency disturbances at PTU-crossings
- Ramping behavior of generators causes frequency excursions

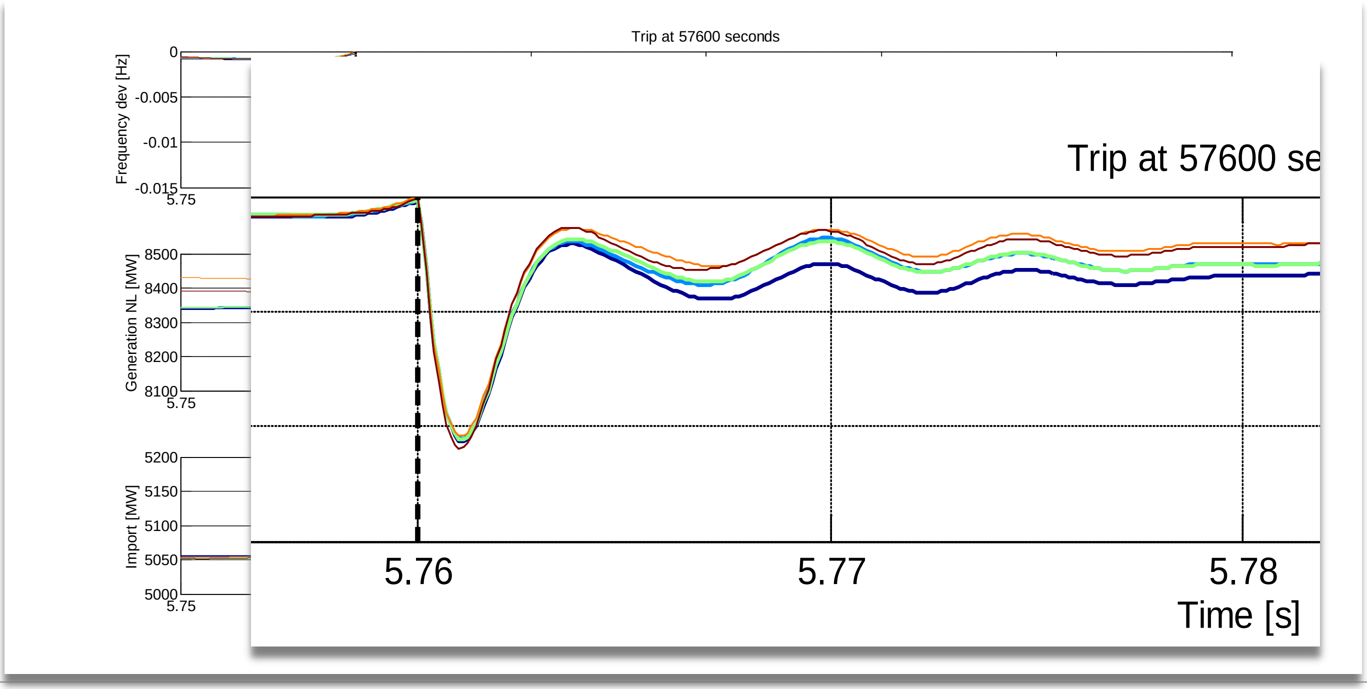






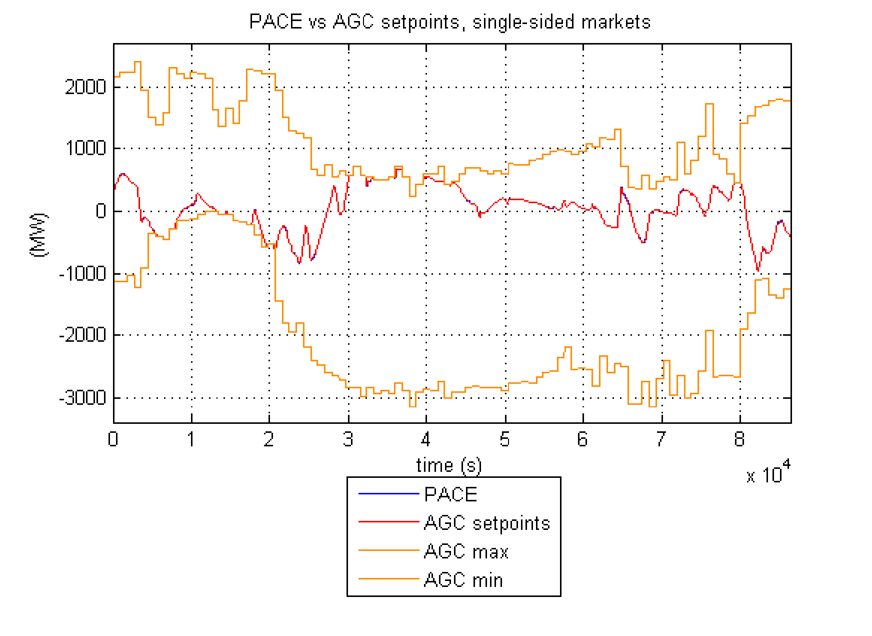
Observations - trip studies

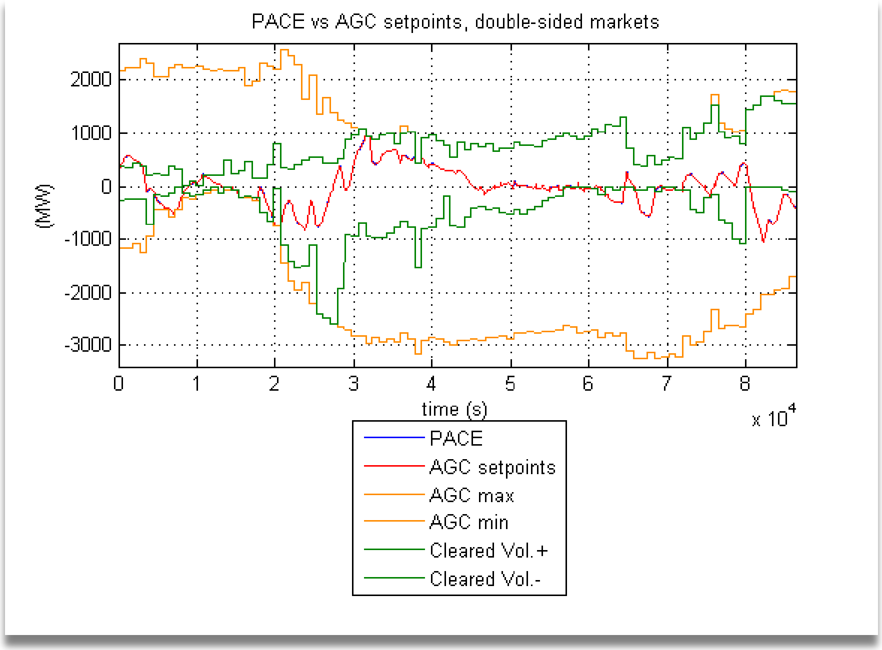
- Power plant trip of approximately 130 MW
- Primary response not affected by double sided market
- Double sided market gives a faster recovery of frequency (green/yellow)
- Double sided market with prosumers gives a faster recovery (orange/red)



Observations - double sided market

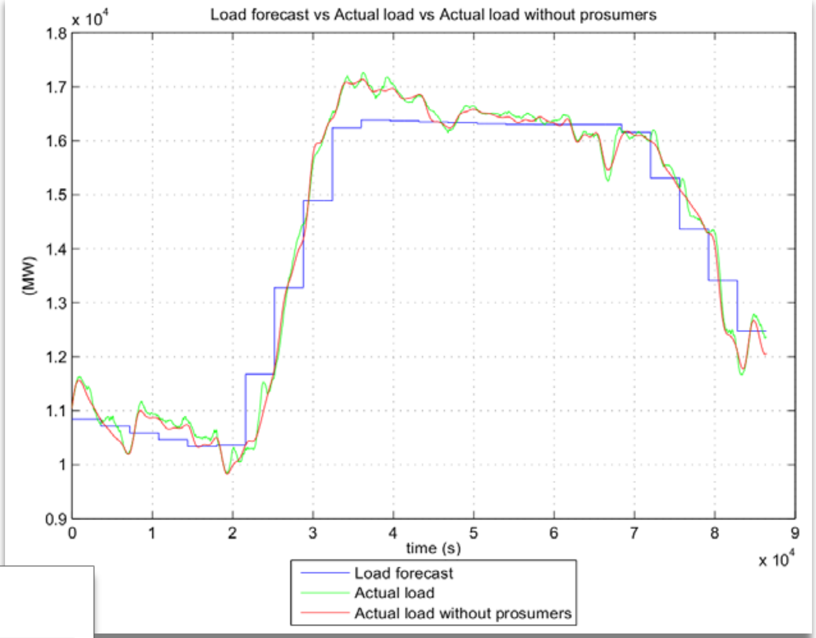
- Double sided market reduces control effort
- Causing imbalance is penalized more in double sided markets
- BRPs are more conservative, more reservations for AS

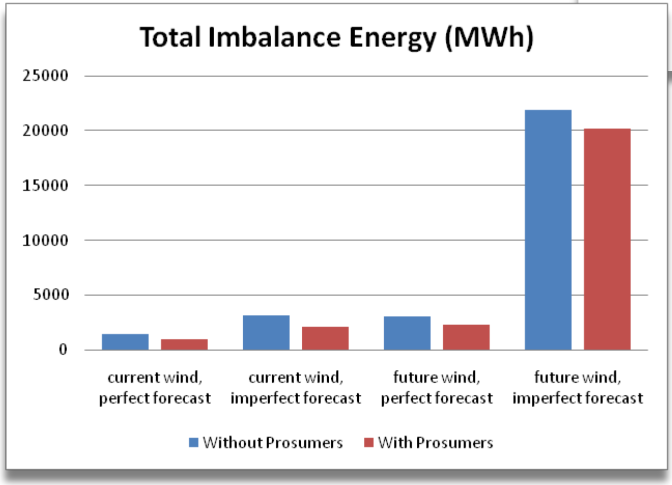




Observations - prosumers

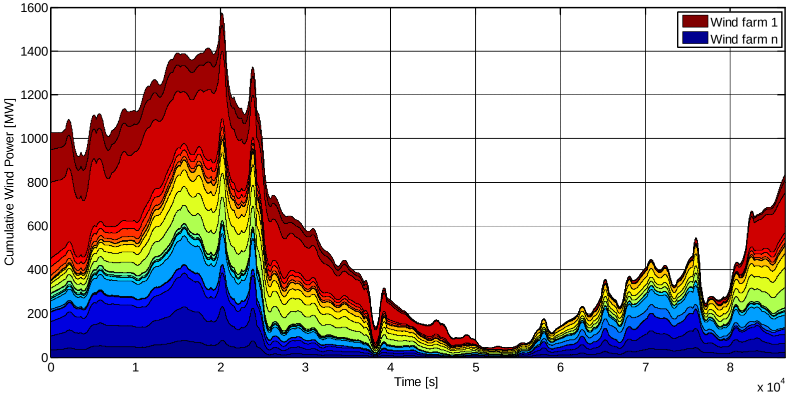
- Prosumers reduce imbalance energy
- Prosumers have no effect on primary response
- Prosumers lead to a faster frequency recovery after a trip





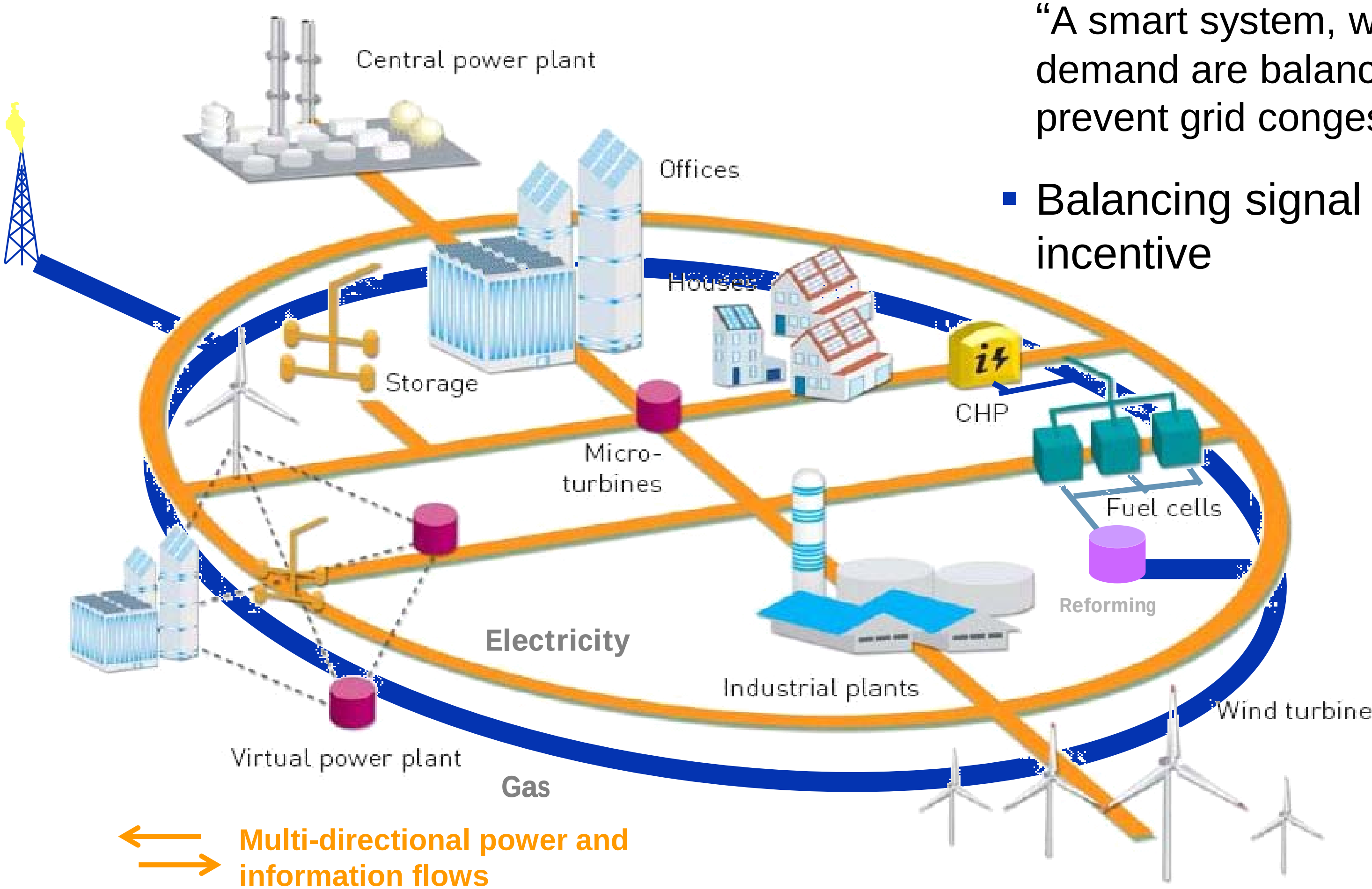
Other model applications

- Trip studies
- Testing of AGC algorithms, double sided market
- Testing of (real-time) dispatch algorithms
  - Improved dispatch with RES in portfolio
  - Over multiple program time units with improved flexibility
- Observing market behavior of market parties
- Determine the effects of energy storage and demand response



How does this enable smart grid extensions?

Tomorrow: Smart Grids



- Definition:

  "A smart system, where generation and demand are balanced on a local level to prevent grid congestion."

- Balancing signal is a local price incentive

What is a local price?

P_{local} = E-Price real-time price

$$P_{wholesale} + P_{balance}$$

$P_{wholesale}$ ↑ DA – intraday

$P_{balance}$ ↑ real-time

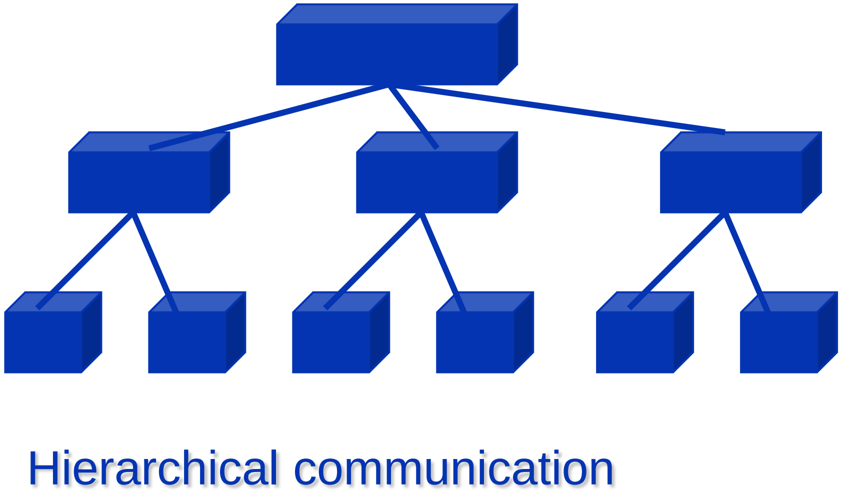
Purpose of Smart grid

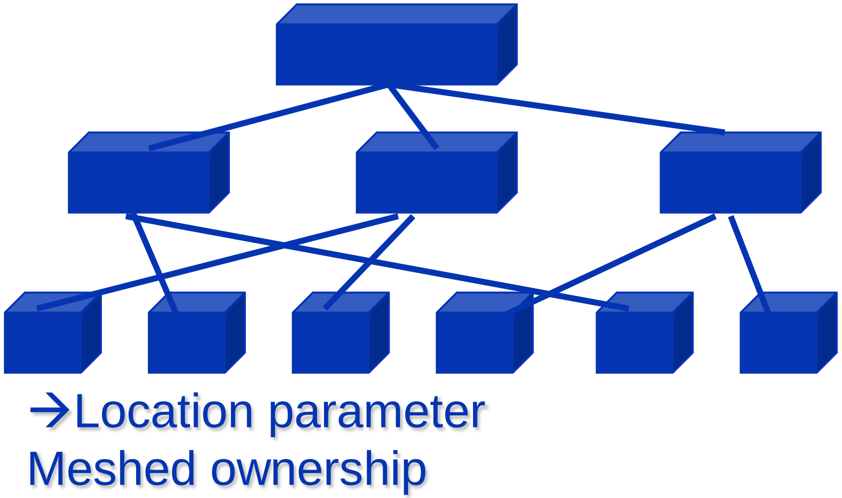
- Management of energy use
  - Shifting load based on availability of generation and grid and price
  - Automated with smart appliances, storage and through demand/load management software
- Allowing of micro trading
  - Sell own generation (PV, µCHP, small wind) and storage (EV, H_2, batteries) to anyone anywhere
  - Hire distribution capacity
- Lower operational cost and capex
  - Remote diagnosis, condition based maintenance, embedded systems, load management
- More market based balancing, less control effort

Challenges for smart grids

- Solved by E-Price::
  - Good relation between local power price and system price
  - Not only day-ahead wholesale price, but real-time price including balancing component

- Open problem:
  - Solve “hierarchy” problem – how to influence local power flows in a mixed grid topology?

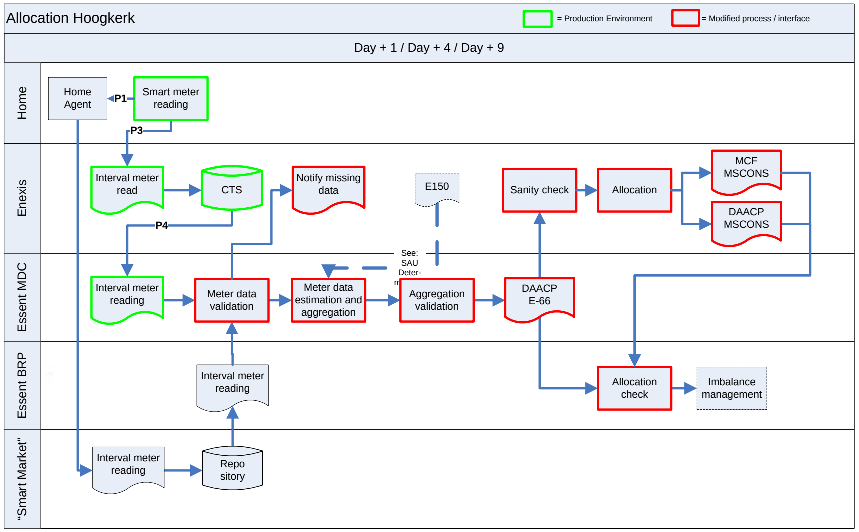


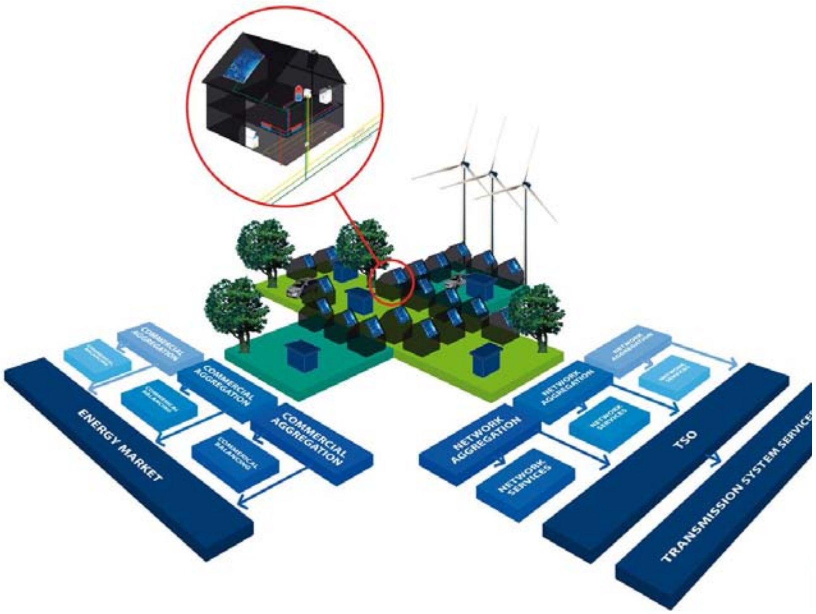


DNV KEMA references

Power Matching City: Smart Meter Allocation

Wholesale processes need to be modified in order to facilitate smart energy concepts such as virtual power plants, real time pricing and time of use contracts for small consumers / prosumers.





In cooperation with a Dutch energy supplier and distribution company

- Modified processes are designed, implemented and validated in a test environment
- Results are shared with the Dutch energy sector and government.

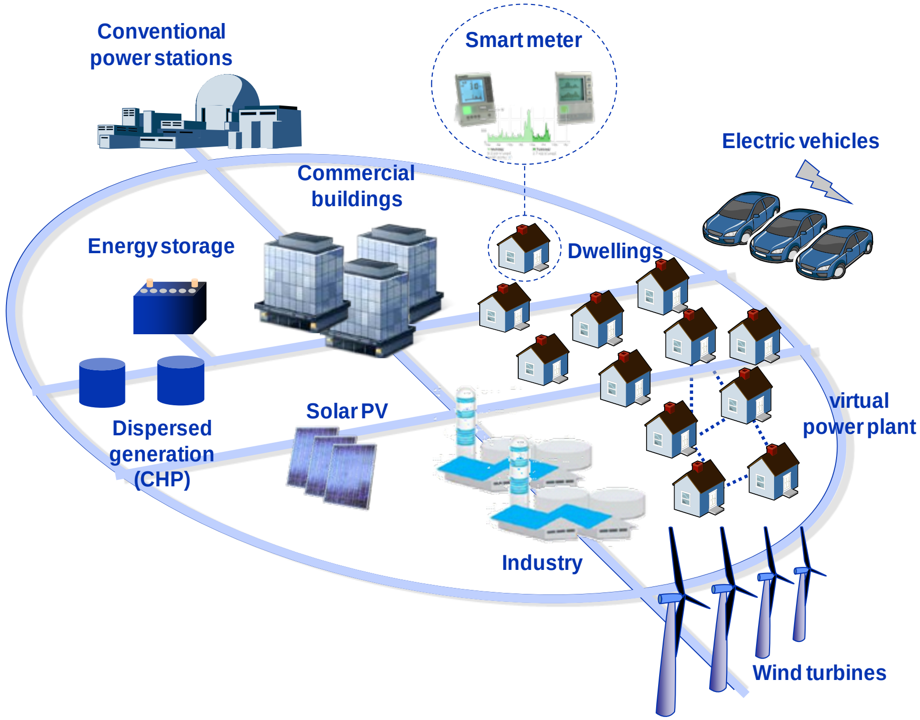
Smart Energy Collective

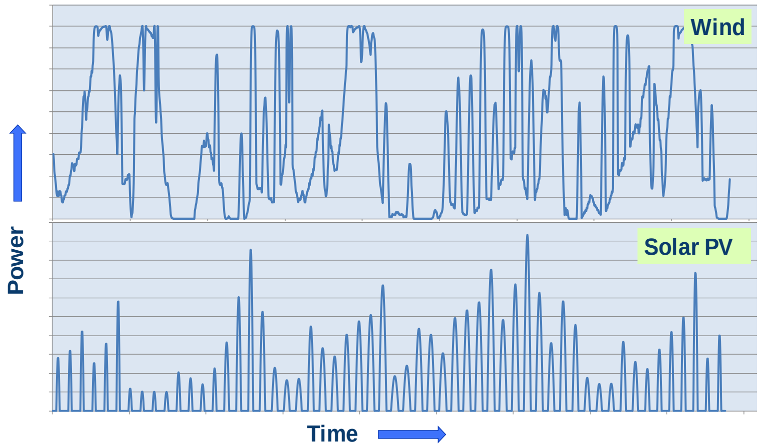
- The development and testing of a set of integrated, interoperable smart energy services with corresponding technologies and infrastructures.
- The set up of an open innovation platform with accompanying organization where these integrated, smart energy products and services can be developed, demonstrated, and tested on a large scale on different locations. Approx. 10 locations will be developed with a total of approx 5000 smart grid connections.
- The development of a common market for smart energy services with sufficient volume.
- Participating: DSOs, TSOs, Energy suppliers, ICT system integrators (Humiq, Logica, IBM, Sogeti), Project development (Heijmans), Financial sector (Rabobank), Installation company (Imtech, Unica), Technology provider (Philips, Nedap, ABB, Siemens, Heliox, Bosch), Product industry (Daalderop, Itron, Miele).

From study to fieldtest

DNV KEMA Smart Grid Cost Benefit Model

Integrated approach to evaluate (avoided) costs for transmission grids, distribution grids, central electricity generation and imbalance services.





- Based on actual load profiles
- Includes advanced technologies (micro-CHP, electric vehicles, heat pumps, etc.)
- Includes effects of electricity storage
- Multiple scenarios possible

Demonstrator: EU ADDRESS project

Retailers

Might act as aggregators of small customers

New contractual relationship

More information received from other market participants

New algorithms for optimising relationship

New business cases

Regulator/Stakeholders/ Manufacturers

Recommendations on new regulatory mechanisms

Solutions specifications

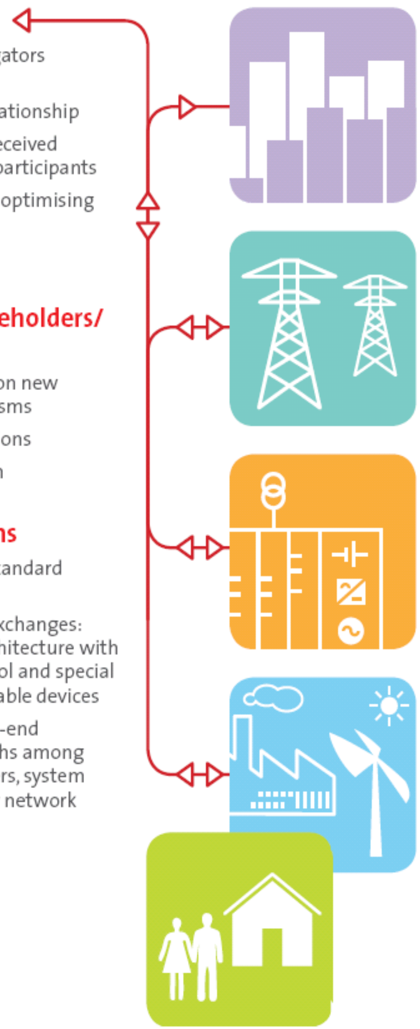
Customer education

Communications

Reliable, real time standard architecture

Definition of data exchanges: service oriented architecture with real time flow control and special interfaces to renewable devices

Definition of end-to-end communication paths among consumers, producers, system operators and other network participants



Markets

More information exchange

Real time price signals to all participants

New business cases

Transmission System Operators/ Balancing Responsible Parties

More information received from other market actors

New algorithms built on this new information

New business cases

Distribution System Operators

New devices for automation, control and protection

More information received from other participants

New algorithms in network devices considering this new information

New business cases

Customers/Producers/ Aggregators

New devices for control of appliances

Smart metering

Devices for interaction with DSO, markets, retailers and other aggregators

Real-time price and volume signals

More information received from other participants (price, collaboration signals)

New algorithms in devices for managing load, generation and storage

New business cases

Objectives:

- Enabling active demand
- Exploitation of benefits from active demand

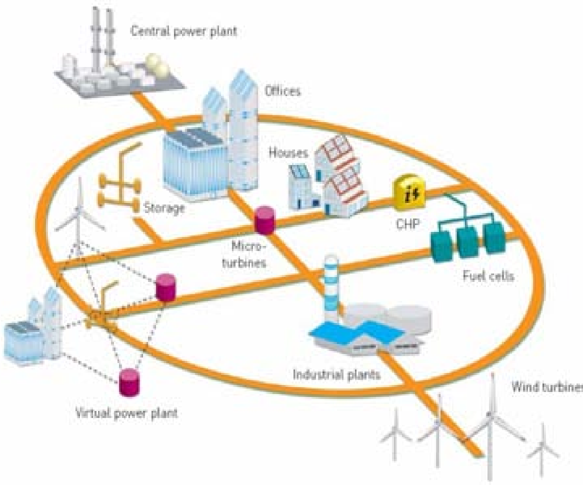
✓ Active customer participation

✓ Increased power system efficiency

✓ Integration of Renewable Energy Sources

GROW-DERS

- Demonstration of grid connected storage systems (Li-ion batteries, flywheels)
- Development of an assessment tool to determine optimal storage applications
- Determine where grid connected storage is most attractive
- Focus on distribution grid (LV)
- EU under 6th framework programme



Large-scale energy storage

- Artificial island in North Sea (The Netherlands)
- Store (wind powered) electricity when demand is low – e.g. at night – and make use of it during the day.

Our contribution

- Innovator
- Initiate project and set up partnership structure
- Feasibility study

www.dnvkema.com