KYOS Webinar
7 September 2021
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Webinar: Energy storage valuation and optimization

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KYOS Energy Analytics

Agenda

15:00 Overview energy storage market – Ewout Eijkelenboom

- Reasons for growing interest in energy storage projects
- Revenue streams of energy storage projects

15:10 Valuation of energy storage – Cyriel de Jong

- Market trading with batteries
- Value stacking with FCR
- Value stacking with solar co-sharing

15:35 – Q&A and discussion

15:45 – End of the webinar

KYOS Energy Analytics

- Provide analytical support to energy companies

- Software to value and optimize complex energy assets with flexibility
  - Energy storage
  - Renewable PPAs
  - Natural gas storages
  - Gas swing contracts
  - LNG contracts
  - Power plants

- Delivered in easy to use, on-line system:
  the KYOS Analytical Platform




More than 100 corporate clients using KYOS software and services

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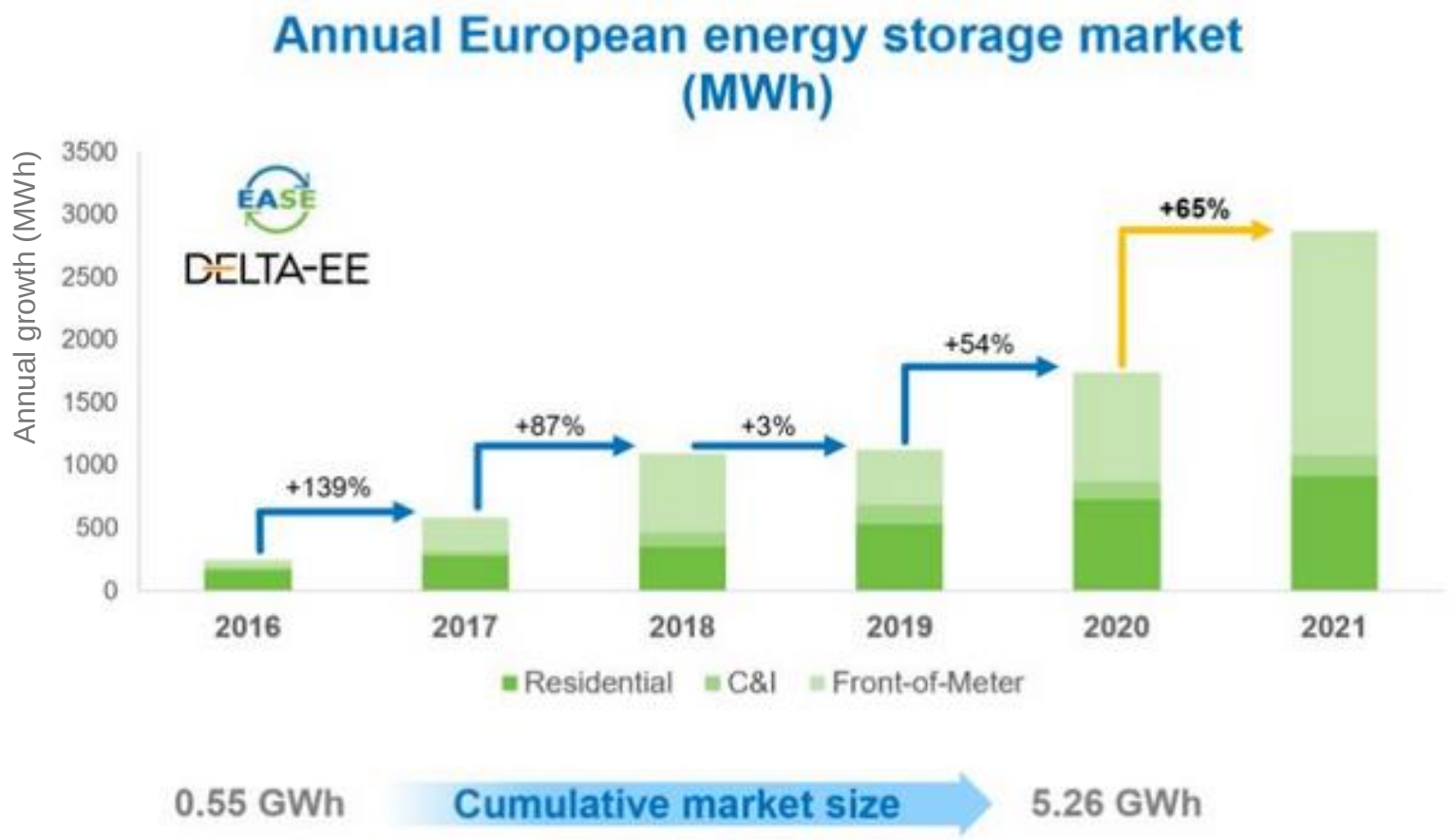
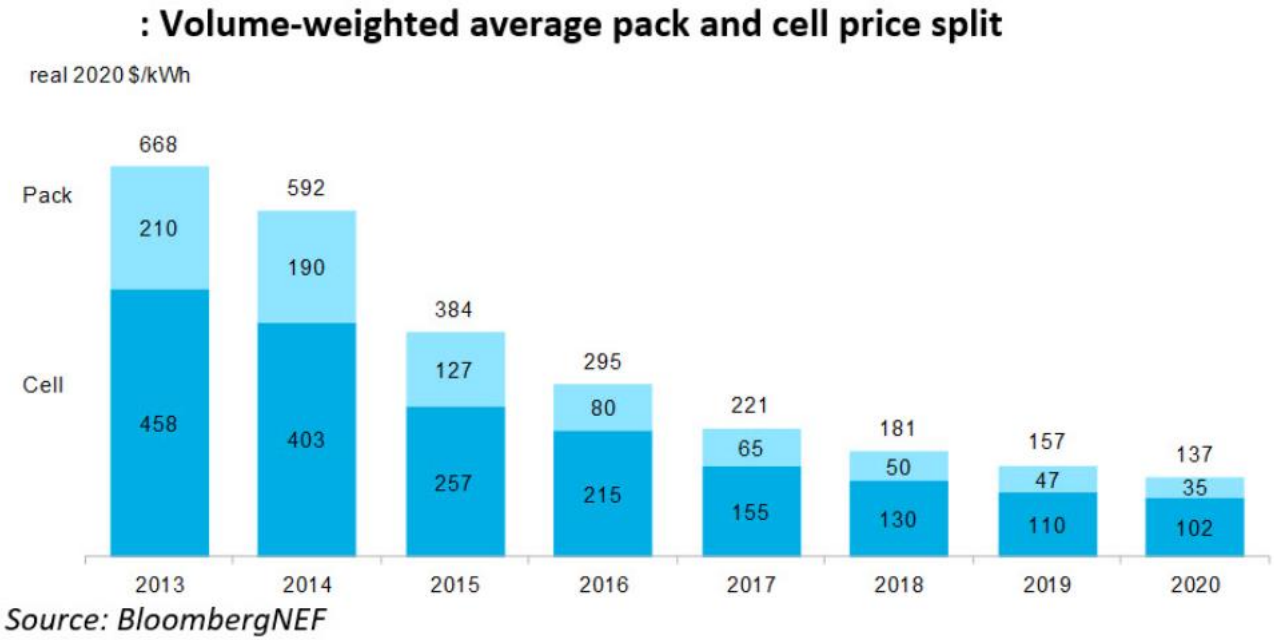
Storage market quickly growing



European Market Monitor on Energy Storage - European Association for Storage of Energy

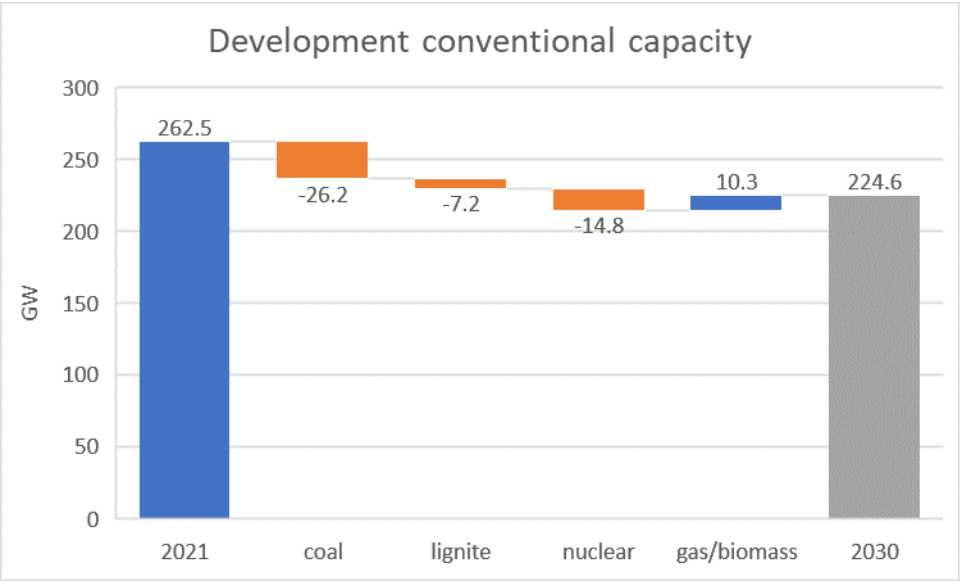
Falling costs of Li-ion battery packages

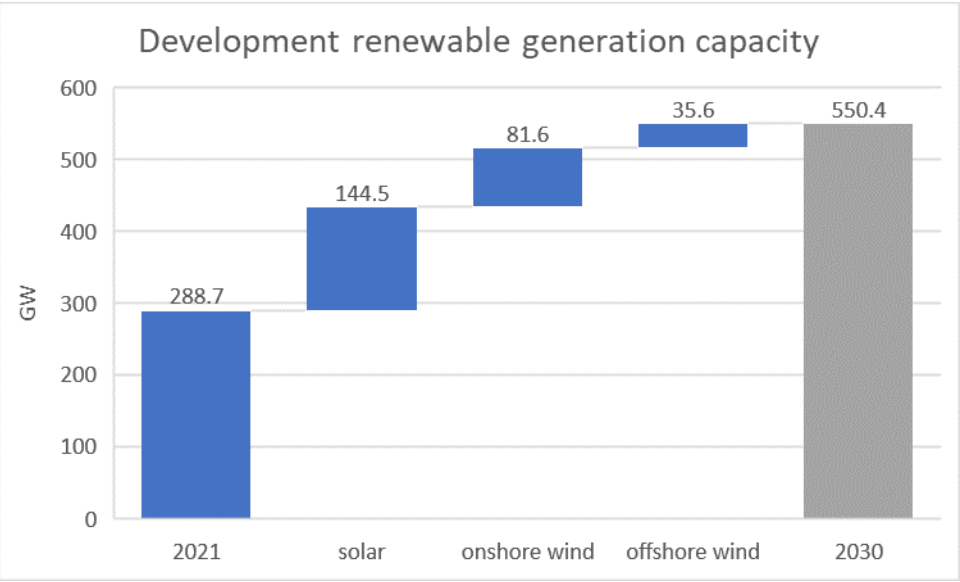


- Cost in 2010: 1,000 USD/kWh
- Costs expected to fall to 100 USD/kWh by 2023

Why interest in energy storage?

- Decrease in conventional power plants capacity
- Large increase in renewable generation





KYOS base case - Countries: GB, BE, DE, NL, FR, ES, IT

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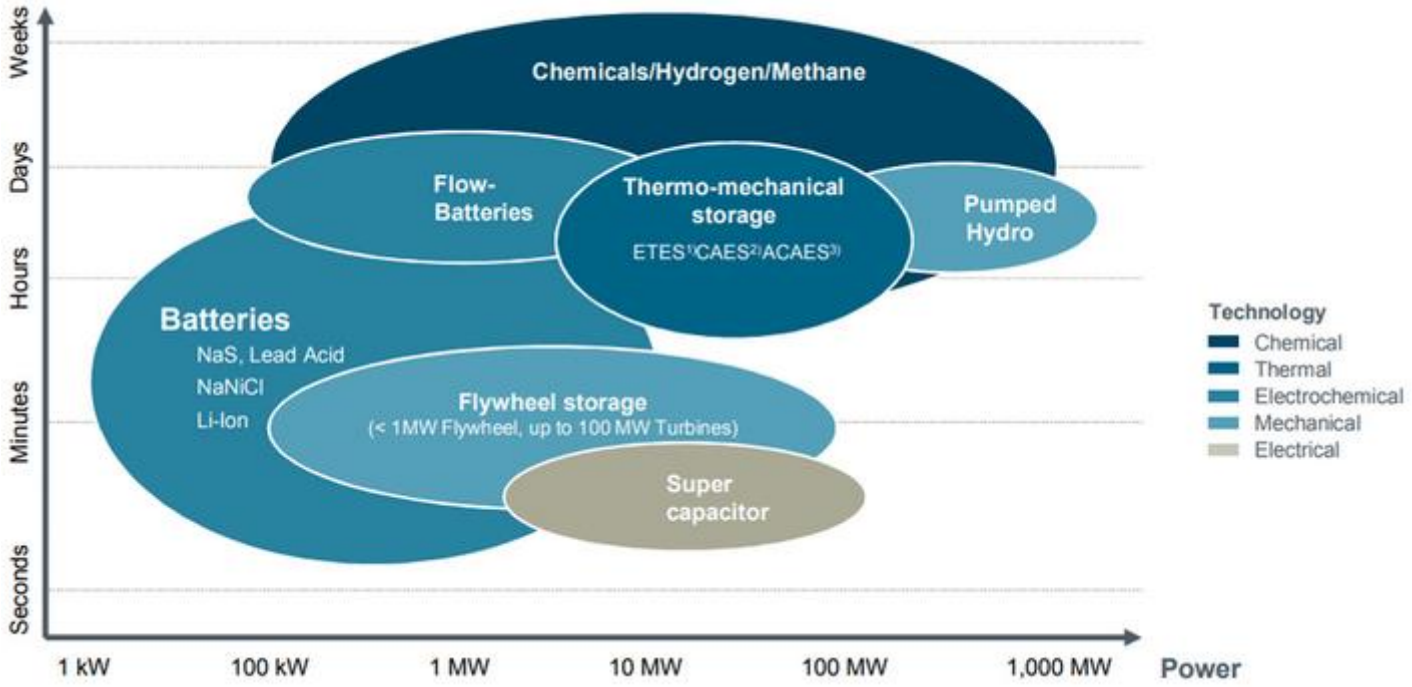
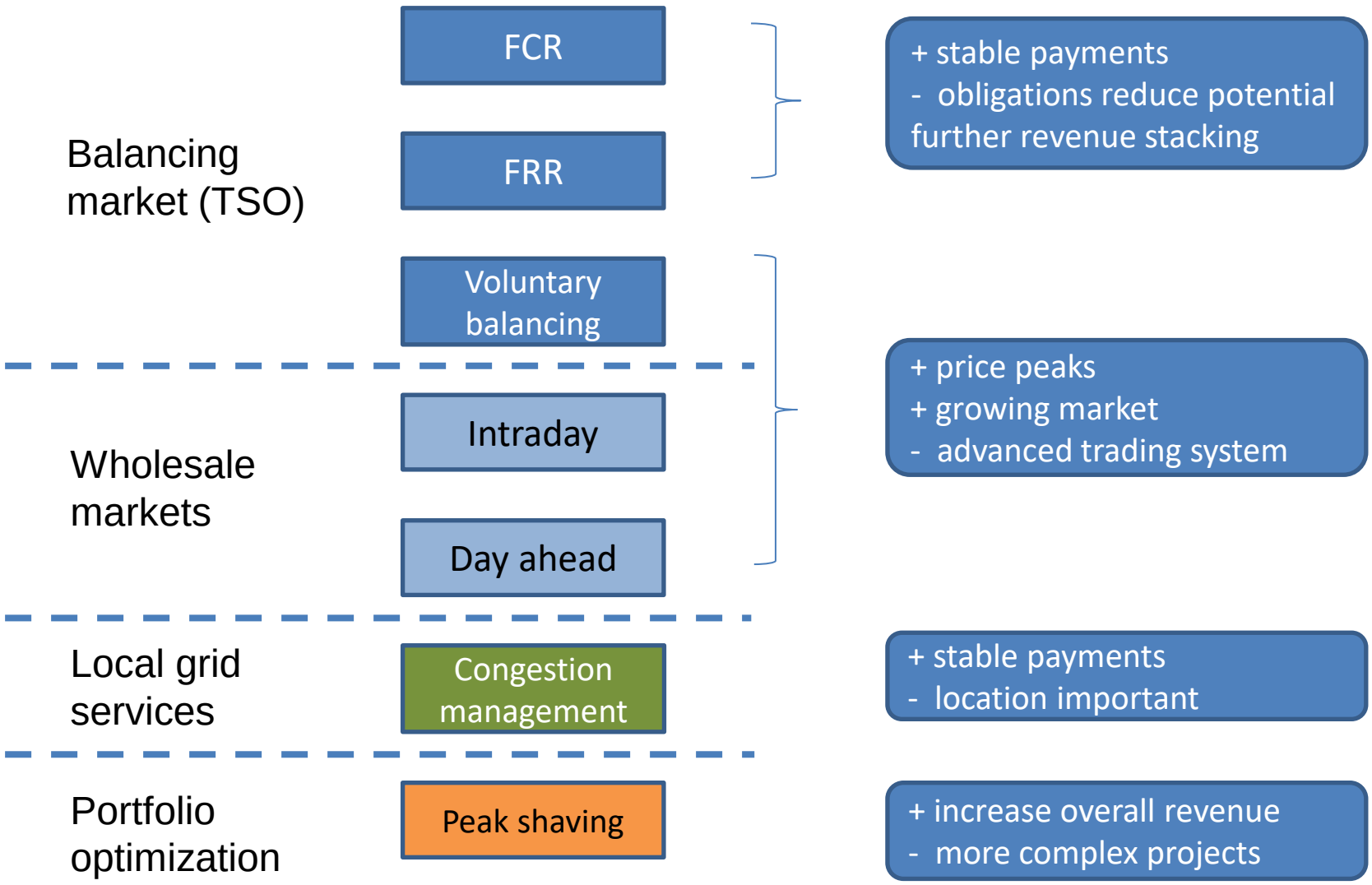
Different types of energy storages



Current status: mainly pumped hydro and batteries
The energy system needs more variation in storage types and especially also longer range storage

Energy storage revenue streams



Battery business case typically combination of revenue streams

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Market trading with batteries

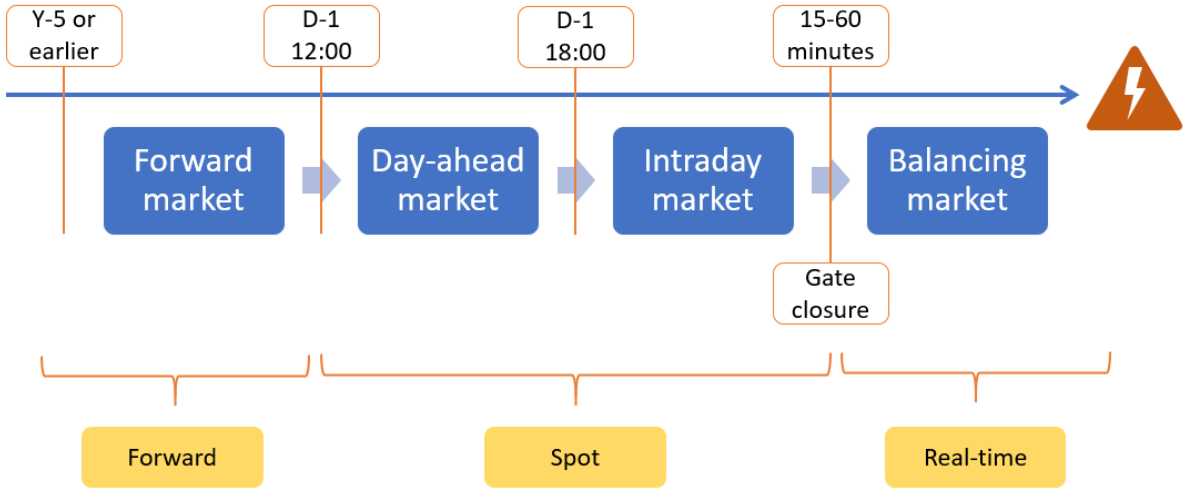
Short-term power markets

Creators of imbalances

- Balancing Responsible Parties (BRP)
- Control generation / consumption
- To match their forecast (e-program)
- If not: create imbalances

Providers of ancillary services

- Provide capacity to the TSO
- Are paid for their services
- Are activated when needed
- Resolve system imbalances



Trading in the market

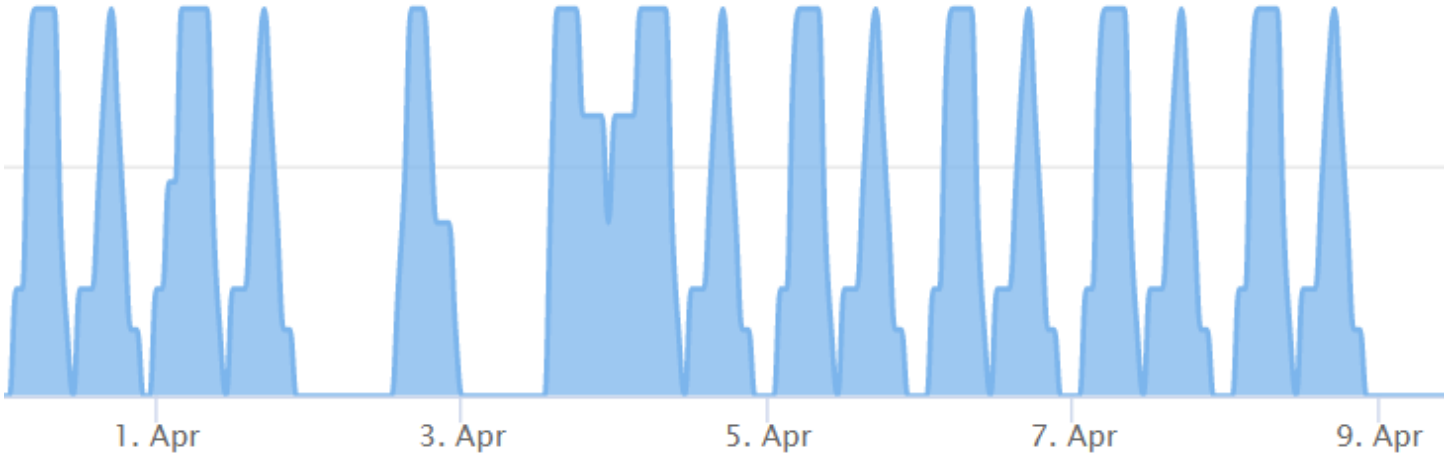
- The battery is used for trading on 1 of the following markets:
  - Day ahead market
  - Intraday market, EPEX ID1 index (most value)
  - Imbalance market

  Joint optimization on multiple markets is possible in practice, but difficult to assess realistically.

  Better choose the most attractive market and combine with FCR and/or peak-shaving solar.
- Trading optimization is performed on a large set of simulation paths, without perfect foresight about future prices. Stochastic optimization.

Methodology: least-squares Monte Carlo (LSMC)

- The KyBattery model finds the optimal (though realistic) trading strategy with the battery in the market
- It finds the optimal action/trade:
  - Charge
  - Discharge
  - Do nothing
- The optimal trading strategy is calculated on a large number of possible price developments using Monte Carlo simulations



Example results, Dutch market

- Expected battery value:

	Low	High
• Day-ahead market:	100	100
• Imbalance market:	150	300
• Intraday market:	250	280
• Intraday + FCR:	500	800

- Imbalance market: difference between high and low depends on ability to forecast imbalance prices
- Intraday market: difference between high and low depends on liquidity in intraday market
- FCR: difference between high and low depends on expected FCR price

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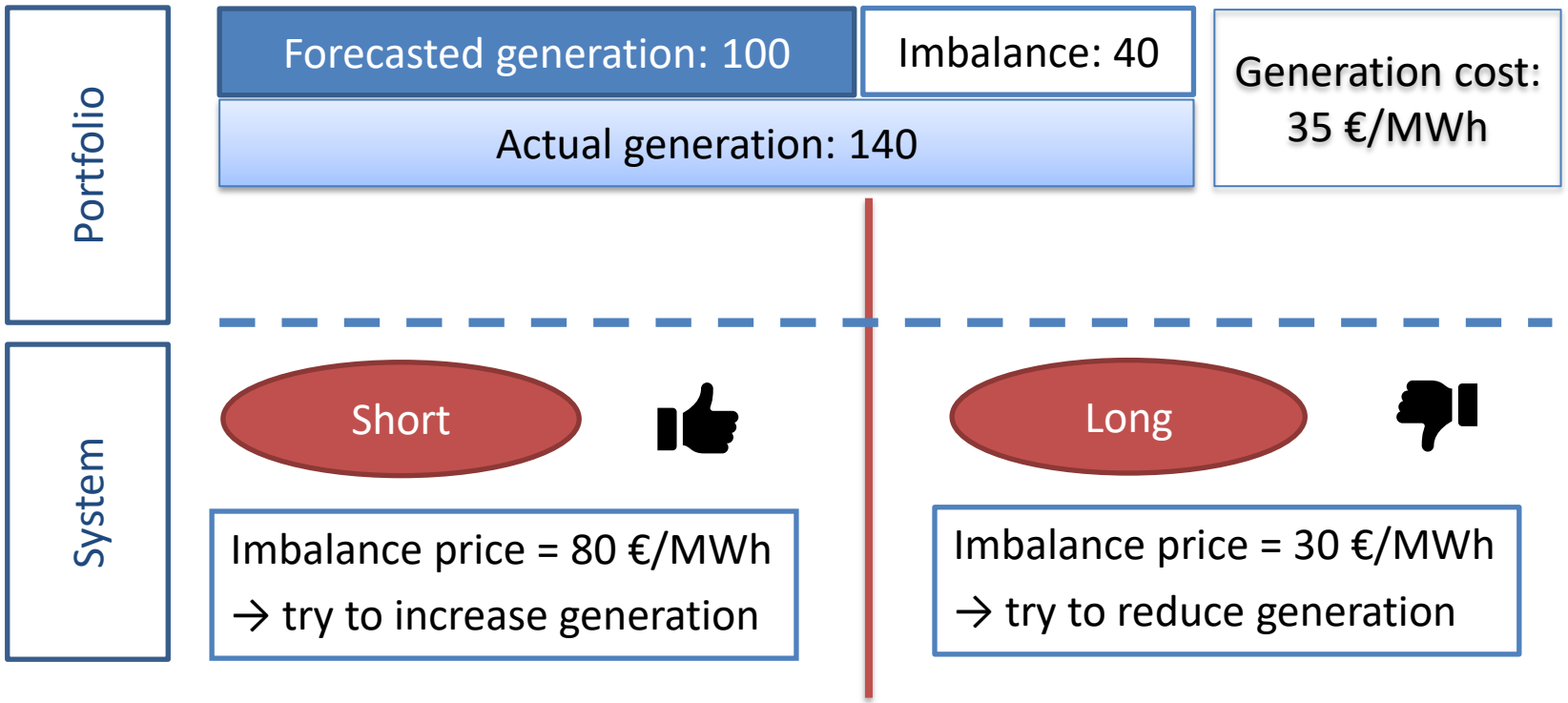
How does passive imbalance trading work?

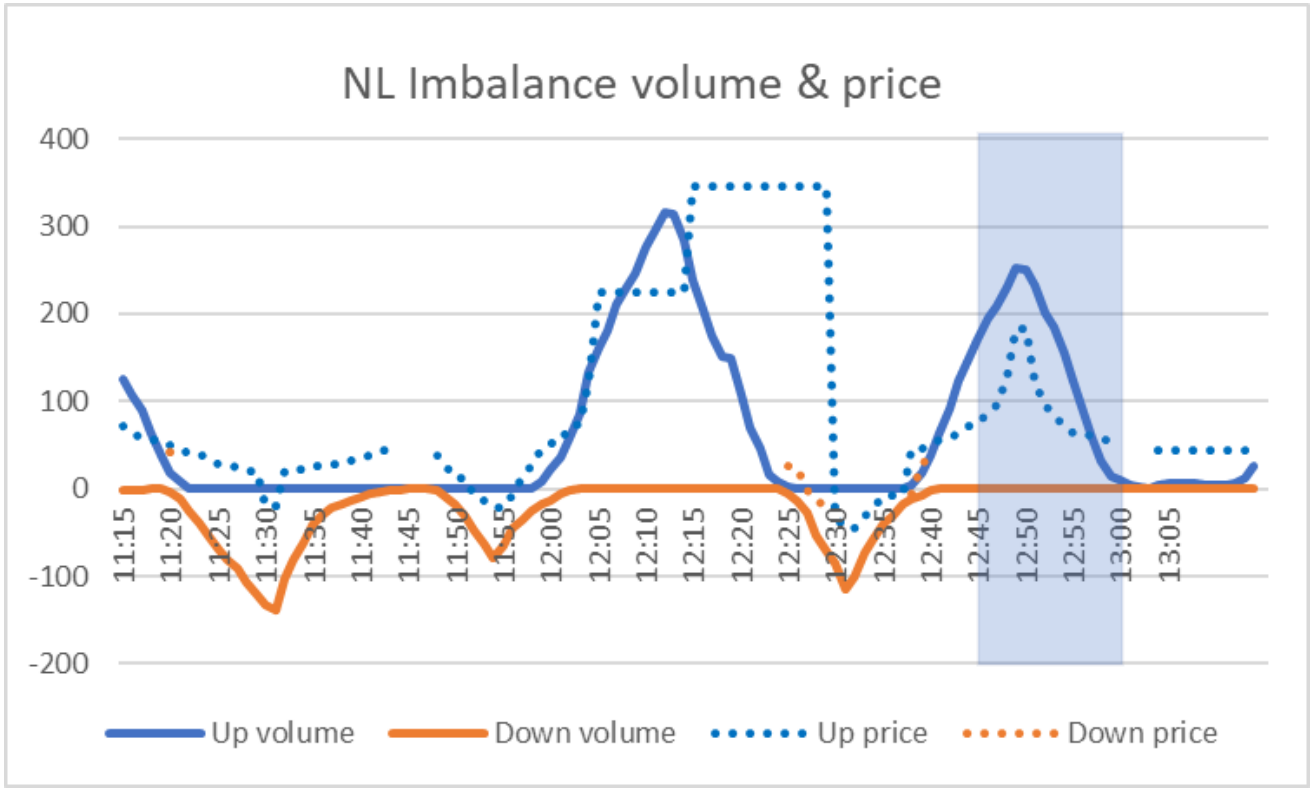
Portfolio imbalance versus system imbalance

- Traditionally, BRPs have focused on minimizing the imbalances in *their own portfolio*; this was even obligatory
- TSOs increasingly accept, or even encourage, BRPs to minimize instead the *system imbalance*



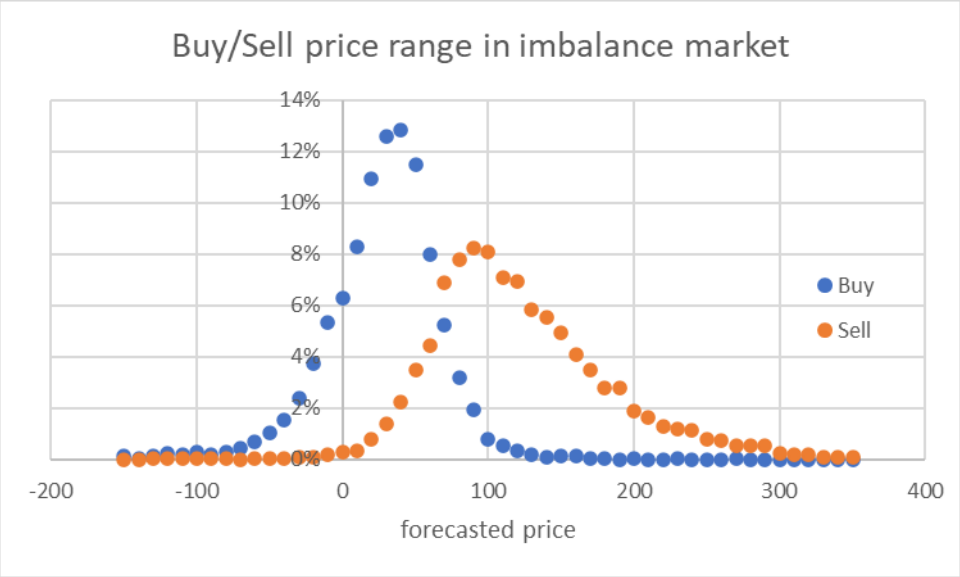
Was this profit opportunity predictable?

- Towards 12:38, the up balancing volumes (shortage) increased
- By 12:45 it was likely that the PTE of 12:45-13:00 would have a shortage, hence it was likely profitable to be long



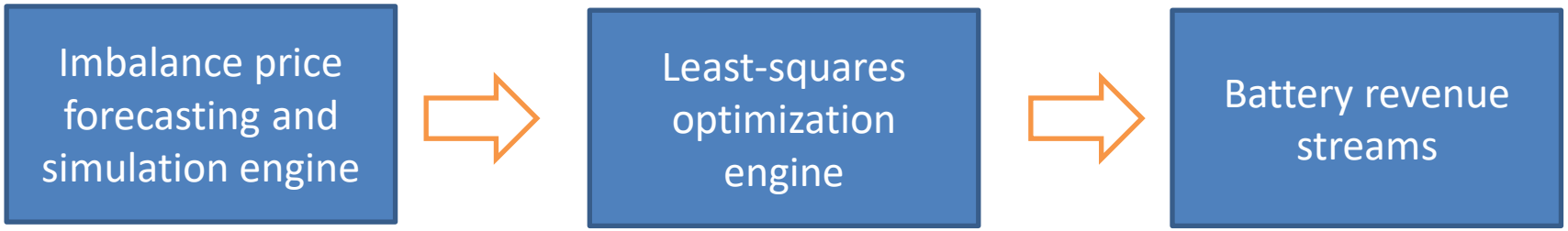
Forecasting imbalance price

- Imbalance price is forecasted for the next PTU
- Actual price will be different from forecast
- Forecasting accuracy can be manipulated in the KyBattery software, ranging from ‘basic’ to ‘perfect’.
- Example actions with imbalance trading:



How to value revenues from PI / NIV trading?

- Requires a short-term forecasting and simulation model for imbalance prices and imbalance volumes, e.g. 15 min basis
- Requires an optimal trading strategy per 15 min.
- Trading strategy should take into account the stochastic (uncertain) nature of the imbalance prices & volumes
- Least-squares Monte Carlo is ideally suited to perform this task:
  - Uncertainty in prices (Monte Carlo)
  - Least-squares regressions to assess uncertainty in values



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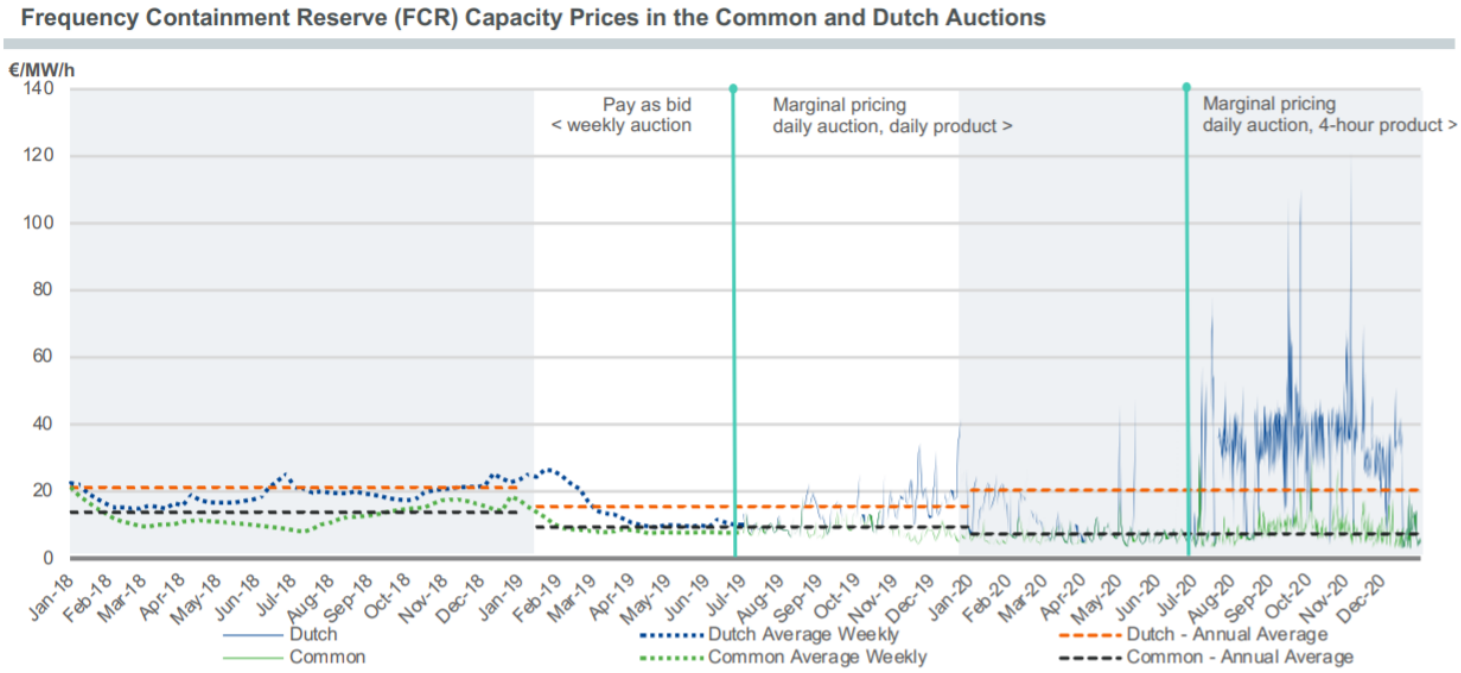
Market trading with FCR

General approach

- FCR: each TSO acquires a certain amount of capacity
- FCR in the Netherlands: acquired in 4-hourly blocks
- Service provider should pass tests to ensure almost immediate deliverability, up and down



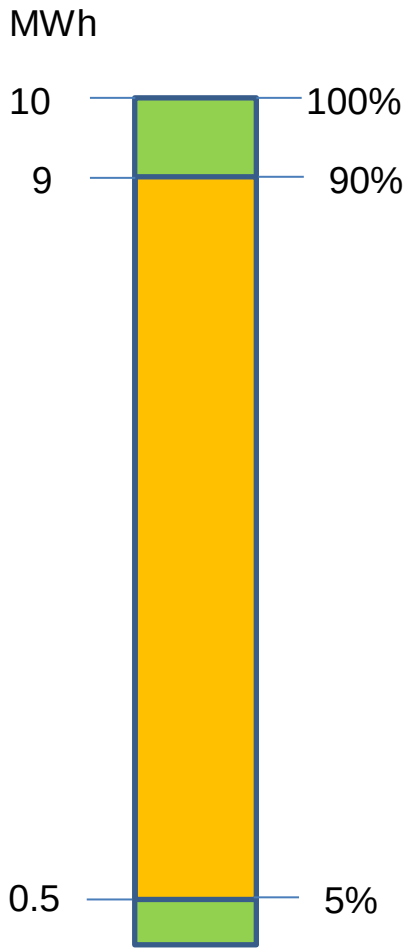
Source: Tennet

Example battery parameters and FCR

- Total energy capacity: 10.0 MWh
- Usable capacity: 8.5 MWh
- Charge/discharge rate: 9.0 MW
- Charge/discharge efficiency: 94%
- Time window: 2022 – 2029 8 years
- Maximum # cycles: 7500 full

  The model uses ‘virtual costs’ to arrive at appr. 7500 cycles

- When offering 6 MW FCR, we keep for trading:
  - Around 6 MWh usable energy storage
  - Around 3 MW charge/discharge rate
  - 6000 cycles per year (1500 less)



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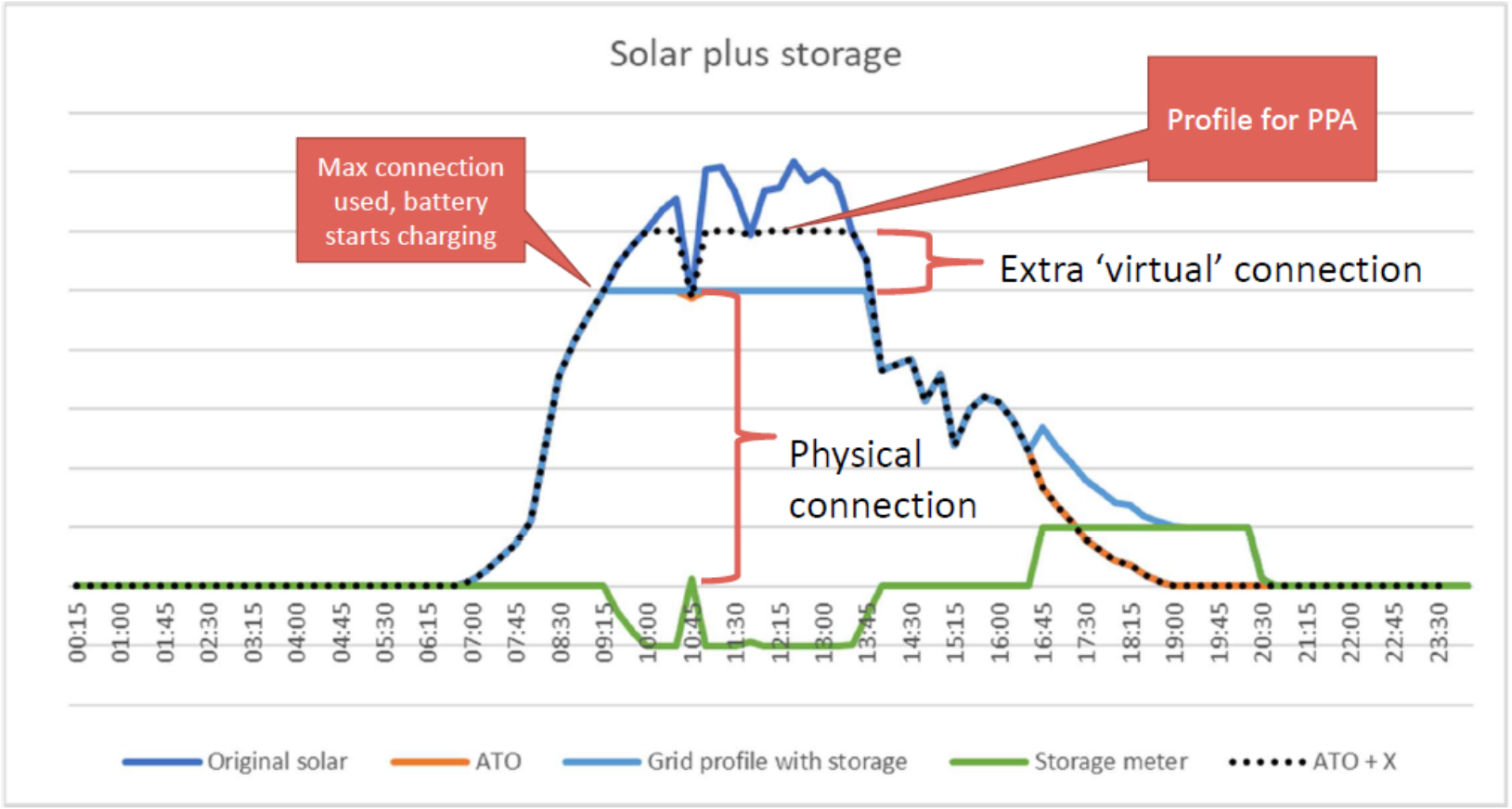
Peak shaving / co-sharing with solar

Extra virtual capacity for solar



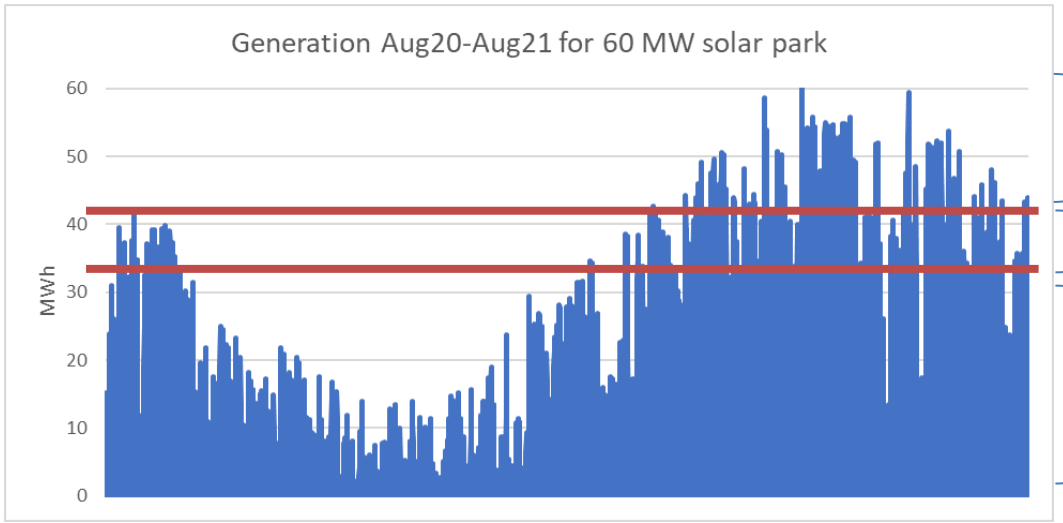
Source: InvestNL / Krachtwerk

Solar generation pattern: 1 year history

Historical analysis:

- 60 MW peak capacity, 42 MW grid connection
- 1 year: Aug 2020 – Aug 2021
- Location in the Netherlands
- Total generation 62.9 GWh, 12% load factor
- 1.26 GWh (2%) cannot be delivered to the grid

Excess generation, above 42 MW:			
	April	126	
	May	223	
	June	636	
	July	243	
	August	32	
	Year total	1260	MWh
	% of gen	2.0%	



	% of MWh	% of time
	2.0%	2.4%
	4.6%	3.4%
	93.4%	94.2%

Overview battery with solar

Solar generation (MW)

60.0

Solar generation capped to 50.4 MW

50.5

Solar generation capped to 42-50.5 MW
Battery stores up to 8.5 MW
Battery cannot offer FCR

42.0

Battery cannot discharge (fully),
but market prices are typically low
Battery cannot offer FCR

33.5

Full solar generation
Flexible use of battery, including FCR

0.0

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Valuing battery with solar

- Savings on grid connection costs (shared or sunk)
- Increased revenues for solar at times of high output
- Requires adequate contract between BESS operator and solar:
  - In specific time windows, solar may nominate charge/discharge, settled against DA prices
  - Nominations must comply with storage parameters
  - Battery pays penalty if nomination cannot be absorbed
  - Battery can still be optimized around the nominations

constrained optimization in KyBattery

Example results battery with solar

- Grid connection savings: 100
- Increased solar revenues: 20
- Loss in trading revenues: - 40
- Loss in FCR revenues: - 50

- Net gain of combination: 30

- Additional advantage: a larger part of the revenue stream is rather predictable

Conclusion

- Batteries earn money with different mechanisms
- FCR has formed an important revenue stream in many markets, but revenues are likely to decrease
- For a sound business case, batteries are optimized across:
  - Intraday and imbalance trading markets
  - Sharing connections, especially with solar
  - Offering other forms of ancillary services (not discussed)

Thank you

Time for Q&A

We look forward to supporting you in the rapidly changing energy sector!

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