



# **Support for low-carbon generation and energy storage in the UK**

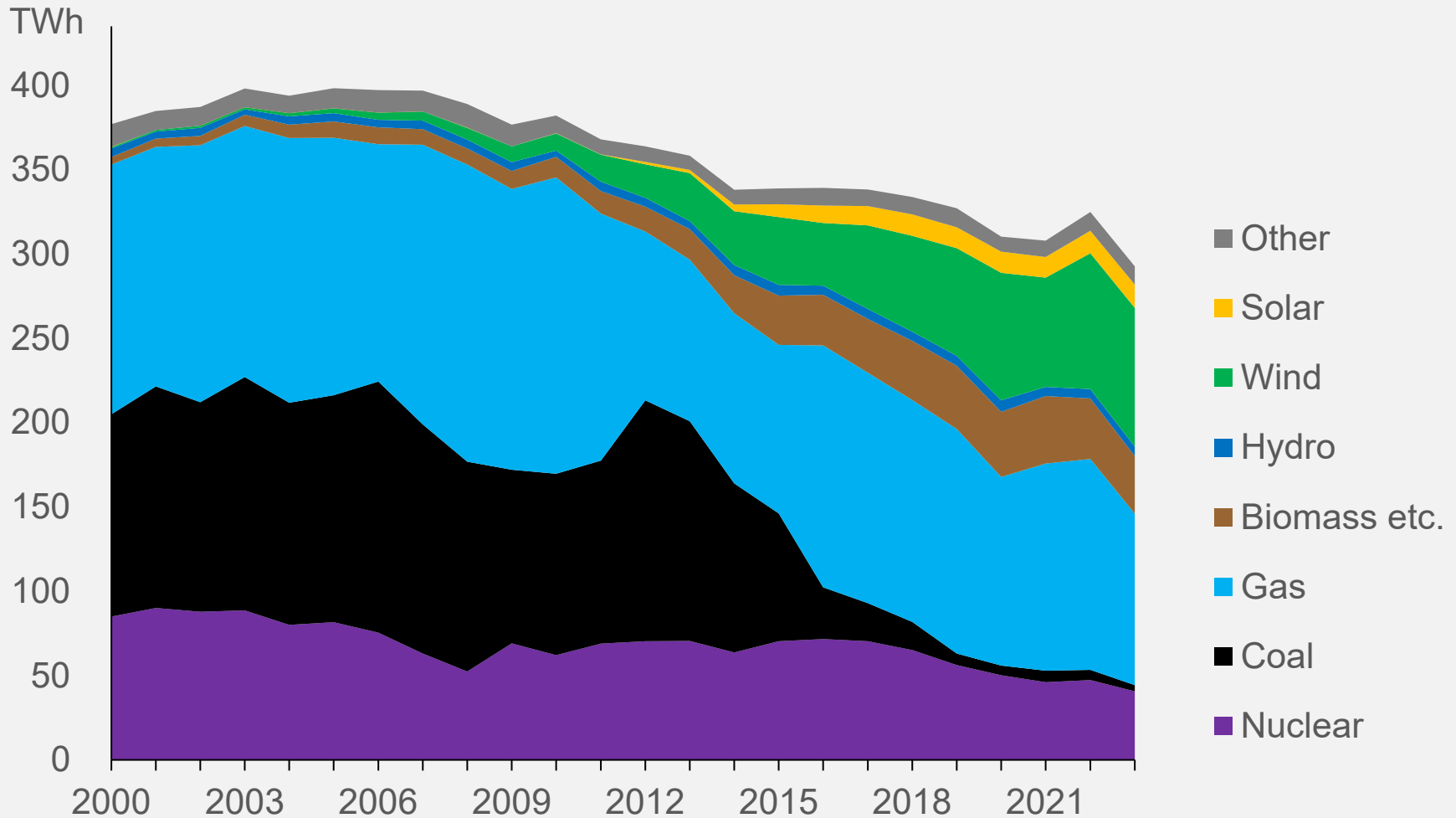
Richard Green

25 October 2024



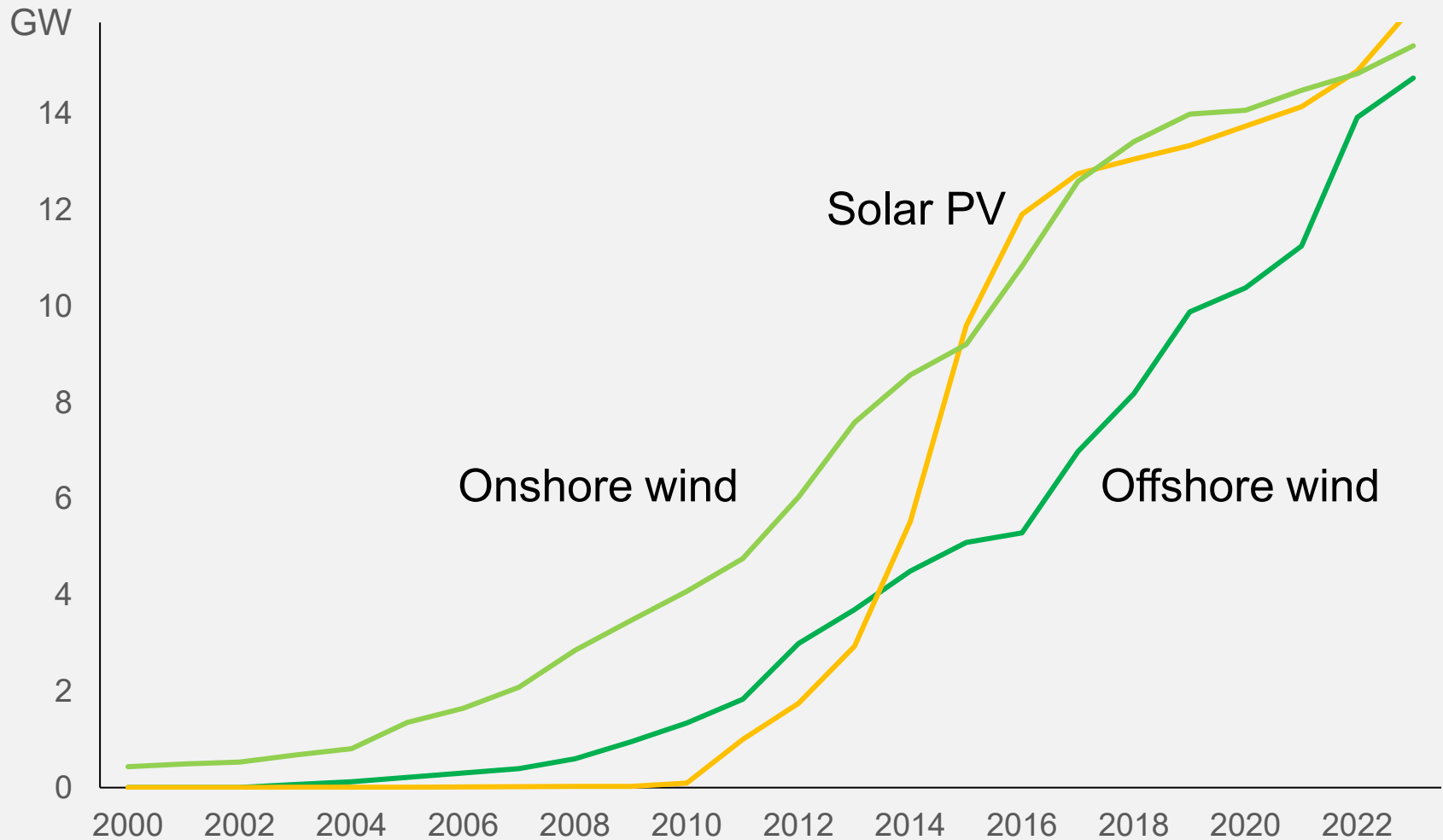
## **The rise of renewables**

# UK Electricity Generation



Source: Digest of UK Energy Statistics

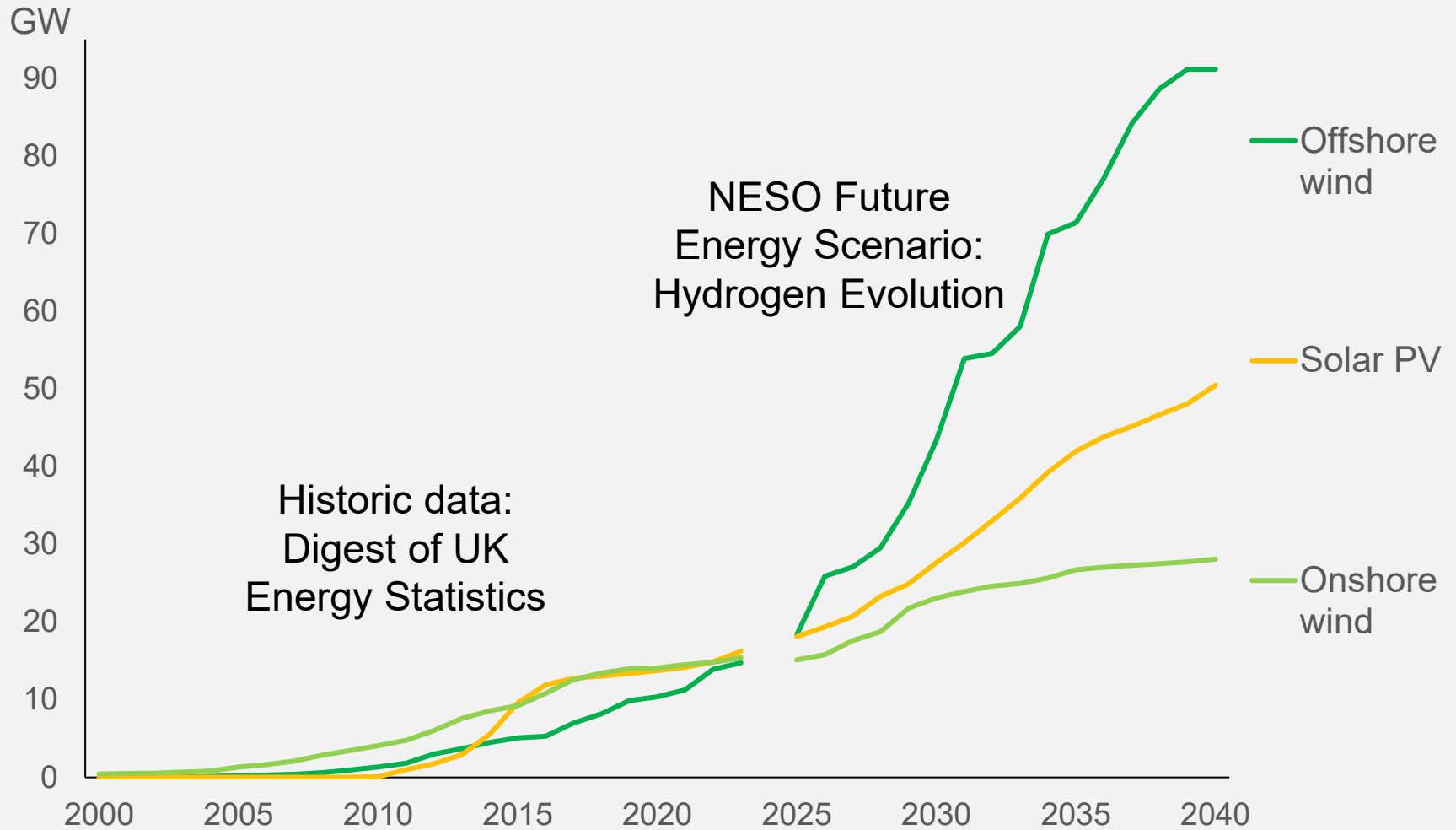
# UK Renewable Capacity



Source: Digest of UK Energy Statistics



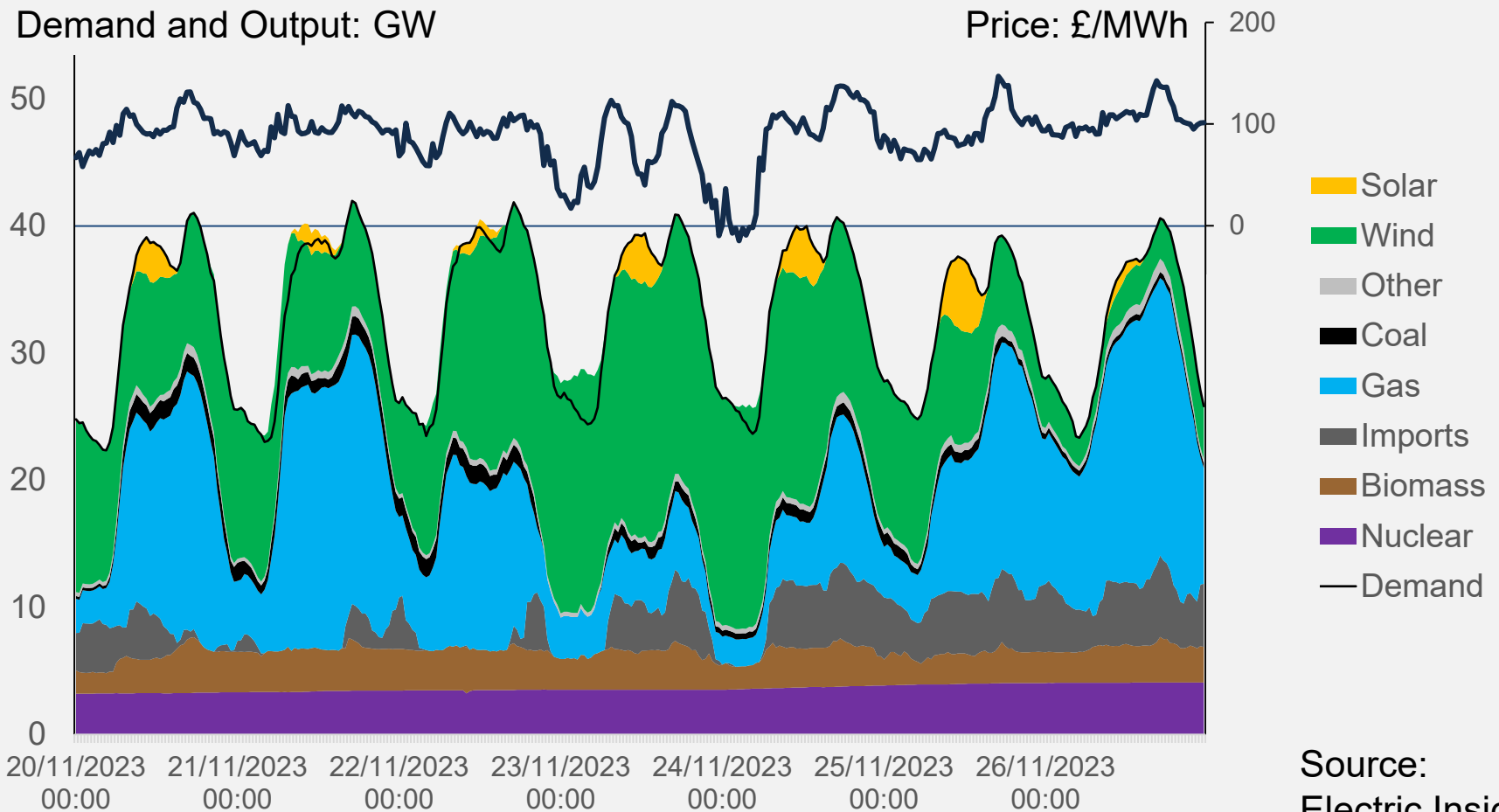
# UK Renewable Capacity



NESO forecasts exclude Northern Ireland

# A week in November 2023

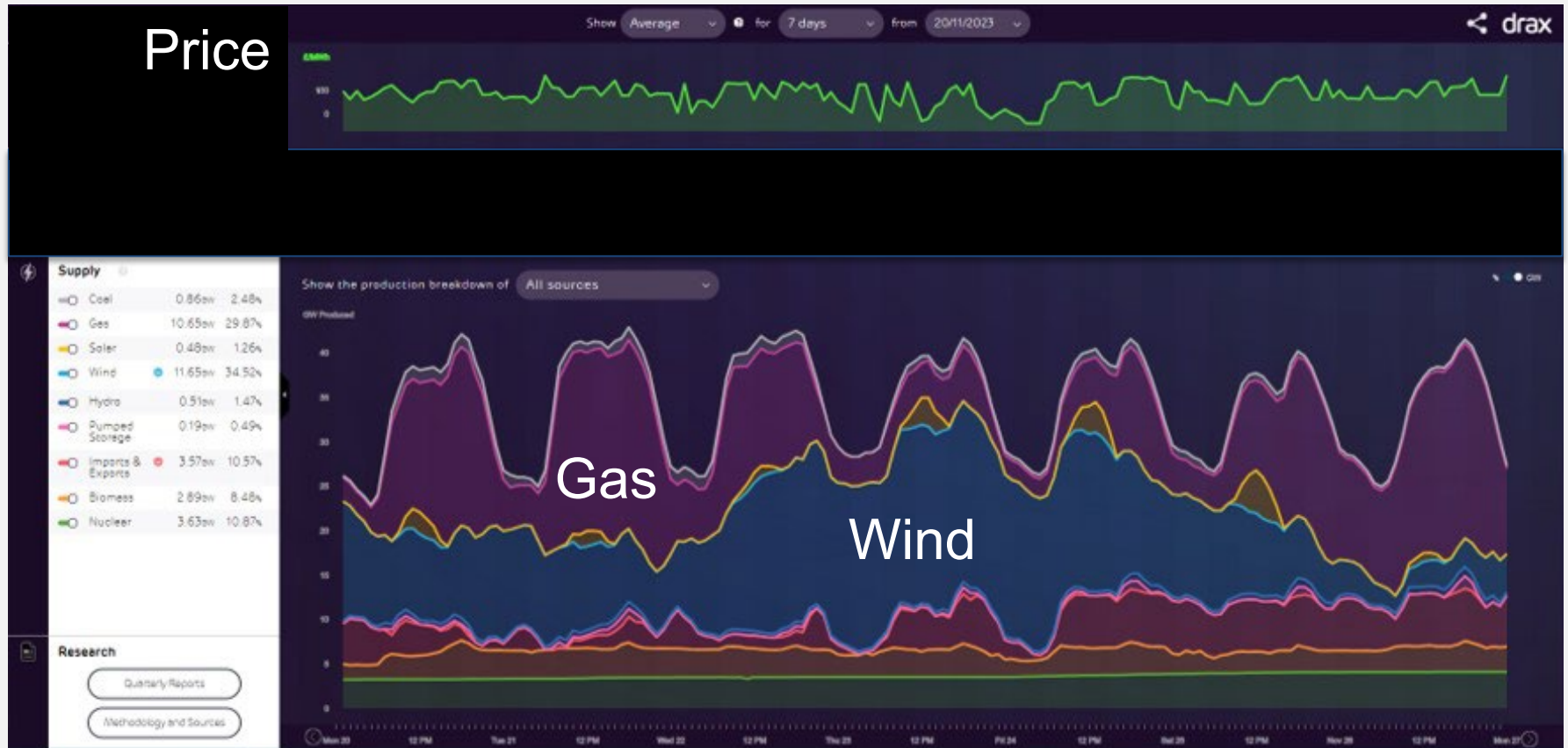
## Day-ahead price and out-turn demand



Source:  
Electric Insights

# A week in November 2023

Display from Drax Electric Insights



[https://electricinsights.co.uk/#/dashboard?period=7-days&start=2023-11-20&&\\_k=jhfelb](https://electricinsights.co.uk/#/dashboard?period=7-days&start=2023-11-20&&_k=jhfelb)



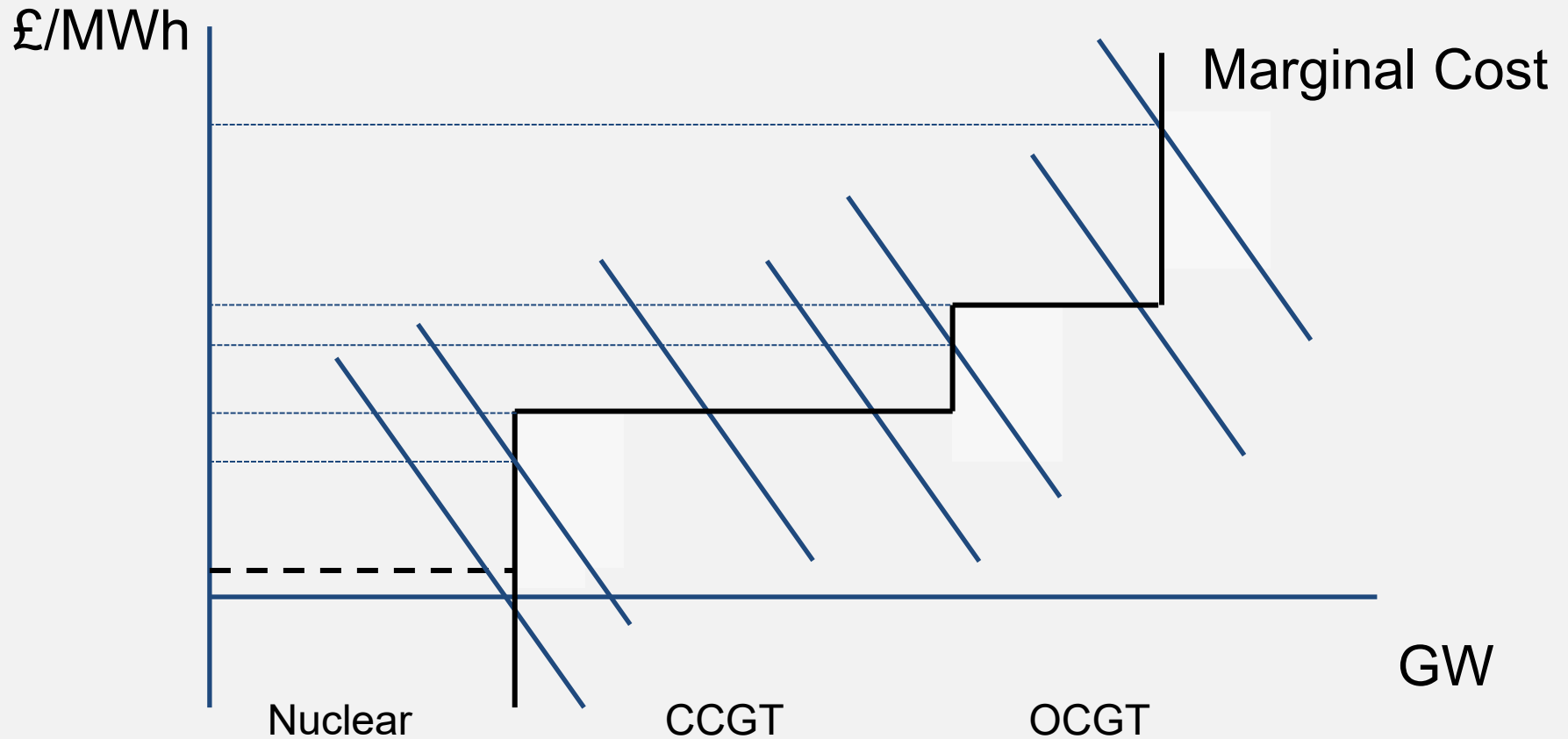
## **Price setting in a power market**

We're not in Cushing any more!



# Demand and Supply

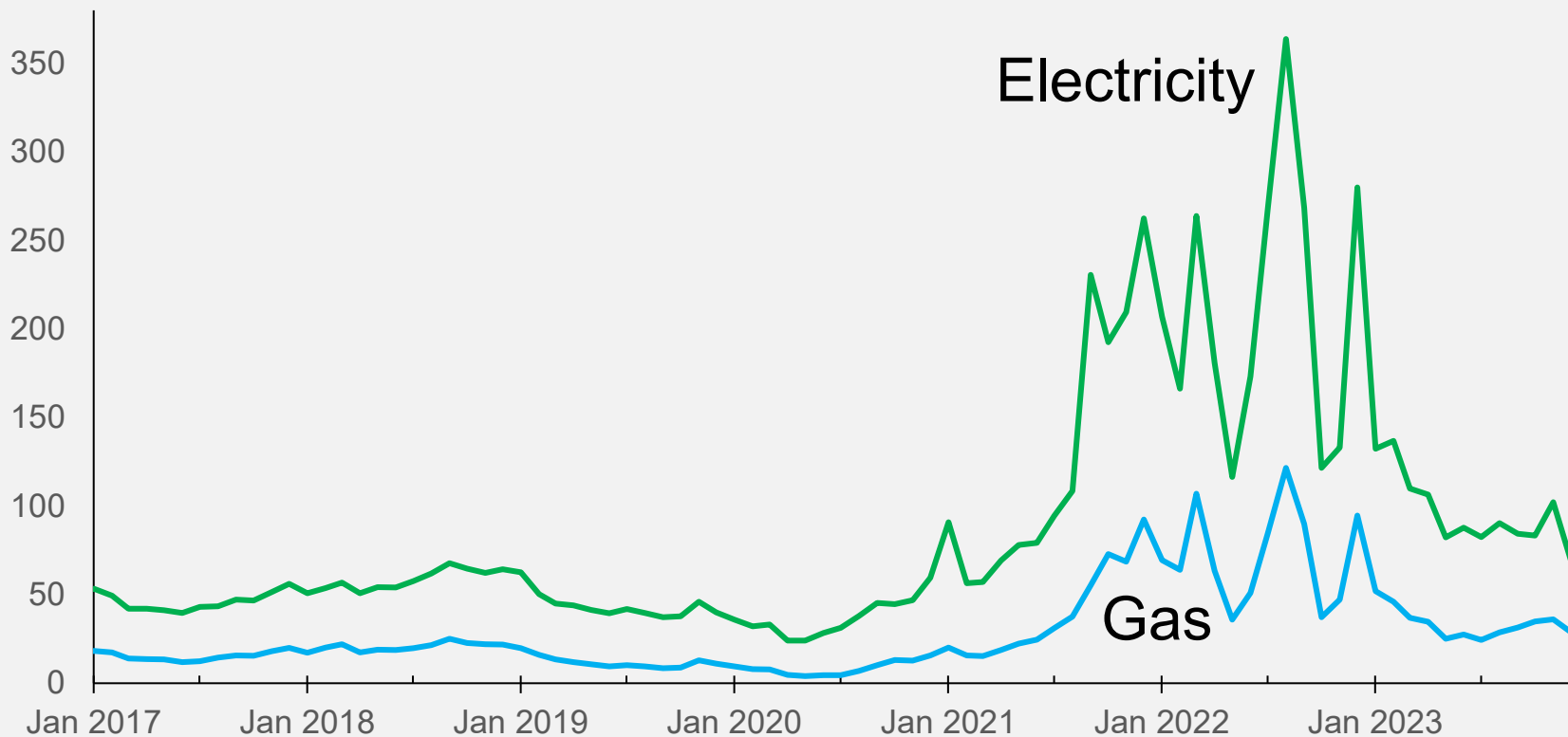
Prices reflect Marginal Costs



# Gas and Electricity Prices

Day-ahead prices (monthly averages)

£/MWh



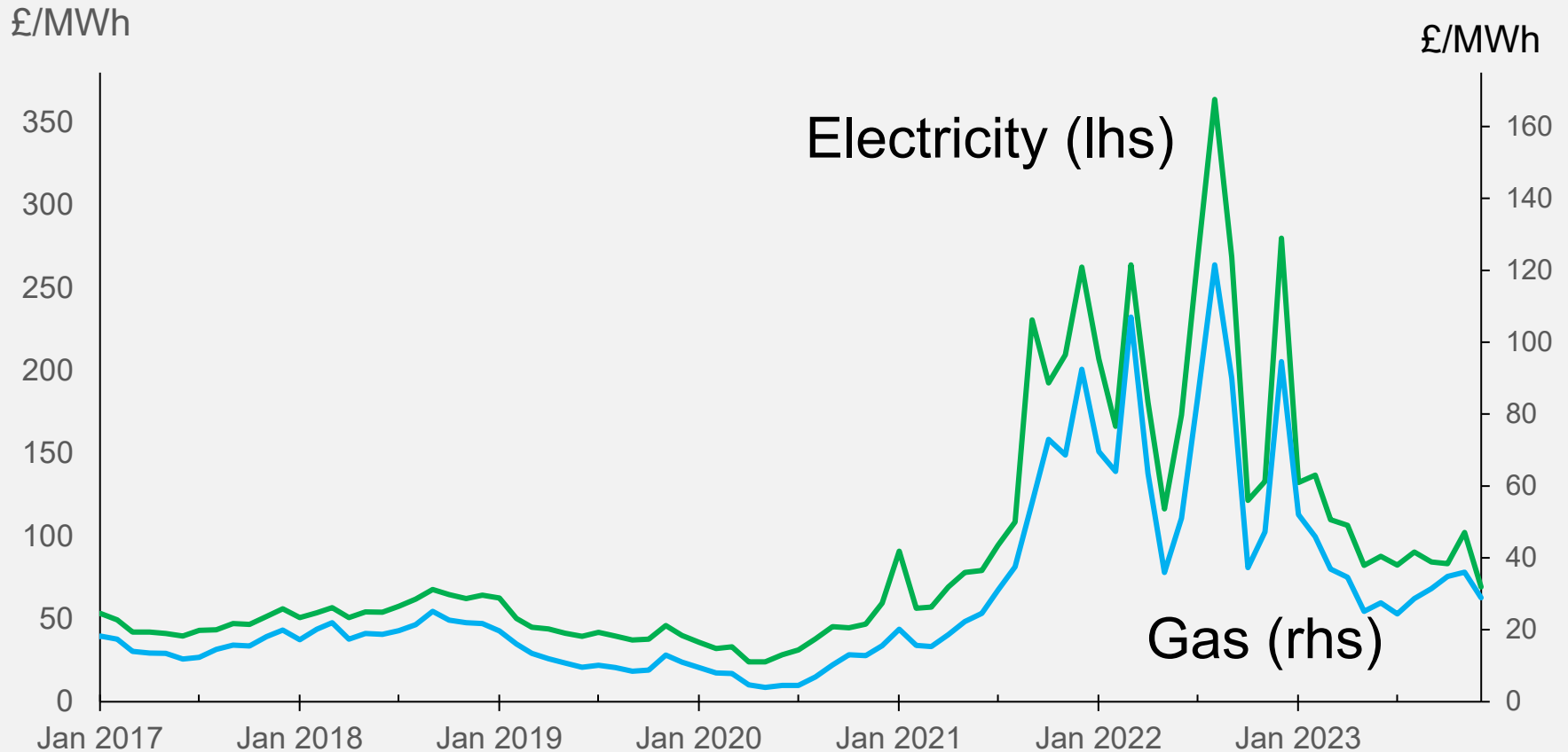
Source: Ofgem, Wholesale Market Indicators

<https://www.ofgem.gov.uk/energy-data-and-research/data-portal/wholesale-market-indicators>



# Gas and Electricity Prices

Day-ahead prices (monthly averages)



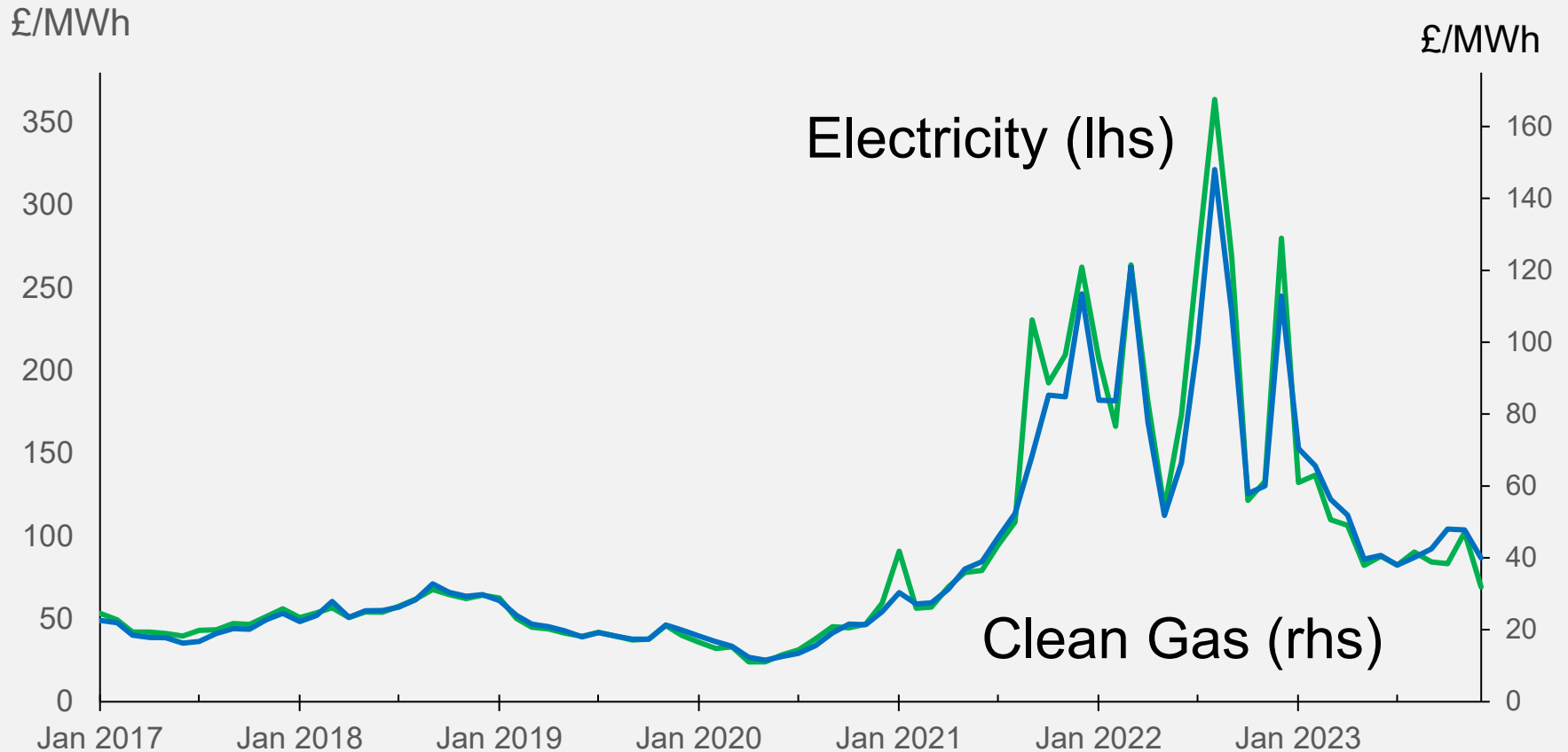
Source: Ofgem, Wholesale Market Indicators

<https://www.ofgem.gov.uk/energy-data-and-research/data-portal/wholesale-market-indicators>



# Gas and Electricity Prices

Day-ahead prices (monthly averages)



Source: Ofgem and Refinitiv

“Clean gas” includes the cost of carbon (permits and tax)

# Electricity wholesale markets

## Common features around the world

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- Forward trading and hedging
  - Most power is traded at prices fixed in advance
- Day-ahead trading
  - This is the point at which generators decide their schedules and retailers procure the rest of the power they need to meet their expected load
- Ancillary Services, Reliability, Congestion
  - The system operator needs to ensure generators' (and consumers') decisions are consistent with the safe operation of the system
- Real-time balancing
  - Few people do exactly what they said they would; this ensures the system stays stable and then recovers the cost of the deviations

# Electricity wholesale markets

## Key differences around the world

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- “US” day-ahead markets are run by the system operator
  - Power and ancillary services are co-optimised
- “European” markets separate electricity trading from constraints and ancillary services
  - System operators may have to “unwind” some market trades so that others can be delivered securely
- “Nodal” markets can have a price for every location
  - Low prices where the lines to export nearby generation are congested; high prices where more power is needed
- “Zonal” (or national) markets start by ignoring congestion
  - One price applies over a wide area and counter-trading is needed to reduce flows on congested links



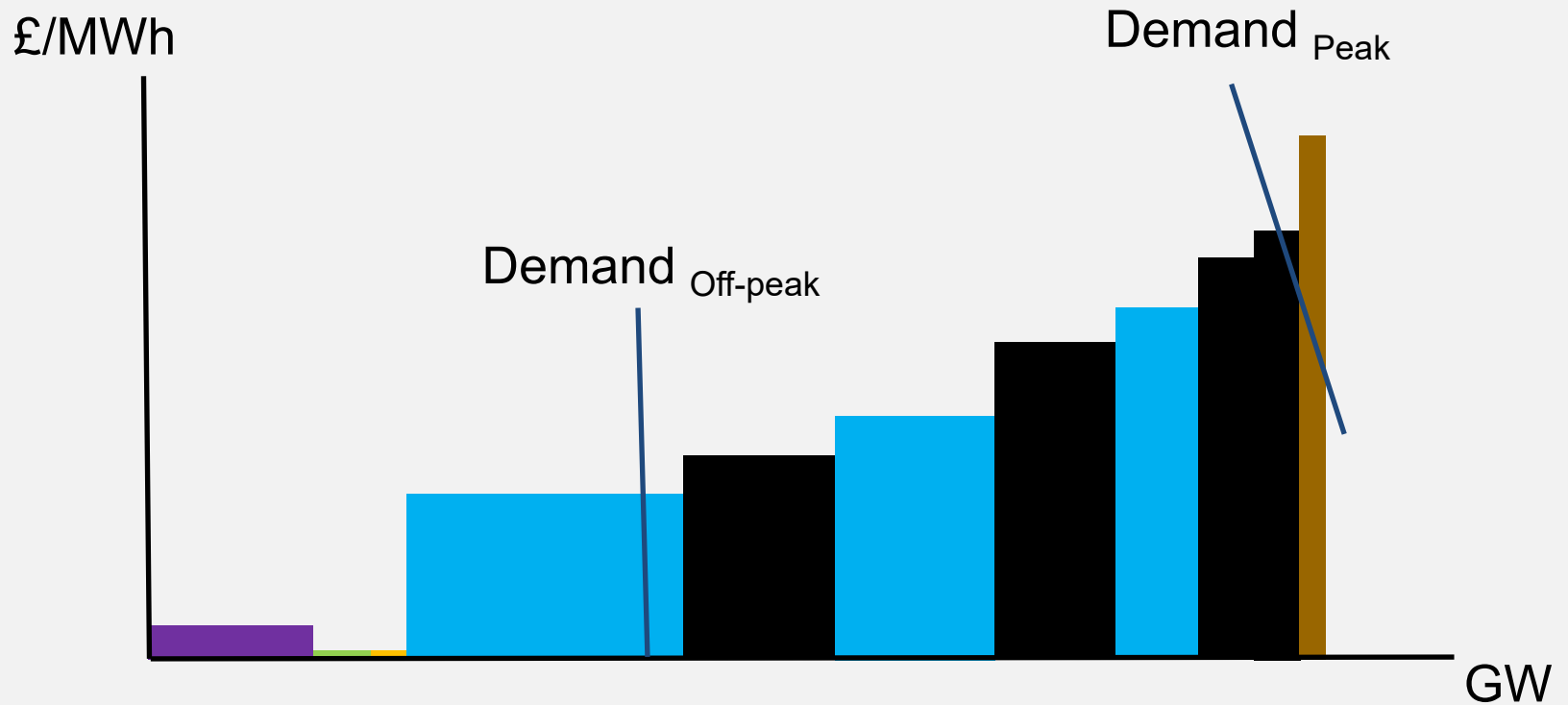
# How renewables change things

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- Renewables are now “cheap”
- Supply will become more variable
- Supply may become more distant
- Prices may become more volatile
- Ancillary services will become more important
  - Reserve / response
  - Reactive power
  - Inertia
  - ???

# Demand and Supply

The “traditional” electricity market

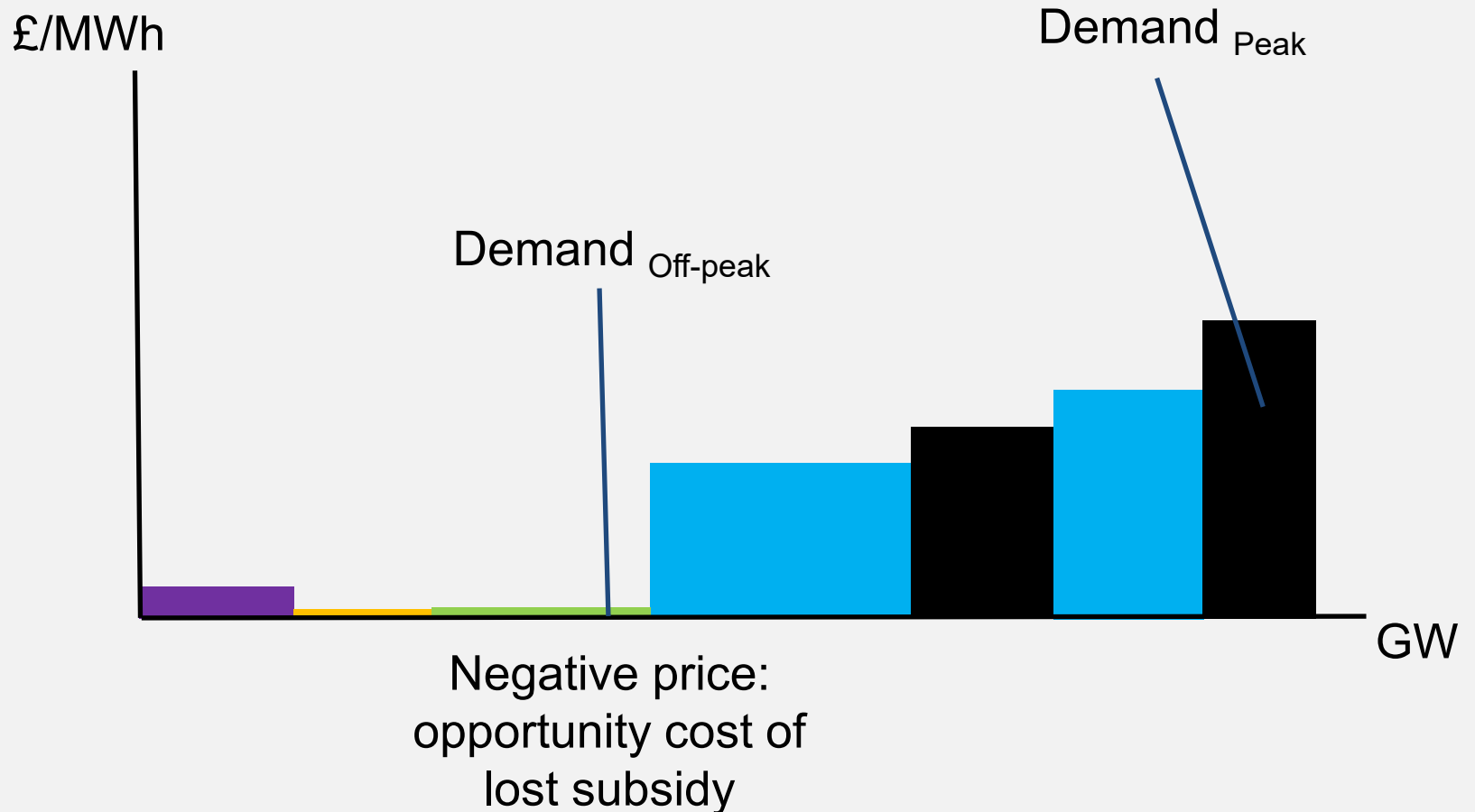






# Demand and Supply

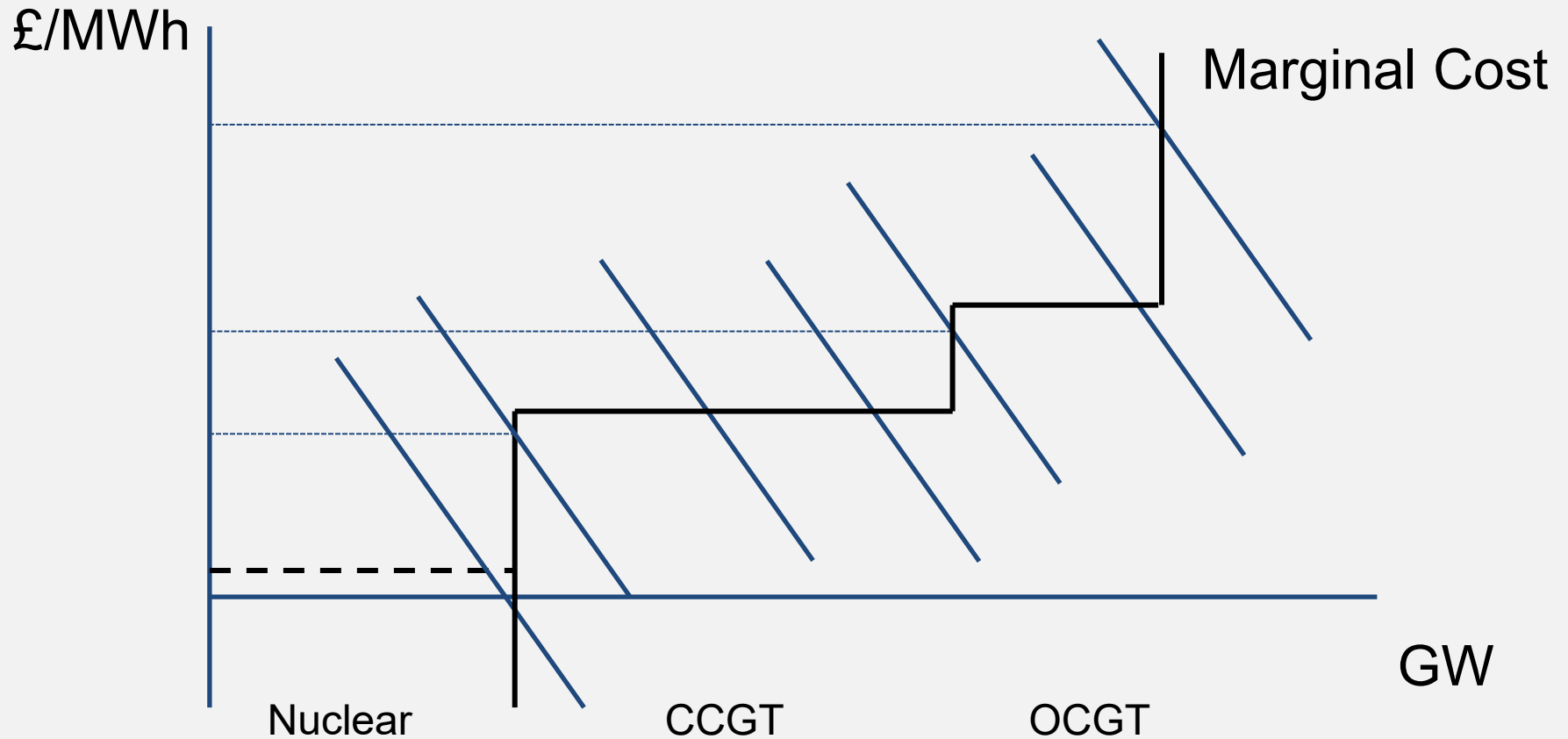
The way we (sometimes) live now





# Demand and Supply

The merit order effect

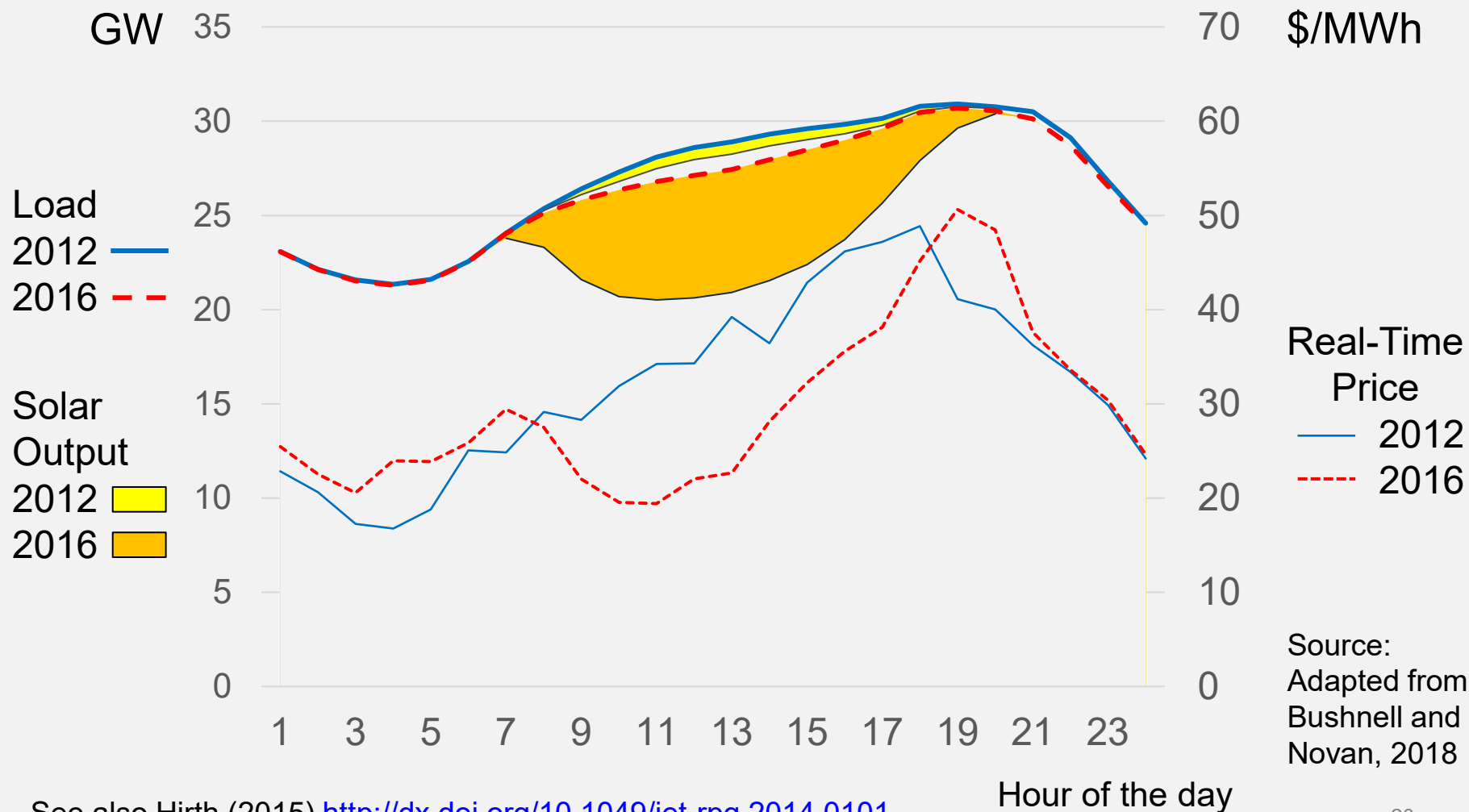




## **How solar PV affects the pattern of prices**

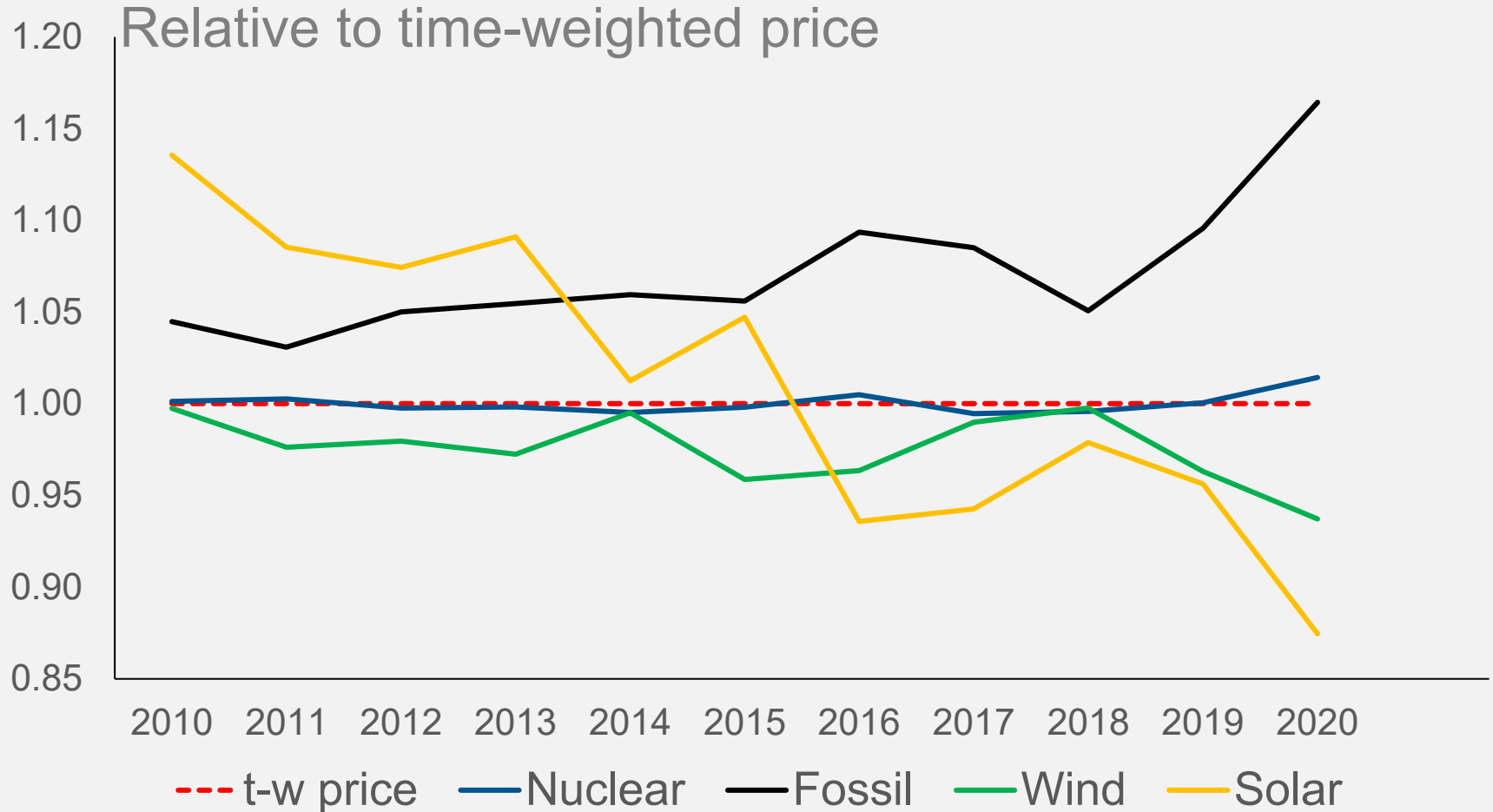
# Load, PV Output and Prices

California, 2012 and 2016





# Output-weighted prices





## **Supporting Investment**



# Renewable Support Paradigms

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	“Regulated”	“Market”
Price fixed	Feed-in Tariff	Contract for Differences
Price supplement	Production Tax Credit / Premium FiT	
Quantity fixed	Renewable Portfolio Standard	Tradable Green Certificates



# British Experience:

NFFO: the 1990s

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- “Non Fossil Fuel Obligation”
- Tenders for renewable generation, fixed-price contracts
- Counter-party was a government-backed agency
- 15-year contracts (in later rounds)
- Many winners did not build their plants
  - Could bid before they had planning permission; some signs of the winner’s curse

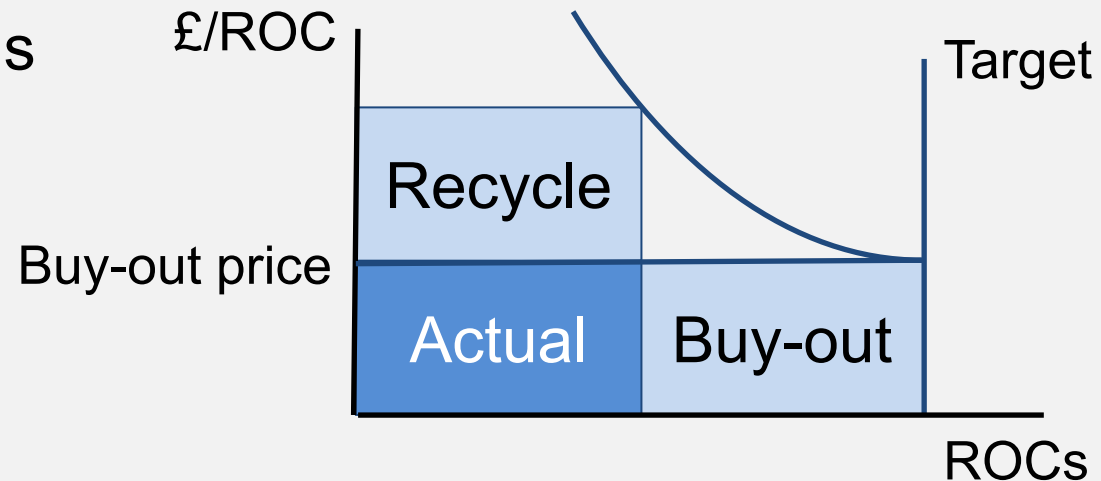




# British Experience:

## Renewables Obligation: the 2000s

- Retailers had to obtain Renewable Obligation Certificates for rising percentages of their sales
  - Pay a buy-out charge for “missing” certificates
- Generators got ROCs per MWh generated for 15 years
  - Initially 1 ROC per MWh; later differentiated by technology
- Buy-out charges recycled to firms with ROCs
- Overall value of subsidy fixed in £bn



# British Experience:

## Renewables Obligation: the 2000s

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- At first, only cheaper technologies were viable
- After “ROC Banding”, more expensive generators got up to 4 ROCs per MWh
  - Banding Reviews were high-stakes revaluations
- Planning permission still hard to obtain
  - Fixed total subsidy meant subsidy per MWh was high
- Generators faced energy price risk and ROC price risk
  - Long-term contracts with retailers at lower prices
- Complex scheme with high transactions costs
  - Not suitable for small generators

# British Experience

## Feed-in Tariffs: the 2010s

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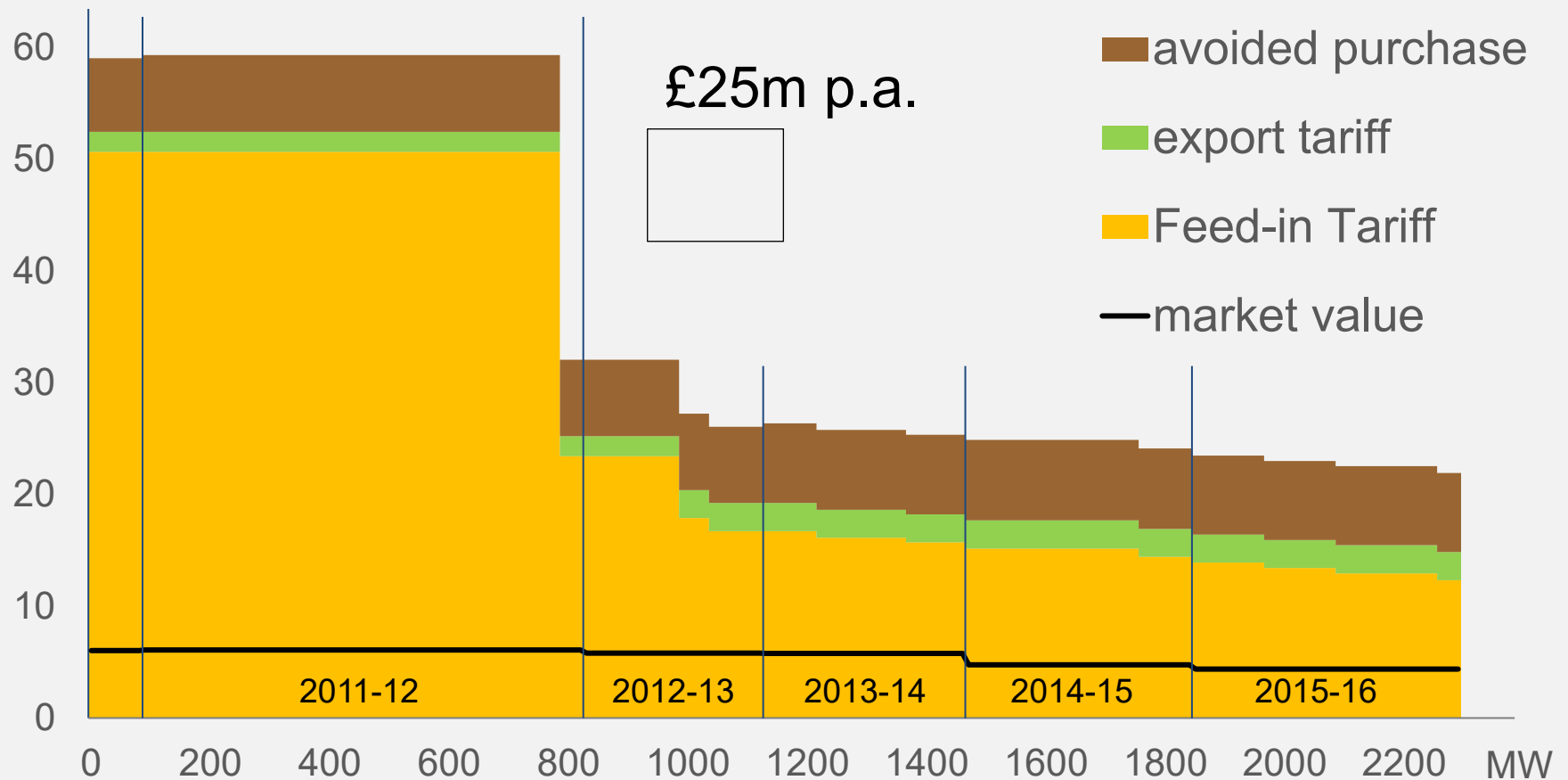
- Fixed-price payments for all electricity *generated* from eligible schemes
  - Some countries only pay for electricity *exported* to grid.
- Payments to new generators fall at pre-announced speed
  - Technology costs sometimes fell much faster
- Tariff rate Reviews and limits on capacity registered per period introduced to limit the cost
  - Cost borne by electricity consumers, but treated as a kind of government spending because Parliament ordered it



# Domestic-scale PV

## Capacity and Revenues, GB

p/kWh (2017)



Source: Ofgem

## Contracts for Differences: the 2010s

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- Fixed-price contracts for large-scale generators
  - Set up as contracts for differences between a reference price (current market price) and the Strike Price
  - Generator has to sell its output in the wholesale market
- Strike Prices set administratively at first
  - Government estimate of renewable generators' costs
  - Negotiated price for Hinkley Point C nuclear station
- Counter-party is a government-owned company
  - Cost passed on to electricity retailers (and consumers)

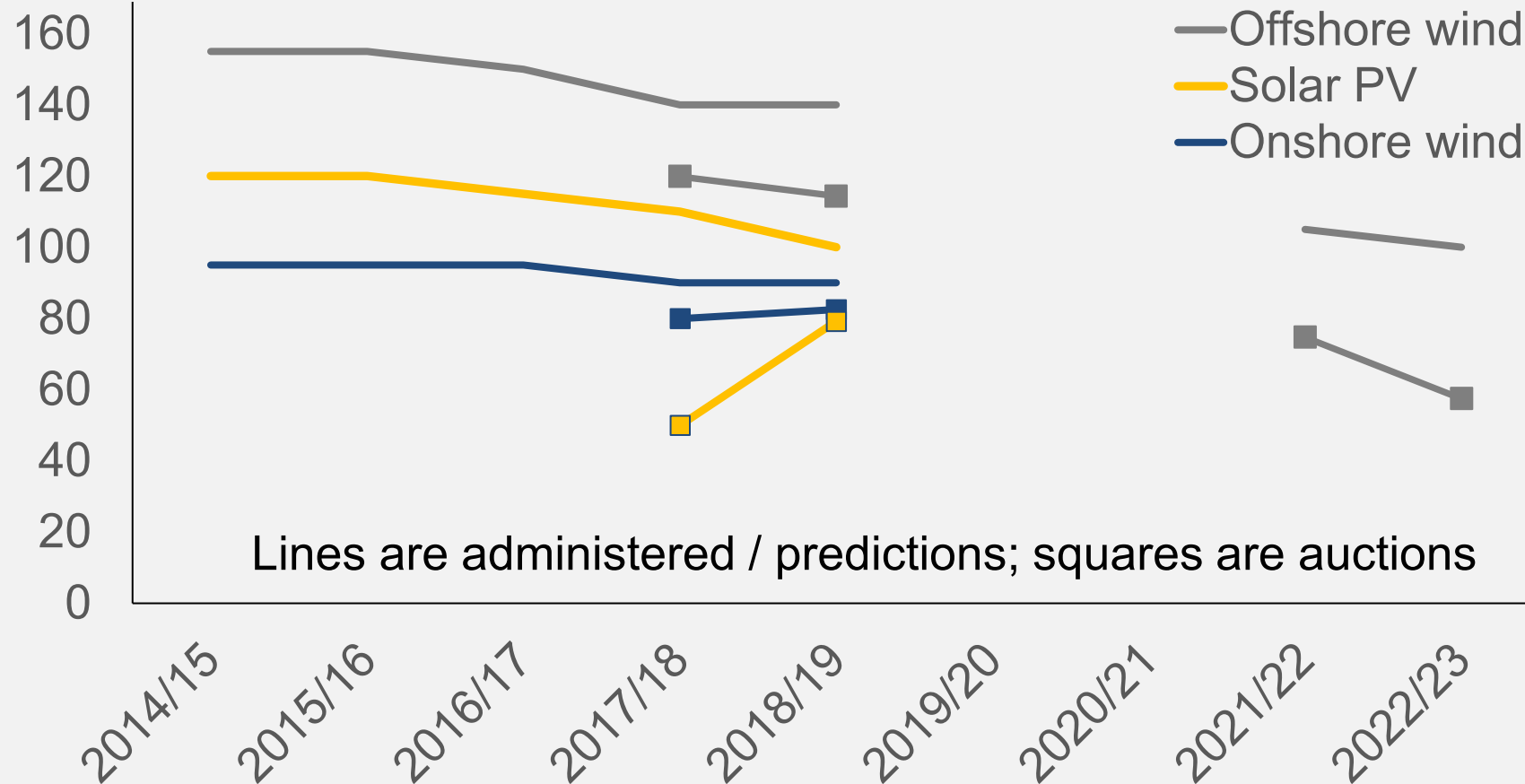


# The benefits of competition

Administered prices vs auction results

£/MWh

£/MWh





## **Support for Storage**

# The need for energy storage

Electricity can't be stored as electricity

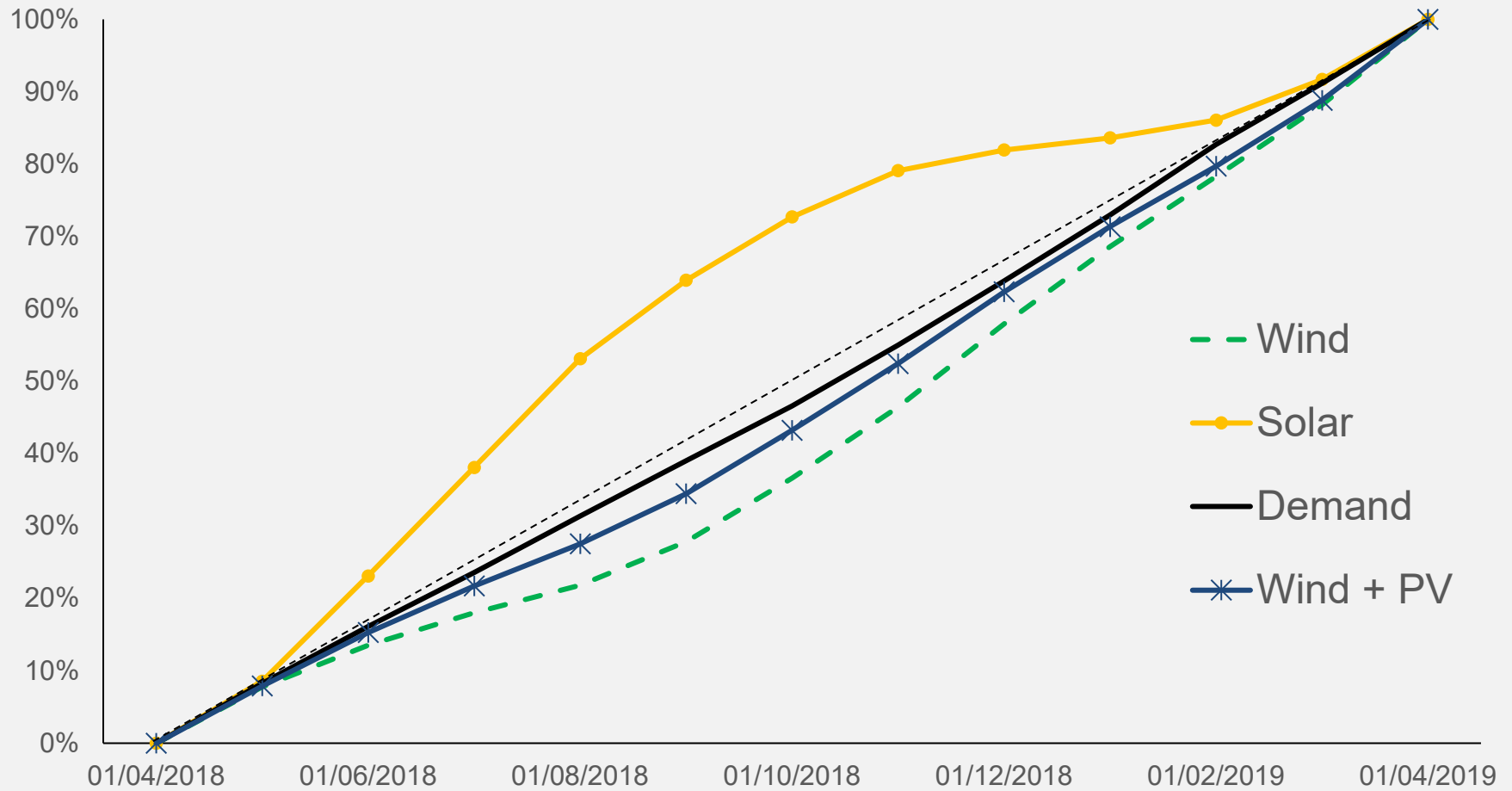
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- Short-term storage
  - Offset intraday variation in renewable output or demand
  - Balance the system against changing output / demand
  - Reserve in case of a sudden failure
- Seasonal shape
  - Offset the underlying pattern of renewable output and electricity demand
- Seasonal gap-filling
  - Offset a week (or more) of unusually low renewable output or high electricity demand





# British electricity: seasonal patterns

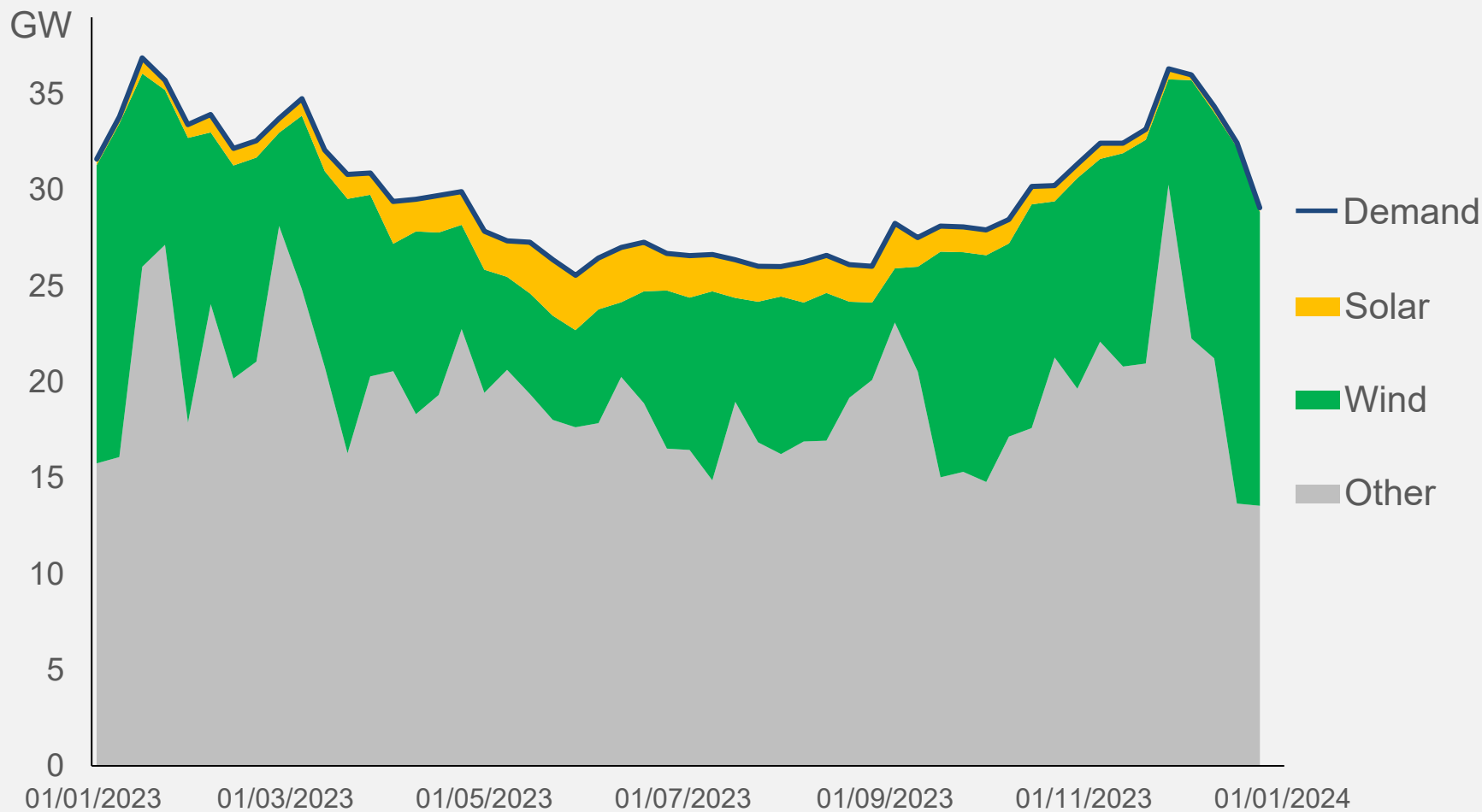


Source: Elexon / National Grid data



# Demand net of renewables

Great Britain, weekly averages



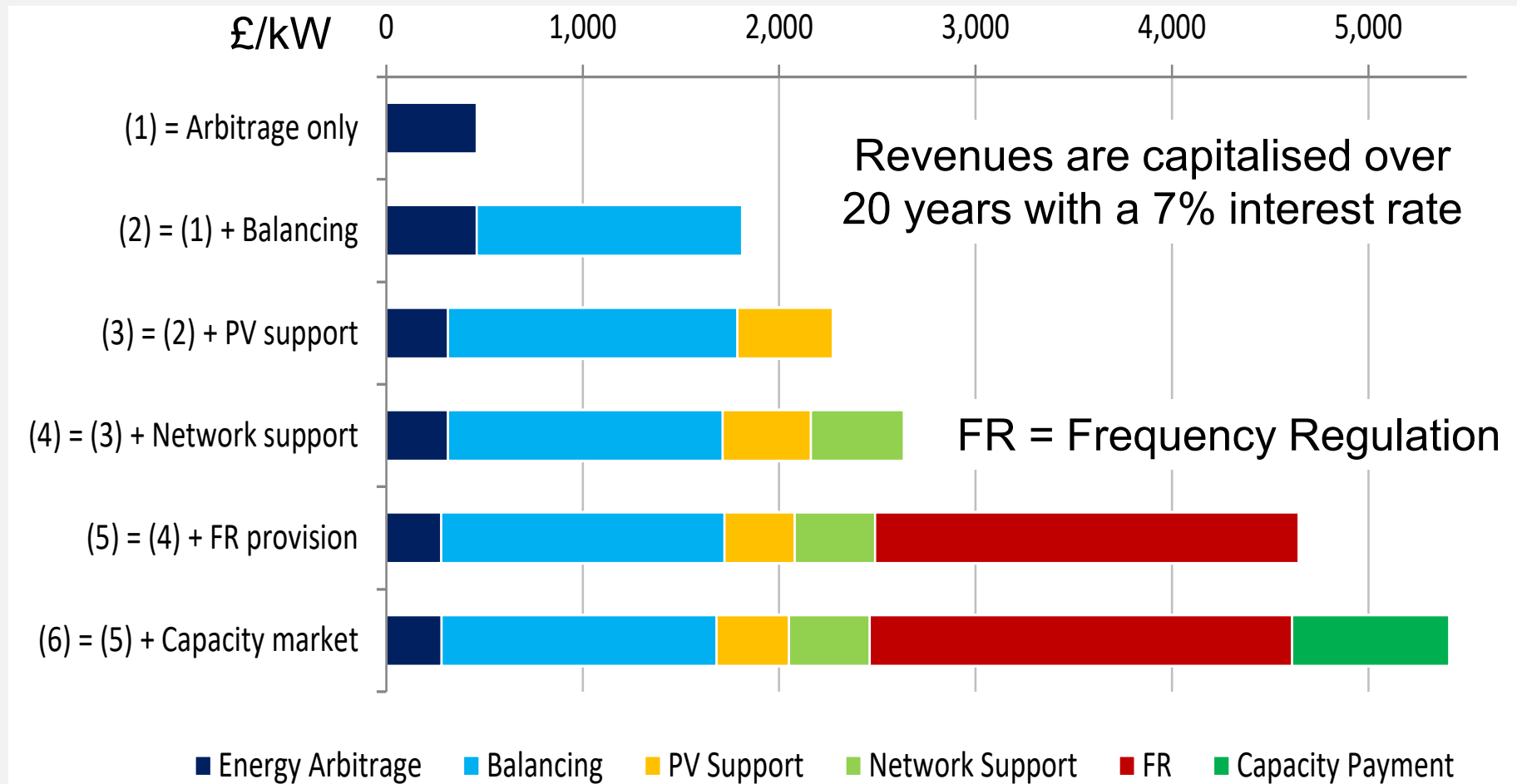
# System Value of Energy Storage

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- **Arbitrage**
  - ✓ Participate in day-ahead energy market
- **Balancing services**
  - ✓ Participate in real-time balancing market
- **PV Support**
  - ✓ Offsetting the difference between predicted and actual generation
- **Network Support**
  - ✓ Reducing need for T & D network reinforcements
- **Frequency regulation services**
  - ✓ Providing energy at short notice to keep frequency close to 50Hz
- **Capacity market**
  - ✓ Helping to meet peak demand, reducing need for peaking plant

# System Value of Energy Storage

“Revenue stacking” / “value stacking”



# Support for storage

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- Early battery projects won innovation funding
  - Most battery investments on commercial terms
- Government deciding policy for long-duration storage
  - “Cap and collar” most likely outcome
- Interconnectors between countries make money from price differences between them, i.e. arbitrage
  - Annual revenues are topped up if less than collar
  - Profits above the cap are paid to the government agency
- Storage revenues depend on price differences over time
  - Mechanism suitable for interconnectors should work for it

**Well-designed support cuts  
risks and costs!**



Photo: R Green