

STATKRAFT'S AGGREGATION BUSINESS IN EUROPE

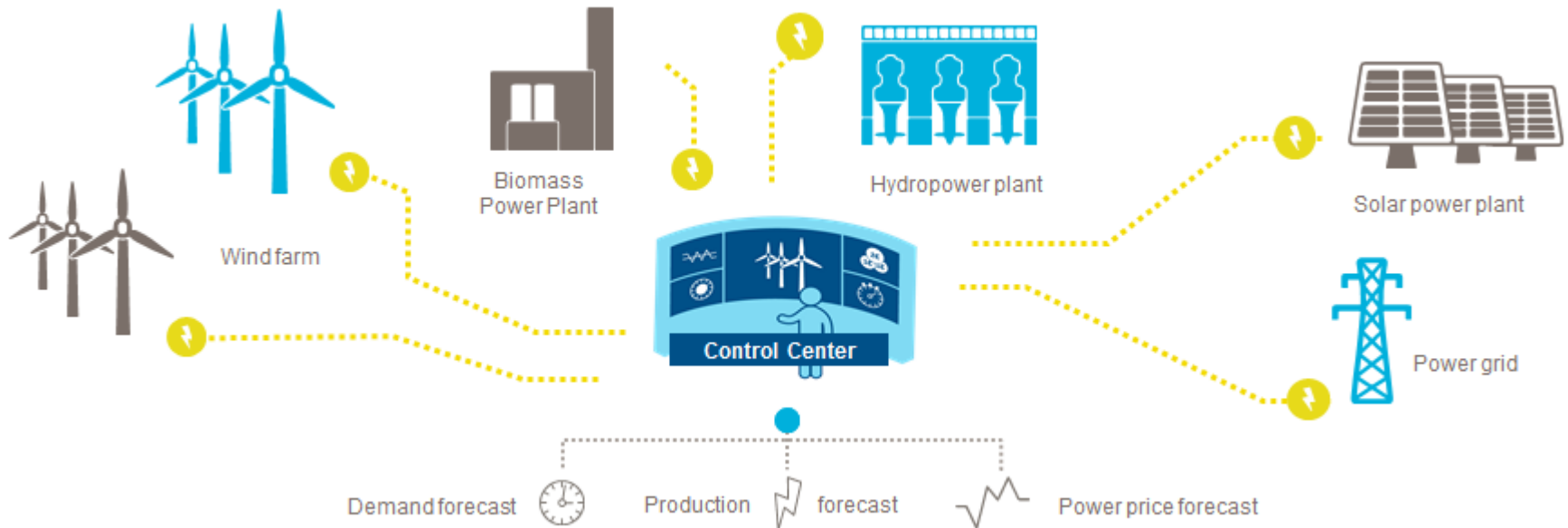
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What is Aggregation?

Aggregation means grouping generators and/or consumers for the purpose of...

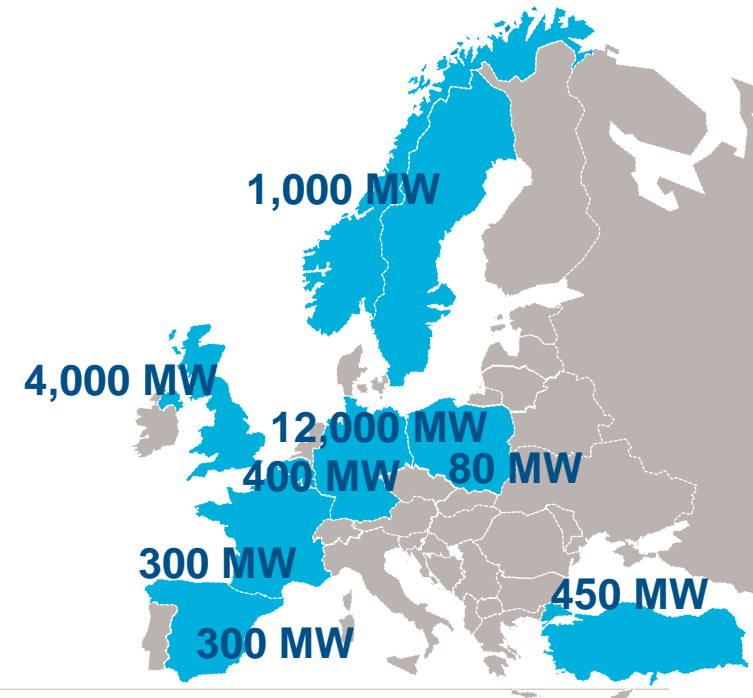
- Participation in wholesale or retail energy markets
- Selling services to the system operator



Statkraft: Europe's largest aggregator



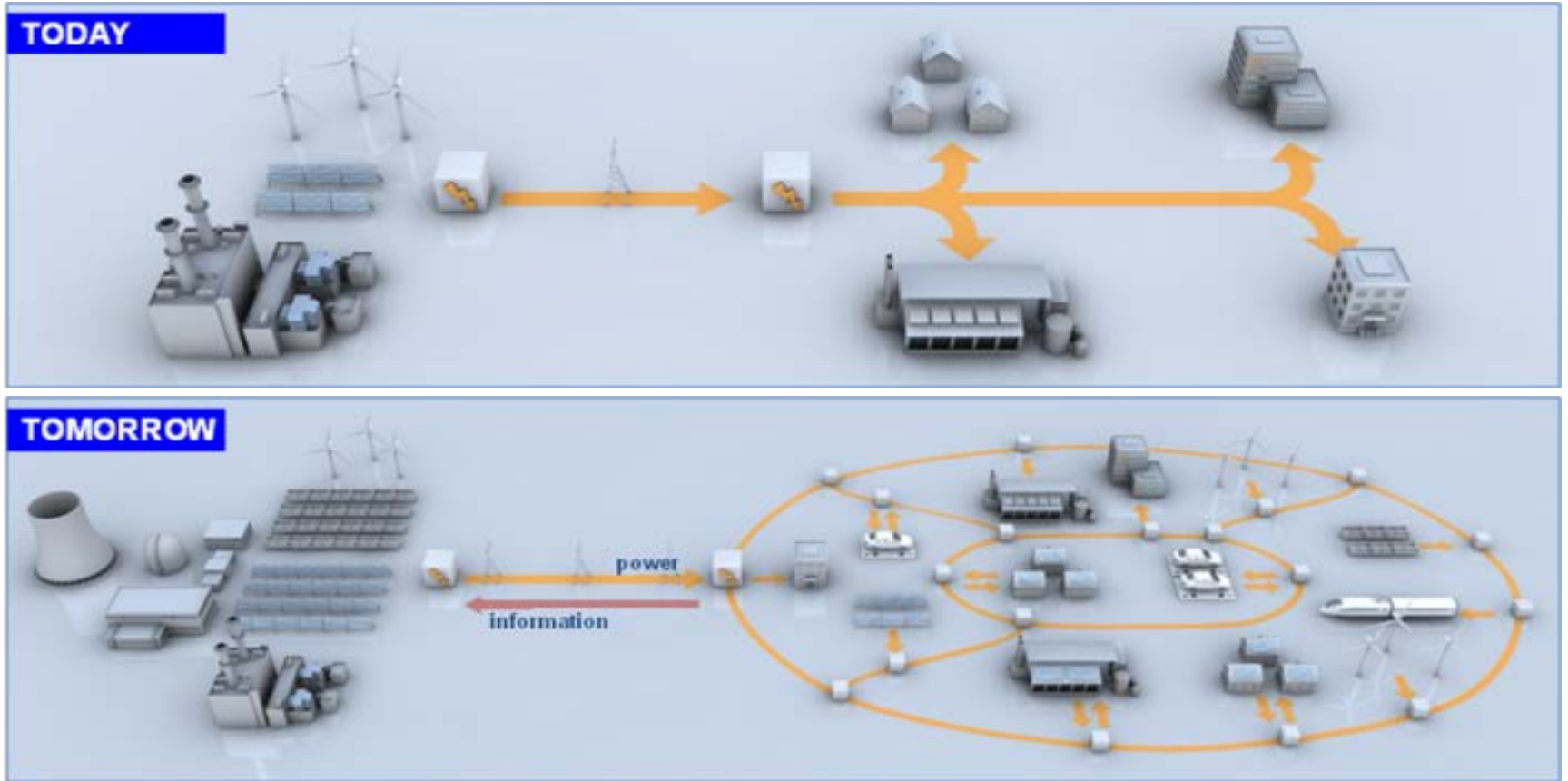
- ▶ Total aggregation portfolio of 19 GW in Europe
- ▶ Focus markets: Belgium, France, Germany, Ireland, Nordics, Poland, Turkey, UK
- ▶ Mainly wind and solar, but increasingly also other technologies (gas-fired generation, biomass, hydro, battery storage, consumers)



Capacity is the ability (or option) to deliver or offtake (sell or buy) electrical **Energy**

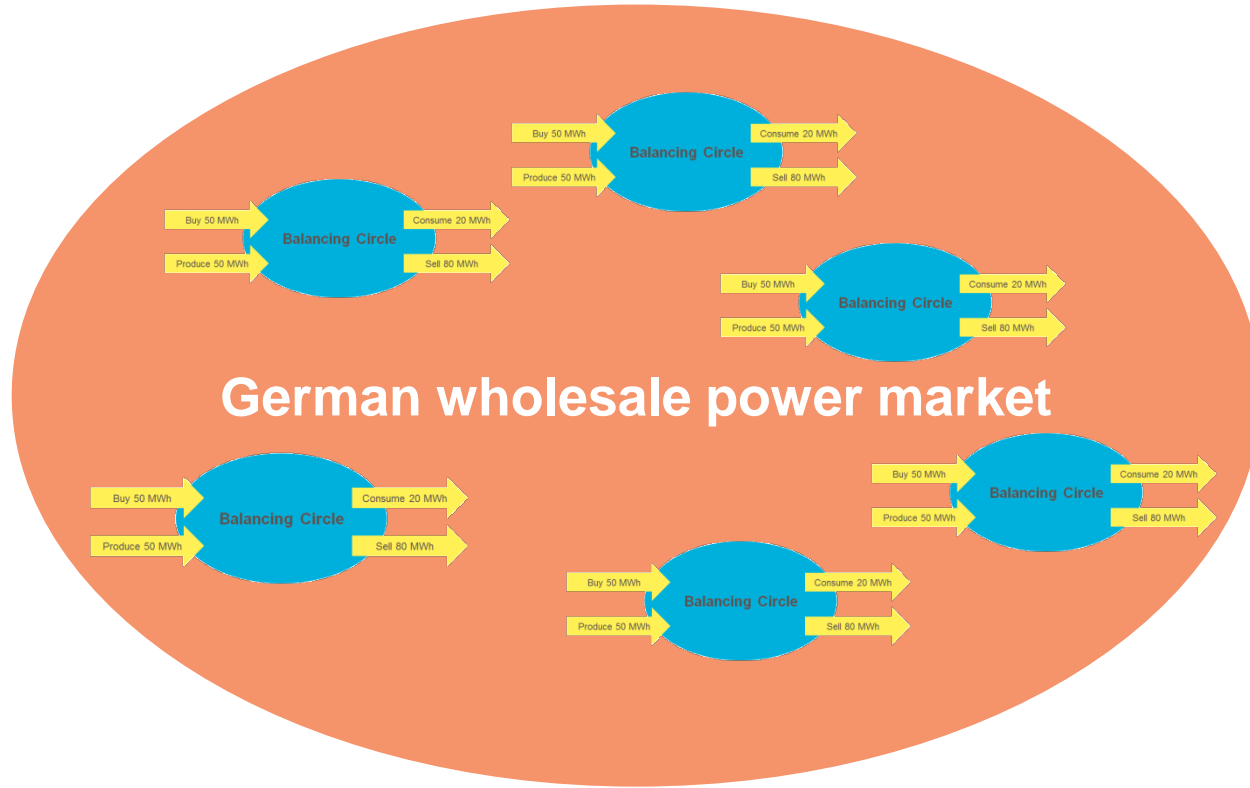
Flexibility is the ability to use capacity without limitations

Aggregation is probably required to operate DER

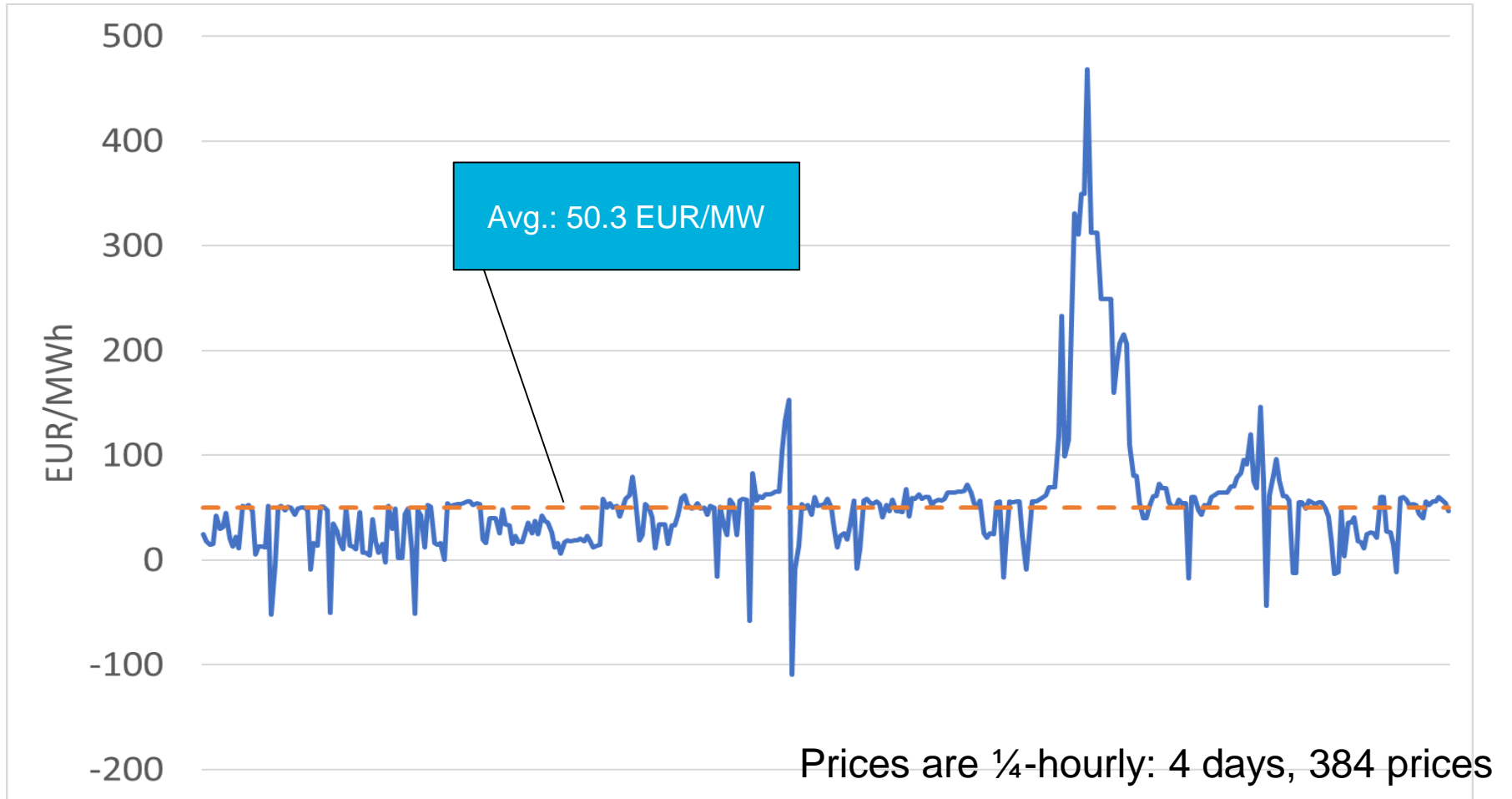


- ▶ What is the business model behind aggregation and balancing?

TSOs use balancing energy to physically balance the grid. Wholesale market participants are BRPs.



Random example: German imbalance prices 23-27 June



Balancing: Sequence of trading deadlines (UK market)

Trading

Physical Delivery

OTC Forward trading

Day-Ahead Auction (hrly)

Afternoon Auction (1/2hrly)

ID1 Auction

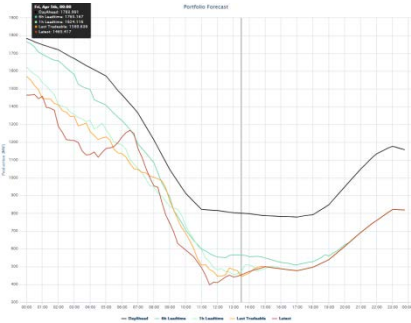
ID2 Auction

Gate Closure Phys. Not.

Gate Closure Cont. Not.

Continuous Intraday Market

Balancing Mechanism



W-1

D-1 (11:00)

D-1 (15:30)

D-1 (17:30)

D (08:00)

T-60

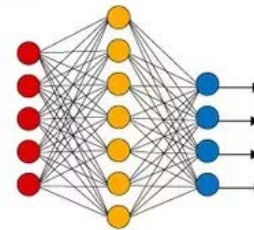
T-15

Statkraft's options to manage our balancing account

- ▶ Regulate assets
 - Hydro
 - Gas fired
 - Battery storage
- ▶ Down-regulate wind/solar or consumption
 - Virtual Power Plant
- ▶ Intraday trading 1.0
 - Power exchanges
 - Over-the-counter
 - Back up agreements

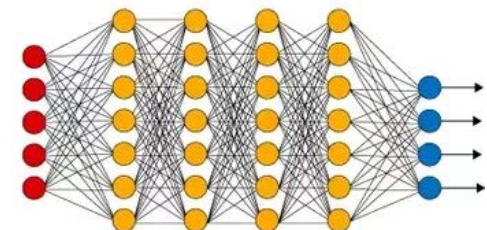
- ▶ Intraday trading 2.0
 - Autobalancing (automated trading)
 - Analysis using, e.g. machine learning

Simple Neural Network



● Input Layer

Deep Learning Neural Network

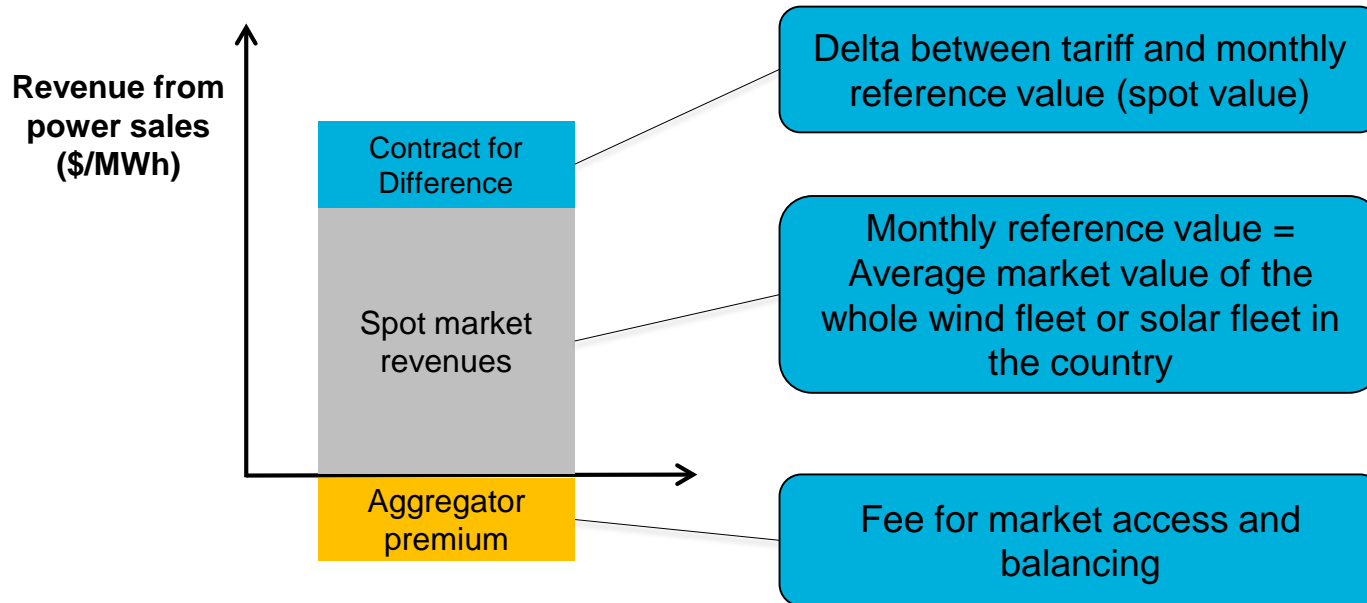


● Hidden Layer ● Output Layer

▶ So what is the business model behind aggregation and balancing?



Business model as seen from the owner of a wind farm



An aggregators' profit and loss account

Income/benefits

- ▶ Client fees
- ▶ Reserve power to TSO (regularly/implicit)

Cost

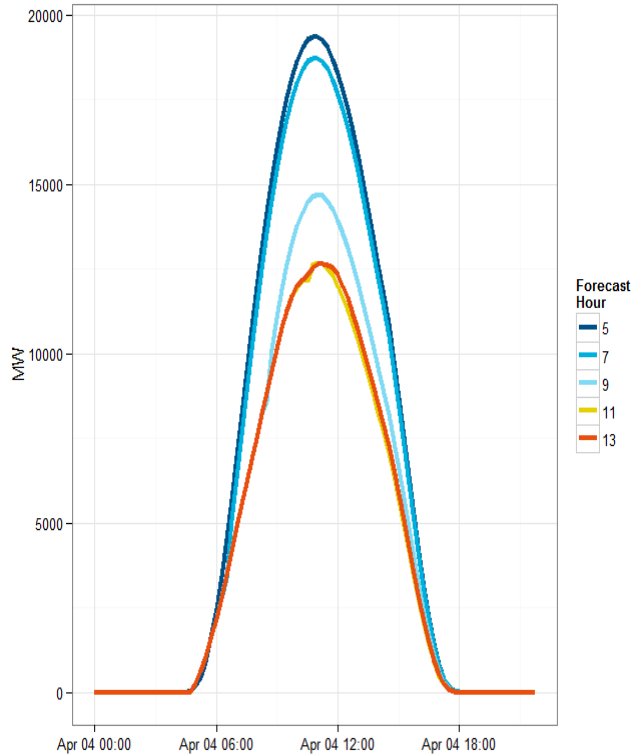
- ▶ Competent people
- ▶ IT (VPP)
- ▶ 3rd party services such as weather forecast

- ▶ Trading income/cost
- ▶ Portfolio effect (Economies of scale/scope)

- ▶ Imbalance income/cost

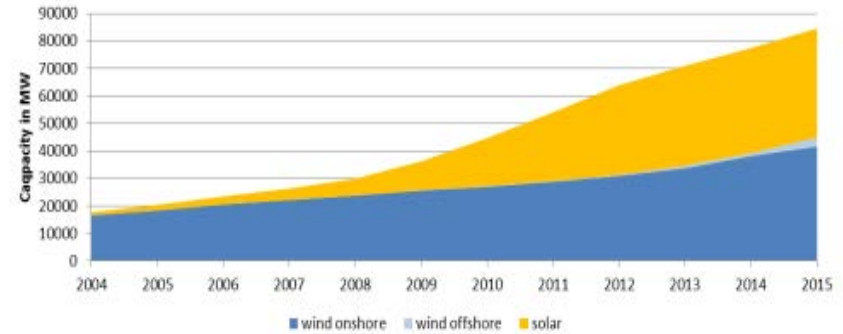
Trading
PnL

High Renewables share requires liquid intraday market

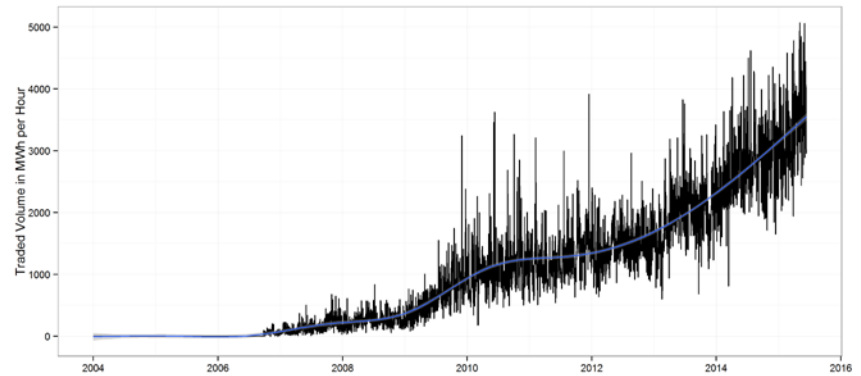


Renewables production forecasts are volatile

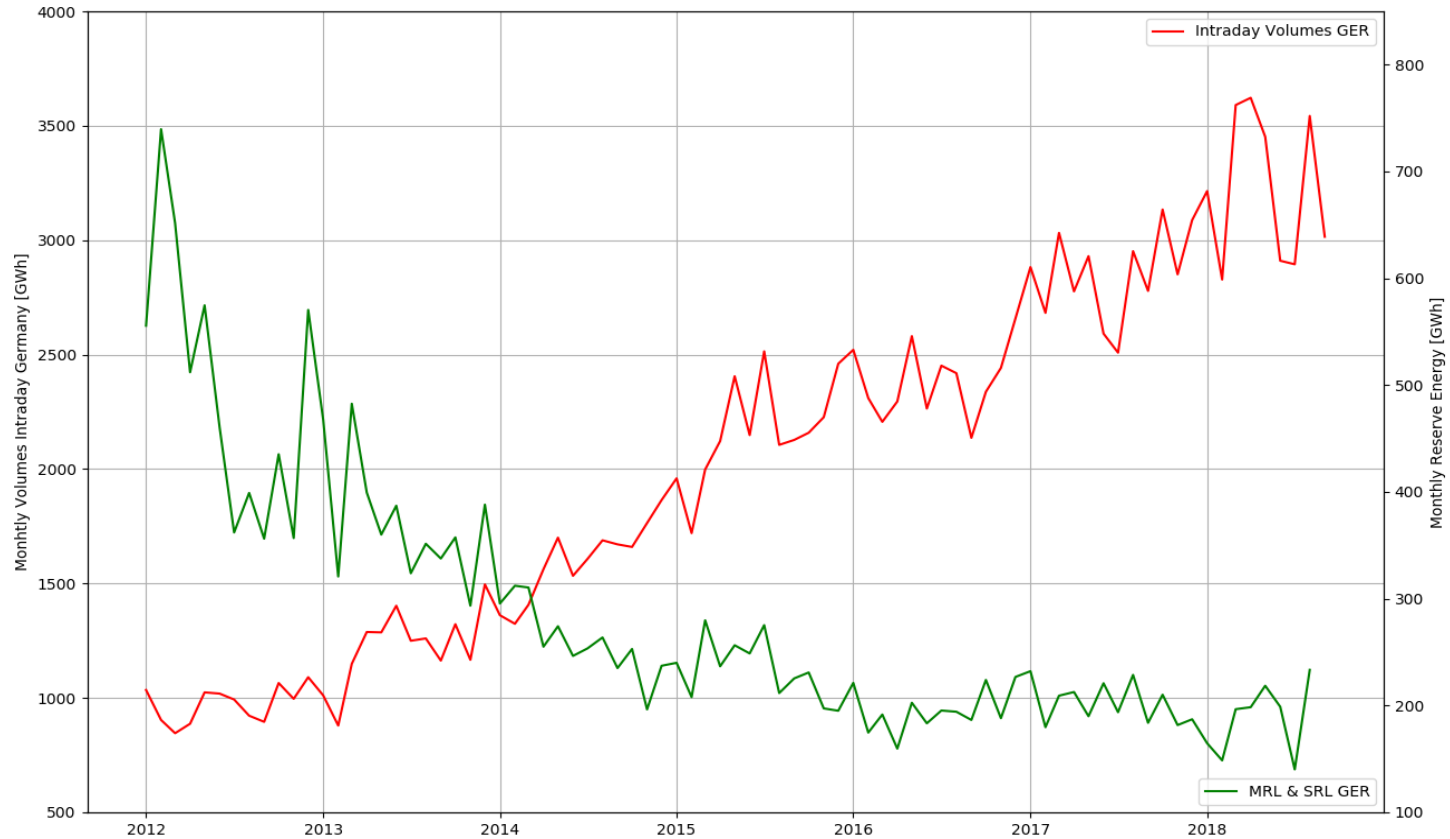
Total Capacity of Variable Renewables in Germany



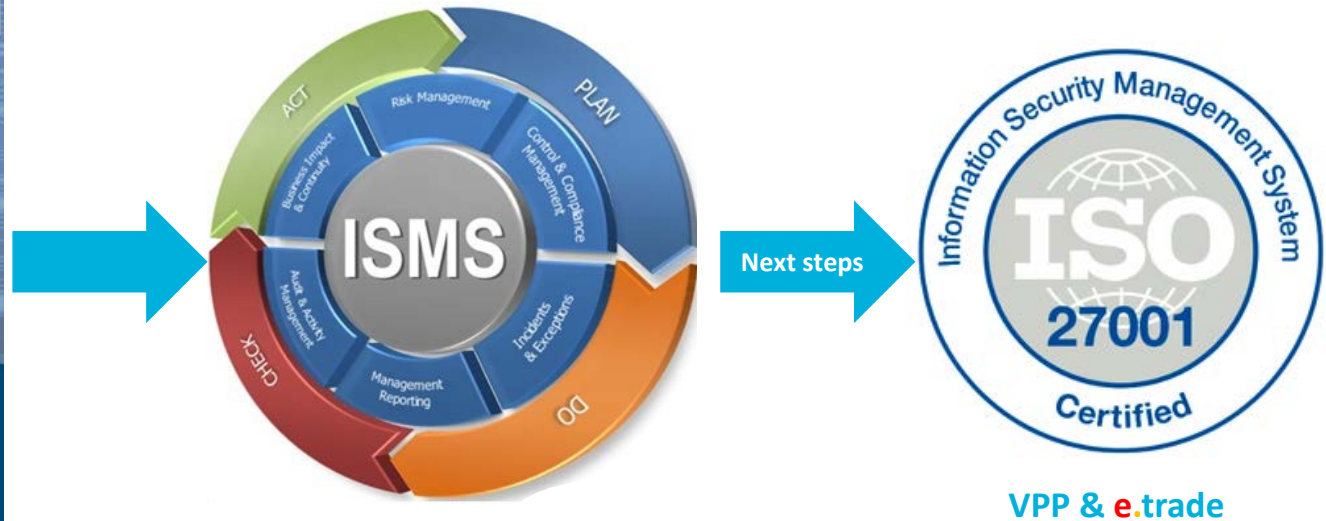
Traded Volume in German Intraday Market



Liquid intraday market lowers reserve requirements



IT Security for Critical Infrastructure



Graph sources: <https://www.bsi.bund.de> <https://www.memecenter.com/fun/714249/isms> <https://medium.com>

From manual to automated trading

Algorithmic Trading

Trading decisions autonomously made and executed by algorithms

Quantitative Trading

Trading decisions based on quantitative models

Optimization & simulation, statistical models, machine learning

Intelligence

+

Automated Trading

Automated execution of well-defined trading strategies

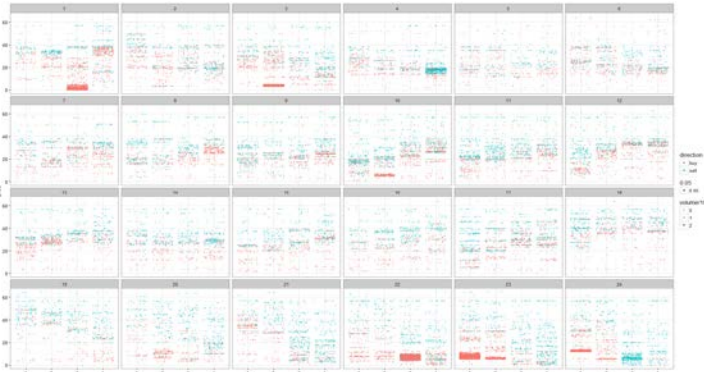
Arbitrage, automated order routing, high frequency trading

Sharp Knives

e.trade – Why algorithmic intraday trading?

The environment

- ▶ **Smaller margins per trade** due to increased market efficiency
- ▶ **Hundred Thousands** of order changes and trades everyday
- ▶ **Thousands** of trades/day necessary for balancing renewable portfolio
- ▶ **Milliseconds** for the market to change/trades to happen



Orders in quarter hour product during a day on German market

Complexity, speed, small margins → Computer

Strategy & special situations → Trader

A large part of our intraday trading is automated

▶ Business Cases:

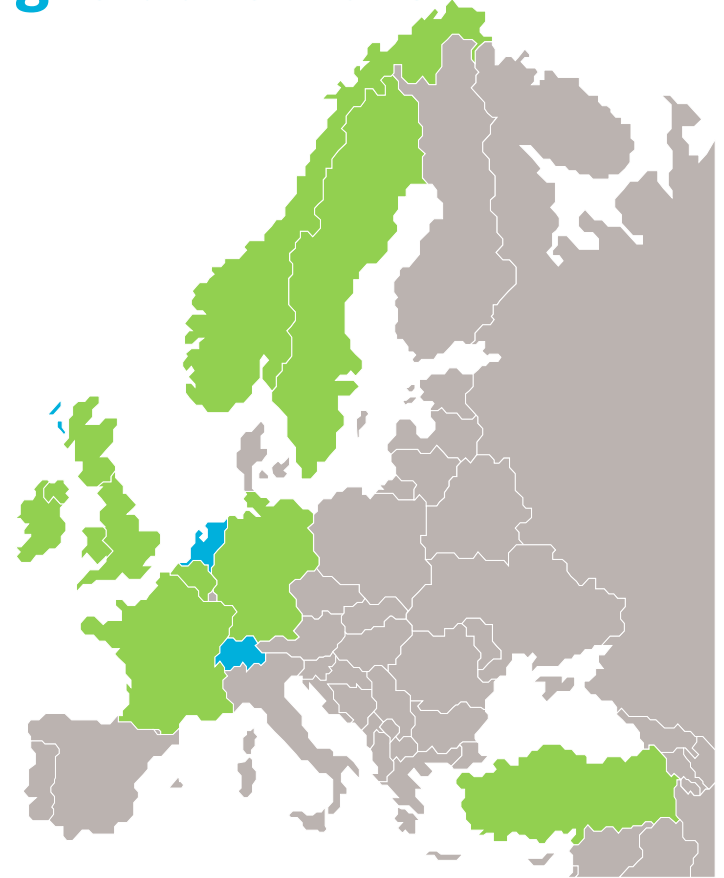
- Renewables balancing
- Intraday asset optimization
- Arbitrage + Market Making + 3rd party Market Access

▶ Connectivity: EPEX / Nordpool / EPIAS

- live: DE, BE, UK (NP), NO, SE
- in preparation: CH, NL, ...

▶ Activity:

- 30 intraday bots running for DE
- Up to 10,000 trades/day = 5-10GWh/day
- 50-80K order modifications/day



Live

In Preparation

24/7 shift duty: Human intervention remains!



- ▶ Dispatching & point of contact for plant operators
- ▶ Trading & Balancing
- ▶ Supervision of Algo Trading
- ▶ Process monitoring

Questions?