Integration and control of distributed units in the future energy system

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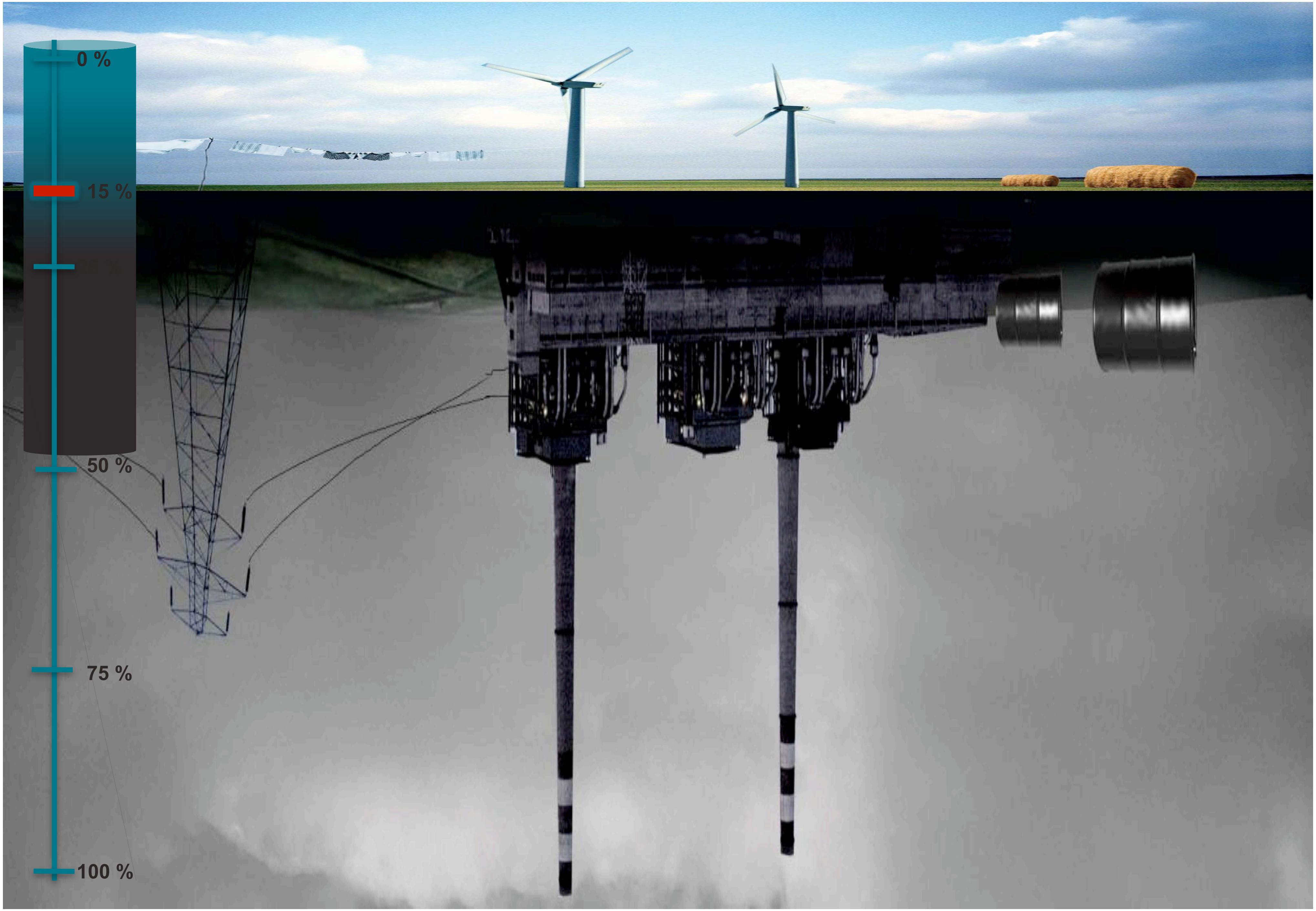

0 %
15 %
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We are not even close to the limit of wind power in Denmark
- intelligent integration of flexibility is one of the keys
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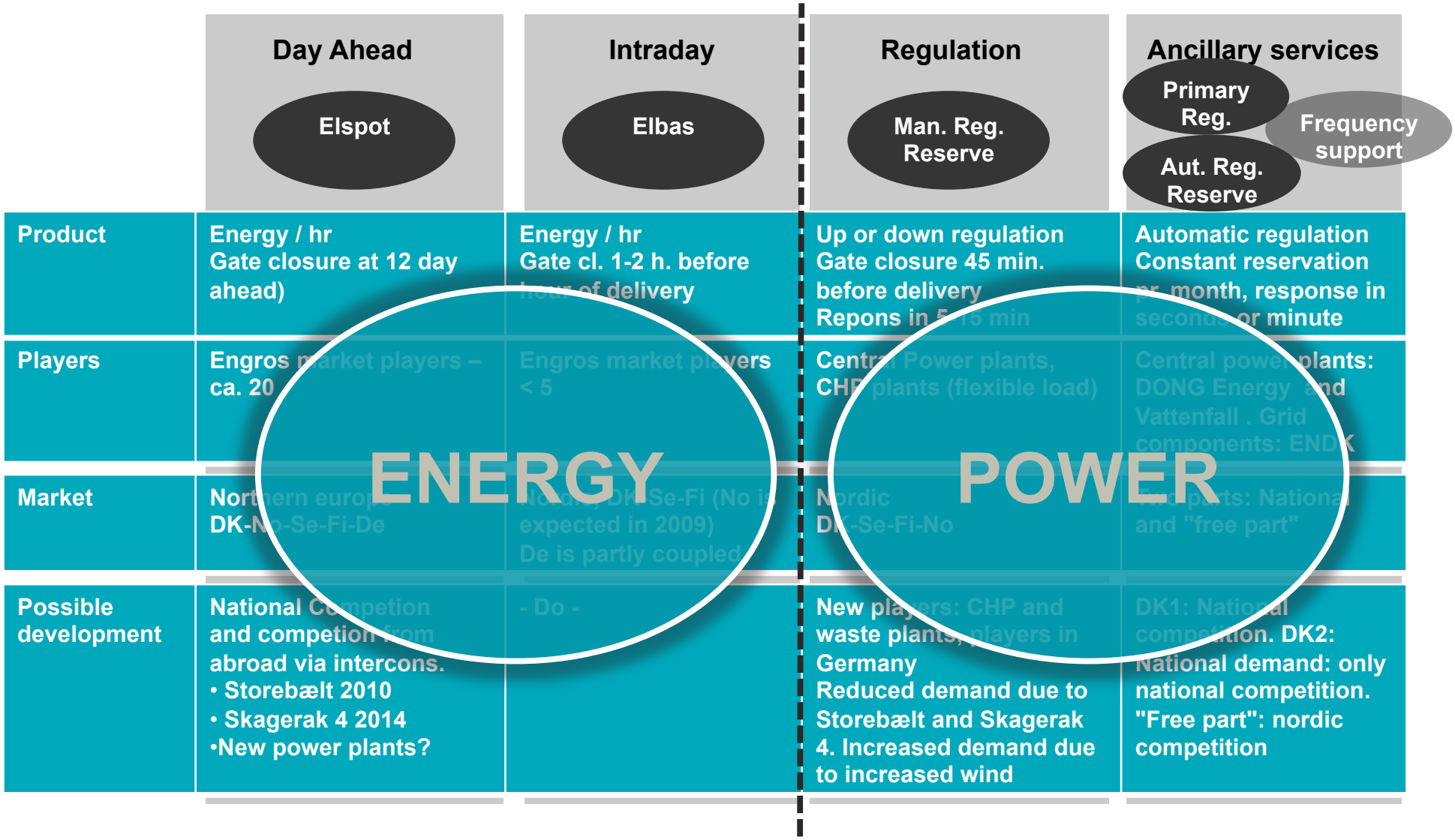
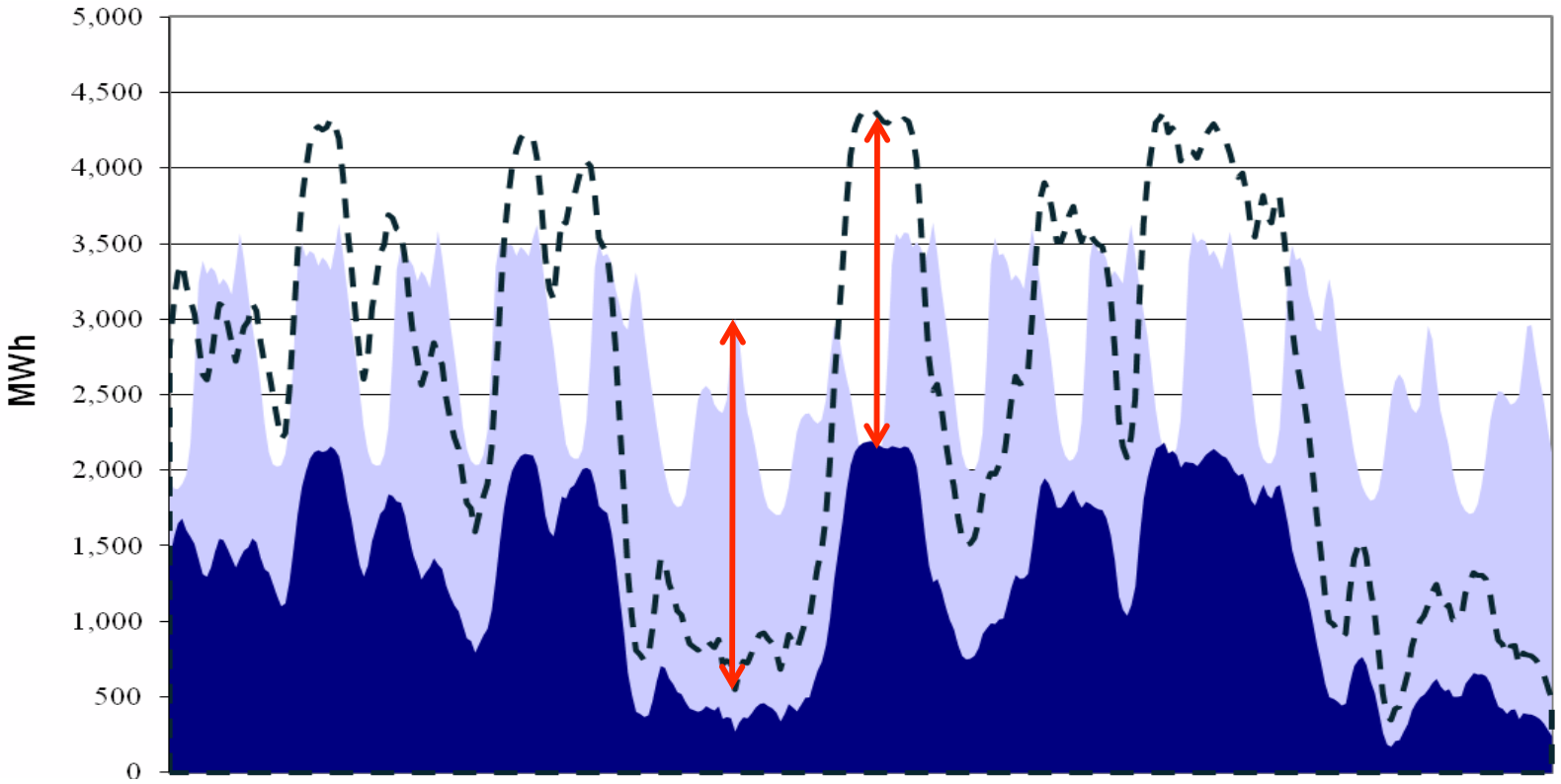
Power markets



The energy balance - challenges

Consumption and wind energy production in West Denmark during 2 weeks



Source: Energinet.dk,from 4-17 December 2006

Wind production Consumption

- - - Double wind production capacity

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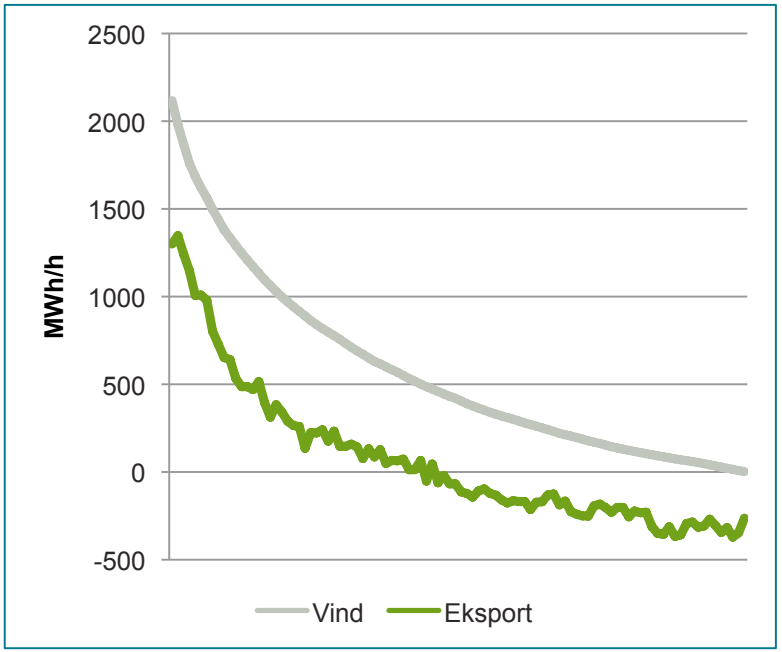
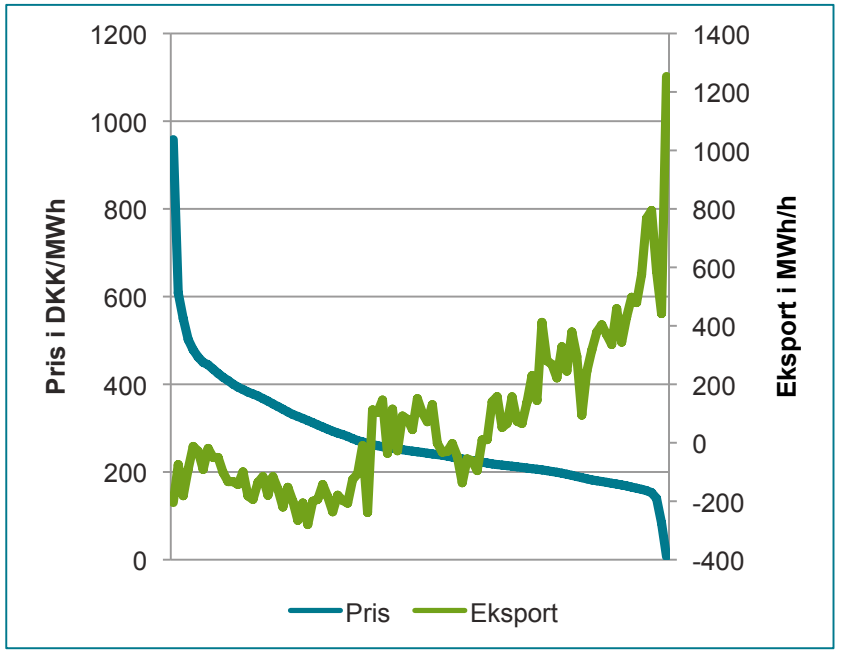
Balancing energy:
Correlation between production, export and prices – DK1

- High wind production → High export and low prices (see figures)
- Increased wind power capacity will increase "zero-price" periods





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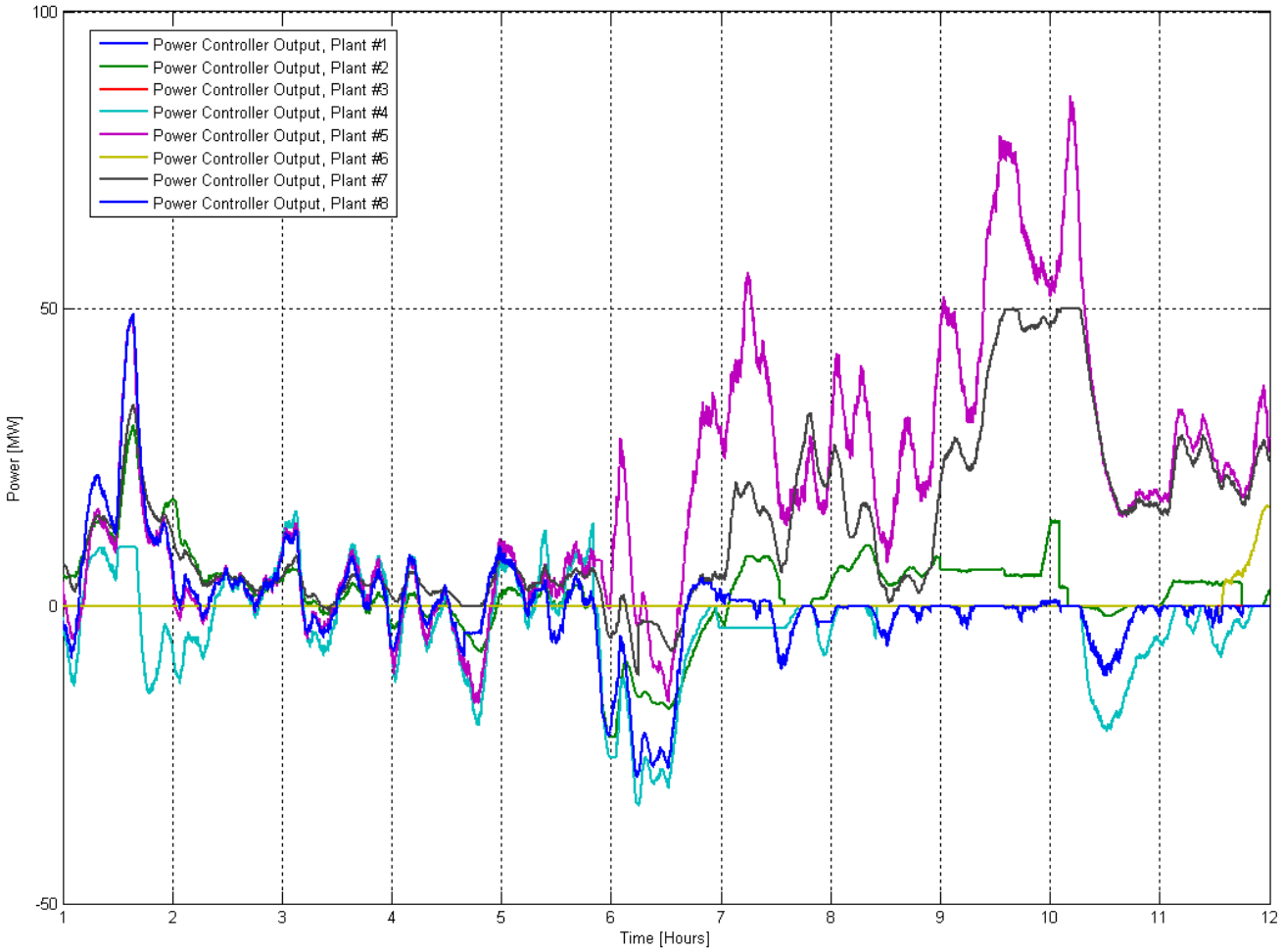
The power balance - challenges



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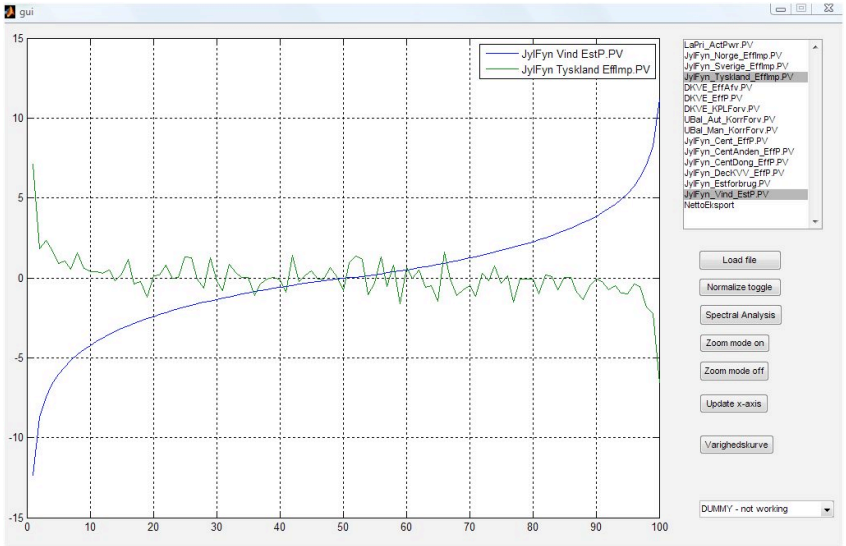
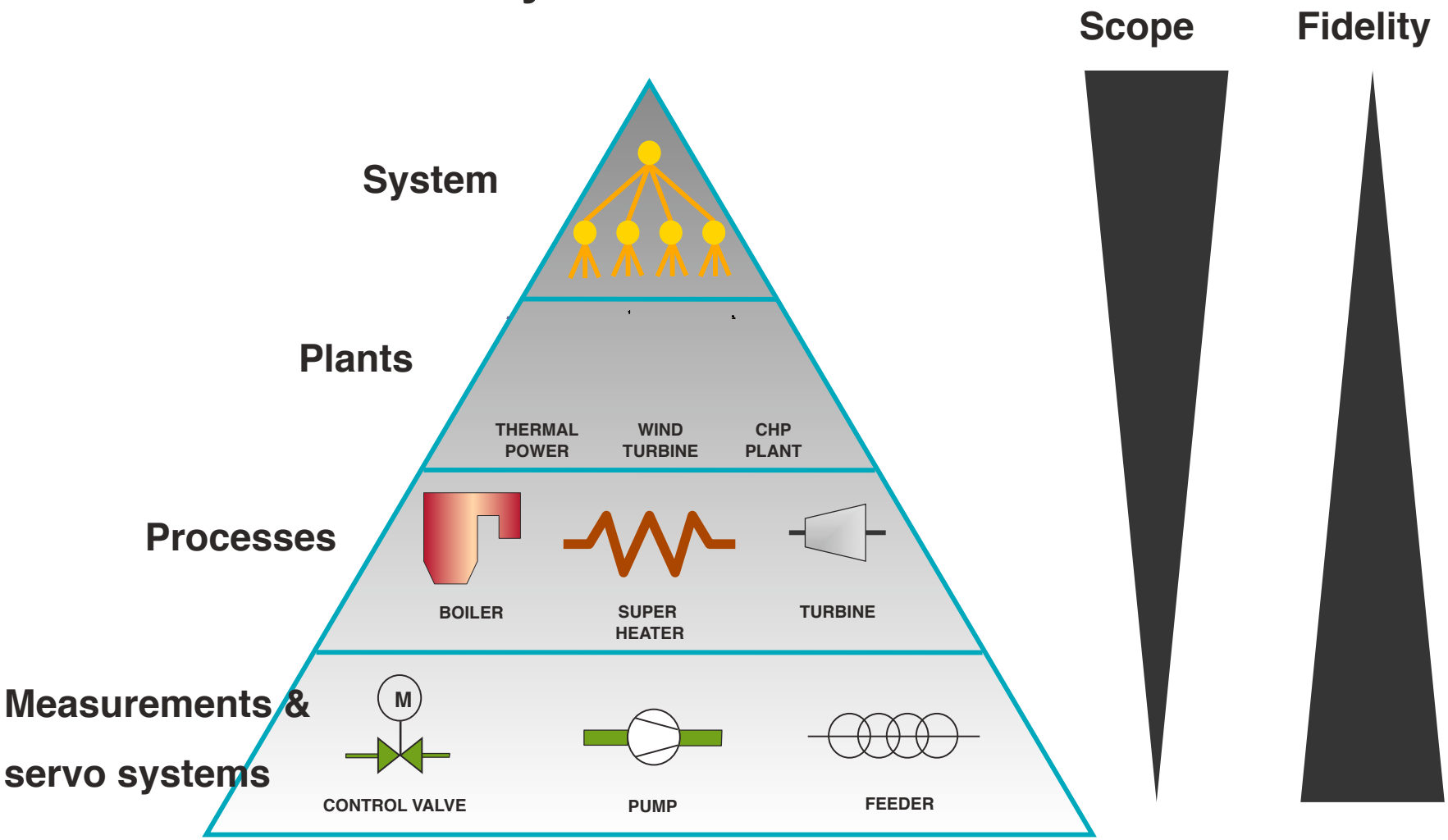
Power balance - trends

- Behovet for balancering på helt korte tidsakser (= primærregulering) er uafhængig af vindproduktionen
- Behovet for balancering af effekt på lidt længere sigt/minutter (= automatiske og manuelle reserever) er direkte påvirket af vindproduktionen
- Vindgradienter (specielt høje) eksporteres i nogen grad
- Høje vindgradienter giver aktivitet på termiske anlæg
- Høje gradienter på termiske anlæg forekommer ifb. med timeskift



Production hieracy



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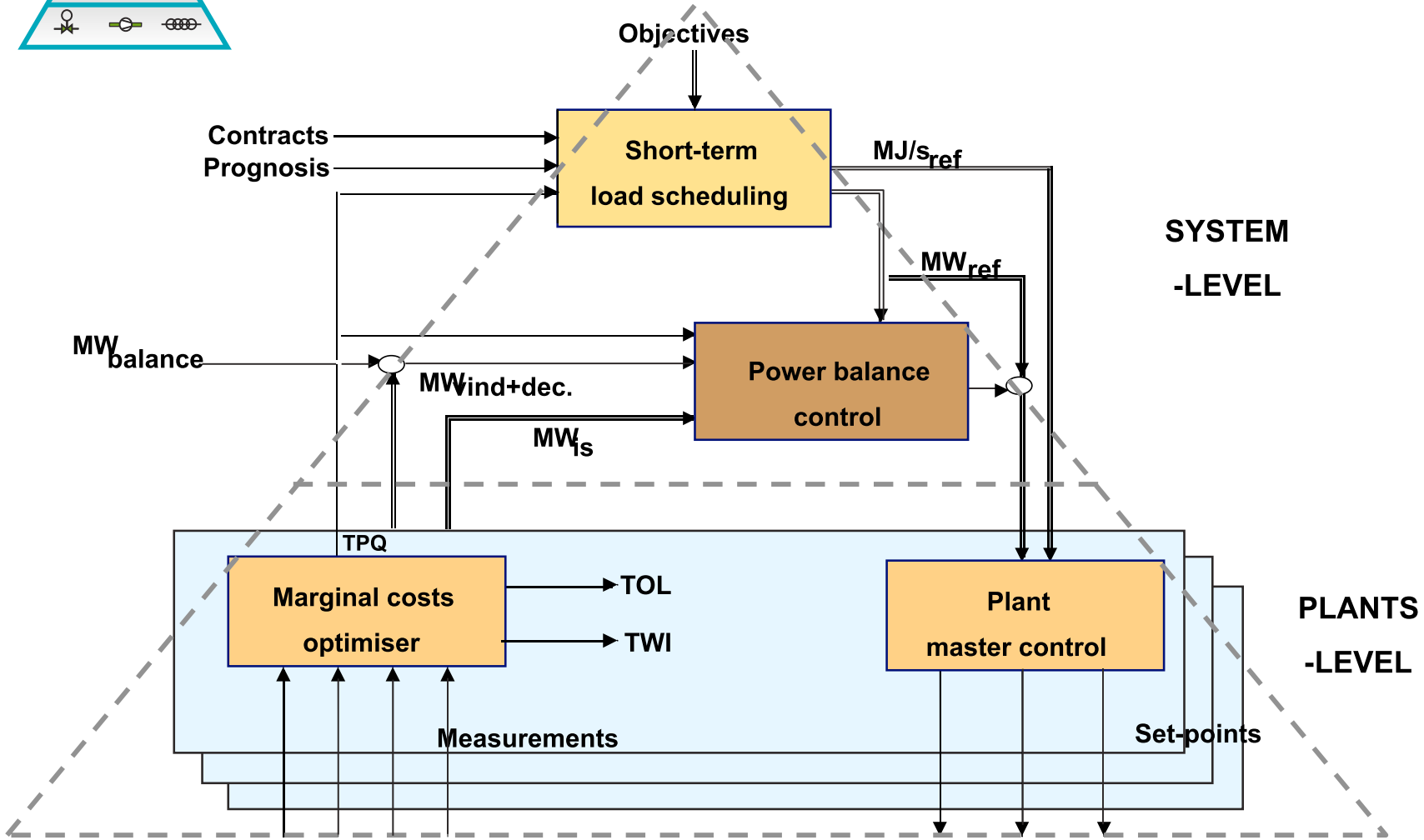
Interaction on top levels



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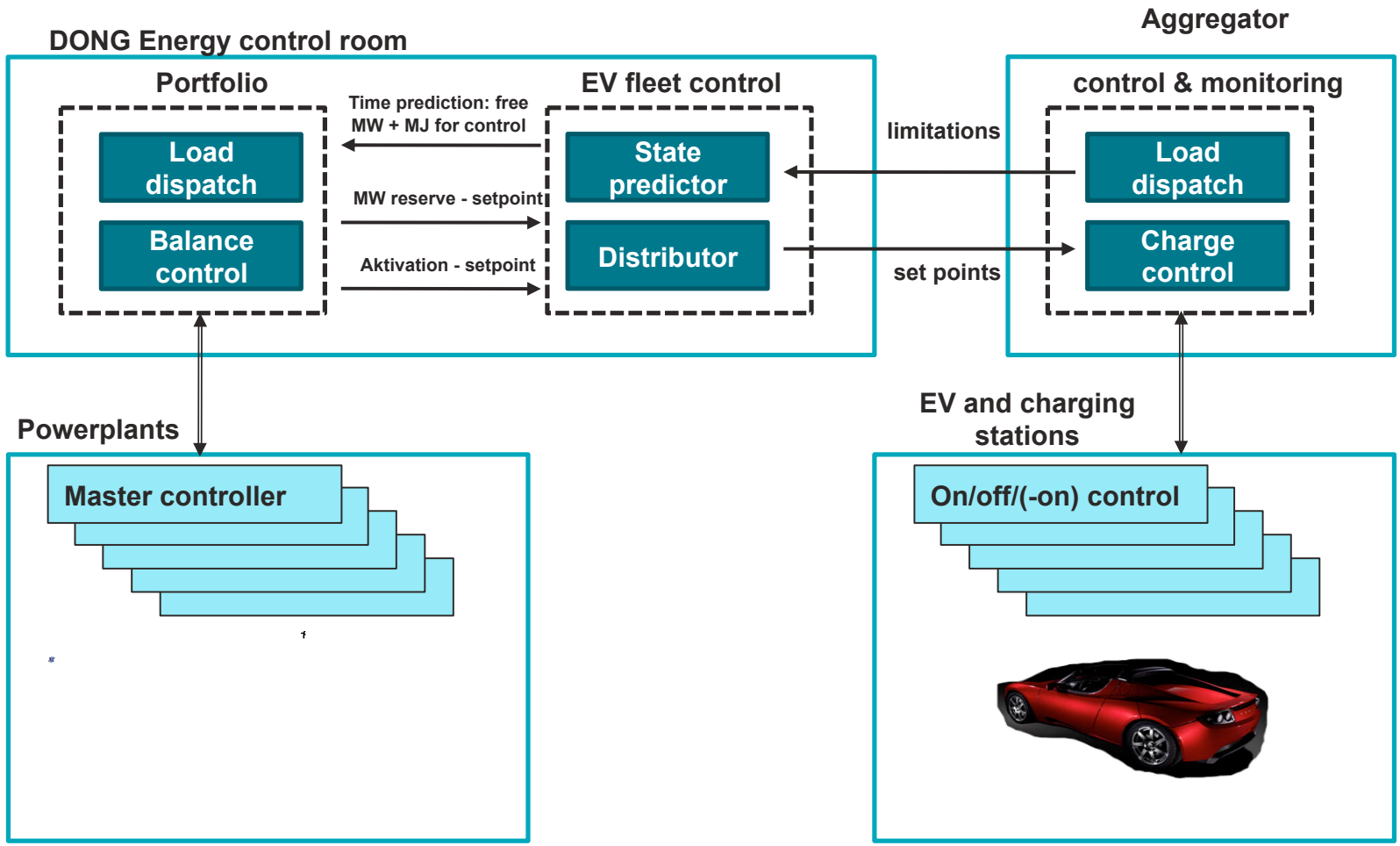
Integration of EV



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Electric cars can utilise excess wind power and recharge at night using cheap electricity

- Electric cars make it possible to utilise more renewable energy
- A single 2 MW wind turbine can provide 3,000 electric cars with energy
- Batteries are four times more effective as an energy provider compared to hydrogen
- Even if all electricity were provided solely by coal-fired power plants, the CO_2 emission per car would be only 50% that of a traditional car
- Electrification of 20% of the Danish vehicle fleet, will result in a CO_2 reduction of 1.1 million tonnes per year

…and reduction of noise and particles

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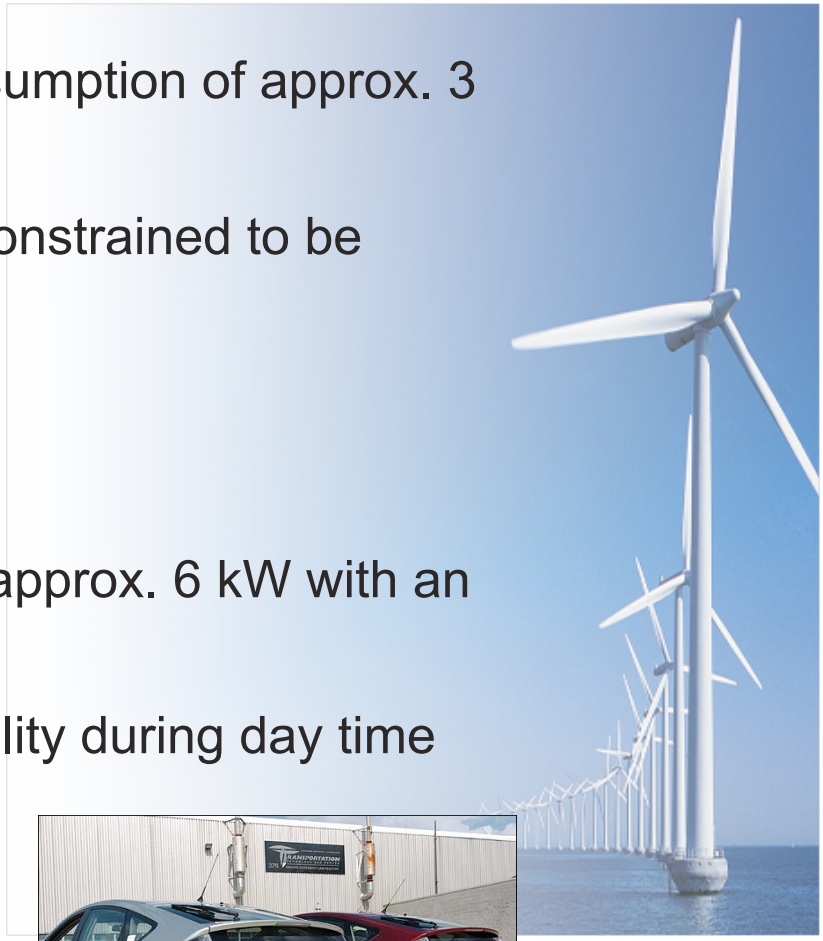
EV's as flexible consumption in the Danish energy system

Energy balance:

- Private cars in DK represent a EV power consumption of approx. 3 TWh – mostly during night time
- EV's and battery stations will be operational constrained to be charging within certain time limits
- Conclusion: limited use for balancing energy

Power balance:

- In private homes charging capacity would be approx. 6 kW with an average of 1 hour charging per day
- High flexibility during night time and low flexibility during day time
- Conclusion: Efficient for balancing power



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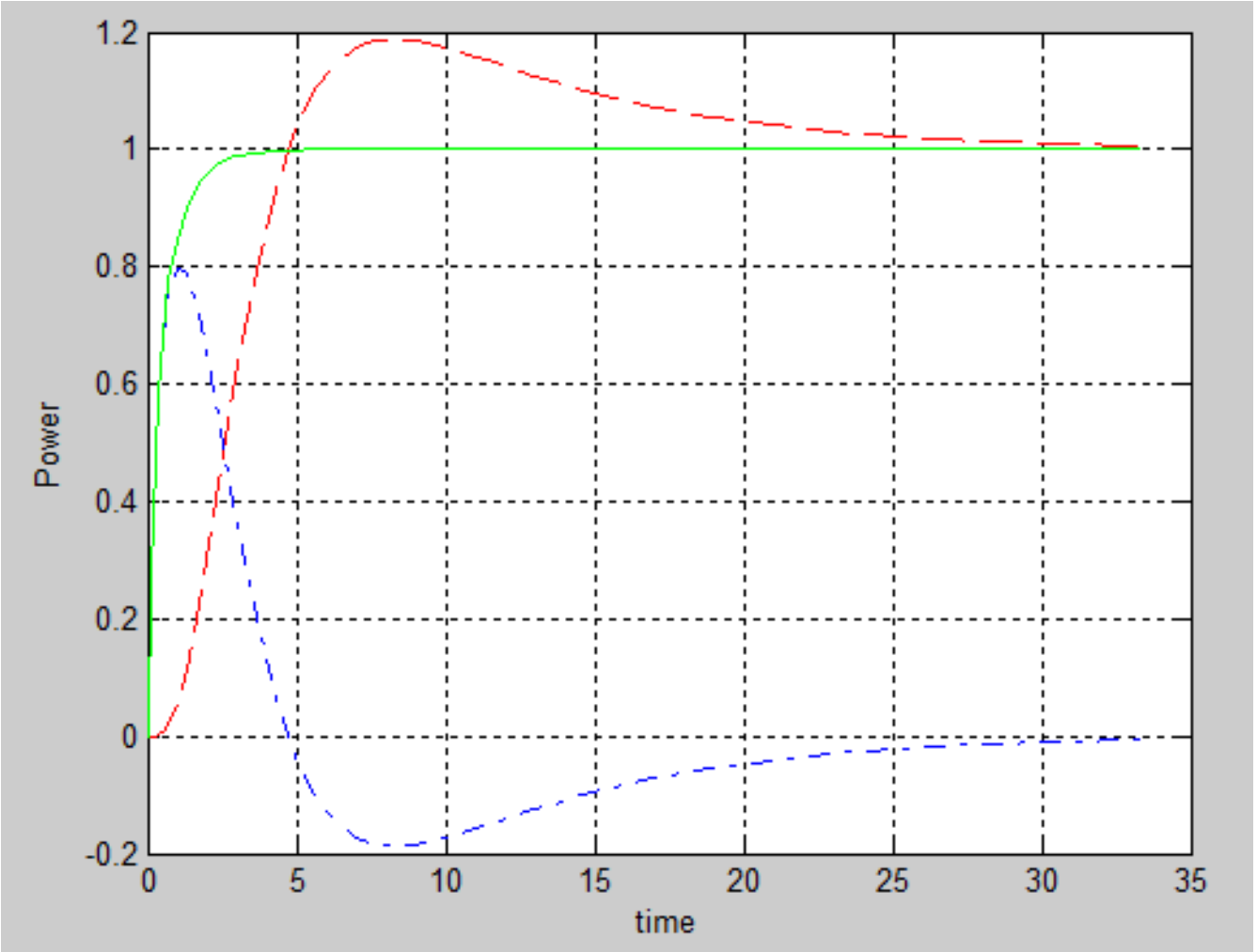
Power balancing: Why do we need real-time intelligent control?



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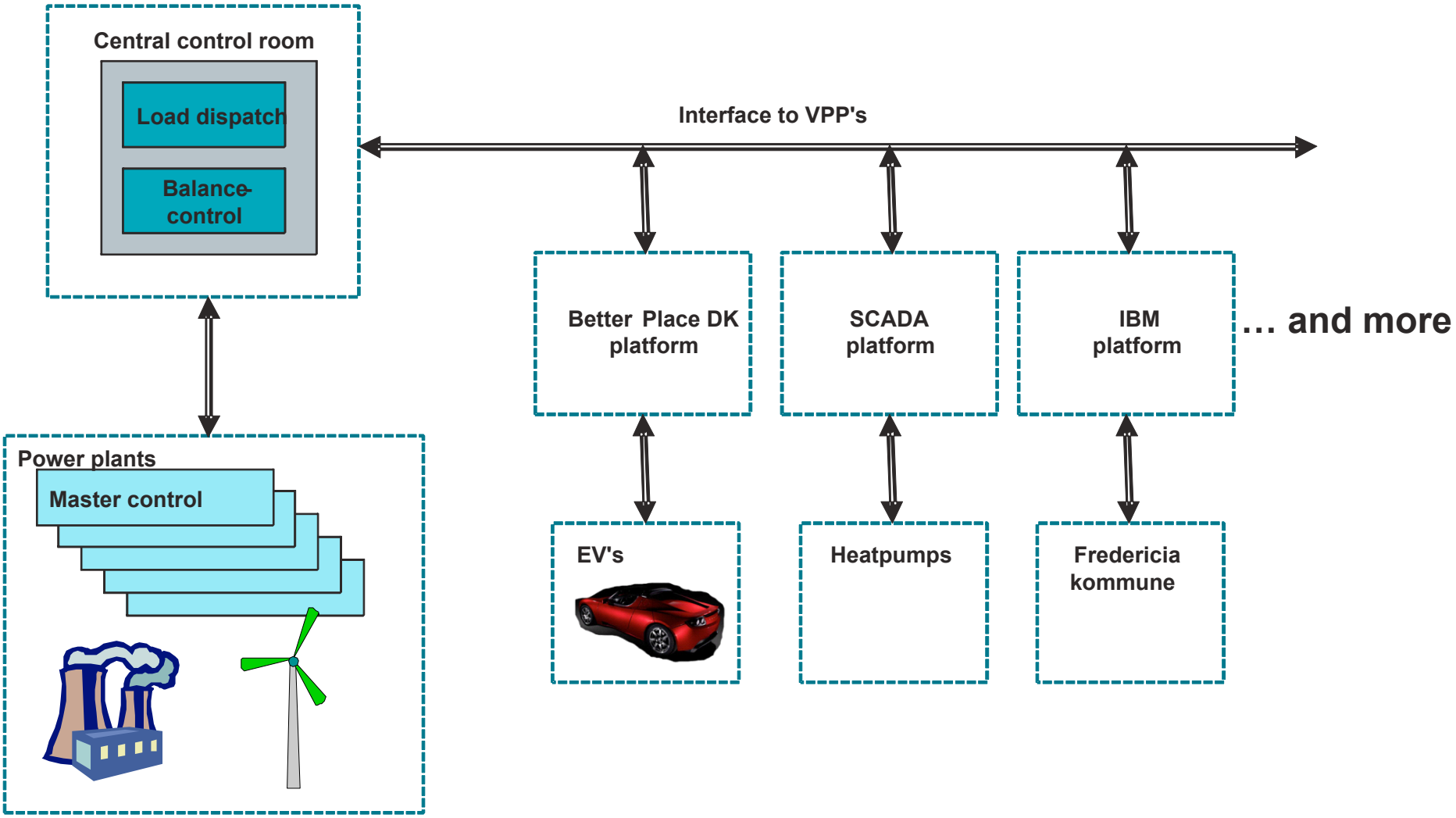
The future: VPP from a DONG Energy point of view …



The future power/energy system – outlook with control eyes

- **"Stochastic" production:** Renewable energy – especially wind power – often includes stochastic features
- **Small distributed units:** Small units (production and consumption) will have to participate in grid stability support
- **"Stiff" system:** Large differences in time constants and other dynamic operational characteristics
- **Constrained system:** Different units (production and consumption) will imply different types of operational constraints – often time varying
- **Topology changing system:** Some units may be leaving/entering the power system and/or changing node during time
- **Local balancing:** Energy flow will not only be top-down in future – calls for local balancing

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VPP – control challenges:

- **Prognosis**: Efficient coordination of flexible units calls for sound estimates on different types of production and consumption – on a range of different time horizons
- **Control methods:** Port folio of units will be very diversified regarding operational features and flexibility – keywords: constraints, model based, distributed, time-varying, scalability, …
- **Infrastructure:** IT platform and communication channels are to tie real-time applications and business applications together
- **Flexible units:** Each individual unit should be "dressed" for offering maximum flexibility – requires proper local design of mechanics and controls
- … and **integrated design** of all these functionalities

→ **"No trouble here", so let's do it …**

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Conclusions:

- **Plenty of non utilised flexibility** in the Danish energy system for solving the future challenges of balancing
- **Intelligent planning, design and control** are the key issues and shall ensure efficient utilisation of flexibility
- Real time functionality (automation) is necessary for power balancing (VPP = **Virtual Power Plants**)
- No natural gifts for balancing energy in Denmark – **new solutions needed** (CAES, large batteries, energy islands, cooperation across borders, …)
- **Wind power production** sets the agenda in DK regarding future needs, but also encompasses an unutilised potential regarding flexibility!