Energy transition to a global carbon-neutral society

Gas Generation’s role in it !

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EnAppSys
- part of MONTEL GROUP

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- News
- Market Price Data Platforms
- Market Fundamental Data Platform
- Long term curves
- Insight & Consultancy

Introduction

At a European level …

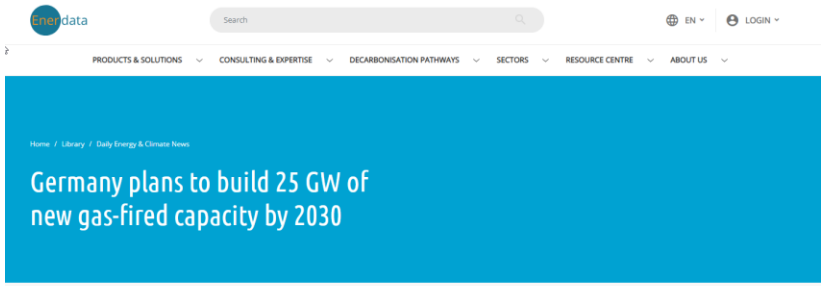
- new activity …
- capacity crunch…
- ageing nuclear/ closing nuclear
- and projected large increases in demand

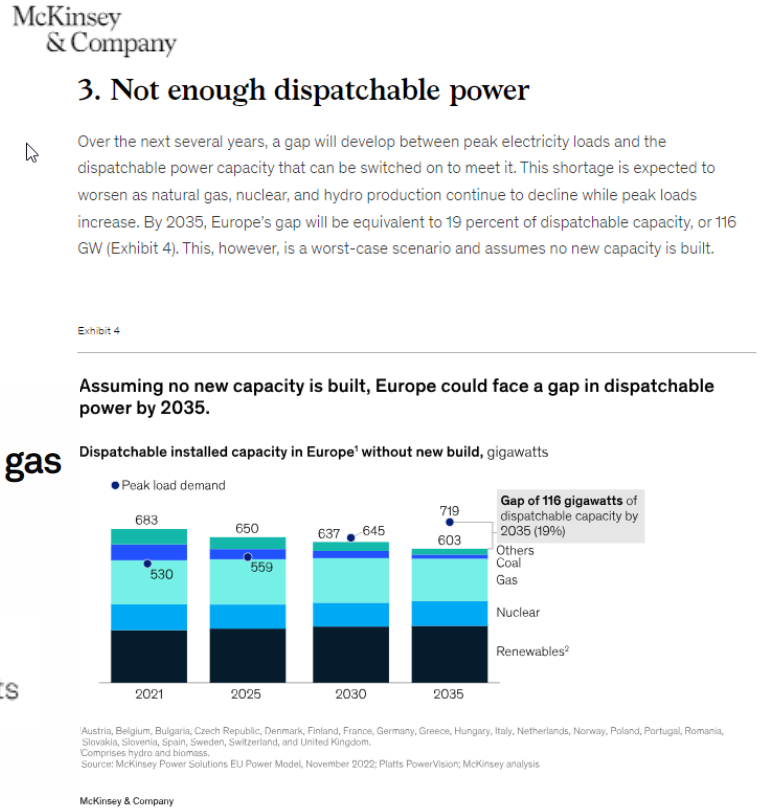
giving positive news for Gas Turbine/ Gas generation Sector

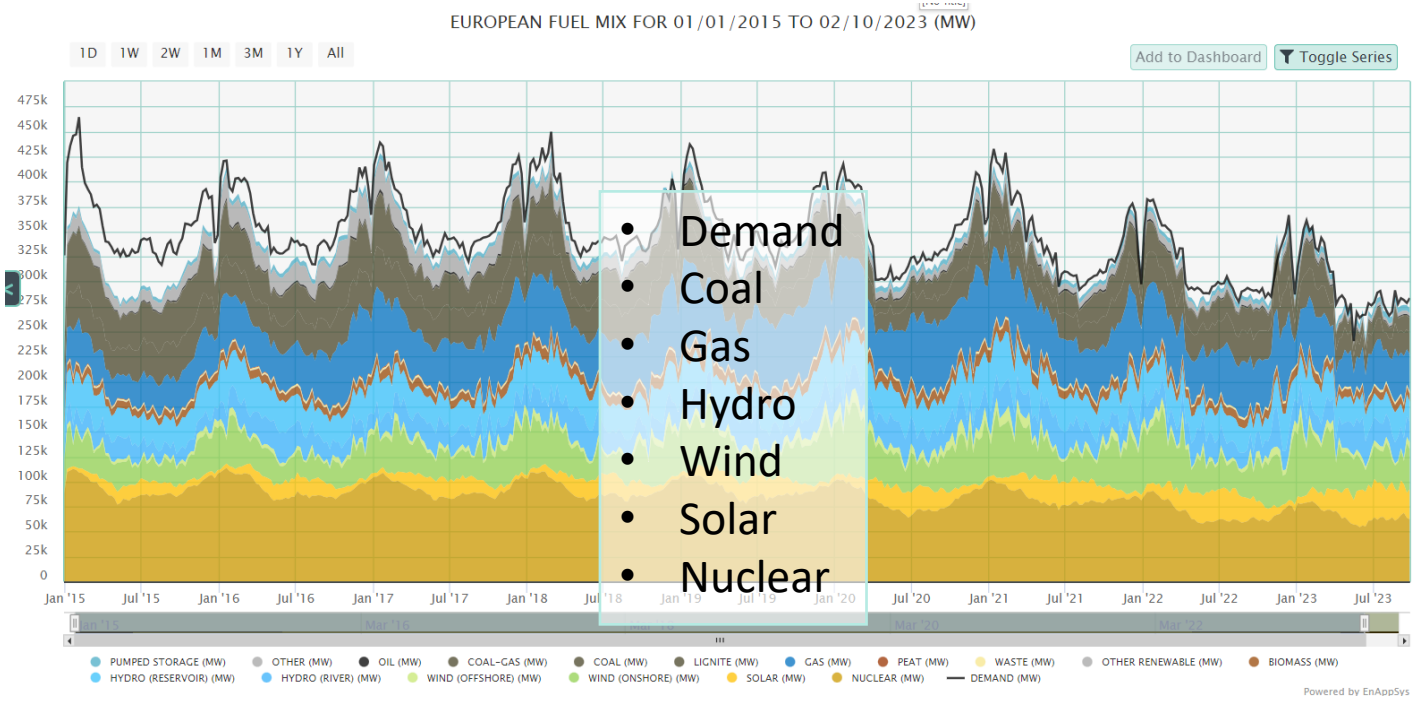
Presentation will Look at how CCG/OCGT Gas Generation is operating in the market

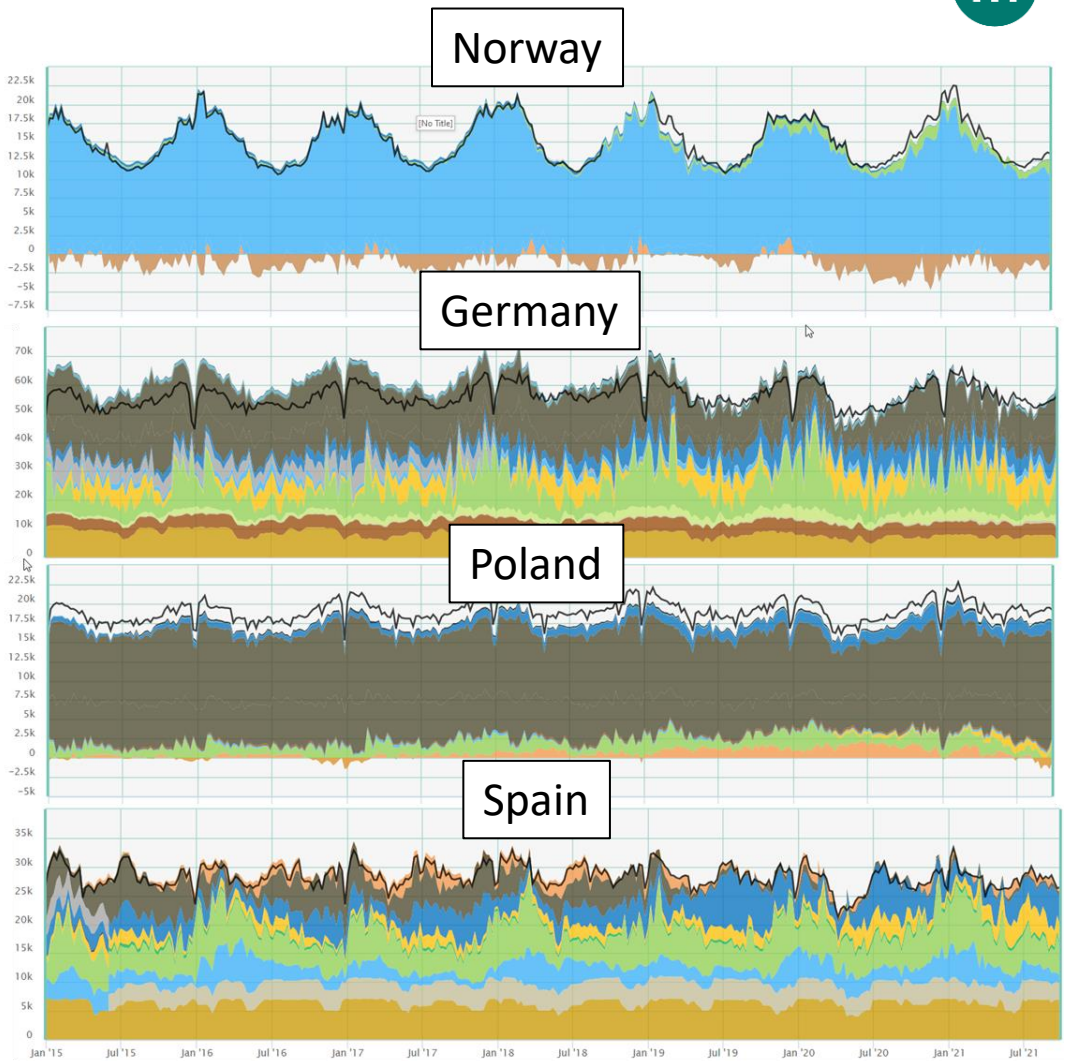
Look beyond it as “bridge” from Coal to renewables

Discuss "Stacked" revenue business cases







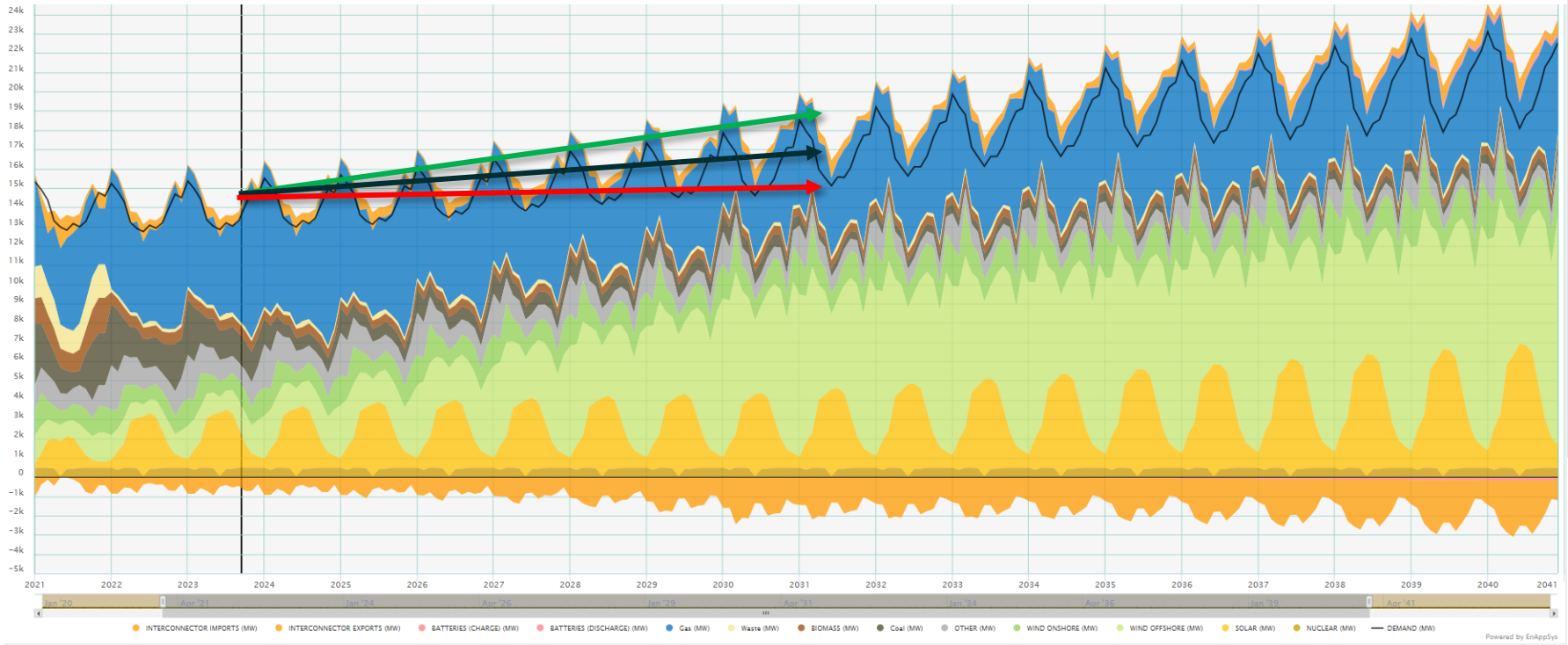


Gas in the EU Fuel Mix

- Still a key part of the fuel mix
- Sits in merit order behind ‘must run’ renewables (and Nuclear)
- EU Countries have differing fuel mixes
- Providing low carbon bridge from coal (Nuclear in Germany !) to net zero
- Prior to the “energy crisis” - traditional spark spread wholesale market business model was challenging

Example Forward Projection of Gas Generation in NL

- Demand (black solid line) to increase, with larger difference between summer and winter due to electrification of heat
- Under net zero significant demand growth from electrification of heat and transport and industry
- Issues when growth of demand/ renewables / closure of coal is out of synch
- Asset types that offer flexible generation will be needed in the future

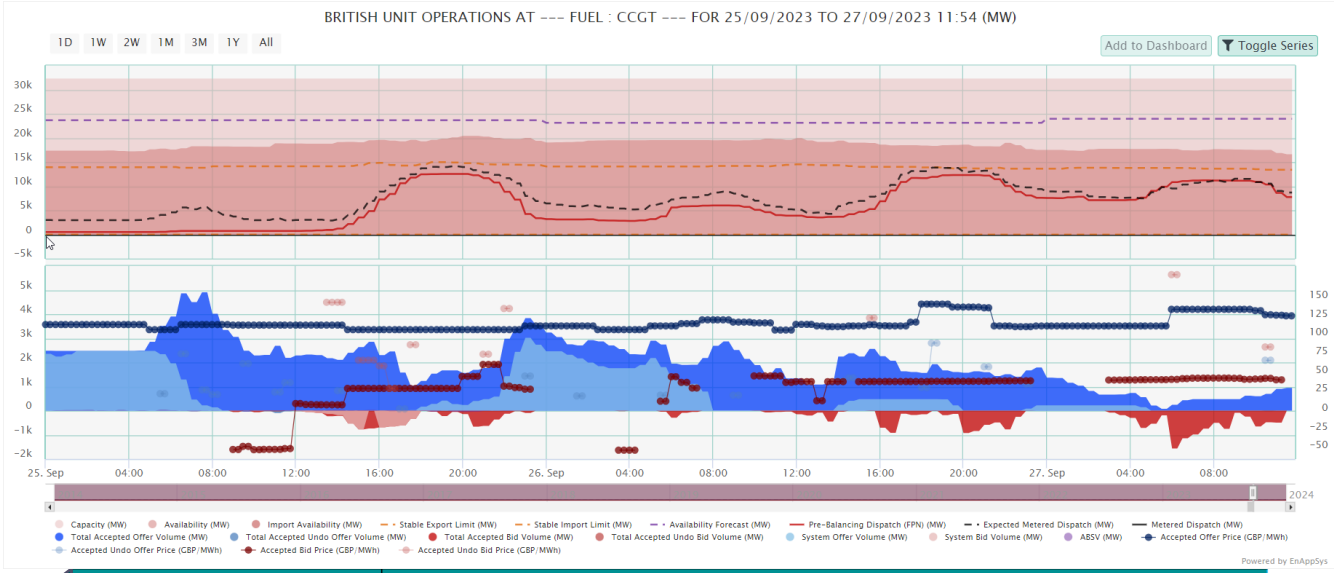


KEY

- Interconnector Import
- Demand
- Gas
- Biomass
- Wind
- Solar
- Nuclear
- Interconnector Export

What role in the power market does gas generation currently occupy?

- Power into wholesale markets (to end users via suppliers and brokers)
- Grid Services
  - Supply/Demand/Renewable Balancing
  - Inertia / Frequency Stability Services
  - Voltage regulation – reactive Power
  - Blackstart
  - Capacity Reserve
- Constraint Mitigation
  - Current EU/GB transmission grids have problems managing renewable growth



Service	Lead Time	Min Availability Duration	Direction	Possible from Cold?	Possible if Online?	GB Equivalent
FCR	0-30s	15m	Symmetrical	No	Yes	Dynamic FFR
AFRR Availability Up	0-30s	15m	Up	No	Yes	MFR
AFRR Availability Down	0-30s	15m	Down	No	Yes	MFR
AFRR Free Bids Up	0-30s	15m	Up	No	Yes	Pumped Storage Spin Gen Low Freq. Response
AFRR Free Bids Down	0-30s	15m	Down	No	Yes	No clear equivalent
MFRRsa Up	15-30m	15m	Up	Yes	Yes	Fast Reserve (ended)
MFRRsa Down	15-30m	15m	Down	Yes	Yes	No equivalent
MFRRda Availability Up	10-15m	60m	Up	No	Yes	STOR
MFRRda Availability Down	10-15m	60m	Down	No	Yes	No equivalent
Redispatch (ROP)	>30m	60m	Up/Down	Yes	Yes	~ODFM (down)
Congestion Distr. Grid	>30m	15m	Up/Down	Yes	Yes	Balancing Mechanism (not a service)

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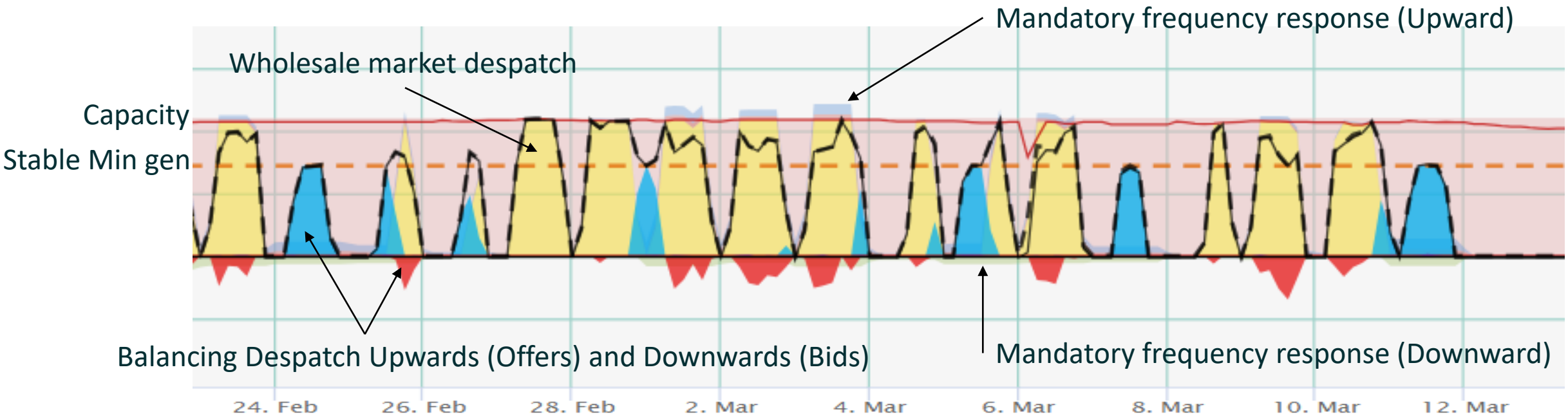
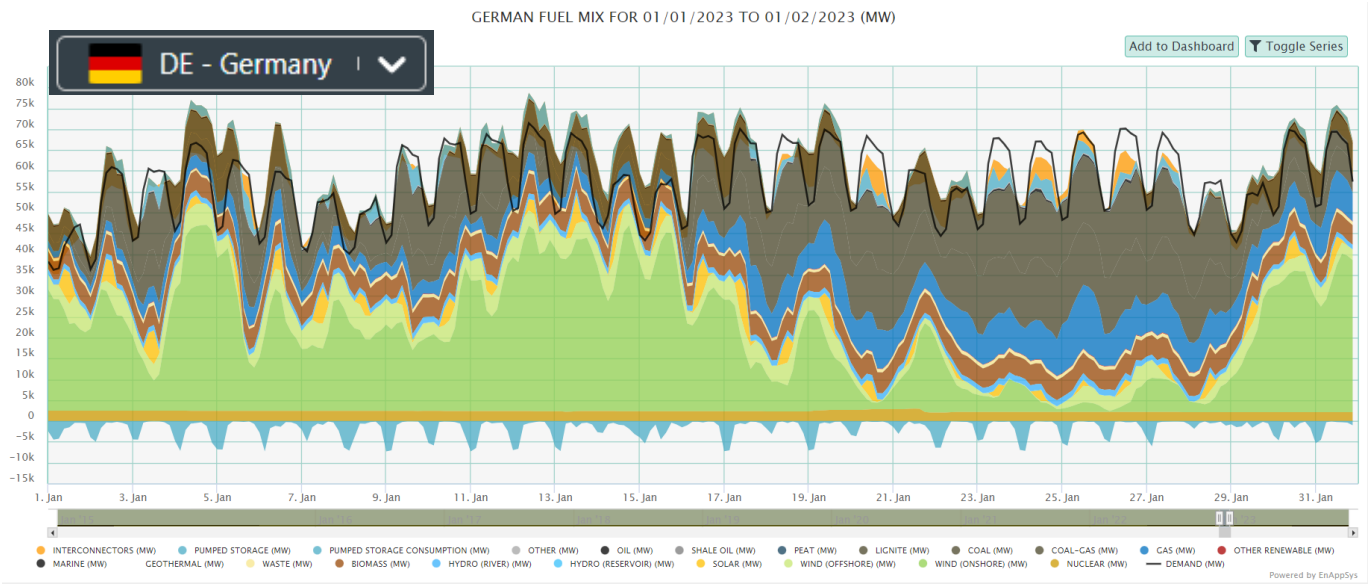


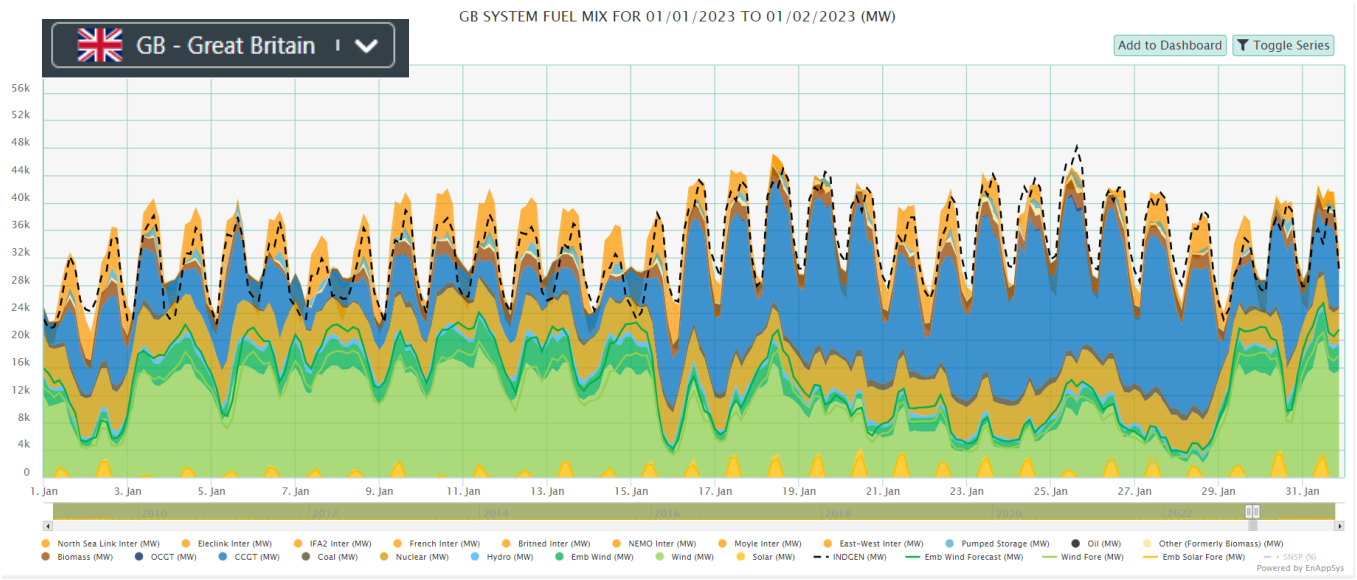
Connahs Quay 2 – 330MW GB CCGT Unit (Single shaft GE9FA)

- Shows operation in multiple areas of the market
- “Stacked Services/ Revenue”
  - Wholesale
  - Balancing
  - Frequency
  - + Reserve Capacity via the Capacity Mechanism

What issues in energy transition does gas generation fill?

- Gas (flexible) generation often presented in net zero as essential to fill the gap
  - Replacement of high carbon emitting power stations (predominantly coal) with gas fired
  - Flexes with renewable output to match supply and demand
  - Provides dispatchable standby capacity
- For larger Combined Cycle Gas Turbines it does the above at scale and provides grid services to stabilise the grid.





Is it the best fit, What are alternatives and why GT's?

Coal Carbon Capture and Storage

- High Capex / high perceived project risk, awaiting government support at scale
- Geography/location for Carbon sequestration
- CCS kit may add inflexibility

Power to Gas – Hydrogen

- Storage and transportation solution (for power case)
- Storage-Conversion technology to power still needed

Large Scale Nuclear

- Long construction cycle
- Lifecycle costs (decommissioning)
- Requires government (and popular) support

Modular Small Scale Reactors

- Technology risk/ No significant build yet

Batteries – Solid State

- High capex v MWh stored - Degradation/ Life

Pumped Hydro

- Geographic limitations
- High capex – long construction cycle
- No significant private sector build to date

Conventional Hydro

- Only works with certain geography
- Cannot 'store' energy can just hold it back

Novel Storage - Flow batteries/ gravity/ CAES

- Similar to Pumped Hydro risk but also technology risk

Gas Turbine generation benefits:

- Proven/ mature technology that exists at scale
- Can burn multi-fuels for energy security
- Fits into existing grid design - lots of sites already!

Gas Generation/ Gas Turbines Role as part of “Storage” and Energy Security Solution

EnAppSys (now Montel) future scenario modelling identified …. a combination of green Power to H_2 and H_2 to Power **essential** to make the market work, at a reasonable cost and meet demand in a fuel mix with high renewable wind

Why ……

Low wind periods ….

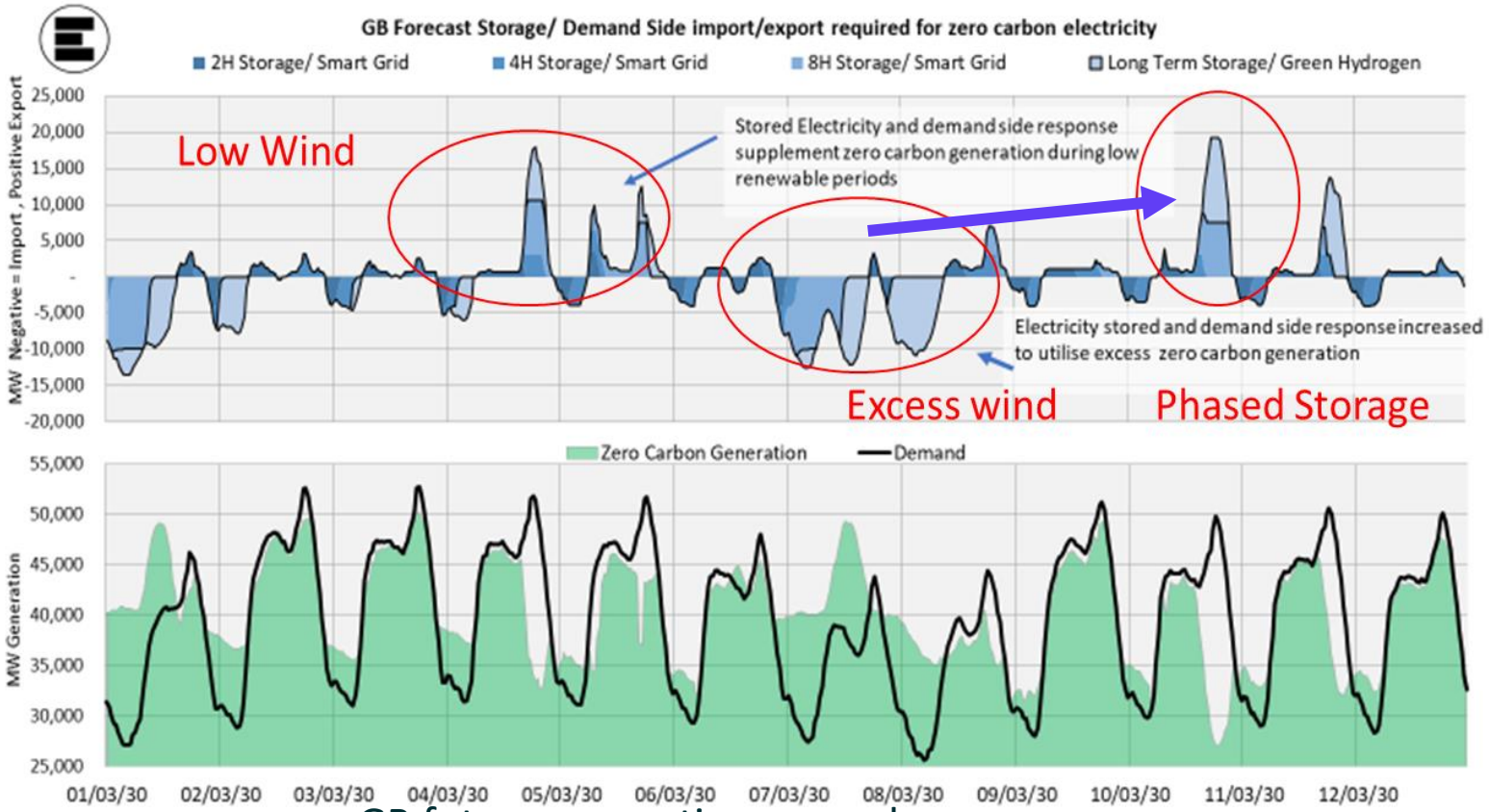
- short and medium term storage becomes depleted
- Even Hydrogen stores may be depleted

<u>A multifuel proven technology can be an integral part of a net zero (and beyond) fuel mix</u>

Renewable developers embracing co-location … batteries/ solar ..share grid resources

Gas turbine plant…Hybrid ?

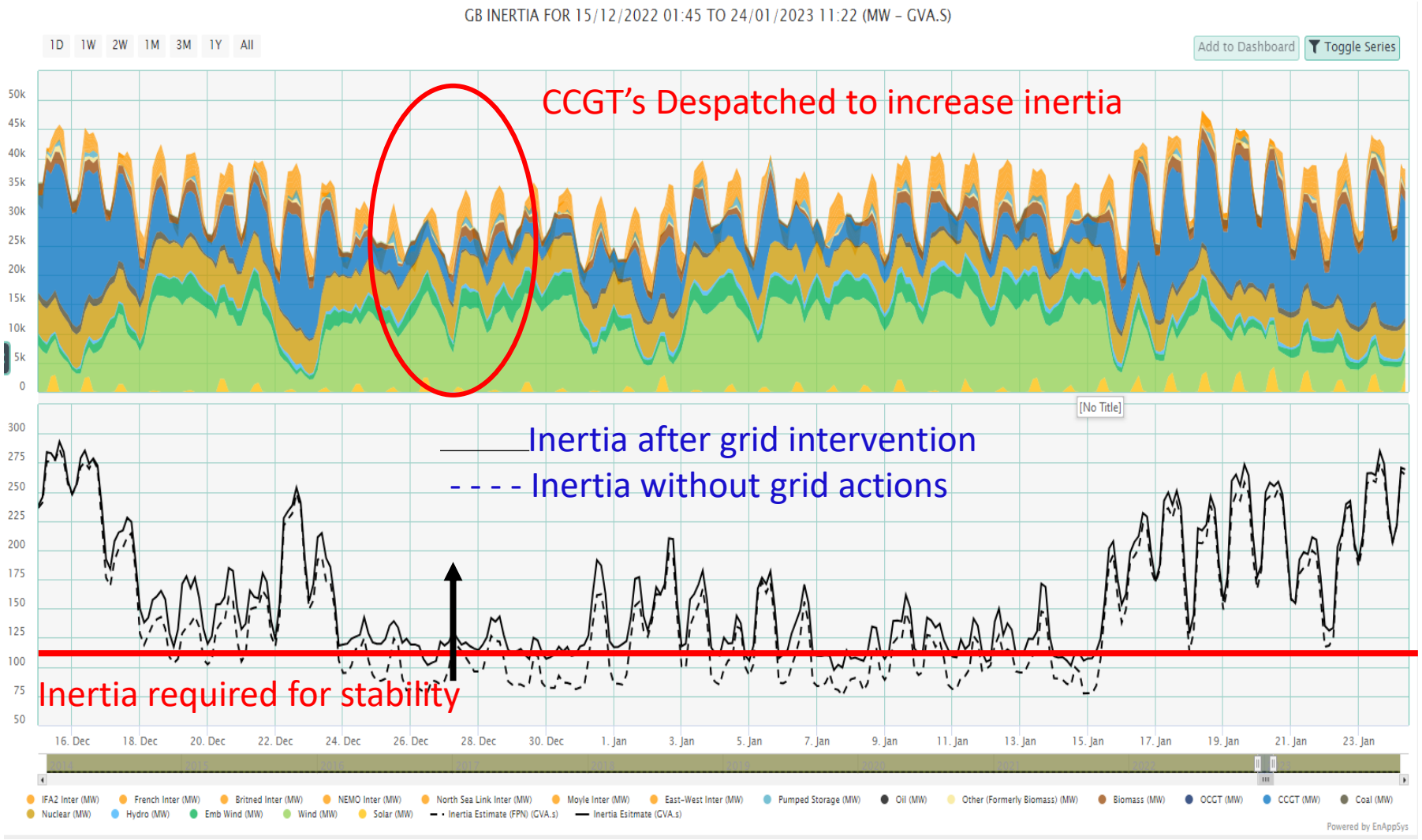
Moving Excess power 3 day forward



GB future generation example

Gas/Gas Turbines Role in grid stability

- CCGT/GT's provide significant inertia (and therefore stability) into the system
- TSO's intervene in periods where inertia is low
- TSO's looking to MW less inertia – eg synch condensers / synthetic inertia
- Can new Gas turbine designs / installations provide 'close to ' MW less inertia ????



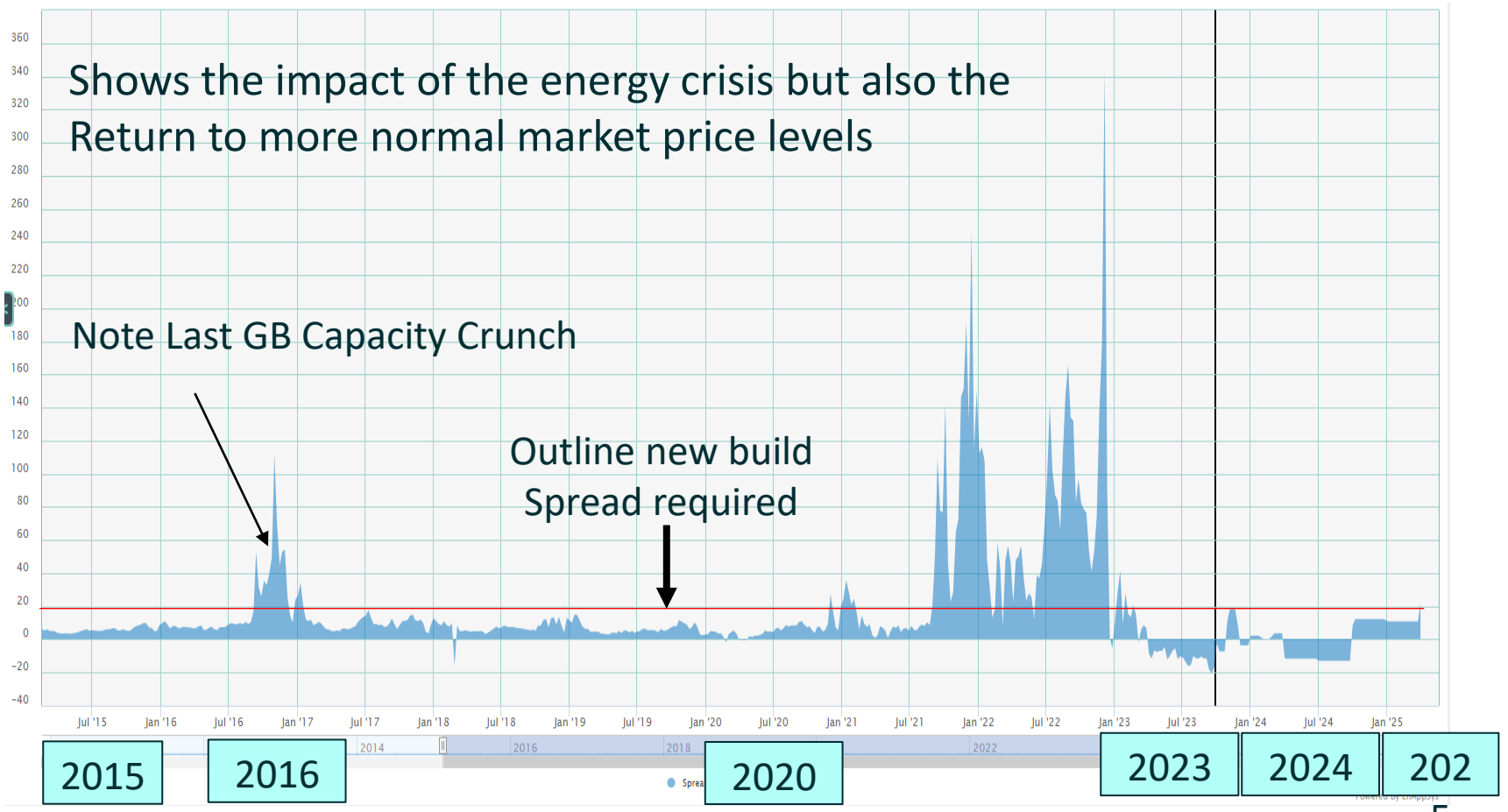
New Investment / Continued Investment Case Challenge

- Traditionally CCGT/CHP/Gas Generation business cases built on forward base load spark spread curves

- The Chart (peak running spread) shows that a simple business model based on wholesale energy sales won't meet new investment criteria alone

- Investment in existing plant similarly will need different business cases

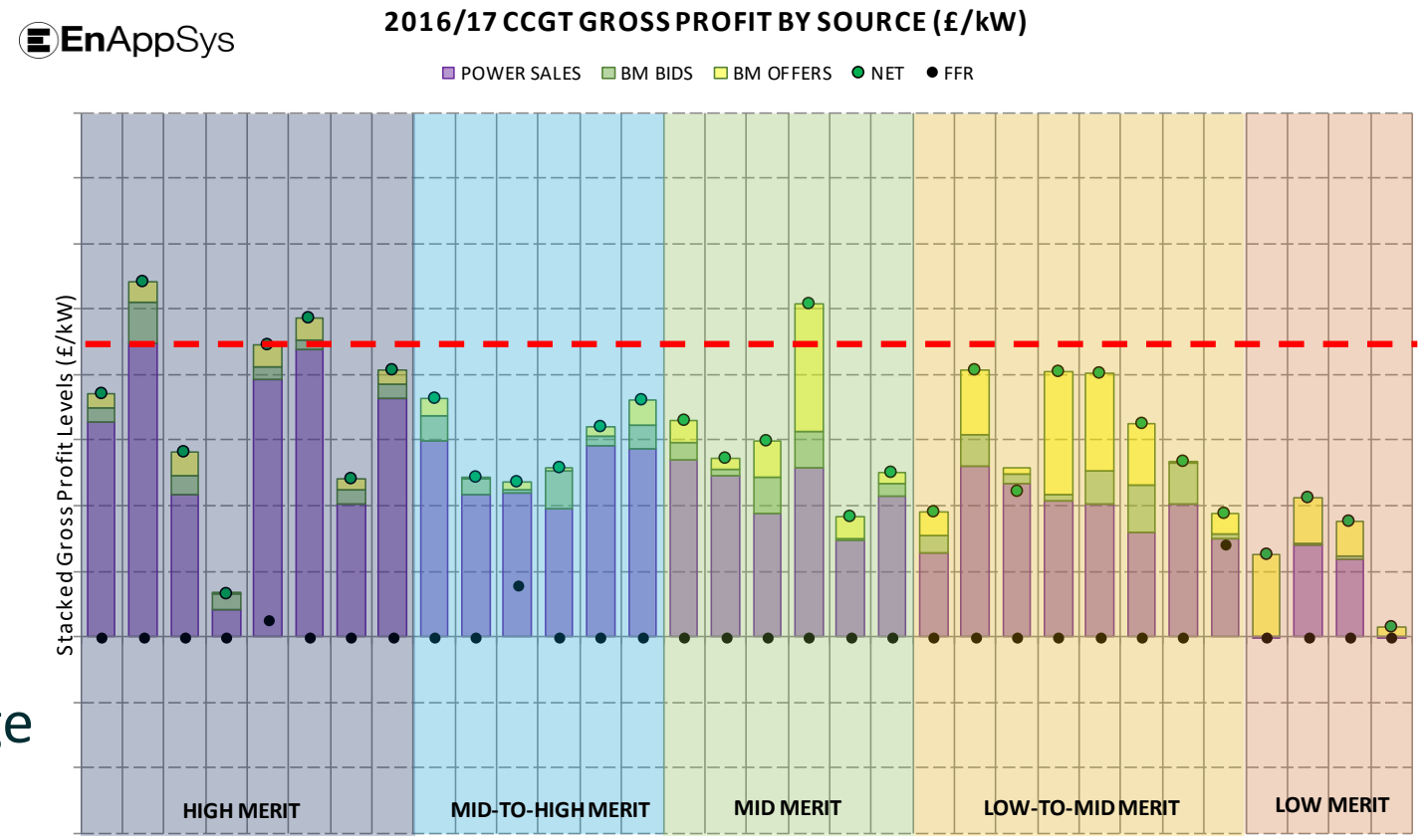
Example Spark Spread Chart (peak running NOT baseload)



Stacking Revenue

- Wholesale market revenue +
- Balancing +
- Grid Services (ancillary services) +
- Fuel optionality +
- PPA support +
- Capacity mechanisms
  (Availability payments by governments for security of supply) + grid services contracts are key

Generation flexibility required to manage asset despatch around negative price periods (and turn into revenue)



Closing

a. CCGT/OCGT/ Gas Generation is a key part in the energy transition
b. Building new plants in rapidly decarbonising markets is challenging without some level of government support and a stacked revenue approach
c. Need to think differently about revenue and operation (build in flexibility, grid services, multifuel)
d. Consider co-location/ hybrid with “new technologies”
e. Key advantages of the industry in being part of the long term solution
    i. Large base built
    ii. Flexibility for future green gas
    iii. Adaptable to carbon capture
    iv. track record of innovation and pushing the boundaries of what is achievable
f. Industry on all sides to embrace and work with new technologies and new fuels.
g. Lobby and input into regulatory discussions

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Thank You

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