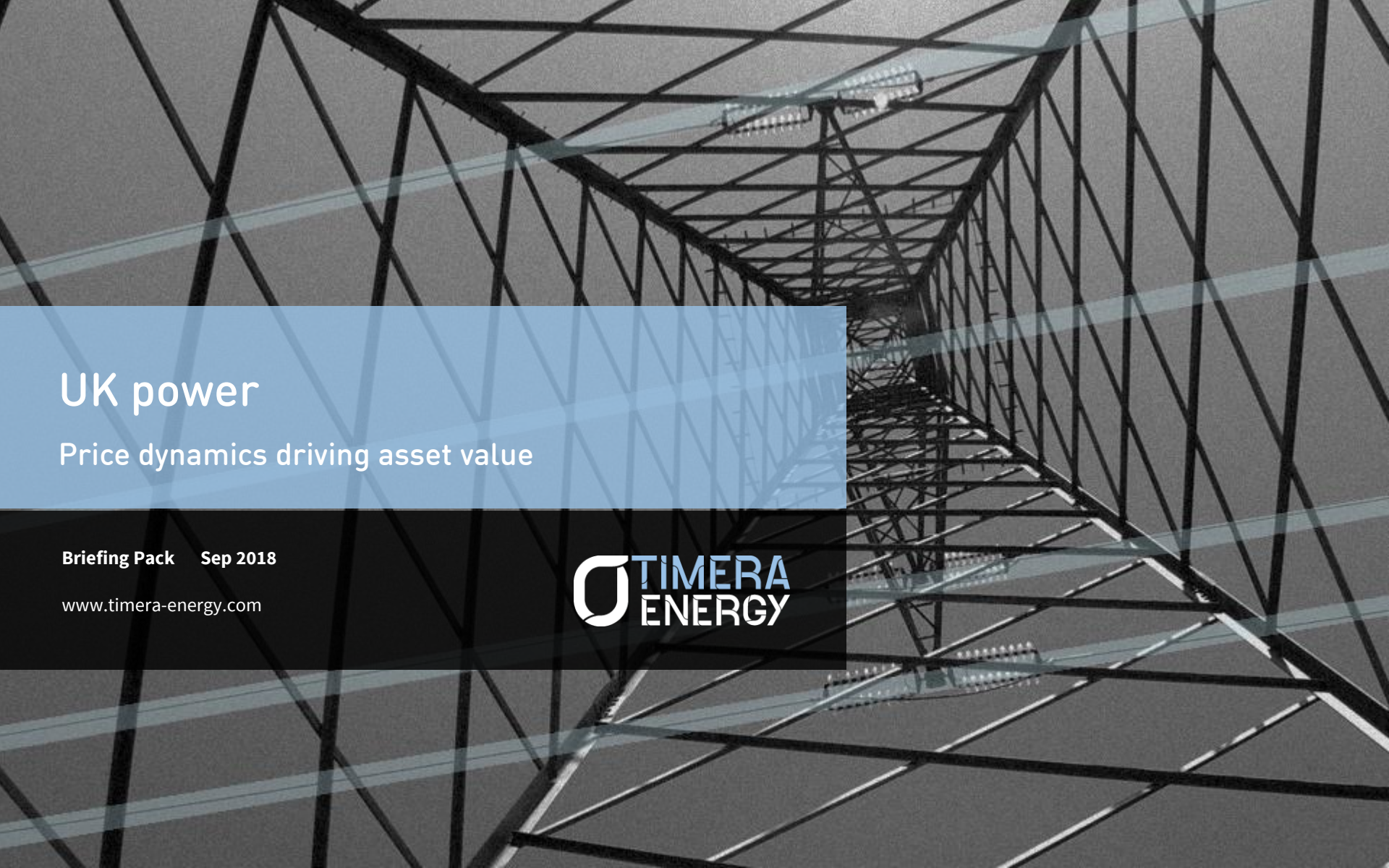

UK power

Price dynamics driving asset value

Briefing Pack **Sep 2018**

www.timera-energy.com

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UK power – pricing & value: 5 key takeaways

1. **Pricing driving value:** Changes in Price Level, Shape & Volatility are altering asset risk/return profiles.
2. **Value shift to prompt:** Asset value capture from price movements near to delivery is increasing.
3. **Shape & volatility to rise:** Increase in the intermittency & steepness of the UK supply stack will drive up price shape & volatility in 2020s… 'wind trumps batteries'.

Heat map: margin contribution of Level, Shape & Volatility

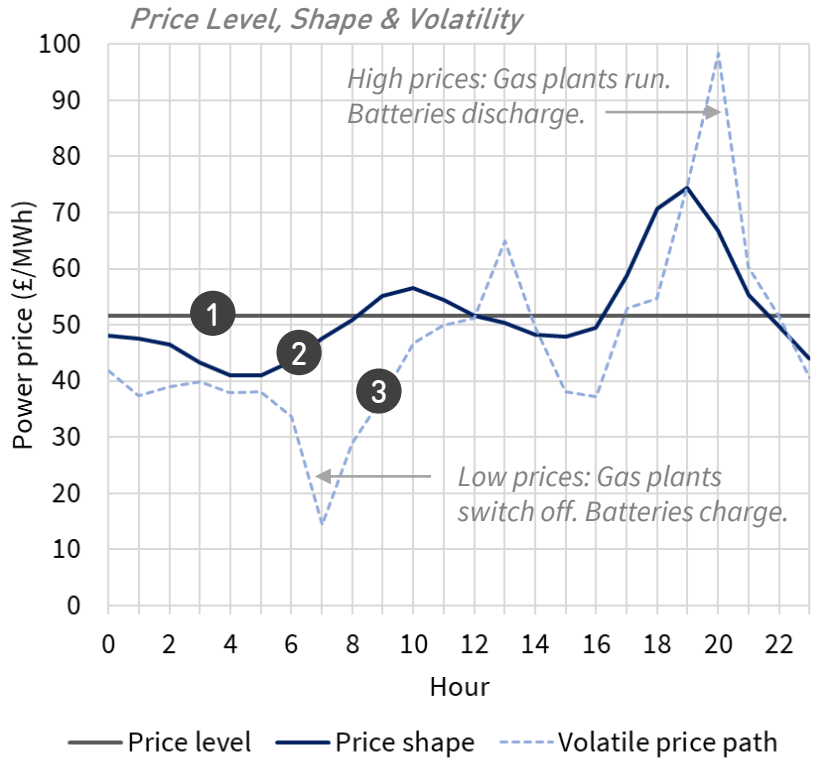
	CCGTs	Merchant Wind & Solar	Engines/ GTs	Batteries
Price Level	3	2	5	5
Price Shape	4	5	3	4
Price Volatility	4	5	2	1

Notes: 1 = dominant margin driver, 5 = lower margin impact.

4. **Value impact differs by asset:** The margin contributions of Level vs Shape vs Volatility vary widely across asset classes (see table). Owner/investor ability to value & manage different price exposures is key.
5. **Capturing value is inherently more challenging:** Investment cases & business models are evolving to reflect the greater complexity of capturing and financing value from shape & volatility.

3 key price dynamics drive asset value

	Price Dynamic	Description	Drivers
1	**Level**	Baseload price	Variable cost of marginal price setting units (gas dominant).
2	**Shape**	Structural intraday price profile	Structural load, wind & solar profiles. Stack shape.
3	**Volatility**	Short-term price fluctuations	Fluctuations in load, wind & solar. Stack shape.

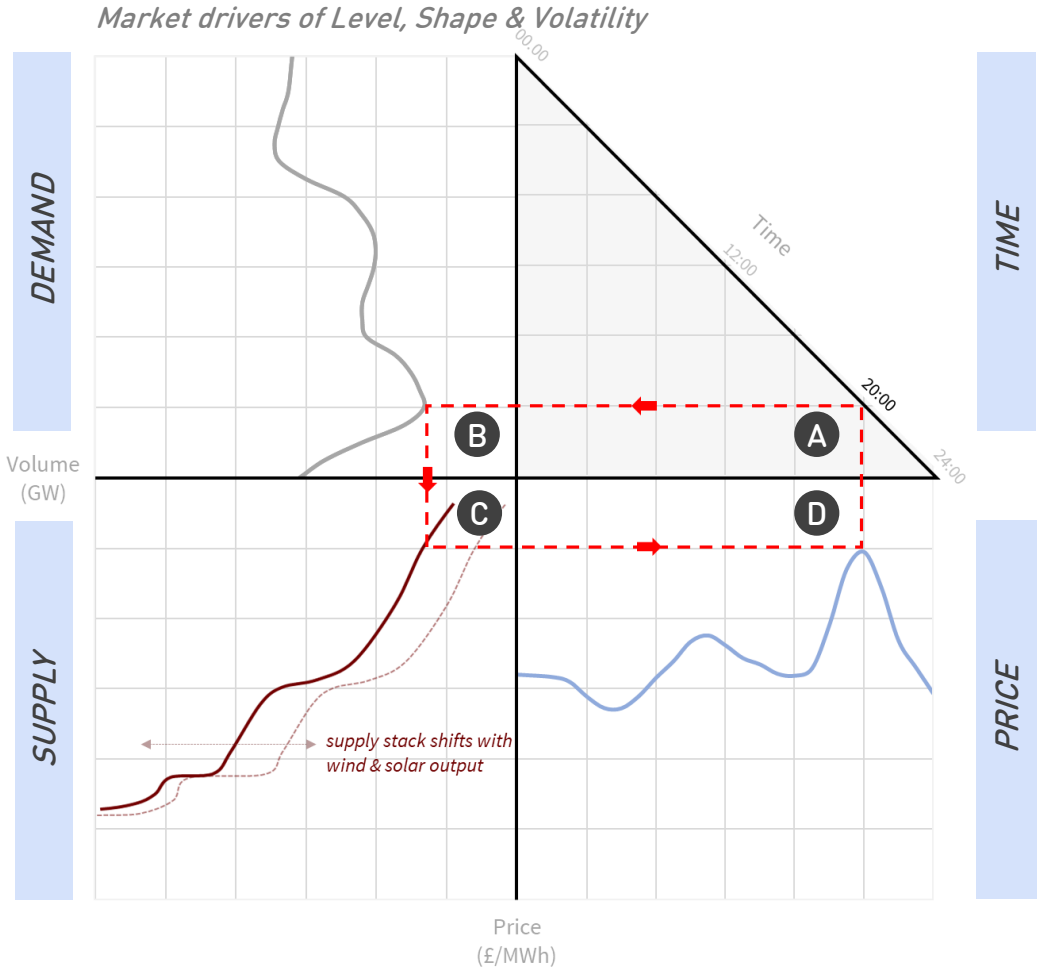


Price formation dynamics

The interaction between load, supply stack and price is illustrated in the diagram.

- **A** *For a given time of the day (e.g. 20:00)…*
- **B** *System demand is determined by factors such as weather…*
- **C** *The positioning of the supply stack to meet that demand depends on prevailing wind & solar output…*
- **D** *The marginal unit required to meet demand drives system price.*

Volatility is driven primarily by fluctuations in load (e.g. weather) & supply stack (e.g. wind/solar & outages).



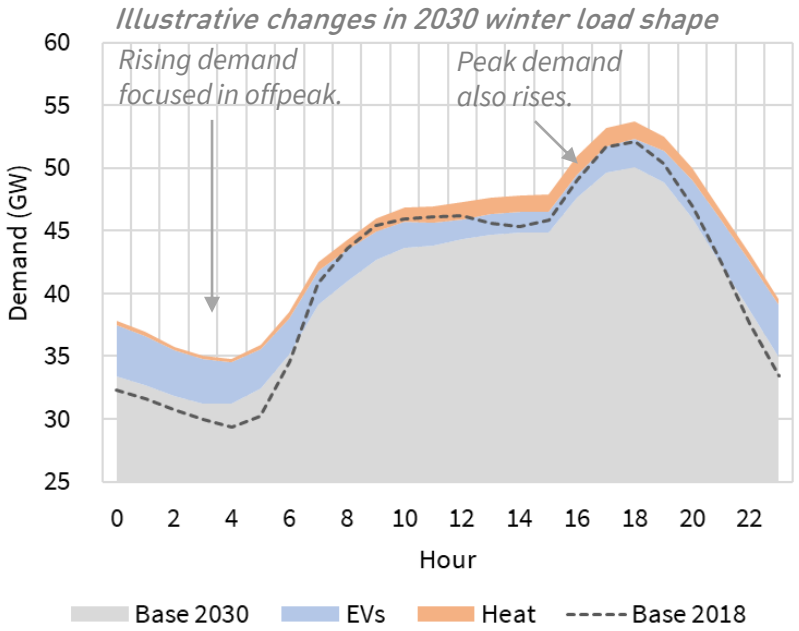
Key market trend 1: Changing load

Drivers:

1. Efficiency measures.
2. Penetration of smart appliances/software.
3. Electrification of transport (EVs).
4. Electrification of heat.

Impact:

- Rising demand.
- Shifting load shape.



Drivers	Demand impact	Load shape impact	Description
Efficiency	↓	↓	*Reduces demand & shape. Lack of clear policy incentives.*
Smarts	↓	↓	*Reduces demand & shape. Strong external technology drivers.*
EVs	↑	↑↓	*Increases demand. Shape depends on battery optimisation.*
Heat	↑	↑	*Increases demand & shape. Major barriers to deployment.*

Key market trend 2: Rising intermittency

Drivers:

1. Growth in wind (30-40* GW by 2030). Large/rapid/uncertain swings in volume.
2. Growth in solar (20-30* GW by 2030). More predictable daily/seasonal profile.

Impact:

- Greater supply stack fluctuations & price volatility.
- Changing intraday price shape (particularly solar profile).

**Note: wind & solar capacity ranges reflect uncertainty in policy support & technology cost reduction (2018 – 2030).*

Intermittent generation swing ranges

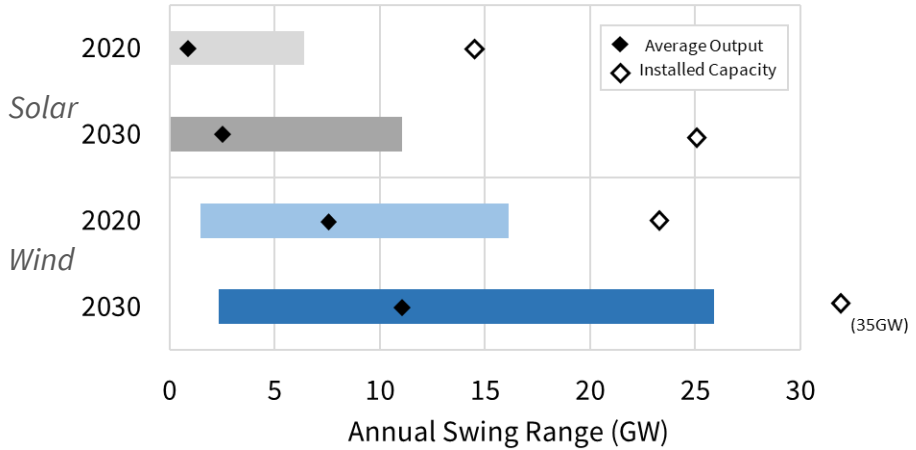


Chart shows annual volume range of low (5th percentile) to high (95th percentile) wind & solar output in 2020 vs 2030 (assuming 25GW solar, 35GW wind by 2030). Illustrates increasing impact of wind/solar in shifting supply stack left and right.

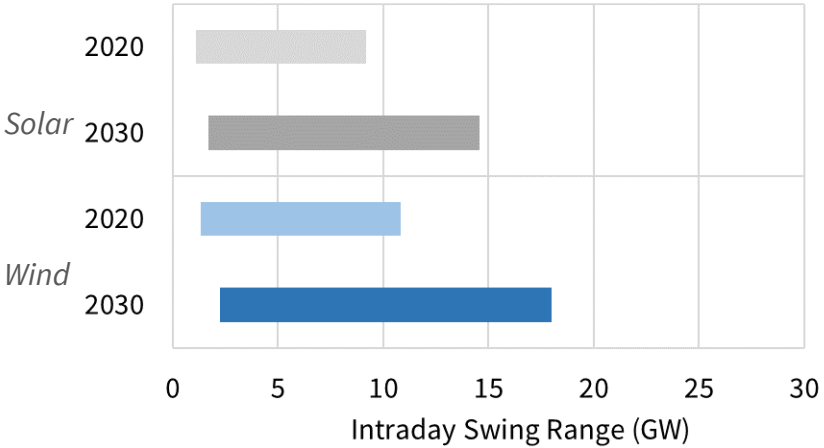


Chart shows intraday swing ranges (5% - 95%) of wind & solar output. For example by 2030, a low swing range for wind across a given day is 2GW vs high swing range of 17GW. Wind swing is somewhat larger and much less predictable than solar.

Key trend 3: Steeper supply stack

Drivers:

1. Top of stack rises as higher variable cost engines/batteries/DSR replace CCGTs/coal.
2. Bottom of stack falling as zero/negative variable cost wind & solar penetration rises.

Impact:

- Greater price shape.
- Rising price volatility.

*Dispatchable 2020 vs 2030 UK winter supply stack **

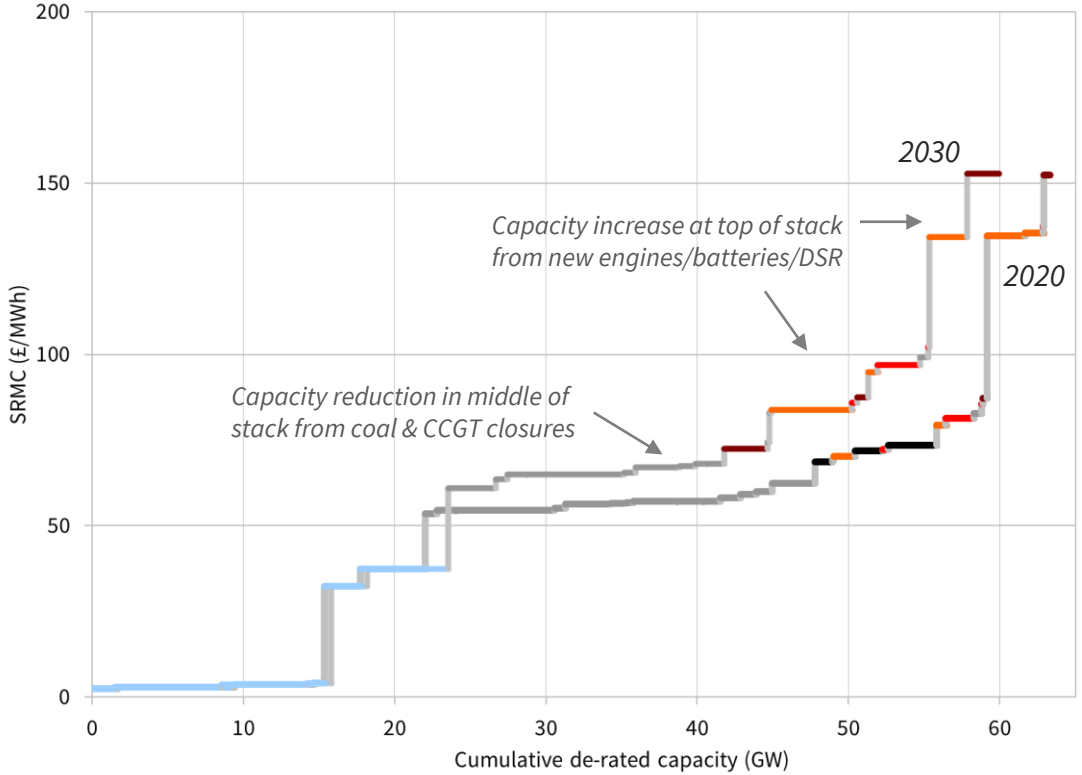


*Chart shows dispatchable supply stack (i.e. includes biomass, nuclear, gas, coal and storage but excludes wind & solar).

Net impact 1: Price shape rises

A. Peak prices rise

- Coal/CCGT closures pulling new peaking flex sources onto the margin (engines, batteries, DSR).
- Variable cost of this new peaking flex is higher, lifting peak prices.
- Peak price shape changing with (i) shifting load shape & (ii) intraday wind/solar profiles.

B. Offpeak prices fall

- Higher wind & solar output (zero/negative SRMC) drags down offpeak prices.
- Gas price linkage remains dominant, but is gradually eroded over time.

Evolution of marginal price setting units (2020 – 30)

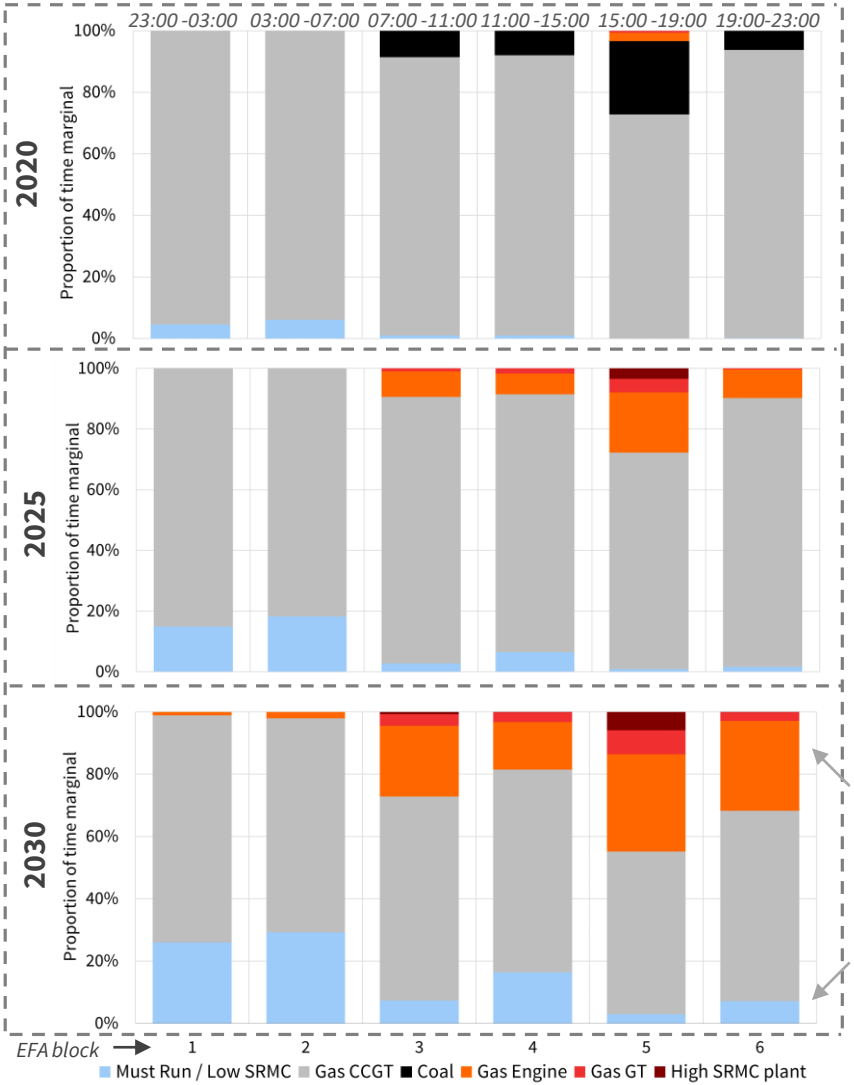


Chart shows the % of time different technology types set power prices across the day.

Analysis is built on a distribution of projected wind & solar output.

CCGTs dominate marginal price setting.

In periods of low wind & solar and high demand, peaking capacity sets prices.

In periods of high wind & solar and low demand, must run capacity sets prices (at low or negative levels).

Higher variable cost engines, GTs, batteries lifting peak prices.

Low variable cost wind & solar pulling down offpeak prices.

Note: scale of impacts depend on evolution of capacity mix & demand e.g. more peaking flex vs CCGTs increases A. More wind & solar increases B, decreases A.

Net impact 2:
Price volatility rises

A. Intermittent swings increase

- Rapid rise in wind & solar output increases supply stack fluctuations.
- E.g. ~17GW wind & ~14GW solar intraday swing ranges by 2030.

B. Stack steepens

- Steeping of supply stack increases price impact of wind/solar fluctuations.
- Output swings can tip market from negative prices to 100+ £/MWh in hours.
- Impact of shifting load shape & rising battery flex outweighed by intermittency.
- 'Wind trumps batteries' i.e. battery capacity (3-5GW by 2030) much smaller than wind/solar swing volumes.

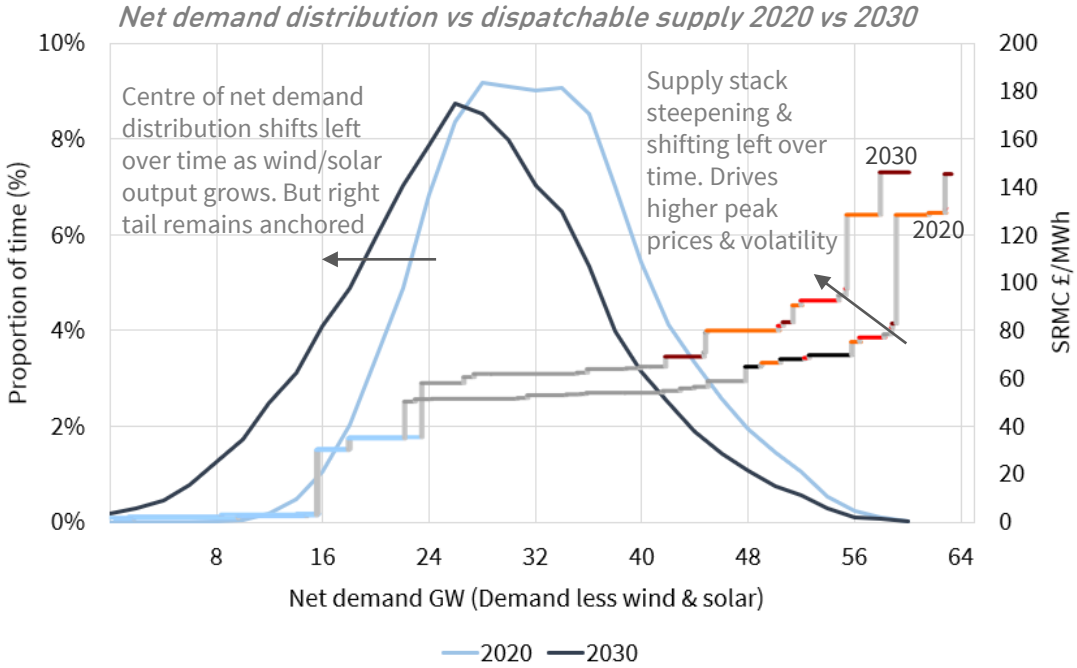


Chart shows projected distribution of net system demand (= load – wind – solar) overlaid on dispatchable supply stack (ex. wind & solar).

The chart illustrates the portion of time that different sections of the supply stack are required to clear net demand. E.g. high load & low wind/solar periods in the right tail of the distribution result in peaking units setting prices. Low load & high wind/solar periods in the left tail result in must run capacity setting zero/negative prices.

Note: pace & scale of impacts depend on evolution of capacity mix & demand e.g. more wind & solar increases B. More peaking flex vs CCGTs increases A & B.

Rising shape & volatility: asset margin implications

**Battery dispatch is based on relative not absolute price signals. Hurdle estimate is dependent on degradation costs & assumed offpeak charging levels.*

Universal impact

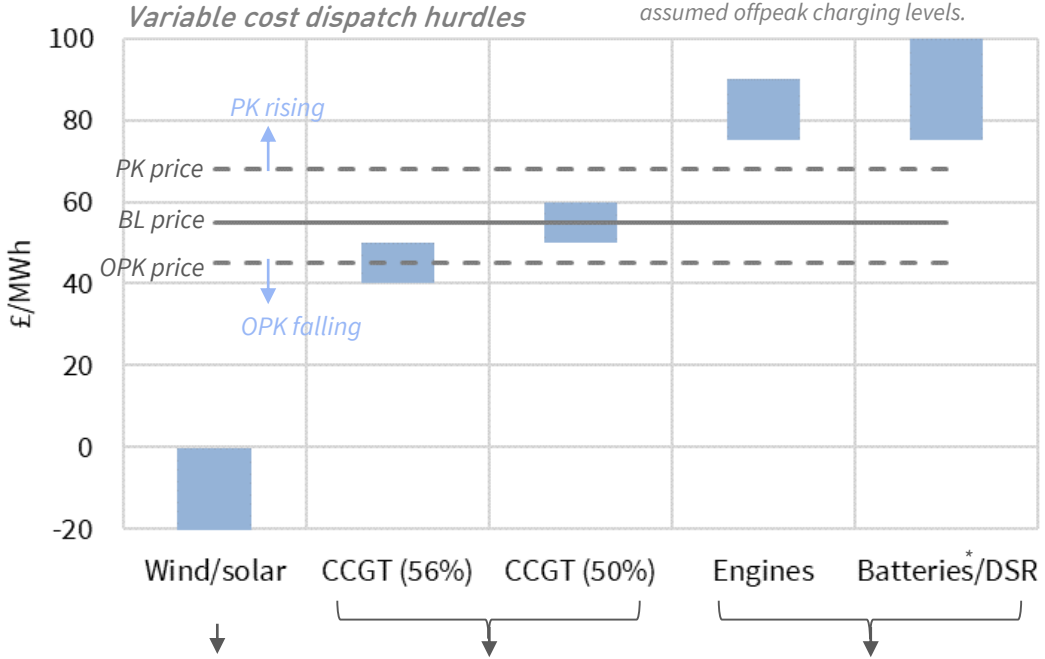
- Drives asset value into prompt horizon.
- Increases value of asset optionality.
- Increases importance of extrinsic value capture.

Asset class impact

Engines/Batteries: Increases wholesale/BM margin capture.

CCGTs: Increases importance of shape & volatility versus price / spark spread level.

Merchant wind/solar: Increases value of option to flex down (2nd order impact).



Type of optionality	*Deep ITM (level key)*	*ATM (level/shape/vol all key)*	*OTM (shape/vol key)*
Impact of rise in shape & vol	*Rise in flex down value*	*Pulls option more ITM in peaks, more OTM in offpeaks*	*Increases no. of periods option pulled into the money.*

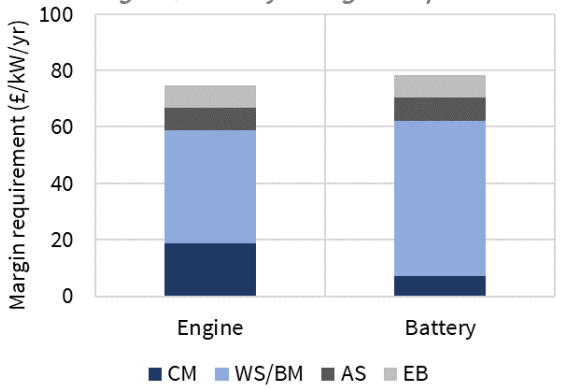
Note: ITM = 'in the money'. ATM = 'at the money'. OTM = 'out of the money'

Value drivers & risks: Engines & Batteries

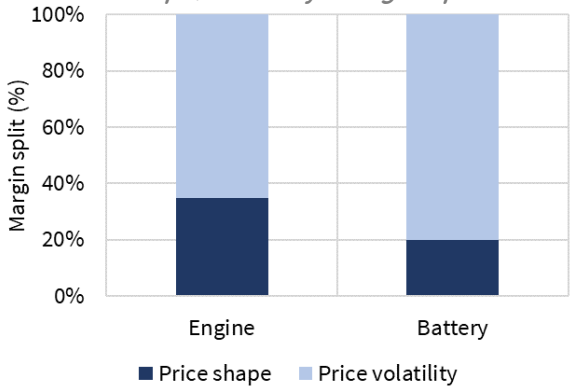
	Engines	Batteries
Value drivers	• Ability to capture shape & volatility value • Variable dispatch cost hurdle (key for shape) • Stacked AS, EB & CM margins	• Ability to capture volatility value • PK vs OPK arbitrage (efficiency/duration key) • Stacked AS (FFR), EB & CM margins
Risks	• BM value erosion (e.g. battery/engine overbuild) • New CCGT build (price & load factor erosion) • Erosion of AS, EB & CM stacked margins	• BM value erosion (e.g. battery/engine overbuild) • Battery cycling degradation & mid-life capex • Policy evolution (e.g. BM, CM, supplier charges)

Note: WS = Wholesale Market, BM = Balancing Mechanism, AS = Ancillary Services, EB = Embedded Benefits, CM = Capacity Market, FFR = Firm Frequency Response.

Engine/battery margin requirement



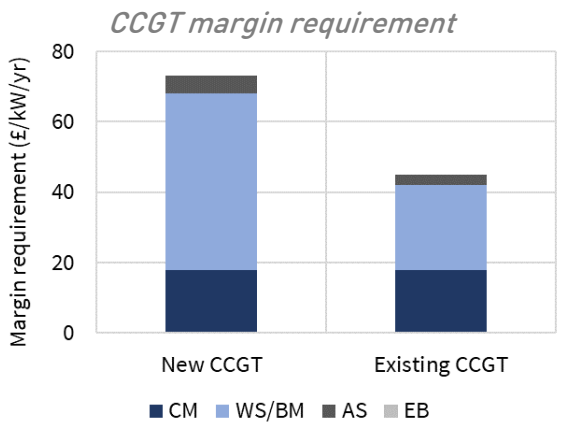
Shape/volatility margin split

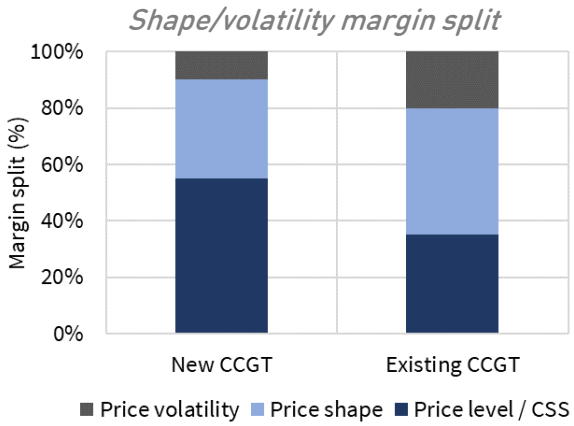


Note: Required margin does not represent Timera view on returns but is a summary of generic investment case numbers for given technologies (i.e. what you need to believe to invest).

Value drivers & risks: New & Existing CCGTs

	New CCGT (e.g. 56% efficient, 20 yr life)	**Existing CCGT** (e.g. 50% efficient, 10 yr life)
Key value drivers	• Variable cost advantage over other CCGTs • Initial capex, capital structure & funding cost • Ability to secure viable 15 yr capacity price	• Asset capability to capture shape & volatility • Reliability, O&M and timing/cost of major maint. • Unique advantage (e.g. location, flex, CHP)
Key risks	• Peak spark spread erosion (e.g. other new CCGTs) • Offpeak spread & load factor erosion (wind/solar) • Adequate paydown of capex in first 5 years	• Scale/pace of peak spark spread erosion • Value erosion from price shape & volatility • Structurally low capacity prices





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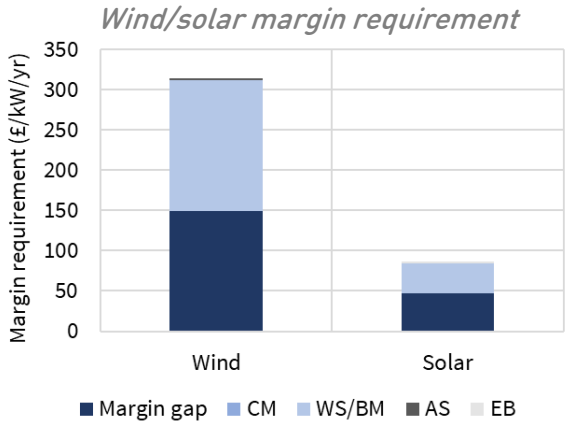
Value drivers & risks: Merchant wind & solar

	Merchant wind	Merchant solar
Key value drivers	• Baseload power prices • Capture price (erosion vs baseload) • Capital structure & funding cost	• Peak power prices • Capture price (erosion vs peak price) • Capital structure & funding cost
Key risks	• Structurally lower NBP gas prices • Correlated wind driven price cannibalization • Regulatory risk (e.g. CM reform, other support)	• Structurally lower NBP gas prices • Erosion of peak price shape (e.g. by solar) • Regulatory risk (e.g. CM reform, other support)



Raising capital for merchant renewables

Developers are starting to test merchant projects with equity investors & lenders.

Key challenge is defining a robust downside level for wholesale power prices. This can be done as a function of:

1. Robust gas price downside case.
2. Distribution analysis of wind/solar price erosion over time (see previous slides).

Note: Required margin does not represent Timera view on returns but is a summary of generic investment case numbers for given technologies (i.e. what you need to believe to invest).

Key challenges: Asset value capture

5 key challenges

1. **Prompt value:** Quantifying & managing asset exposure to price shape & volatility.
2. **Liquidity:** Lack of liquid granular products to hedge shape & volatility.
3. **Transaction costs:** value erosion from execution of hedging & optimisation.
4. **Risk adjustment:** Appropriate discounting of uncertain revenue streams.
5. **Pricing options:** Structured probabilistic framework to define, price & exercise asset optionality across WS, BM, AS & EB markets.

WS/BM value management for flexible assets

	Energy margin		
CCGT	Forward mkts [~60%] Some forward intrinsic value (e.g. winter, pks) Hedging strategy influenced by mkt conditions, costs	Prompt [~30%] DA auction drives optimised schedule Additional extrinsic value capture from price volatility	Bal Mech [<10%] Focus on bid/offer acceptances in BM Strategy influenced by gate-closure position (typically lower value)
Gas engine	Forward mkts [0%] No forward intrinsic value Energy margin capture focused on prompt, increasing margin risk	Prompt [e.g. 30-50%] Lock in positive margin in DA auction Dispatch & hedges can be adjusted within day (lower value)	Bal Mech [e.g. 50-70%] Focus on capturing cash out price value Risk from cashout forecast error and value erosion
Battery	Forward mkts [0%] No forward intrinsic value capturable Energy margin capture focused on prompt, increasing margin risk	Prompt [~20%] DA auction drives initial optimised schedule. Further extrinsic value capture from intraday volatility	Bal Mech [<~80%] NIV chasing & BM. Risk from cashout forecast error and value erosion. More value from intermittency & cashout reform

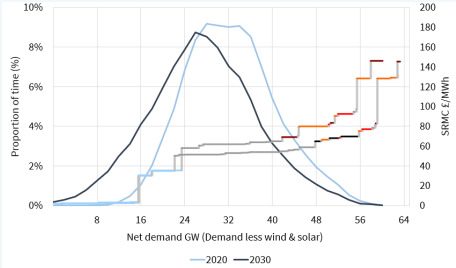
Key challenges:
Raising capital & analysing value

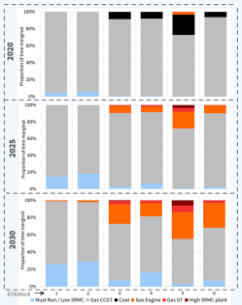
	Engines & Batteries	CCGTs	Merchant wind & solar
Challenges in raising capital	• Quantifying a realistic distribution of margin capture from price shape/volatility	• Developing a realistic case for sustainable inframarginal rents across a long payback period	• Establishing a 'bankable' lower bound for wholesale power prices (via gas market)

Analytical challenge: 2 part analytical framework key to supporting robust asset investment & value management decisions

1. Market modelling

Supply stack modelling needs to capture the evolving impact of wind/solar and load distributions & associated uncertainty. Robust modelling of swings in wind/solar/load and changing stack shape, drive realistic projections of price level, shape & volatility.

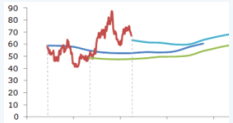




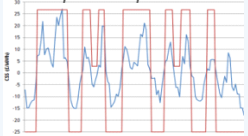
2. Margin modelling

Probabilistic framework required to generate robust projection of asset risk/return and the value of optionality. Stochastic modelling of price dynamics & asset dispatch underpins margin distribution analysis.

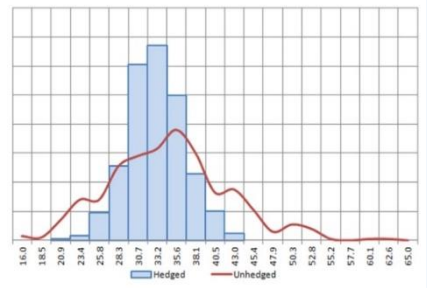
1. Stochastic price simulation



2. Dispatch optimisation



3. Distribution of asset risk/return



Timera Energy offers expertise on value & risk in energy markets

Specialist energy consultancy
Focus on LNG and European gas & power assets

Extensive industry expertise
Practical knowledge from senior industry roles

Pragmatic commercial focus
Investment, valuation, contracting & mkt analysis

Strong client base
leading energy companies (producers, utilities, funds)

Leading industry blog
15,000+ regular readers, publications, conferences

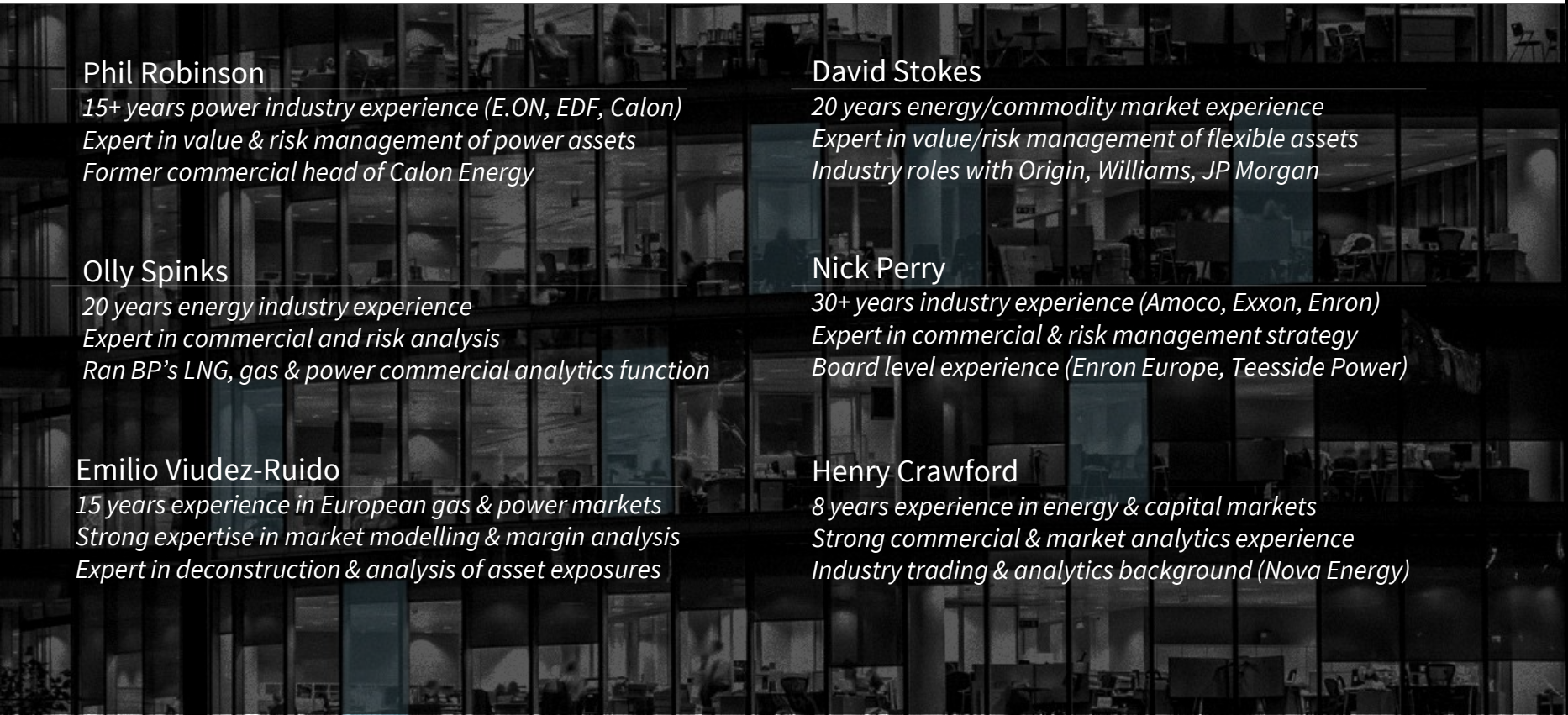
Our clients include

Relevant recent UK power credentials

Project	Client	Summary
Peaker acquisition	**Fund**	*Market analysis, asset valuation & due diligence to support bid for UK peaker portfolio.*
Peaker investment	**Utility**	*Analysis of relative economics of gas engines vs OCGT vs battery investment options.*
CCGT investment	**PE Fund**	*Valuation & investment advice to support acquisition of portfolio of UK gas assets.*
Flex management	**Supplier**	*Advice on how to structure route to market contracts to support peaking flex services.*
Value management	**Generator**	*Support for development of hedging & risk management strategy for CCGT portfolio.*
Margin strategy	**IPP**	*Advice on gas plant margin strategy, including impact of contracting on risk/return.*
Market access	**Generator**	*Advising UK portfolio generator on R2M contract structure & counterparty selection.*
EfW investment	**Fund**	*Margin analysis and asset valuation to support bid for UK EfW portfolio.*
Market analysis	**Fund**	*Analysis of UK power market evolution & impact of peaker & battery roll out.*

Timera Energy power team members

Our team members have extensive senior industry experience and practical commercial knowledge.



Phil Robinson

15+ years power industry experience (E.ON, EDF, Calon)
Expert in value & risk management of power assets
Former commercial head of Calon Energy

Olly Spinks

20 years energy industry experience
Expert in commercial and risk analysis
Ran BP's LNG, gas & power commercial analytics function

Emilio Viudez-Ruido

15 years experience in European gas & power markets
Strong expertise in market modelling & margin analysis
Expert in deconstruction & analysis of asset exposures

David Stokes

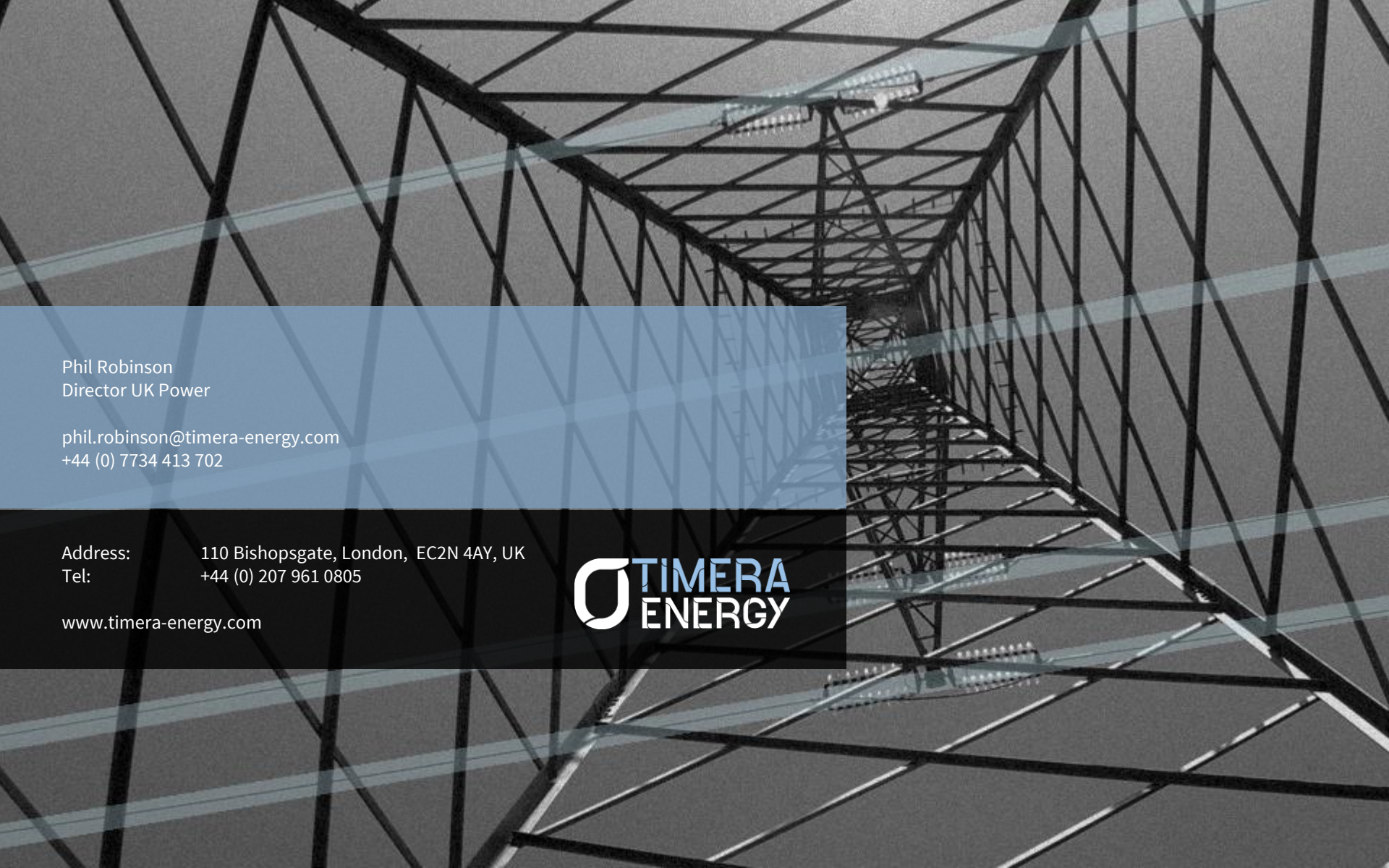
20 years energy/commodity market experience
Expert in value/risk management of flexible assets
Industry roles with Origin, Williams, JP Morgan

Nick Perry

30+ years industry experience (Amoco, Exxon, Enron)
Expert in commercial & risk management strategy
Board level experience (Enron Europe, Teesside Power)

Henry Crawford

8 years experience in energy & capital markets
Strong commercial & market analytics experience
Industry trading & analytics background (Nova Energy)



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