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Will investments in energy storage pay off?

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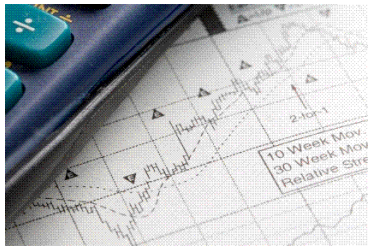
Introduction KYOS

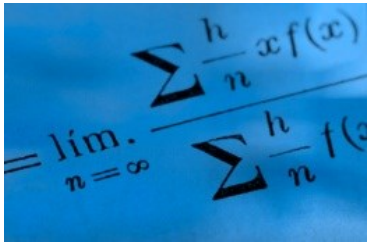
Who is KYOS?

- KYOS founded in 2008
- Specialist in energy & commodity markets: trading, valuation, risk management
- Core product: KYOS Analytical Platform

What do we offer in power markets?

- KyPlant - power plant optimization, hedging and valuation
- KyCurve - forward curve builder, using market prices
- KySim - Monte Carlo price simulation engine, multi-commodity
- KyPF - fundamental power market model





Will investments in energy storage pay off?

- The big challenge: balancing supply and demand in the future power system
- Balancing seconds or seasons? The move from batteries to hydrogen and other seasonal storage
- Will future power prices be extreme enough for a sound energy storage business case?

Where can batteries best be applied?

Mostly suitable short cycles of storage, sometimes just seconds

- Ancillary services: primary, secondary, tertiary
- Grid reinforcement
  - Lower investments in grid required
  - Flexible / transportable
  - May be directly connected to renewable energy source
- Retail market, self-sufficient homes
- Balancing 15-min markets

But: the future power system needs more!

Growth in renewable production

- Table shows combined GW capacities in DE+AT, FR, NL, BE, GB
- Lignite, coal, oil and nuclear will gradually be reduced
- Gas + biomass have to fill part of the gap (KYOS assumption)

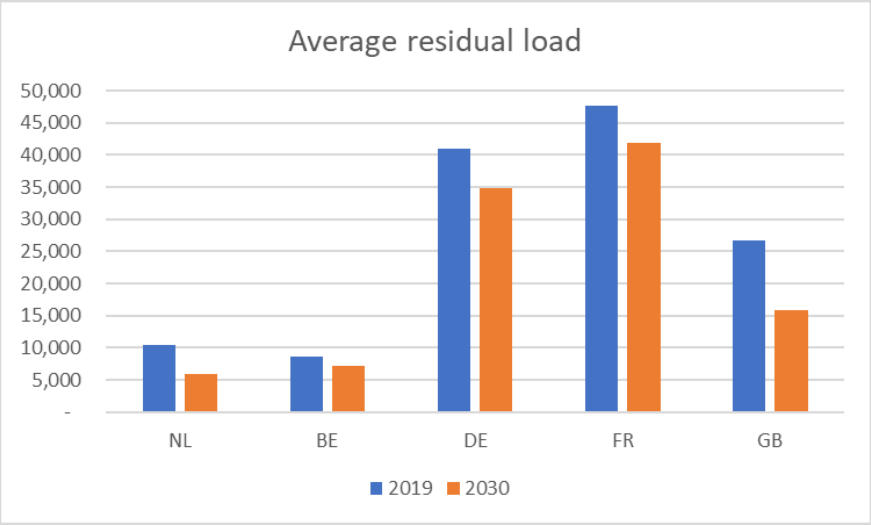
TOTAL PLANT CAPACITIES	2017	2030
Natural gas	93	107
Hard coal	43	21
Lignite	20	6
Biomass	10	25
Nuclear	88	52
Oil	10	7
TOTAL	264	218

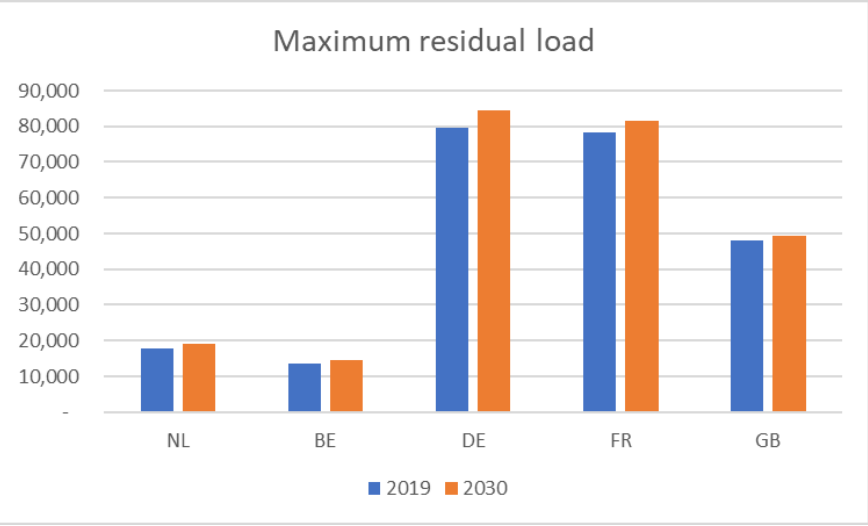
Will there be a gap to fill?

Residual load = Load – (wind + solar + hydro production)

Flexible generation needed to supply residual load:

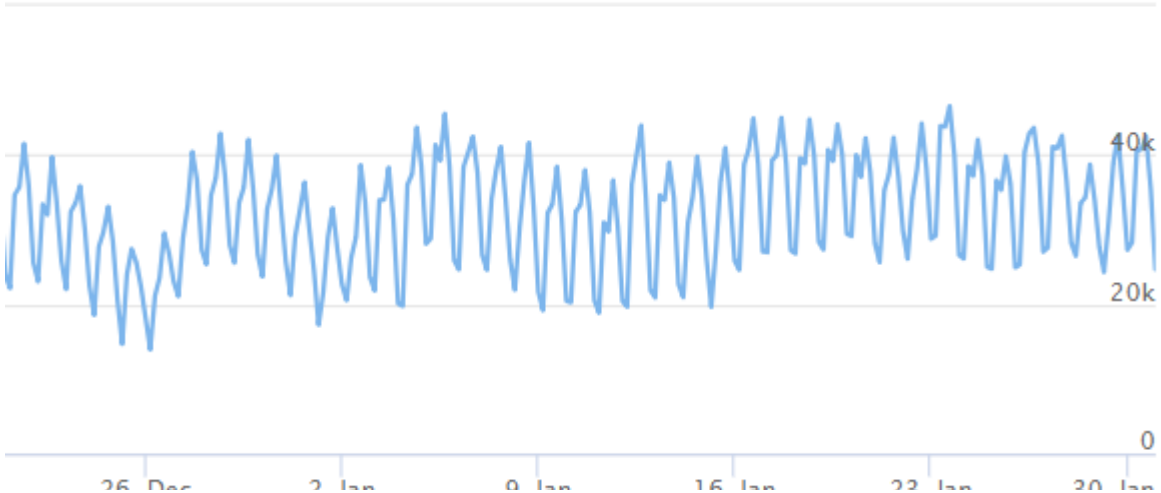
- Coal, gas, biomass, nuclear, oil, …
- Pump-hydro
- Other forms of energy storage





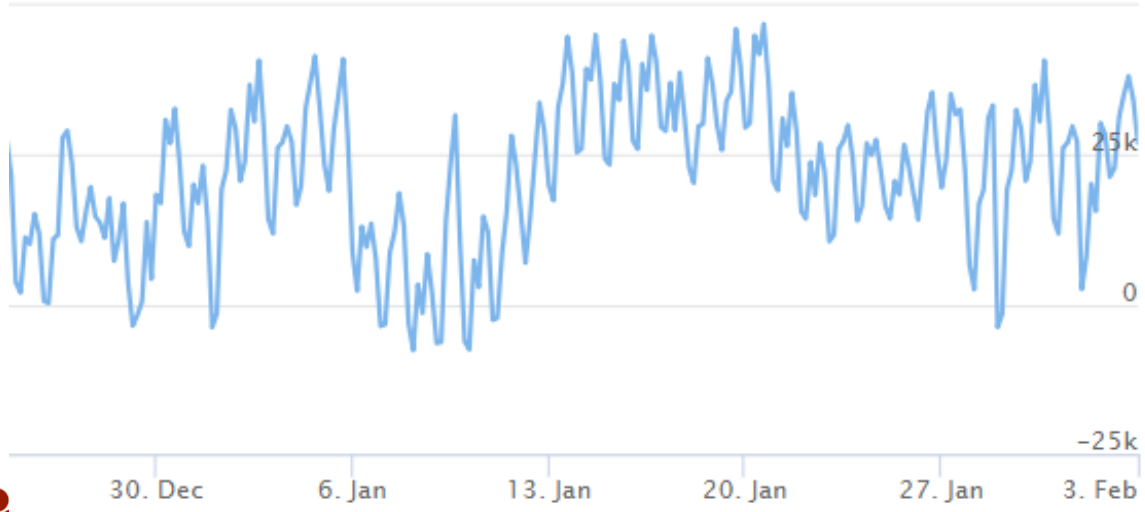
Residual load patterns will change

GB market: 2030 forecast versus 2017 (6 weeks around New Year)



2017

Predictable pattern between 20 and 40 GW, driven by demand



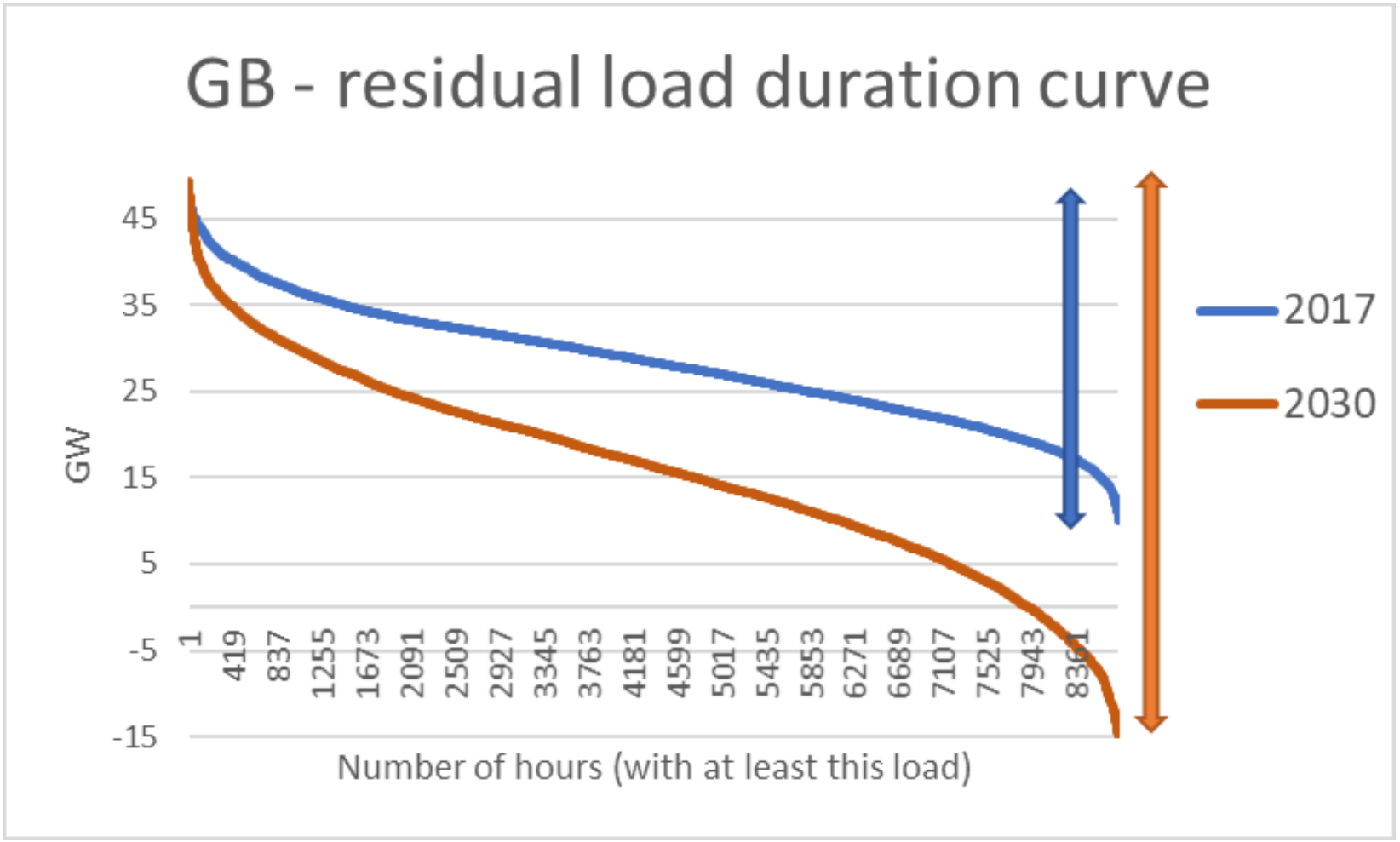
2030

Very volatile pattern between -10 and 45 GW, driven by renewable production (wind mainly)

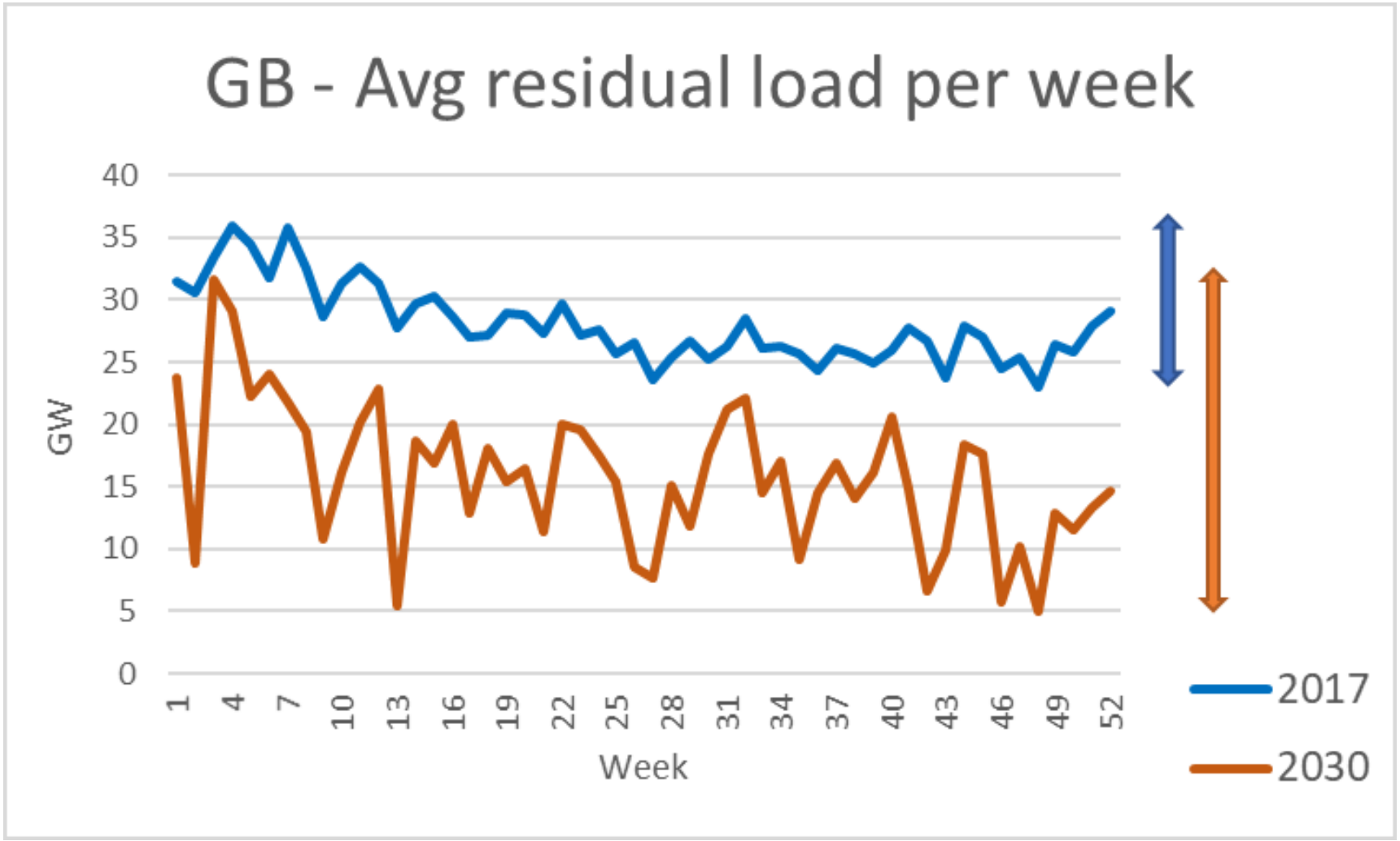
2008
2018

KYOS

Required ‘swing’ capacity will increase (1)

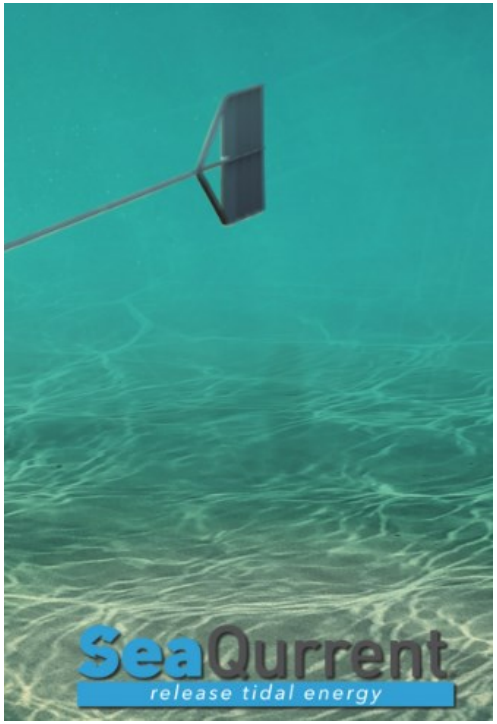


Required ‘swing’ capacity will increase (2)



How are we going to solve this?

- More ‘baseload’ renewable generation:
  - Run-of-river, reservoir hydro
  - Tidal energy
- More flexible ‘renewable’ generation
  - Biomass plants
  - Fossil plants with CO2 capture
- More gas-fired generation



AND

- Storage

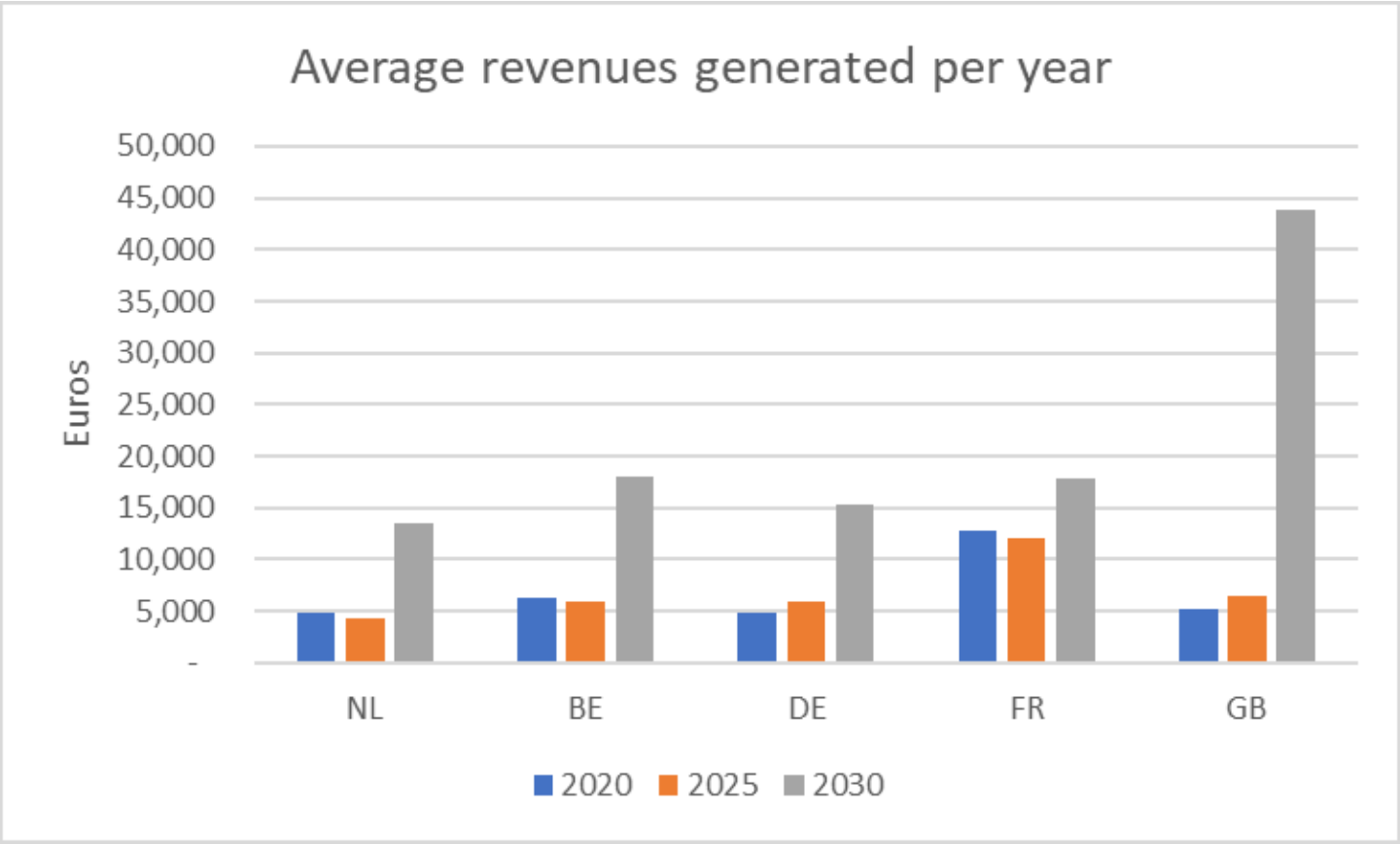
Making a case for energy storage

- Assess the value in the day-ahead power market (excluding revenue streams from ancillary services and balancing)
- All storages:
  - Supply 1 MWh of power per hour
  - Store 1 MWh of power per hour
  - Have an efficiency of 50% (2 MWh needed to store 1 MWh)
- Three ‘sizes’:
  - 1 hour (‘battery’)
  - 6 hour (‘pump-hydro’)
  - 144 hour (‘seasonal’)
- Five markets: NL, BE, DE+AT, FR, GB

Comparing revenues of the storages

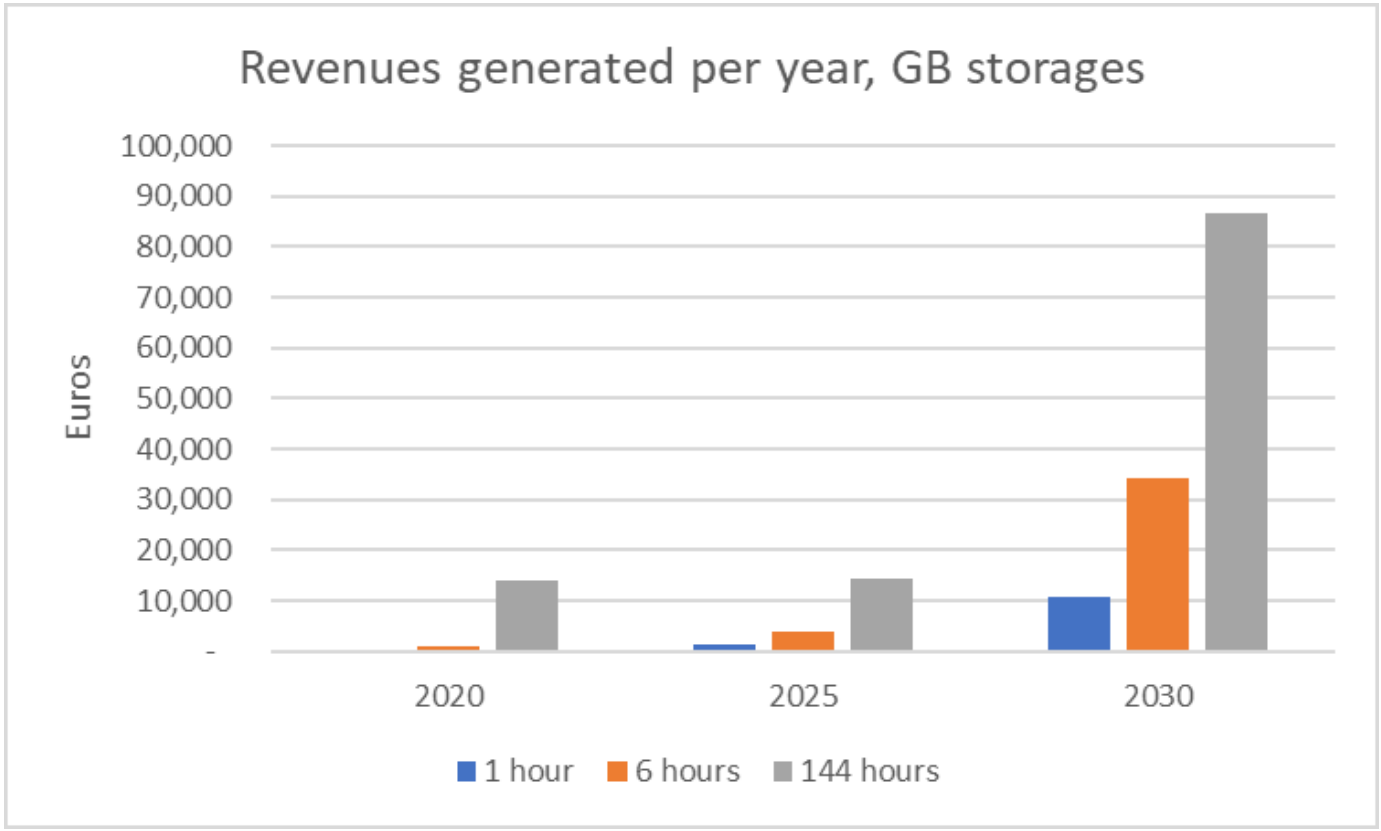
France most attractive in 2020 and 2025

Jump in value in 2030, especially in GB market (wind!)



Assessing storage revenue in the GB market

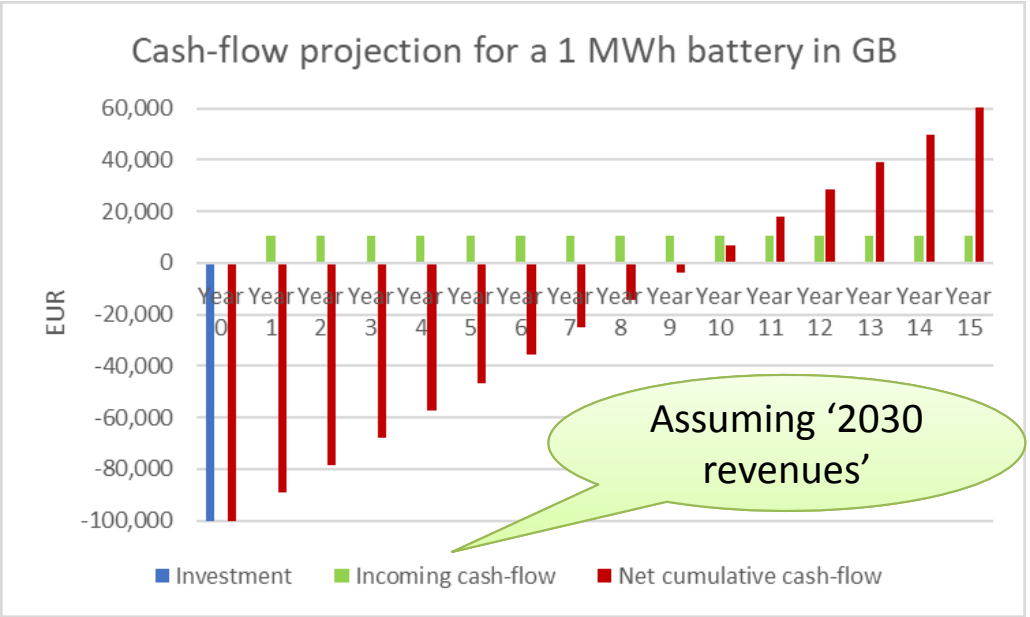
In 2030, storages with larger capacities may successfully make enough money in the ‘main’ power market



10-yr pay-back time for short-term storage in GB

- Costs of lithium ion battery storage:
  - Currently: 200 EUR/kWh
  - 2025-2030: 100 EUR/kWh?

- For the 1 MWh storage:
  - Lithium ion battery economical
  - Annual revenues 10,000 Euro
  - Payback time 10 years

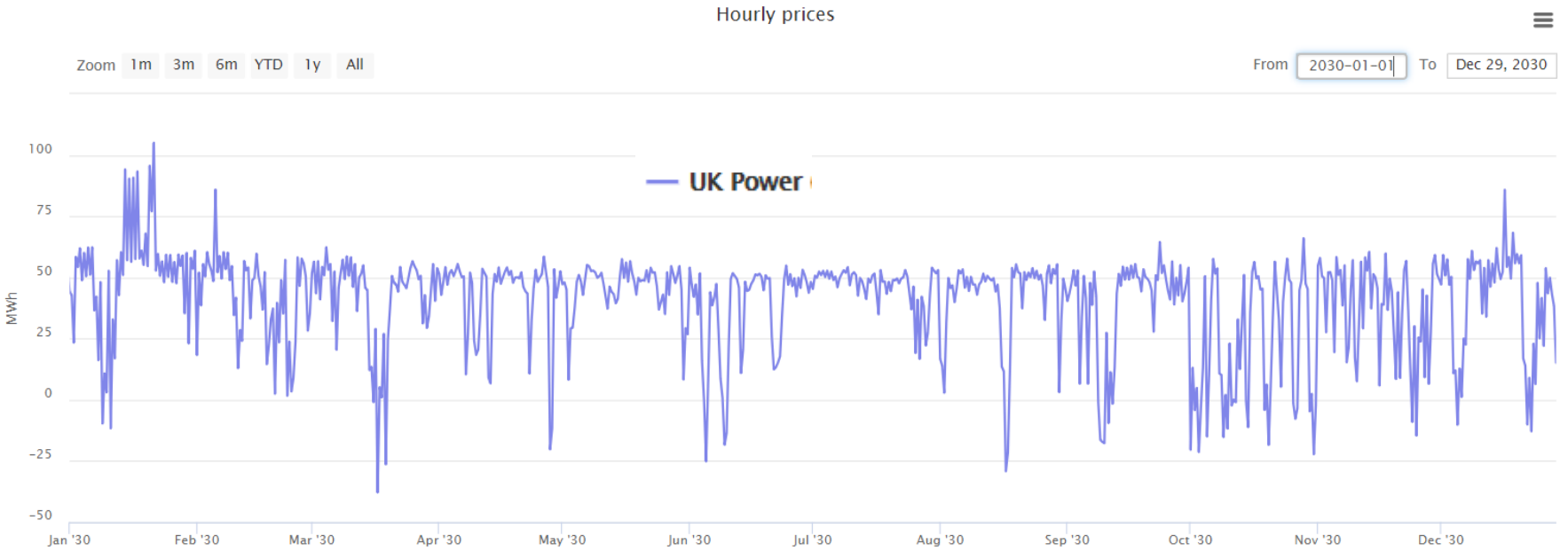


- For the 144 MWh storage:
  - Batteries are far too expensive (payback time of > 150 years)
  - Based on 1 source, we estimate costs to be around 12 EUR/kWh, leading to a payback time of 20 years

- Keep in mind that additional revenue streams (ancillary services), and additional costs (maintenance, financing) are not considered.

Forecasted power prices

- Important to move away from a simple stack or pure merit order model, because it ignores start costs, ramping between min and max, heat supply (CHP), and storage
- Market price is not simply ‘SRMC’, but should also consider costs of starting and opportunity costs of storage



Business case for energy storage difficult

- How to analyze?
  - In order to assess future scenarios, a simple stack or merit order model is not enough. The actual market behaves differently.
  - Start/stop costs, limited flexibility of plants and energy storage are often setting the price and making prices more volatile.
- What did we find:
  - The business case for energy storage is difficult (or impossible) until at least 2025 if used in the main energy-only market.
  - Only from 2030, prices in certain markets (GB in particular) can become so volatile to make a good business case

KYOS celebrates its 10-year anniversary

Create your own power price scenarios!

KyPF: fundamental power market model

- **Fundamental power market modelling**
- medium- to long-term price assesment
- power plants setting the price
- import/export

- **Main applications**
- For investors:
  value investments, scenarios
- For power traders:
  forecast power prices
- For policy makers:
  assess implications of policies
- For you?