Creating a flexible grid Marketplace

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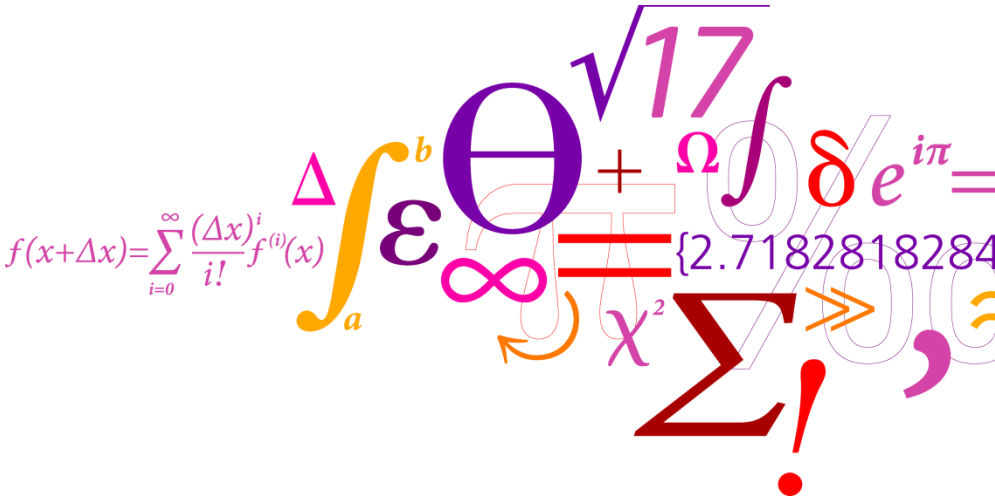
TwinPV workshop, University of Cyprus, 13-14 December 2016

With strong contribution from:
Lars Henrik Hansen, Dong Energy

Results mainly from iPower SPIR project



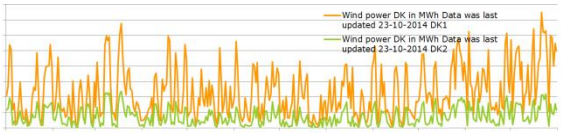
DTU Electrical Engineering
Department of Electrical Engineering

Outline

- Markets – Existing, integration of DER
- Market based services
- FLECH concept
- FLECH service specification
- FLECH service verification and settlement
- Contracts between FLECH – Aggregator – DER (customer)
- FLECH prototype status
- New markets – EcoGrid 2.0

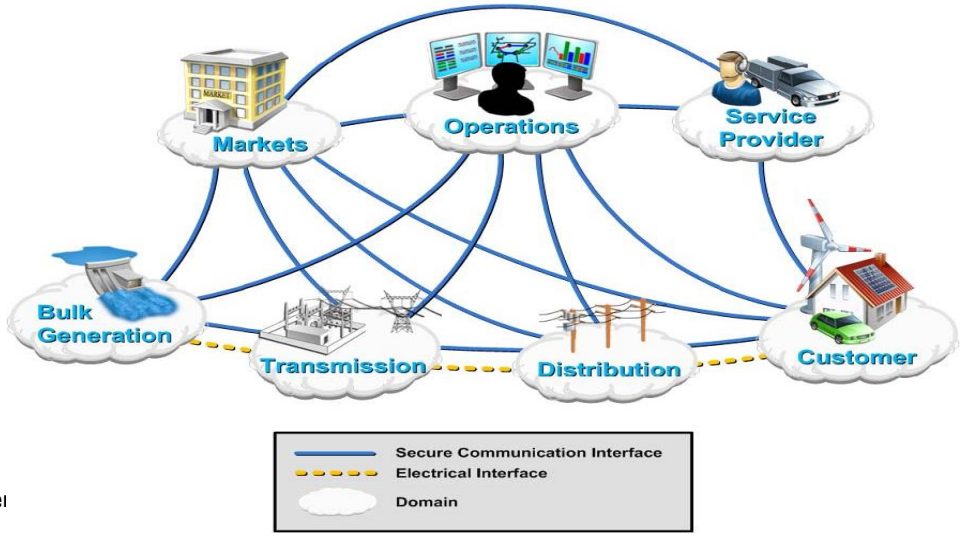
System challenges and potential solutions I

- The power system has to be safe, reliable and balanced at all time instances
- The fraction of renewable energy will increase as we are moving towards a fossil free system
  - Wind and solar power has inherent fluctuations and limited predictability



- There will be a substitution of fossil fuels for electricity
  - Increased consumption and changed consumption pattern

- Operation of the power system will increasingly be market based
  - This means a separation and clarification of responsibilities and a requirement for more formal interaction between the involved parties



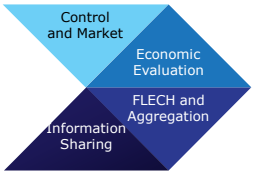
System challenges and potential solutions II

- Significant fractions of the electricity consumption are associated with some form of intrinsic storage
  - Hot water in the district heating system
  - The heat capacity of buildings, commercial as well as domestic
  - Goods in cold stores
  - Batteries in Electric Vehicles and stationary batteries
- By controlling the electricity consumption the energy storage can provide some of the required flexibility to shape the instantaneous power consumption to the instantaneous power generation
- Power consumption can therefore absorb some of the fluctuations from renewable energy and therefore contribute to enable a power system based on renewable energy


iPower - Partners

26 partners, budget 16 MEUR
Project period: 2011 - 2016

What is iPower



Domestic Demand Response

Consumer Behaviour

Industrial Demand Response

Distribution Grid Operation

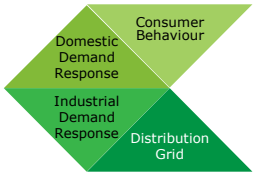
What is iPower

Control and Market Operation

Socio-economic and Investor Evaluation

FLECH and Aggregation

Information Sharing



Market based services
Starting point

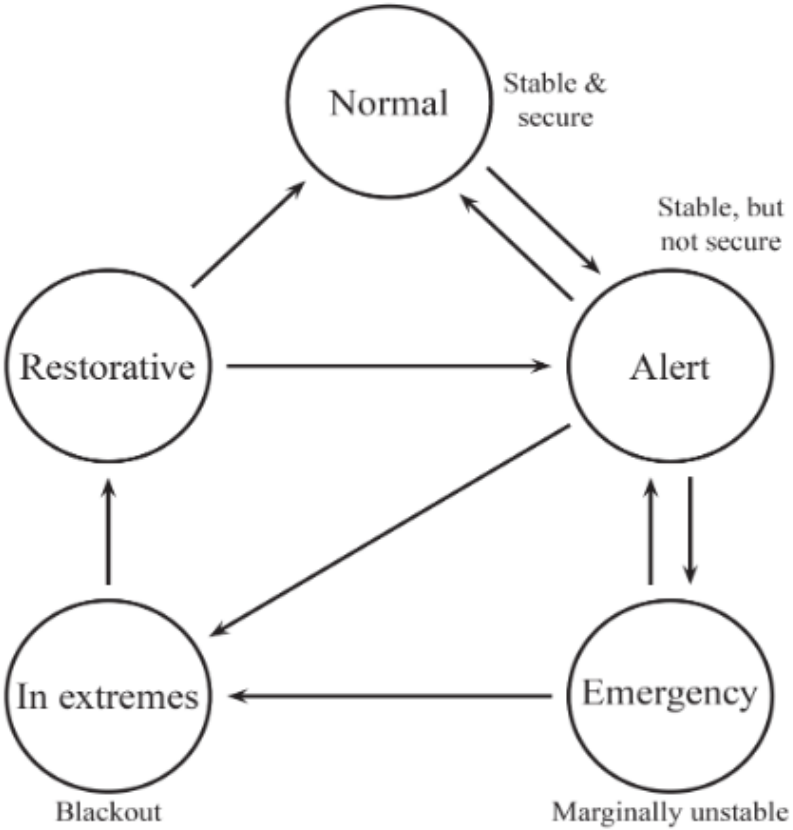
Drivers:

- Increased power consumption due to electrification.
  - Heat pumps, EVs, battery charging stations, …
- Increased share of distributed generation.
  - PV, micro wind, µCHP, …
- Demand participation in energy balancing services (demand response) can create peaks.
- Etc.

- iPower boundary condition:
  - to develop and utilize flexible consumption and production solutions which:
    - offer new possibilities for optimal handling of distribution grids.
    - are based on market solutions ensuring an efficient energy system.

Market based services
System priorities

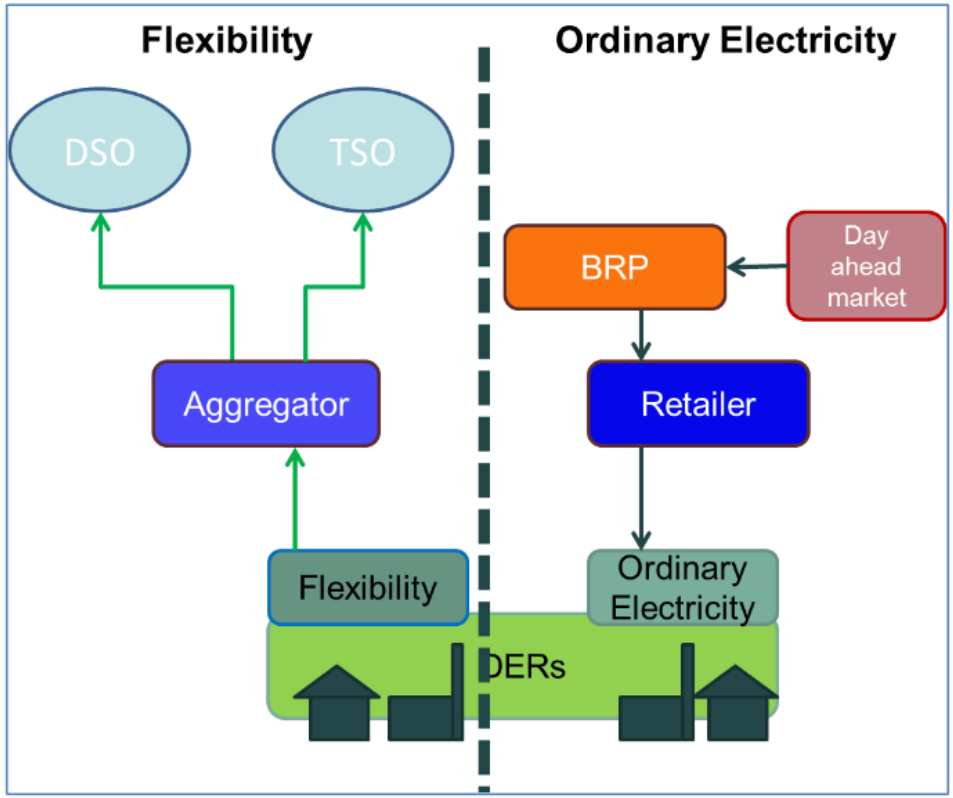
- Power system operating states and state transitions



- General priority of services:
  1. Emergency situations
  2. Local constraints/requeirements
  3. Global constraints/requeirements
  4. Planning and financial aspects
- Prioritised needs:
  1. Emergency actions (TSO)
  2. Alert actions (TSO/DSO)
  3. Local voltage control (DSO)
  4. Peak-shaving (DSO)
  5. Voltage support (TSO)
  6. Mvar bands (DSO)
  7. Frequency control (TSO)
  8. Other ancillary services (TSO)
  9. Imbalance issues (BRP)
  10. Power quality (DSO)

Market based services Design philosophy

- Target diverse new services, commercial, but coordinated from system point of view with priority ordering:
  - TSO service may disturb DSO operation, therefore priority for DSO
  - DSO services need to be oriented on DSO planning process (not energy market)
  - Avoid situations of market power; don't be more expensive than business as usual
- Enable potentially for disruptive technology:
  - Energy constrained units (all demand response)
  - Aggregator business models
- Conclusion:
  - New market player setup for trading flexibility services



DSO – Distribution System Operator
TSO – Transmission System Operator
BRP – Balance Responsible Party
DER – Distributed Energy Resources

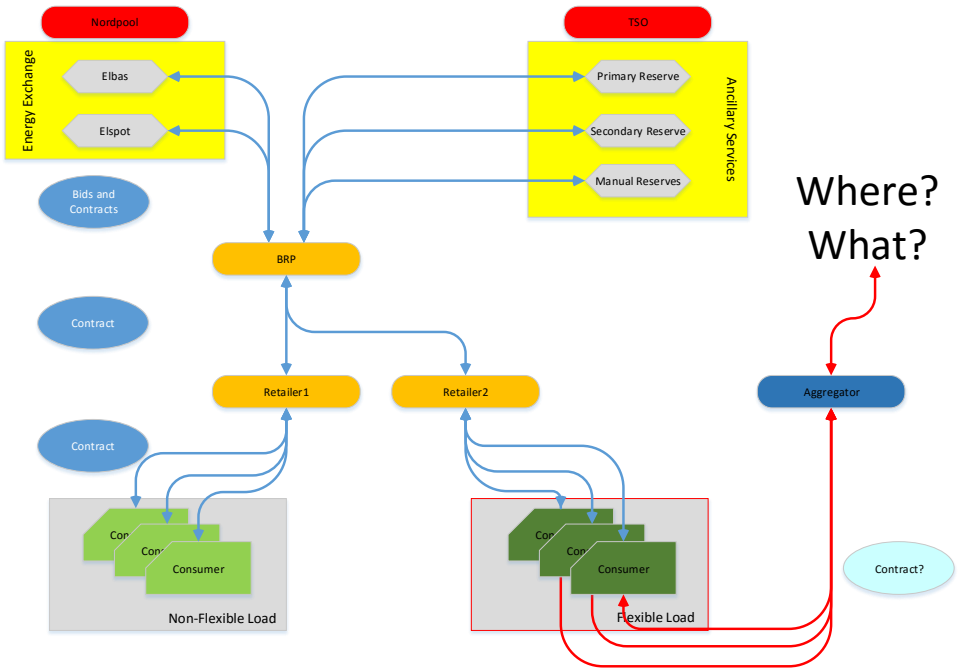
Stakeholders and roles

- Transmission System Operators **TSOs** have the responsibility of maintaining transmission system operation and a need for balancing the system
- Distribution System Opreators **DSOs** have the responsibility to serve the customers and for secure and reliable operation of the distribution system

- Balance Responsible Parties **BRPs** have an incentive to meet the forecasted consumption/generation

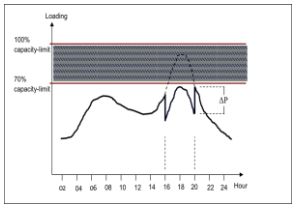
- Distributed Energy Resources **DERs** owned by end users can provide flexibility, but it has to be organised to overcome
  - Many small contributions that have to be coordinated
  - Investment costs for making units controllable
  - Transaction costs
  - Available flexibility

- Aggregators **AGGR** can coordinate DER
  - They can be the agents on the markets for flexibility

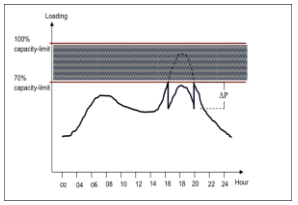


Use cases (I)

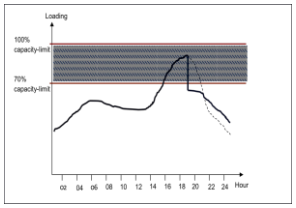
- 7 standard DSO services (iPower project)
- Proof-of-concept (DSO, aggregator, DER units)



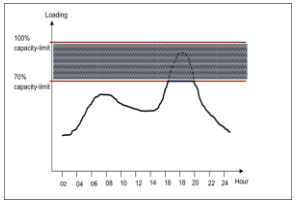
PowerCut planned



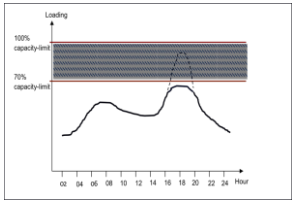
PowerCut urgent



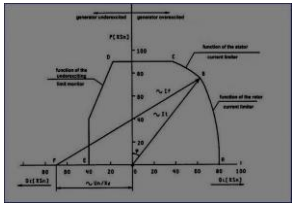
PowerReserve



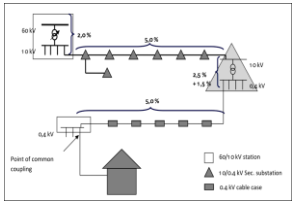
PowerCap



PowerMax



VoltageSupport



VArSupport

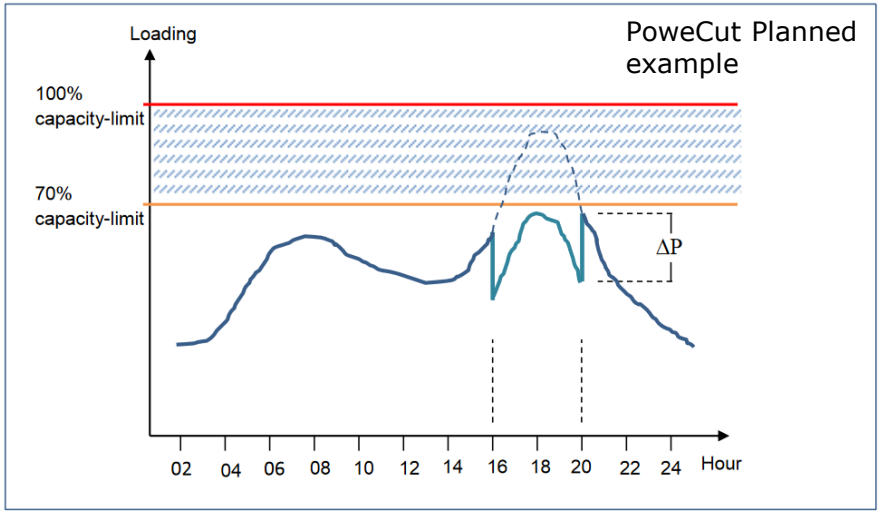
Market based services
Product specifications

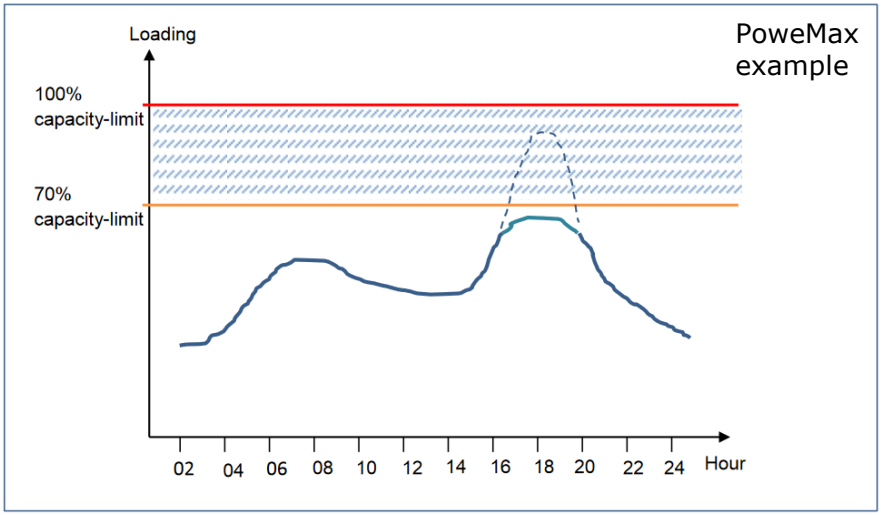
- "bottom-up market development" :
  - Needs driven, competitive
  - Low trade volume (at start)

- Targeted DSO services:
  - PowerCut Planned (load management)
  - PowerCut Urgent
  - Power Reserve
  - PowerCap
  - PowerMax
  - VoltageSupport (voltage management)
  - VArSupport

- TSO service:
  - Fast Frequency Reserve

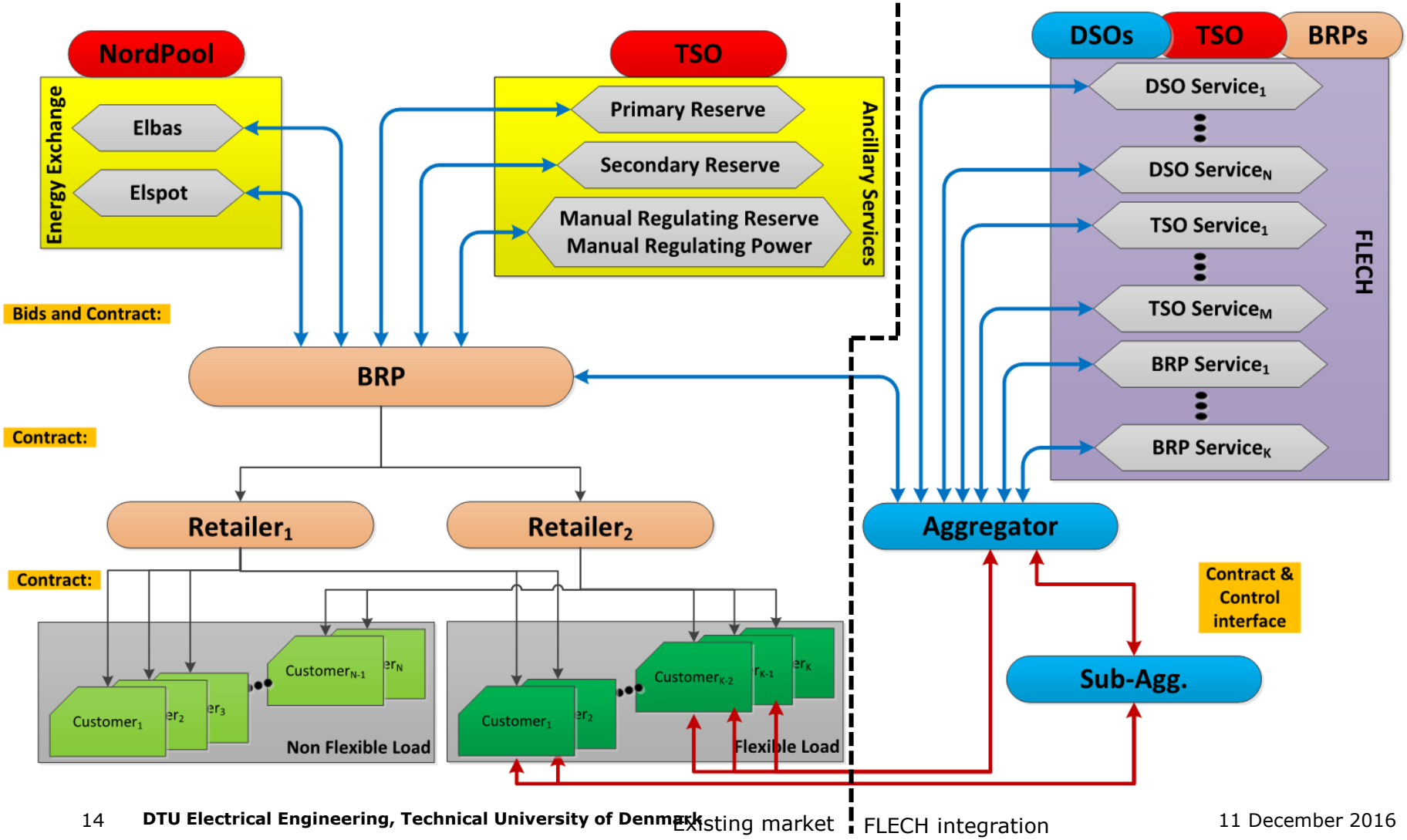
- BPR service:
  - Portfolio Balancing



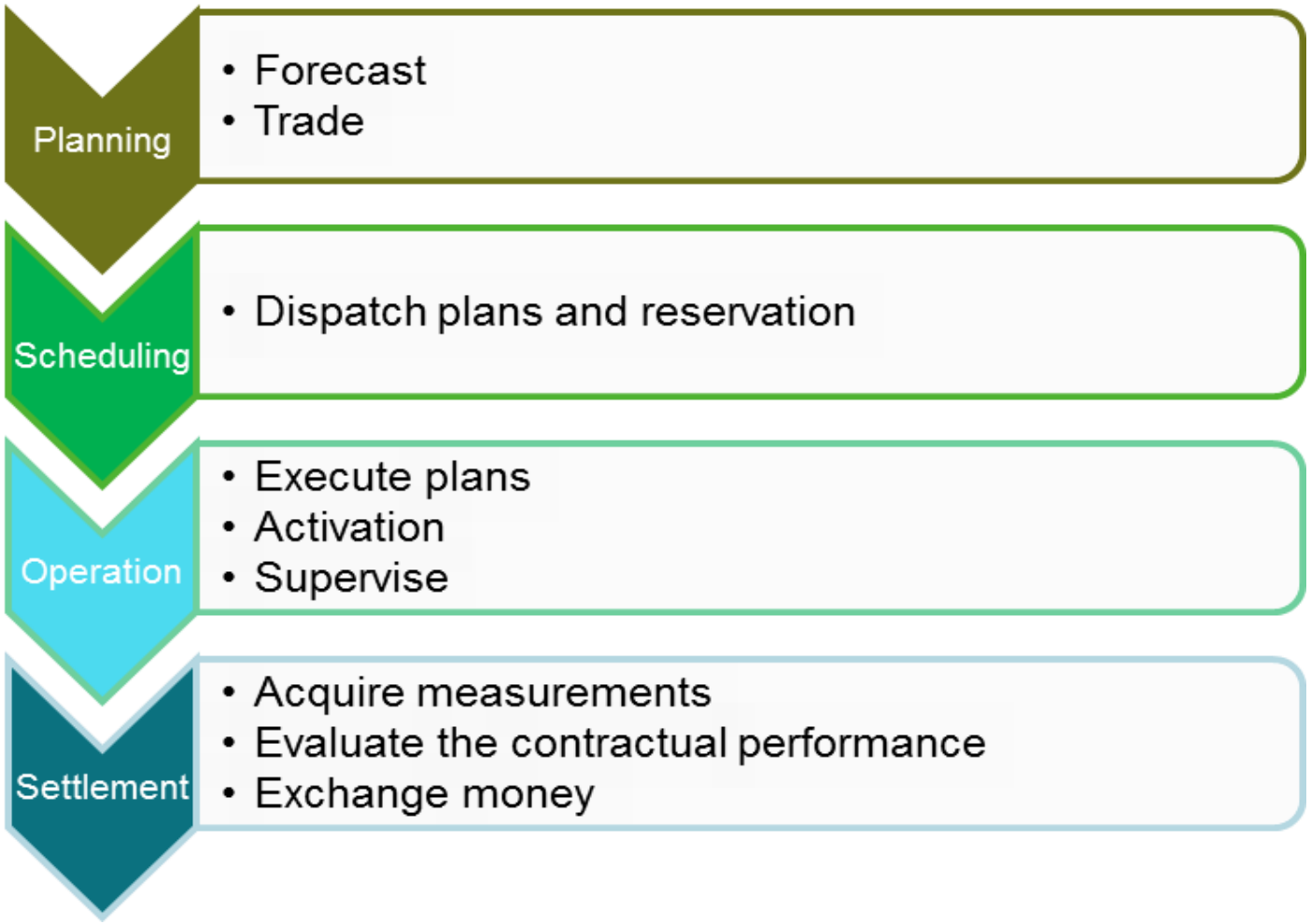


FLECH concept

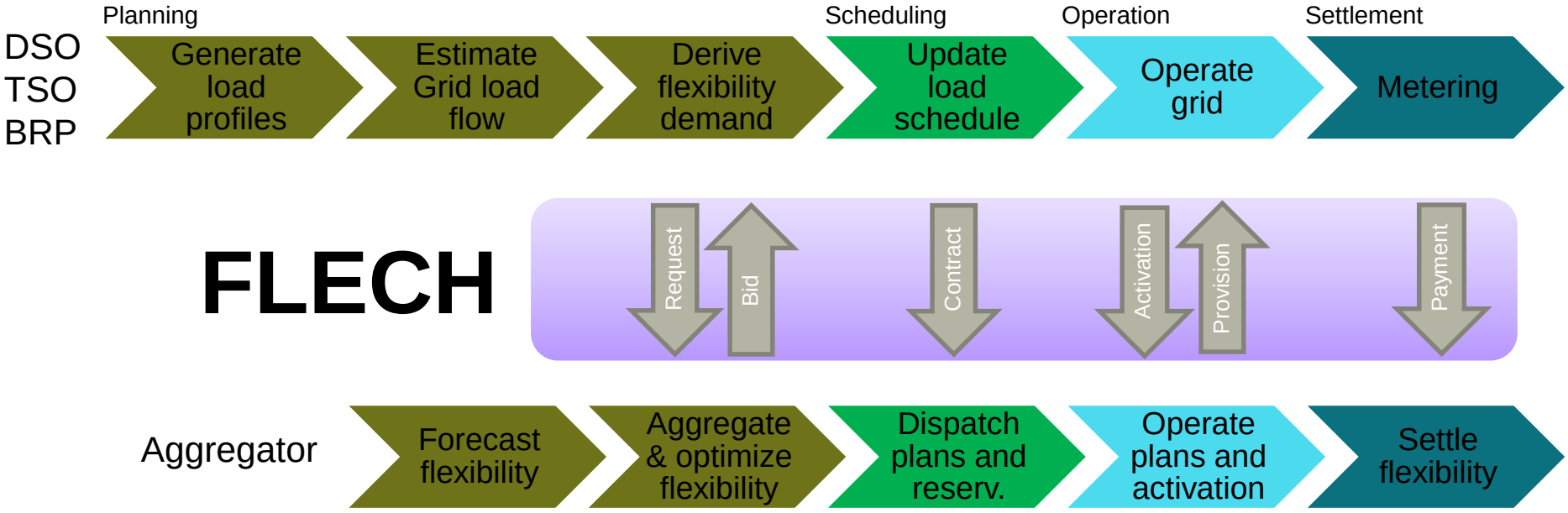
FLECH in existing market setup (consumption)



FLECH concept
Traditional decomposition



FLECH concept
Interaction between DSO,TSO or BRP and Aggregator

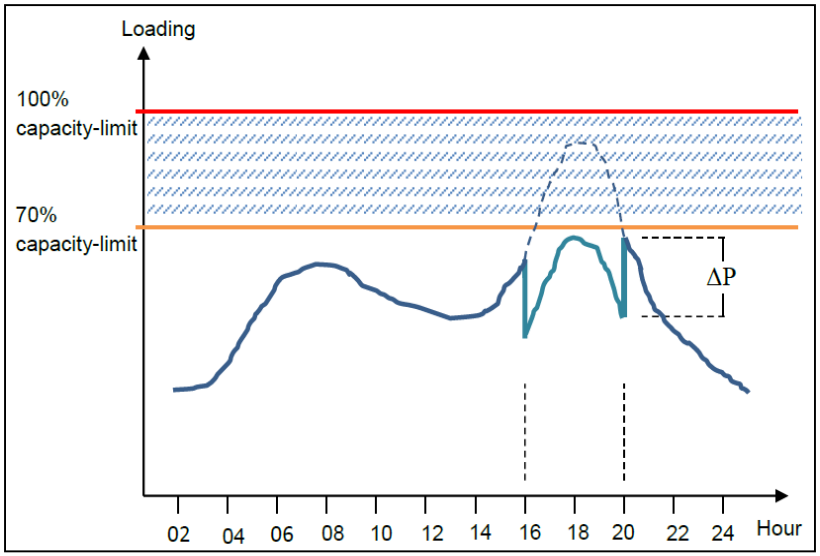


FLECH service Specification

DSO service example: PowerCut Planned (PCP)

PowerCut Planned:

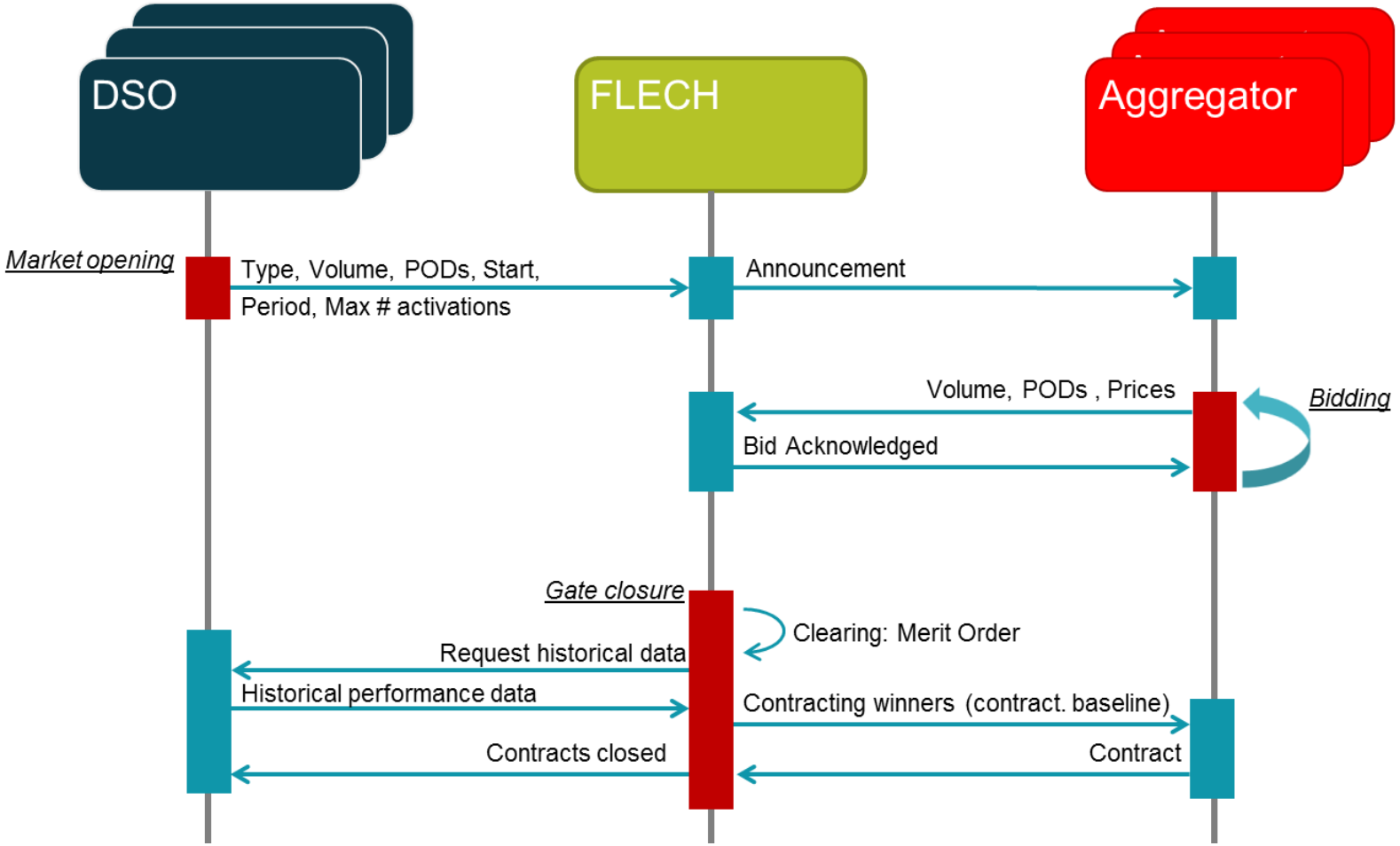
- Trading of this service comes naturally in two steps:
  - A long-term reservation of capacity to ensure sufficient flexibility.
  - A short-term activation scheme.



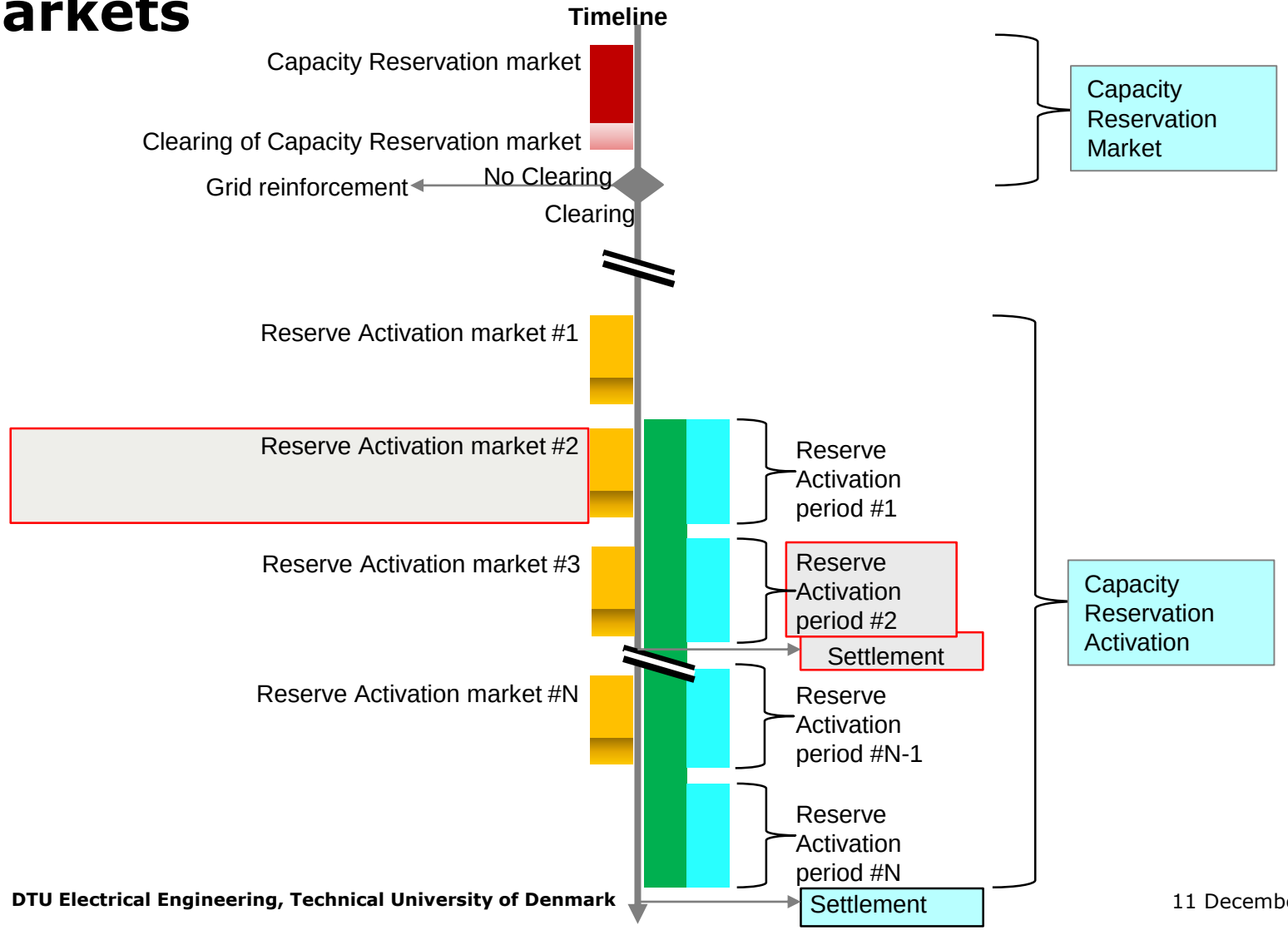
First DSO service:

- A **Capacity Reservation market** – where the DSO requested flexibility is reserved, and
- An **Reserve Activation market** – where the activation part is handled.

FLECH service acquisition
Example: Capacity Reservation market (PCP)

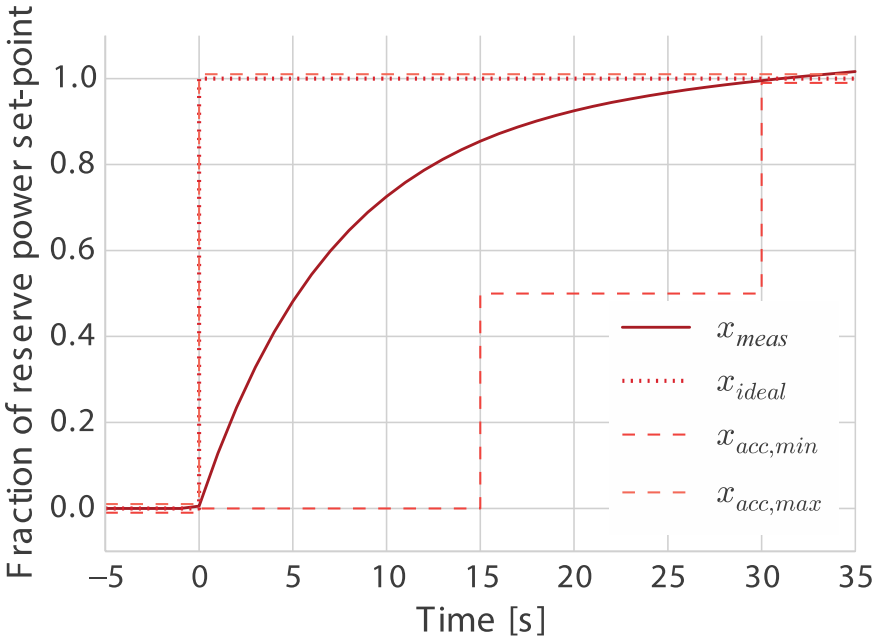


FLECH service verification and settlement Example: Timeline of the PowerCut Planned markets

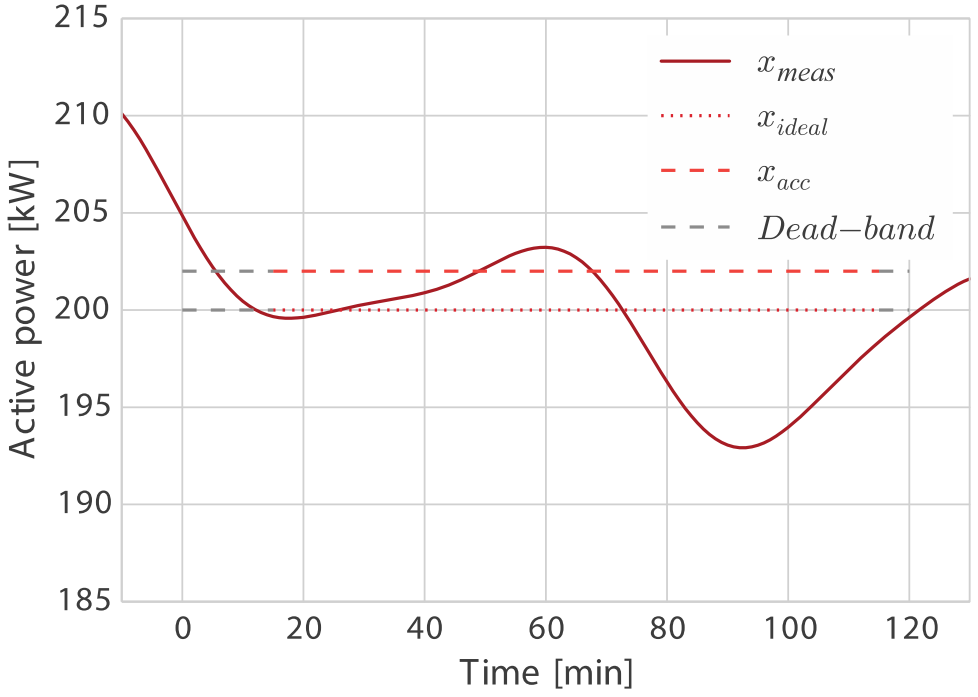


FLECH service verification and settlement

How do we know the service was delivered?



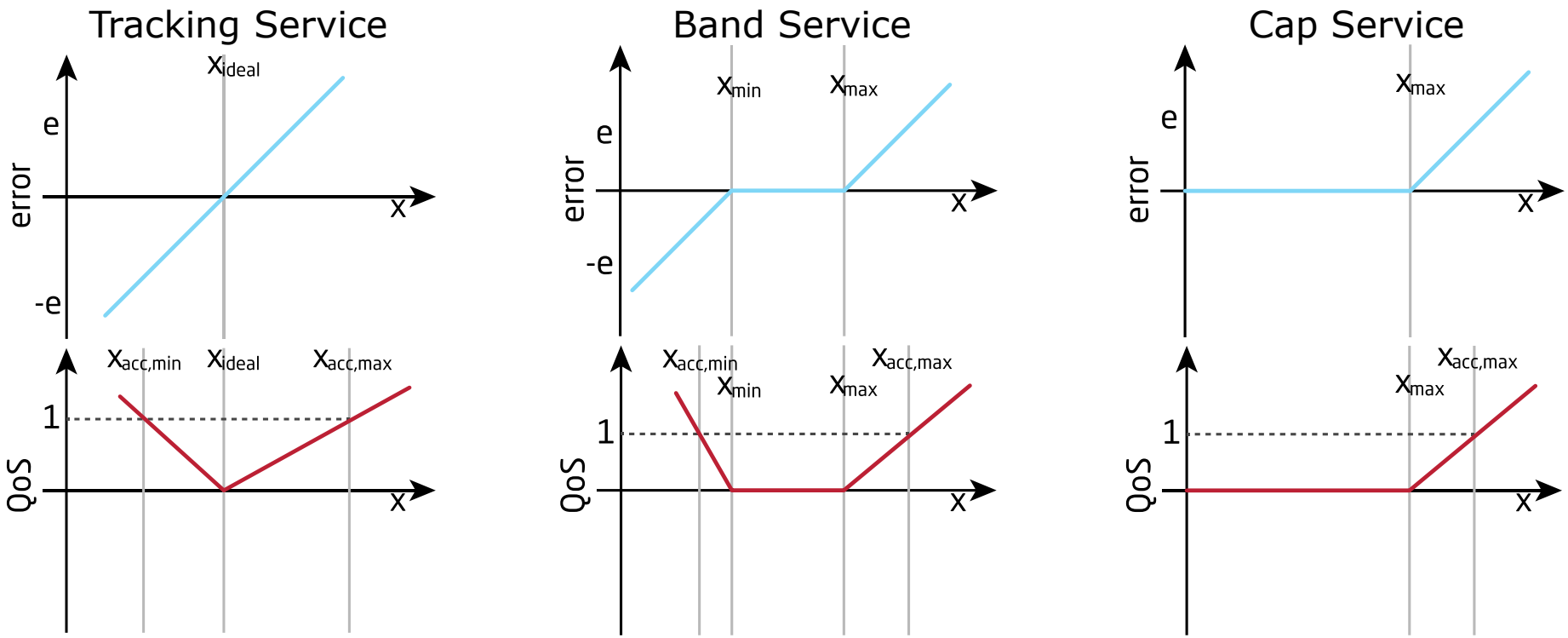
Primary Frequency Response



PowerMax DSO service

FLECH service verification and settlement

- Generic Service Models are needed for Verification and Settlement:



Source: Bondy, Thavlov, Bundsgaard, Heussen. "Performance Requirements Modeling and Assessment for Ancillary Services in view of Demand Response." submitted to: Transactions on Smart Grids

FLECH service verification and settlement

- Mapping of models and services

Generic Service Model	Service Example
Tracking Service	Primary and Secondary Frequency Control
Band Service	Electric Vehicle Fleet Operator
Cap Service	PowerCut PowerCap PowerMax

FLECH service verification and settlement

- Currently verification is done on an "on/off" basis:

  Remuneration = delivery(yes/no) * clearing price.

- Performance based remuneration will give incentive to good quality of service provision:

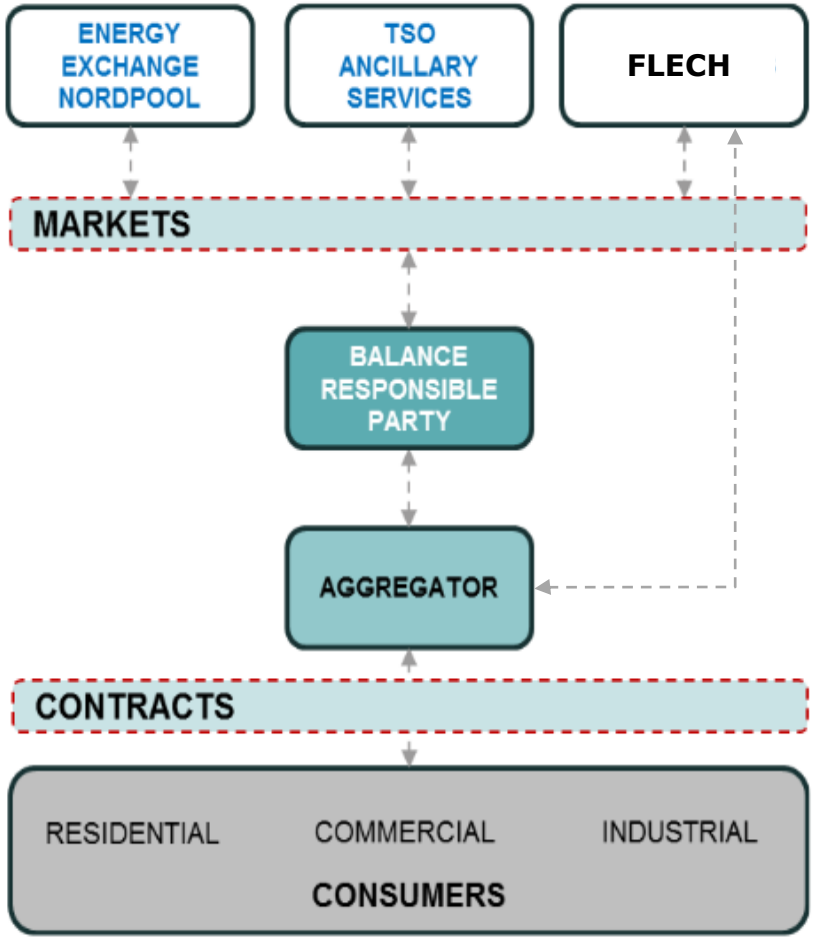
  Remuneration = performance * clearing price.

- Direct and statistical verification procedures must be investigated.

- Metering requirements must be adjusted.

FLECH – Aggregator – DER (Customer) Contractual targets/requirements

- Consumers (Residentials):
  - Primarily concern is access to reliable and affordable supply of electricity.
- Consumers (Industrial):
  - Primarily concern is access to reliable and cost efficient electricity.
- Aggregators:
  - Competitiveness by holding a portfolio of high capacity, low marginal cost resources and applying a strategic operational plan that optimizes the market value.
- FLECH:
  - Standardised services with low transaction costs.



FLECH – Aggregator – DER (Customer) Contract and types

- Specification and enforcement of mutual commitments as agreed upon between the contracting parties require a clear contractual framework as documentation and evidence of the practical circumstances, responsibilities and liability.
- A flexibility contract concerns determination of the scope of services, a compensating mechanism and a range of other conditions regarding trigger events, advanced notification, frequency and duration of activation.
- A contract must provide sufficient incentive for both parties' participation to be in accordance with the contracted conditions while maintaining individual rationality.

Contract types

- Moral, Hazard:
  - The consumer cannot perfectly observe and verify the actions of the aggregator.
- Adverse,Selection, I:
  - The aggregator is far superior to the consumer in terms of access to and understanding of information that affects the potential value of the flexibility contracts.
- Averse, Selection, II:
  - The aggregator's derived value from a contract depends on the scale, certainty, and operational agility of the contracted capacities and the consumer may have incentive to obstruct the delivery of the agreed flexibility.

FLECH prototype status

	Developed	Implemented
• Targeted DSO services:		
– PowerCut Planned	√	√
– PowerCap	√	-
– PowerMax	√	√
• TSO service:		
– Fast Frequency Reserve	√	(√)
• BPR service:		
– Portfolio Balancing	√	√

- Demonstrations:
  - PowerCut Planned
  - PowerMax
  - Fast Frequency Reserve & Portfolio Balancing
  - Voltage control

✓ April 2014 at IBM Lyngby.

✓ November 2014 at DTU Risø.

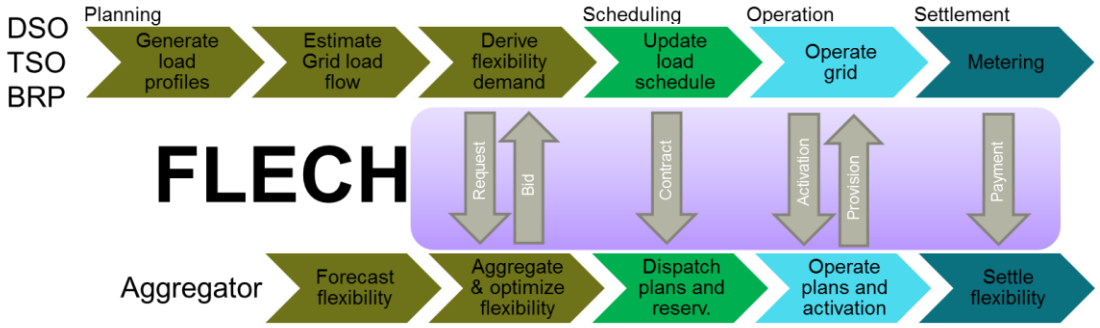
✓ November 2015 at Dansk Energi.

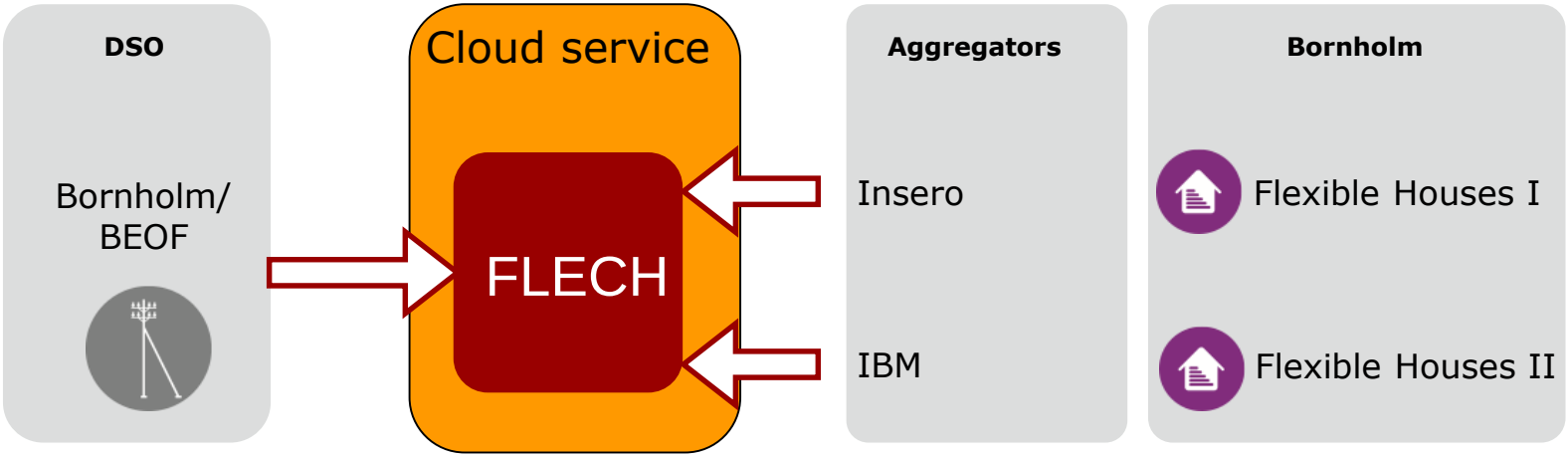
✓ May 2016 at DTU Risø

- Future application in the EcoGrid 2.0 project.

FLECH Demo Setup in EcoGrid 2.0 @ Bornholm

- New Market setup
- Collaboration between ICT developer (IBM), Aggregators (Insero+IBM) and University (DTU)





Conclusion

- Unbundled electricity sector points at DSO level markets
- For markets to exist it is necessary to specify the products that will be traded
  - With DERs delivering the services it is an added complexity
- iPower project was a research and innovation project with participation of universities and large industry and SMEs
- FLECH was developed as a solution for a standardized exchange between power system actors for requesting and delivering predefined services
- It was demonstrated as part of the project and is now being further developed with a new market setup.

Questions

Thank you

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