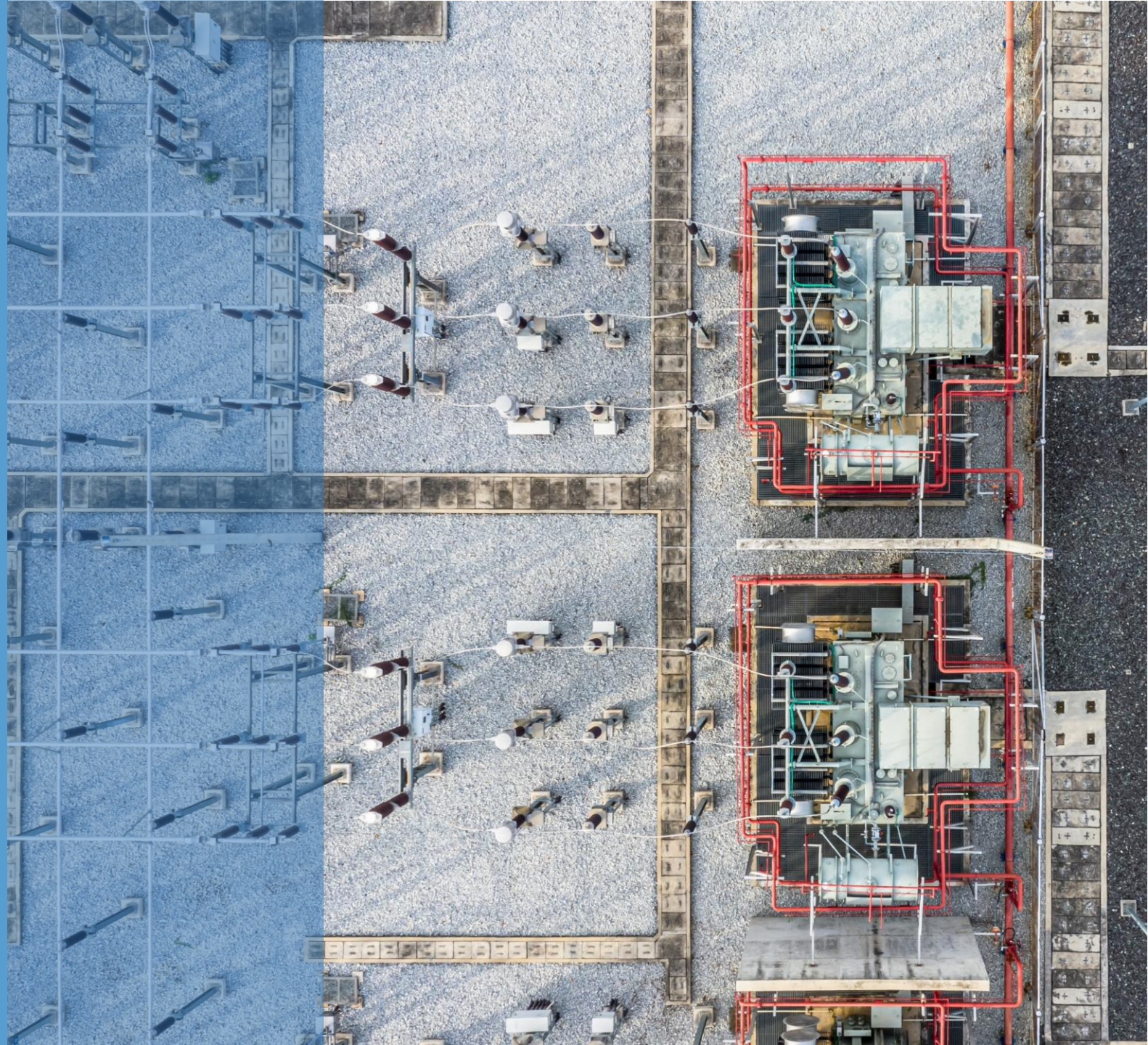
The flexibility to decarbonise

Europe's flex deficit & investment requirement

27 Feb 2020



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Contents

Executive Summary: Europe needs flex

Europe needs flexible capacity investment

Key takeaways

Irreversible momentum is building behind European power sector decarbonisation. This is a tough but achievable goal. However the popular ‘renewables + storage’ narrative oversimplifies the challenge ahead. Europe needs much broader flex investment.

1. Capacity transition	Decarbonisation is driving rapid structural changes in the power sector capacity mix
2. Closures	Capacity closures are set to significantly outpace renewable additions (despite new targets)
3. Flex deficit	Europe will shift from capacity overhang to deficit across next 3 years (30GW shift by 2023)
4. Price signals	Flex price signals (price shape & volatility) are set to rise with intermittency & market tightening
5. Investment	Large investment in new flex capacity is required across Europe (at least €55bn by 2030)

2 pack sections

We set out our analysis in two sections

1. Market drivers of a surging requirement for flexible capacity
2. Flex asset investment case dynamics & opportunities.

What markets do we consider?

Drawing the boundary

We focus on 7 key liberalised markets that are:

1. Closing large nuclear & coal fleets
2. Rapidly deploying renewables

We refer to this group as the E-7 which covers:

- Germany
- France
- UK
- Netherlands
- Belgium
- Italy
- Spain

E-7 coal & nuclear closures by 2030

Note: in some markets capacity closures will be much higher as ageing CCGTs close (e.g. UK, IT, ES)

E-7 changes in de-rated capacity (GW)

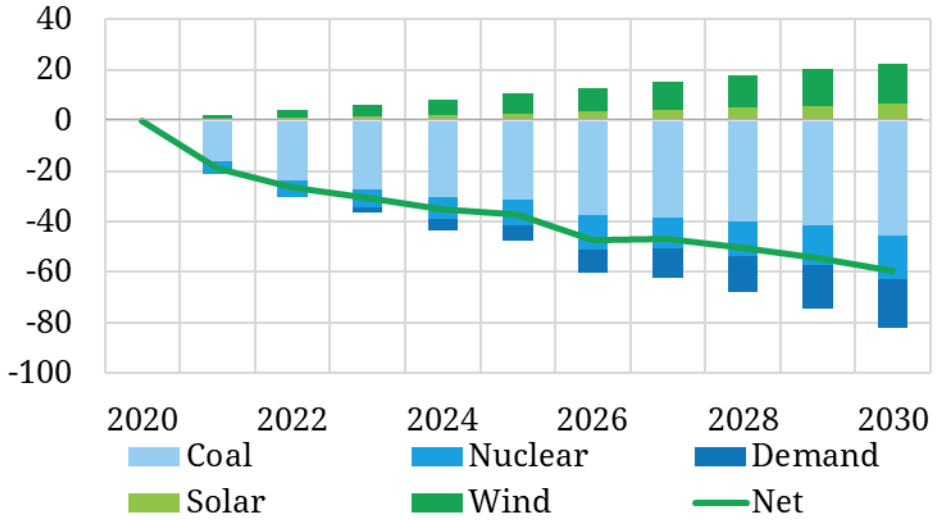


Chart shows net E-7 capacity reduction split out by wind & solar added vs coal/nuclear closed.

30 GW capacity reduction by **2023**

60 GW capacity reduction by **2030**

This does not account for another **20-30GW** of closures of ageing gas plants.

What type of flex does Europe need to decarbonise?

4 key types of flexibility are required to support decarbonisation

Flexibility type	Description
1. Capacity (MW)	Flex to meet residual demand peaks (load – wind – solar)
2. Energy (MWh)	Flex to generate incremental energy output
3. Load shifting	Flex to shift energy 1. across time and 2. between different locations
4. Balancing services	Real time flex e.g. balancing, frequency response, fast reserve, inertia

Ability to provide flex varies significantly across asset classes

Asset type	1. Capacity	2. Energy	3. Load shifting	4. Balancing	Considerations
Batteries					Very fast. Duration limitations. Net negative energy.
Interconnectors					Key to locational shift. Price dependent. Net zero energy.
DSR					Fast time shift. Duration limitations. Net zero energy.
Hydro					Very flexible. Limited cost-effective resource potential.
Hydrogen					Flexible. Currently high cost. Green H_2 net negative energy.
Gas peakers					Low capex & flexible. High variable cost. Carbon footprint.
CCGTs (inc. life extend)					V flexible. Carbon footprint (albeit falling with load factors).

Darker blue indicates higher contribution towards 4 types of flex required.
Red indicates a net negative energy contribution, i.e. asset uses more electricity than it generates.

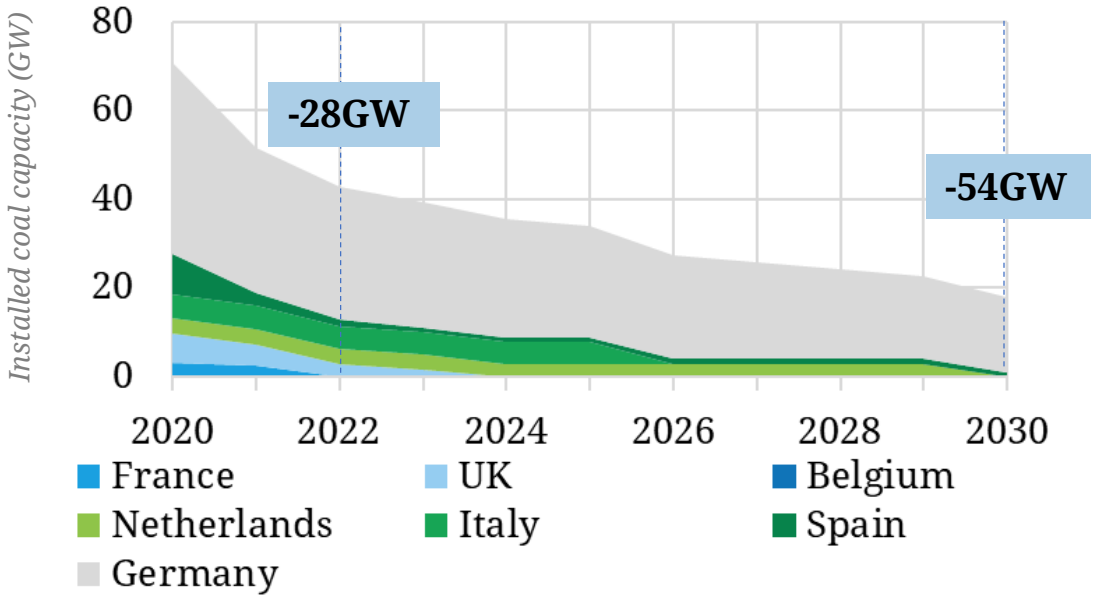
Drivers of flex capacity requirement

Europe closing coal fleet

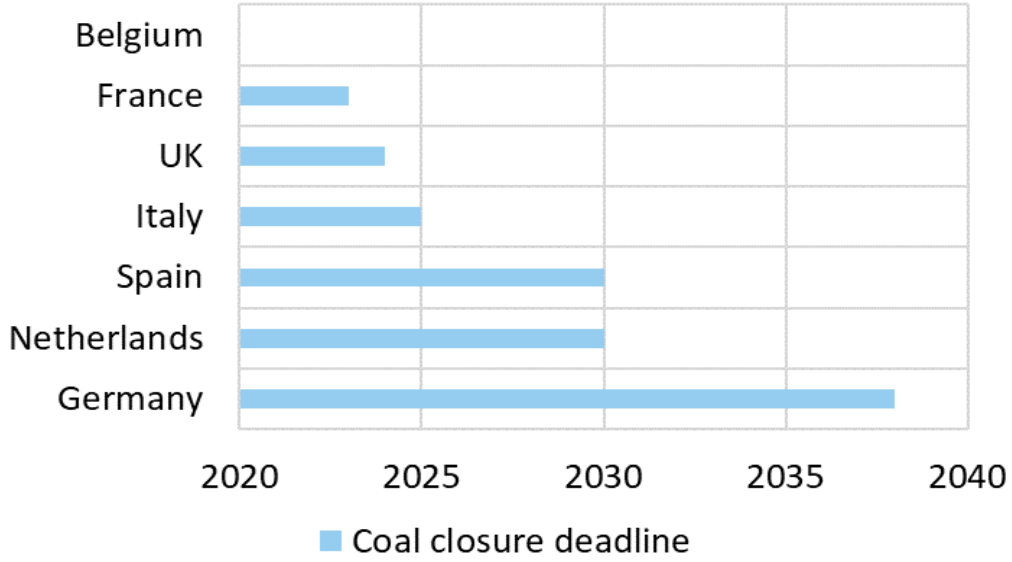
Decarbonisation is driving legislated coal closures across Europe

- Germany's 2038 deadline for coal closure means all E-7 countries now have policies to close remaining coal plants.
- Belgium exited coal in 2016. France is set to be next in 2022, followed by the UK in 2024.
- Overall, 28GW to close by 2022 & 54GW by 2030.

E-7 installed coal capacity



E-7 coal closure deadline



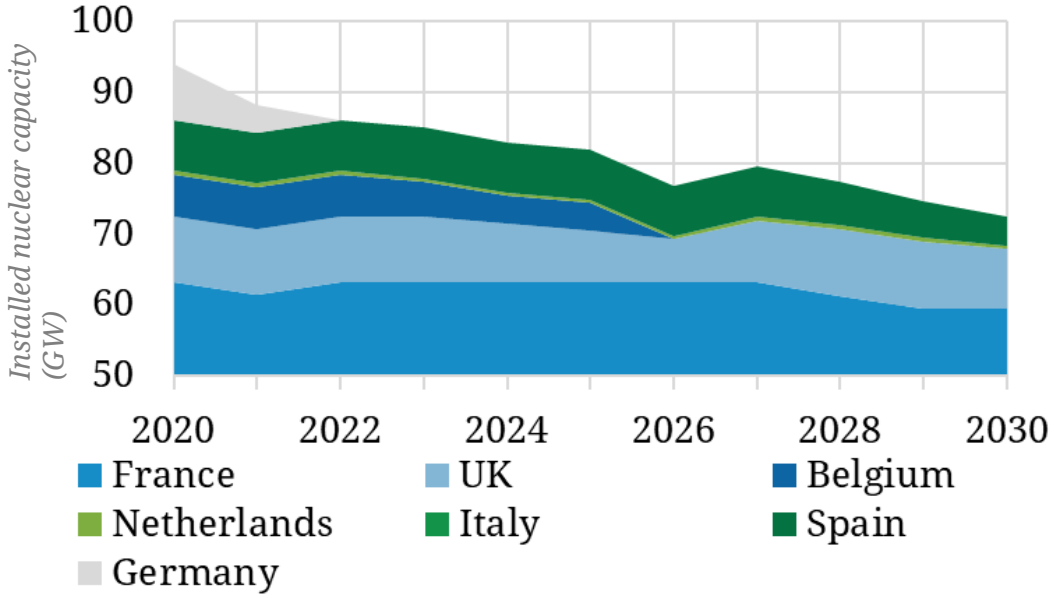
Source: Timera Energy, national governments

Nuclear plants being closed in parallel

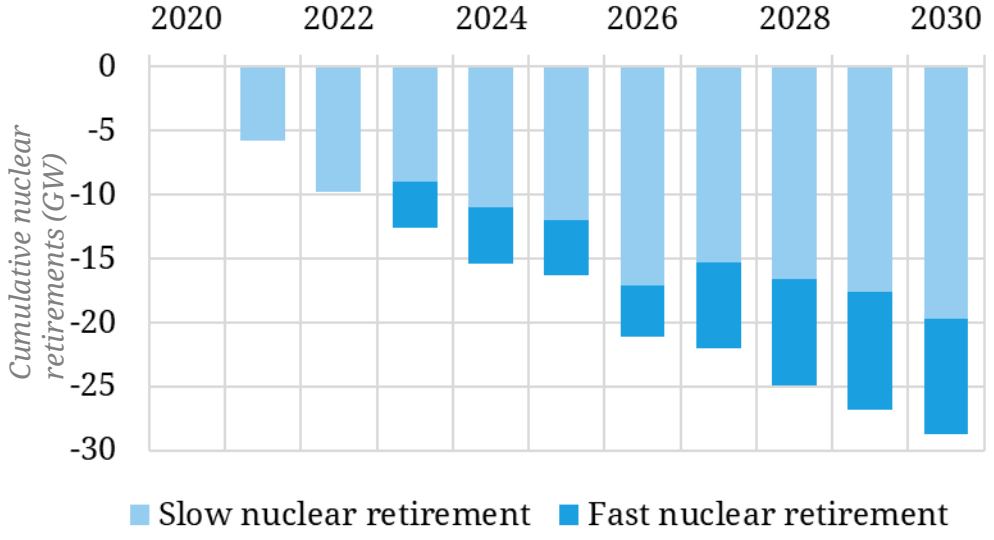
Nuclear closures retain broad public support with capacity set to fall fast across 2020s

- Coal closure timetable coincides with legislated closure of nuclear capacity, with a net 21GW of nuclear closures by 2030.
- In order to be conservative on the capacity impact of nuclear closures, our analysis in this pack assumes nuclear life extensions in France & UK ('slow retirement' path in chart).
- Current regulatory timetables would see 29GW of nuclear closure by 2030 ('fast retirement' path in chart).

E-7 installed nuclear capacity



E-7 nuclear retirements



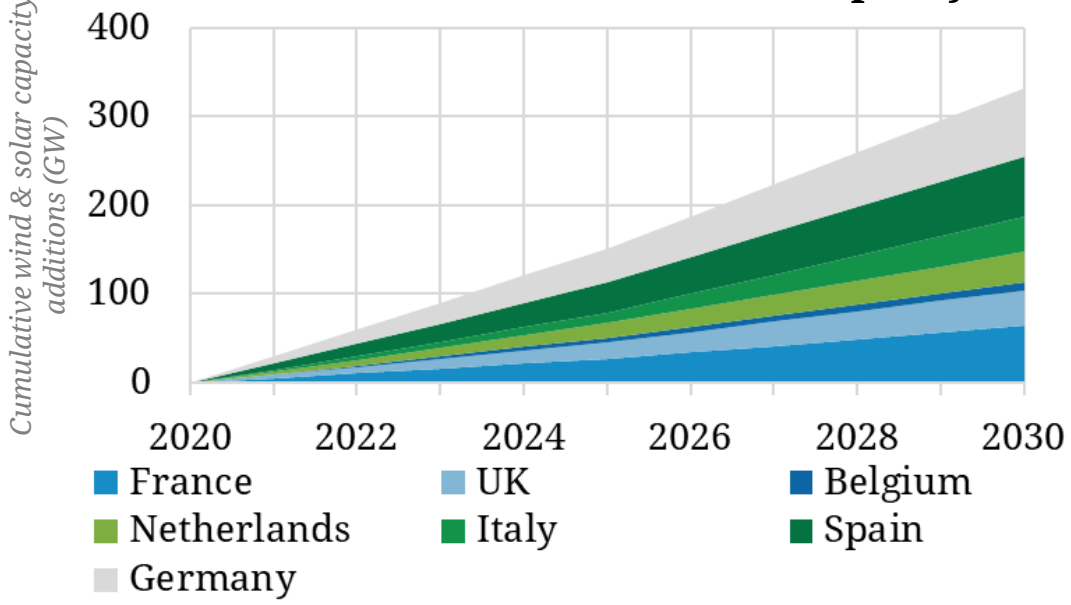
Source: Timera Energy, national governments

Renewables build is accelerating

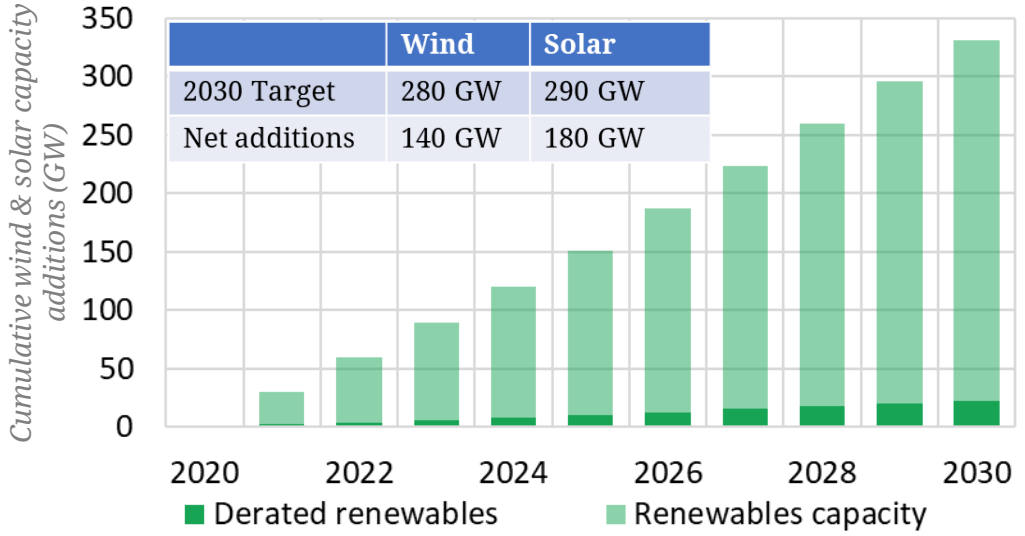
Policy narrative is that wind & solar will plug the capacity hole

- Cost declines and recent increases in policy targets are set to drive a rapid rise in wind & solar capacity (see charts).
- Security of supply standards across Europe are set based on de-rated capacity and wind & solar contributions are low.
- Wind & solar de-rating is based on 'capacity credit' for incremental supply (e.g. in UK 12% for offshore wind, 2% for solar).
- Average load factors are higher than de-rating factors (e.g. 40% offshore, 10% solar), but can't be relied upon to meet demand peaks.

E-7 incremental wind and solar capacity



E-7 de-rated wind & solar capacity targets



	Wind	Solar
2030 Target	280 GW	290 GW
Net additions	140 GW	180 GW

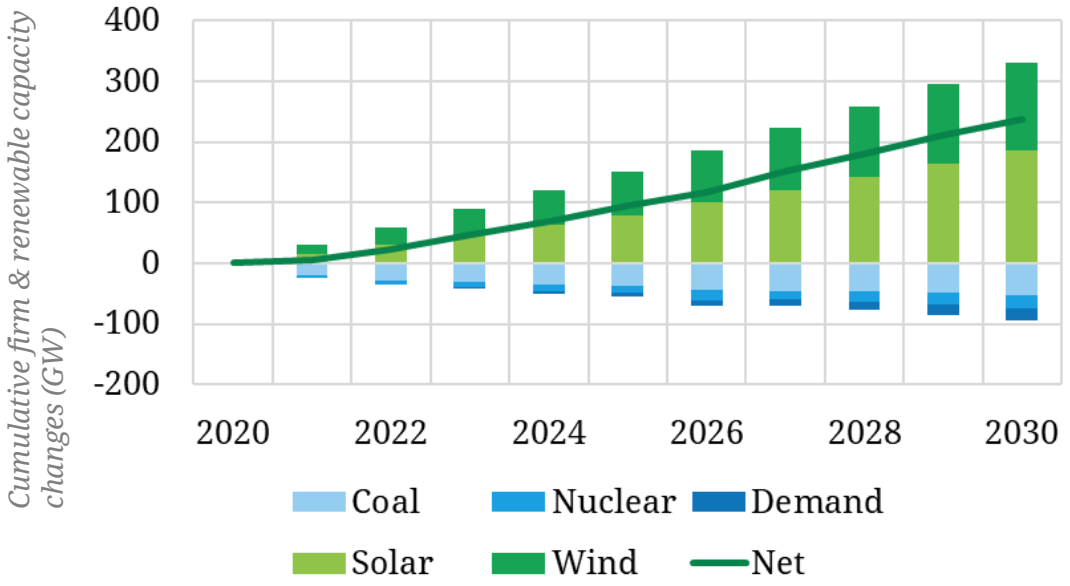
Source: Timera Energy, national targets

Major European capacity deficit despite renewables

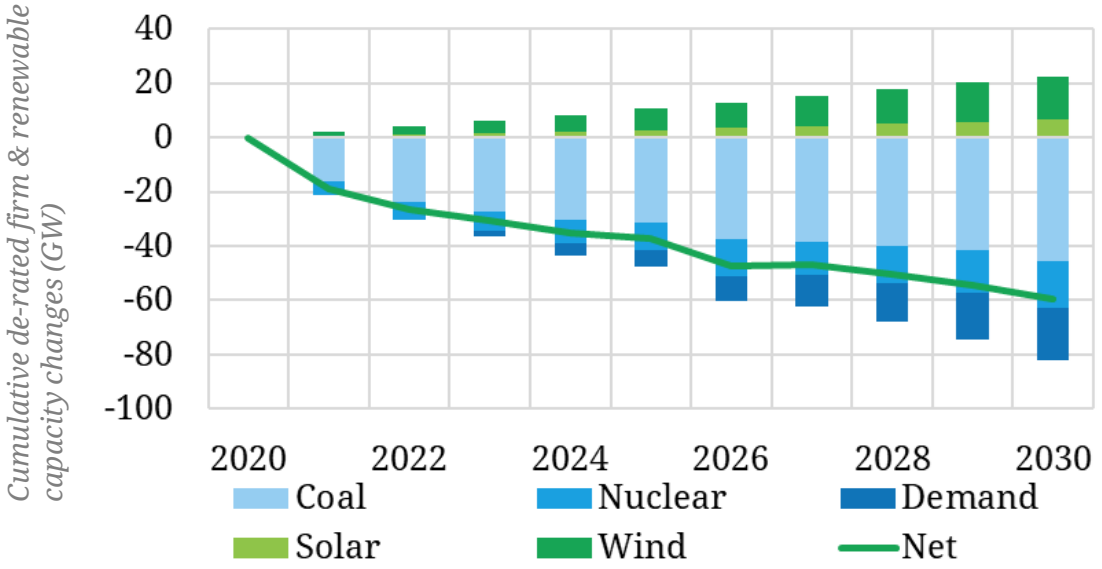
Europe to swing from capacity overhang to deficit across next 3 years

- The policy narrative is not backed by numbers… even if new wind & solar targets are met.
- At least 30GW reduction in net de-rated capacity set to happen by 2023 across E-7 markets (assuming latest RES targets).
- This grows to 60GW by 2030 as electrification boosts demand. Another 20-30GW of potential closures of ageing gas plants.
- Accelerating renewables build won't plug the gap: Europe needs investment in flex … at least €25bn by 2025; €55bn by 2030.

E-7 incremental nominal capacity



E-7 net incremental de-rated capacity decline



Source: Timera Energy

Why flex matters: Low wind & solar period

German case study

- By 2030, Germany will have over 190GW of wind & solar.
- Flexible capacity is set to fall by 30GW by 2030 (nuke/coal closures).
- Chart shows how Germany will still require large volumes of flex to meet demand during periods of low wind & solar output.

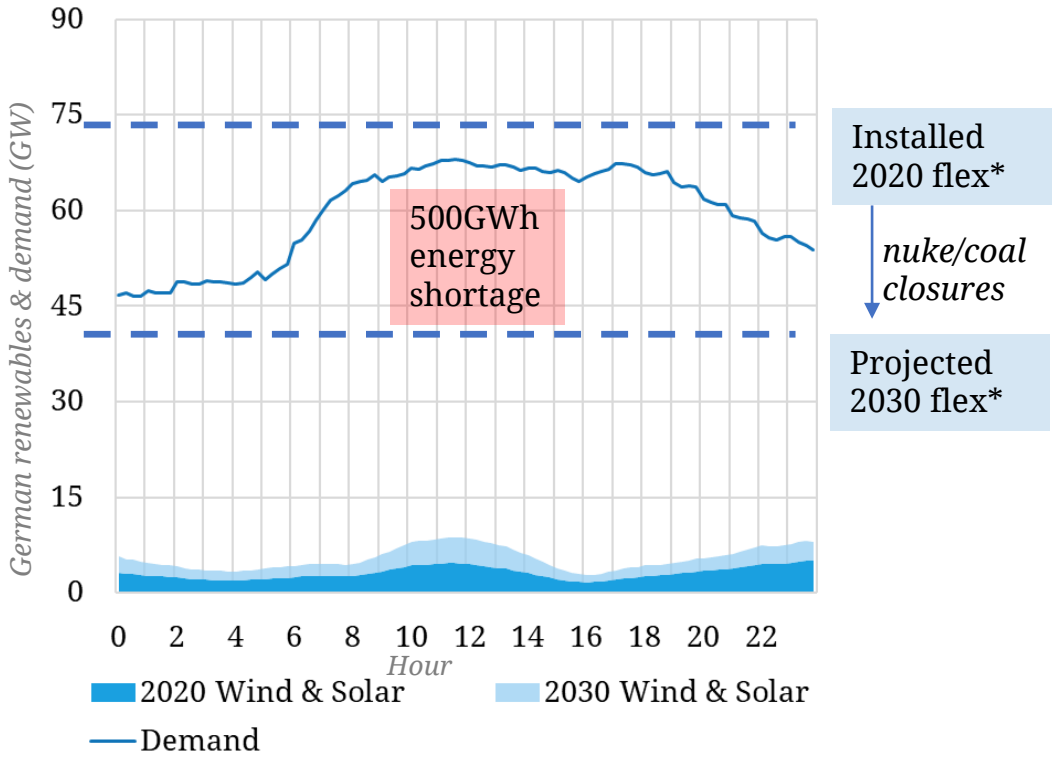
Load shifting flex alone is not enough

- Low renewable periods can last days/weeks & impact all of Europe.
- In 2030, Germany could face an energy shortfall of over 500GWh per day in low renewable periods (~250GW battery equivalent).

Energy flex is needed

- Large energy deficits can not be met by storage alone.
- Storage & DSR can temporarily shift / balance energy but are net consumers. Interconnectors can relocate but not create energy.
- That leaves a key role for gas (e.g. engines, CCGTs & CHPs), albeit at falling load factors over time as renewables grow.
- Hydrogen is also likely to play an important role providing storage & energy.

German low renewable day (GW)



Source: ENTSOE, Timera Energy

Chart shows demand profile vs renewables output for a recent actual German market day (2020). Installed flex capacity in 2020 comfortably covers renewable shortfall.

Now consider 2030. Chart shows incremental wind & solar output scaled up for 2030 capacity growth. But 30GW lower flex capacity in 2030 leaves a large capacity deficit.

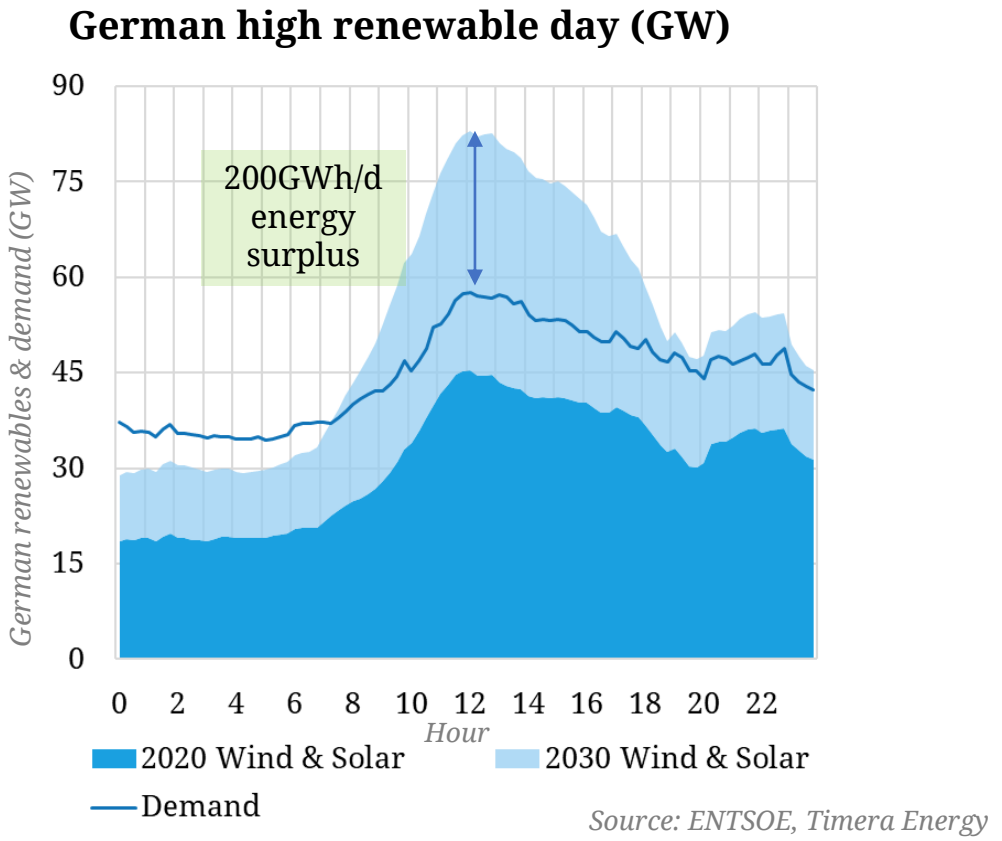
Why flex matters: High wind & solar period

German case study (part II)

- Over-supply requires significant downward flex investment (e.g. storage, DSR, electrolysis) to avoid large scale curtailment & network stability issues.
- By 2030, peak German solar output may reach 60GW.
- High solar periods will push large volumes into other European markets, where correlated high renewable volumes are also trying to 'escape' (i.e. glut stress events).

Negative flex is key

- On high renewable days, Germany may need to export up to 25GW
- Over 1.5TWh of excess energy could be generated across a windy & sunny week, saturating available storage.
- DSR, electrolysis, storage & interconnectors will need to combine with rapidly flexible thermal capacity to accommodate large renewable swings.



Source: ENTSOE, Timera Energy

Chart shows renewables output vs demand profile for a recent actual German market day (2020). Wind & solar output typically falls short of total German demand.

Now consider 2030. Chart shows incremental wind & solar output scaled up for 2030 capacity growth. Much higher wind & solar output in 2030 causes a large energy surplus.

Intra-day output swing ranges

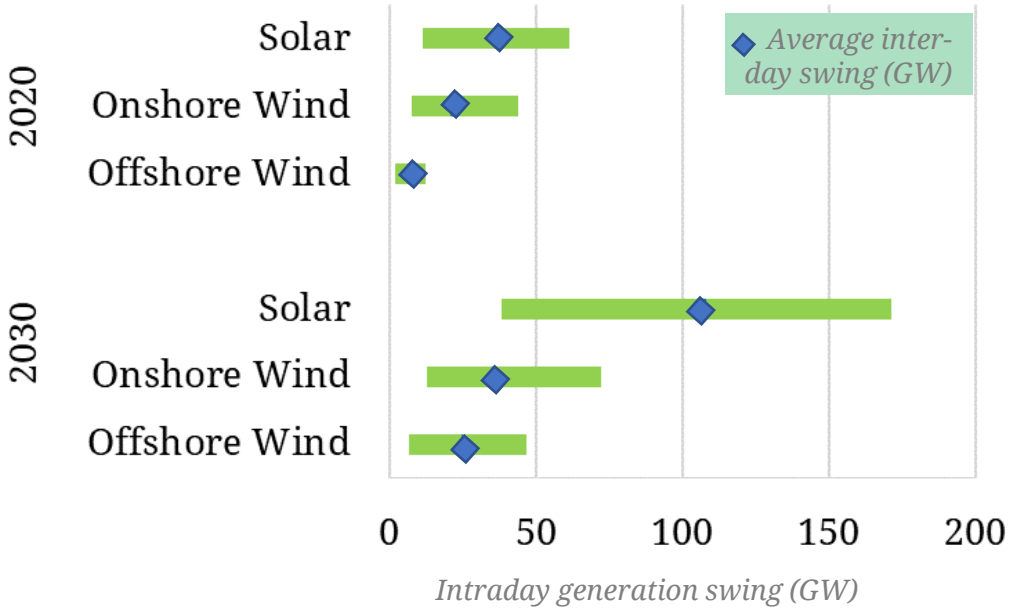
Huge increase in intra-day wind & solar swings

- Large increases in renewables capacity do not preclude periods of no sun and low wind conditions across Europe.
- By 2030, 100+ GW swings in renewables output may take place within minutes as sun & wind conditions change.
- Wind seasonally balances solar, but are uncorrelated within-day, i.e. wind and solar can spike/fall together.

Intra-day swing ranges in numbers

- The chart shows est. E-7 intraday swing range distributions for wind & solar (diamond = 50%, green bar 5-95%).
- For example:
  - 100GW+ average intraday solar swing range by 2030
  - More than 170GW intraday solar swing potential.
- By 2030, E-7 renewables will swing up to 215GW within-day, against a current power demand of c.230GW.

E-7 intra-day generation swings (GW)



Source: Timera Energy

Intra-day swings transform flex requirement

Intermittency will require unprecedented flex

- Power system flexibility has historically focused on servicing relatively mild fluctuations in peak / offpeak load.
- Intra-day swings from intermittency are of a different scale and speed (see numbers on previous slide).
- This will lead to structural changes in the 'flexibility gap' (demand – wind – solar) that needs to be filled by dispatchable flexible capacity (see chart).

Big implications for existing & new flex assets

- System flex requirements will reshape the merit order:
  - Flexibility will compete with efficiency e.g. lower efficiency engines displacing CCGTs given high ramps & no start costs
  - Downwards flex will become a key system requirement.
- This will drive flex investment in existing assets e.g. to reduce min stable generation levels & increase ramping flex.
- Negative flex requirements will grow substantially (e.g. storage, DSR, interconnectors, electrolysis).

Illustrative intraday German summer flex gap (GW)

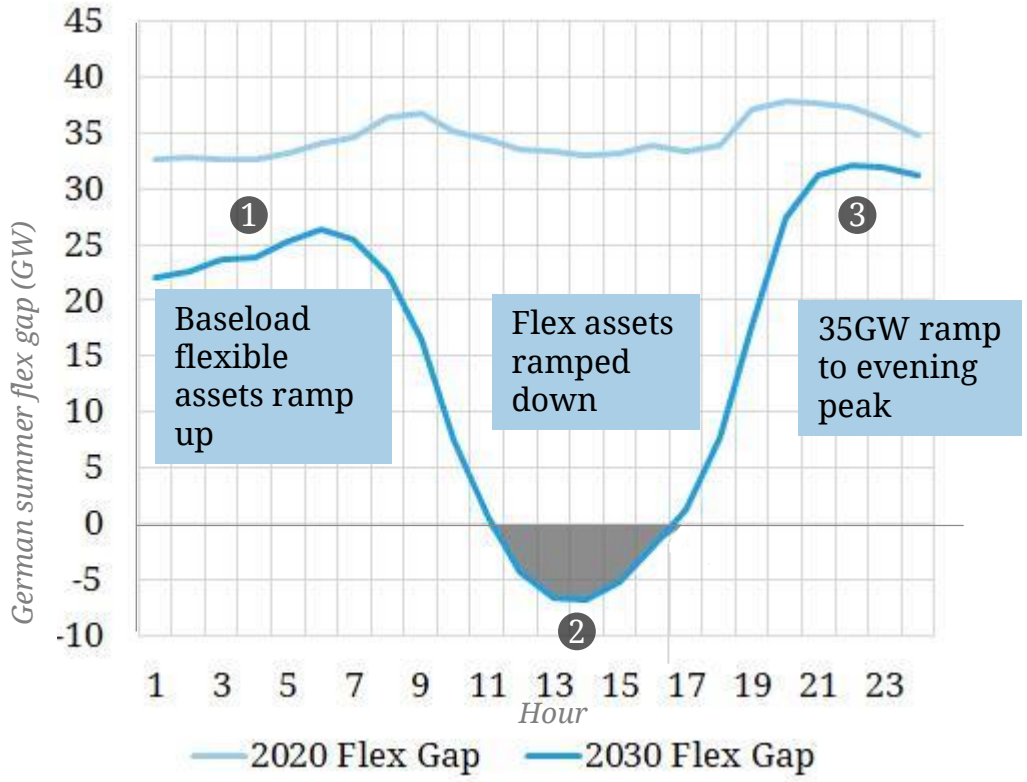


Chart shows 'flex gap' requirement (demand – wind - solar) across a typical German summer day in 2020 vs 2030, accounting for increased renewable capacity

Source: Timera Energy

Structural rise in price shape and volatility

2 key wholesale market price signals for flex capacity

1. Price shape – incentivises peaking flex & load shifting
2. Price volatility – incentivises flex response

Structural drivers support an increase in both

Factors driving higher price shape

- *Renewables surplus*: Rising occurrence of low/zero/negative prices during periods of high renewable output.
- *Flex gap*: Increasing role of higher variable cost flexible capacity (e.g. gas peakers, storage, DSR) setting prices.

Factors driving higher price volatility

- *Intra-day flex volatility*: Large intra-day swing ranges in wind & solar (shifting flex asset value capture to prompt horizon).
- *Inter-day flex volatility*: Flex gap distribution widens as intermittent renewables increase price swings.
- *Storage saturation*: Extended periods of high/low renewables quickly fill/deplete storage, removing price stabilisers.
- *Parallel E7 renewable build*: Renewable output between countries is highly correlated, resulting in pan-European flex highs & lows.

Intraday swing in German flex gap distribution

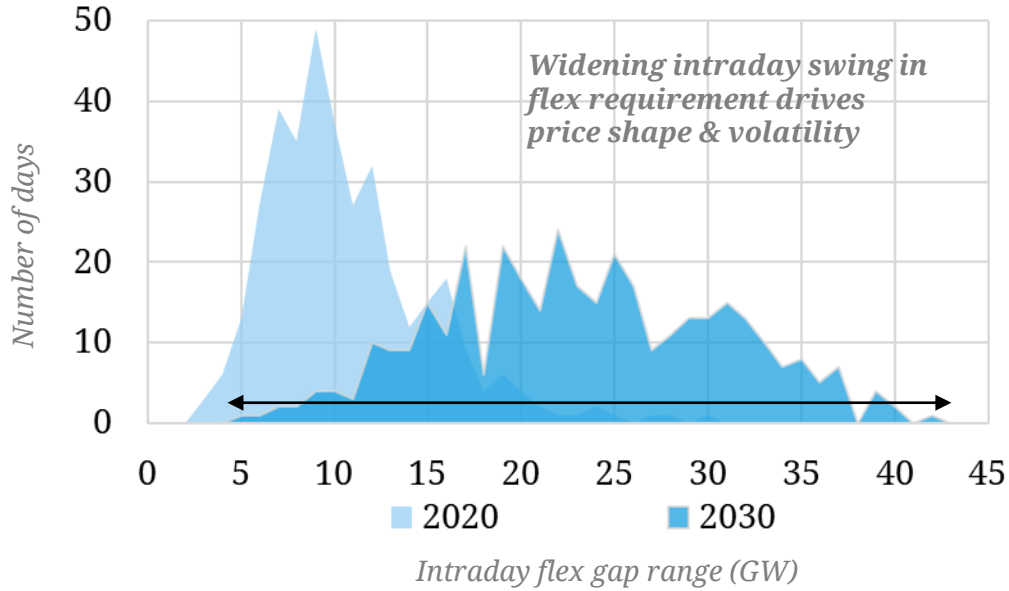


Chart shows the projected distribution of range in flex gap (the highest – the lowest flex requirement within day) in Germany in 2020 versus 2030. Flex gap distribution increases substantially, as does price range to balance markets. This is set to cause much higher price volatility.

Investment in flexible capacity

Building a flex asset investment case

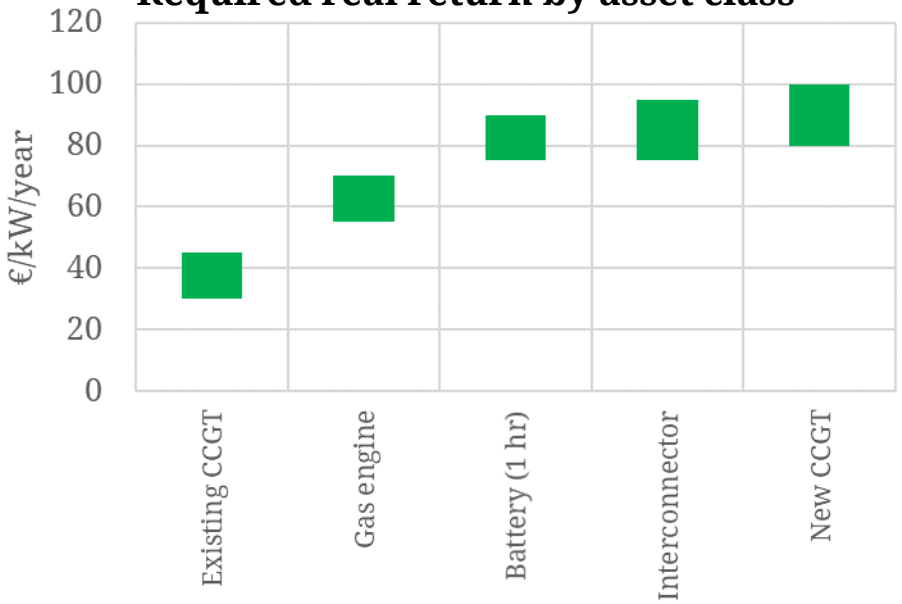
Investment case drivers

- Asset classes vary by capex, opex, risk, intrinsic vs extrinsic value.
- But investment case for all assets depends on relationship between:
  - Required risk adjusted return on capital
  - Asset margin distribution (e.g. 50% vs 10% & 90% returns).

Quantifying margin distribution requires:

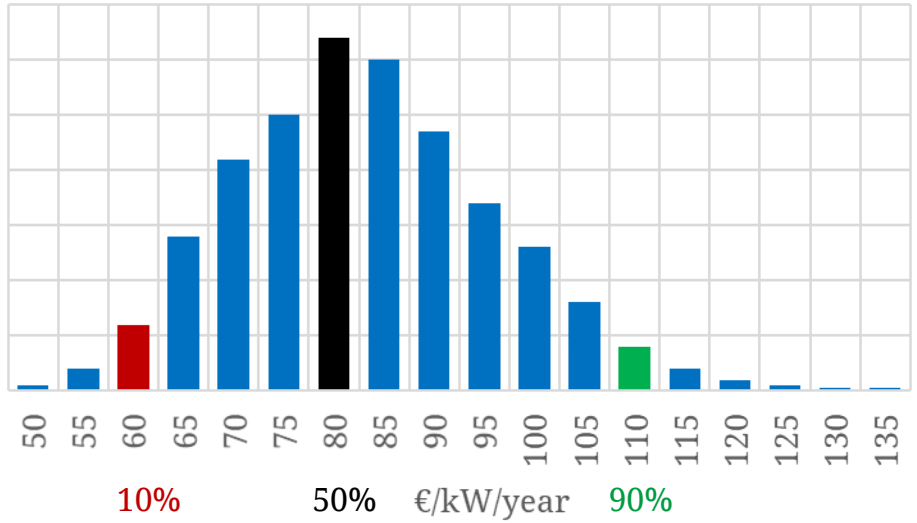
1. Market 'supply stack' model capturing uncertainty.
2. Asset dispatch model optimising across co-dependent margin streams (e.g. wholesale, balancing, ancillaries).

Required real return by asset class*



** Based on Timera Energy analysis of required asset returns*

Margin distribution (storage example)



1. Market 'supply stack' model (500+ stack simulations of wind, solar & load conditions)

→

2. Asset dispatch optimisation model (dispatch vs 500+ sims of prices using realistic monetisation strategy)

→

Quantifying flex asset value

Conventional supply stack & dispatch modelling increasingly undervalues asset flex & misrepresents risk

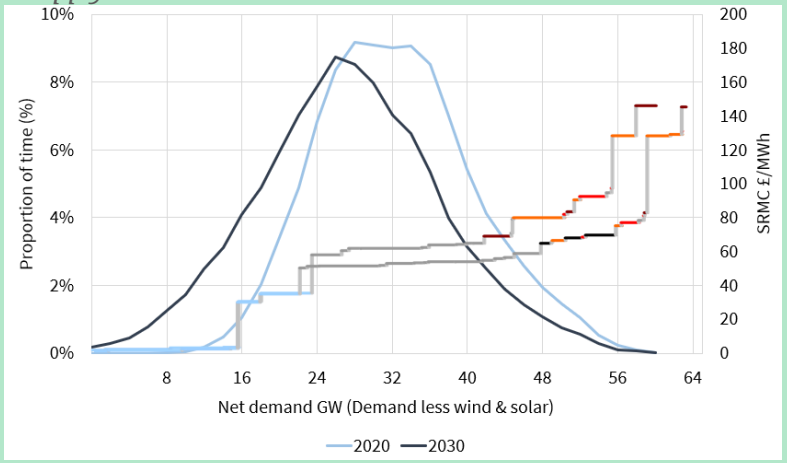
We apply a two step simulation based modelling approach to generate realistic flex asset returns

1. **Market modelling:** we simulate multiple (e.g. 500+) correlated profiles for wind/solar/load via a stochastic stack model
2. **Margin modelling:** market model results feed into a stochastic asset dispatch optimisation model to produce margin distributions.

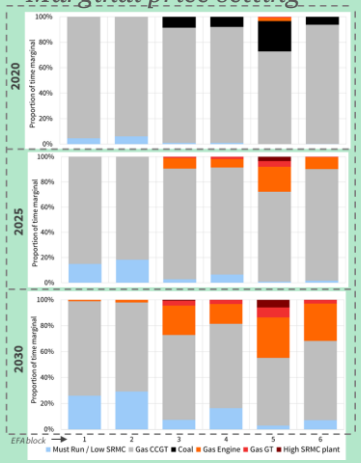
1. Market modelling

Supply stack modelling needs to capture the evolving impact of wind, solar & load distributions & associated uncertainty. Simulation based modelling of intermittency & changing stack shape, underpin realistic projections of price level, shape & volatility.

Supply stack simulation



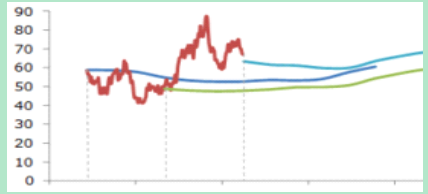
Marginal price setting



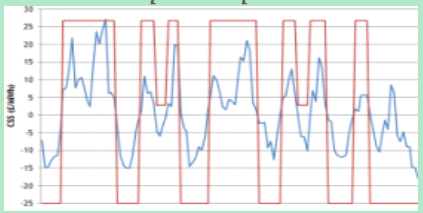
2. Margin modelling

1. Market analysis used as input to generate 500+ simulations of market prices. 2. Model then optimizes flex asset dispatch against each price path to generate a realistic margin distribution. 3. Model captures impact of asset hedging & optimisation strategy to generate value distribution.

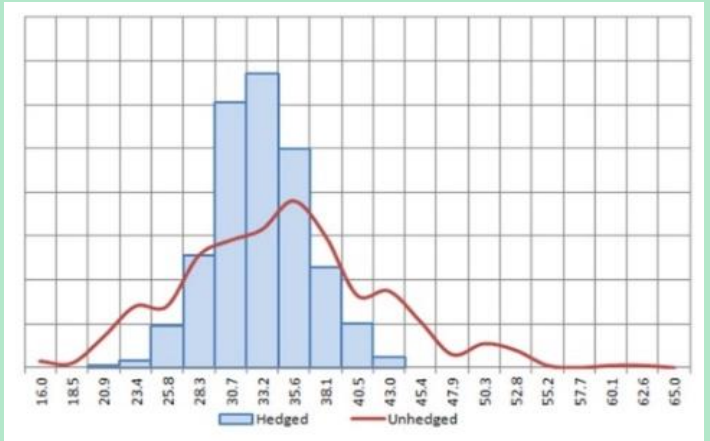
1. Market price simulation



2. Asset dispatch optimisation



3. Distribution of asset margin & risk/return



Benchmarking value downside & upside

Building confidence in modelled value

- There is no substitute for sophisticated market & asset modelling of flexible asset value.
- But... How can I sense check the model? How do I get comfortable with value downside if the model is wrong?
- Equity & debt investors are becoming more comfortable with flex asset risk. Transparent benchmark analysis & backtesting helps.

1. Margin drivers

Two key price signals drive flex asset margin:

I. Intraday price shape (e.g. peak vs offpeak)

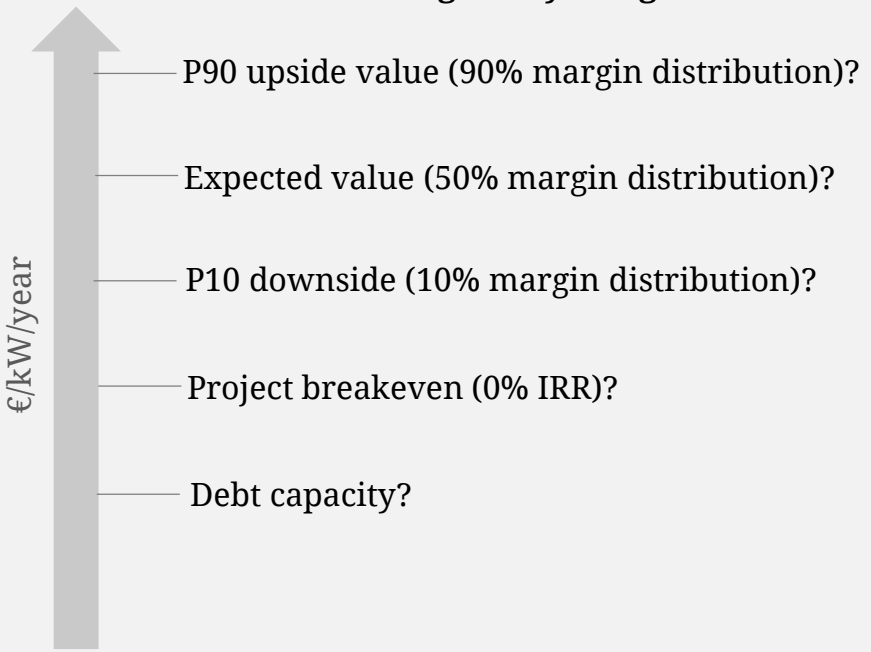
II. Spot price volatility (e.g. due to intermittency)

Margin levels can be benchmarked to build confidence.

2. Margin build up benchmarks*

4. Additional price volatility	additional price volatility above underlying 'noise' level
3. Structural price volatility	underlying price 'noise' due to inherent swings in wind/solar/load
2. Structural price shape	structural intraday shape that can be captured in forward market
1. Non wholesale market	capacity payments, ancillaries, locational benefits

3. Benchmarking of key margin levels



Note: margin benchmark buckets can be interdependent

Flex asset contracting structures

Contracting can address 3 issues

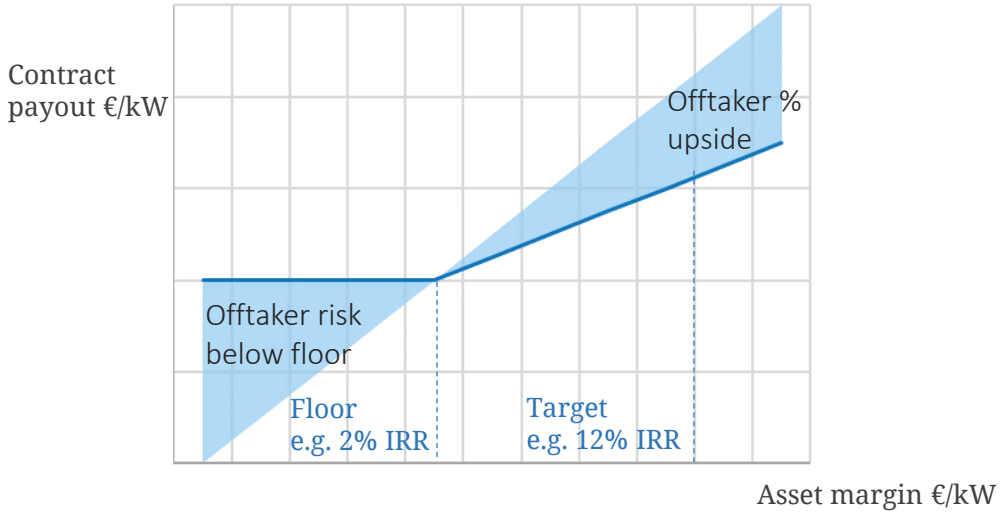
1. Downside protection
2. Market access
3. Incentivised trading value capture.

Flex asset contracting structures are evolving

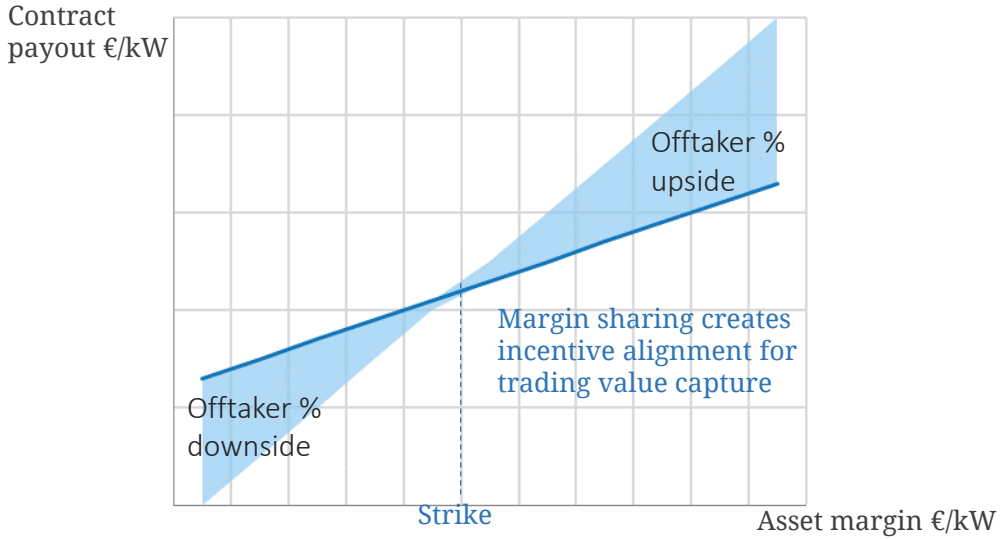
Different approaches to limiting/sharing/tranching risk e.g.

- Margin floor (top diagram)
- Margin risk sharing (bottom diagram)
- Different equity tranches
- Corporate PPAs (evolving demand for 'load following' PPAs)
- Hedging or insurance.

Margin floor with upside sharing



Upside & downside margin sharing



Policy support tailwinds

Policy support for flex is grossly inadequate

- Currently there is a disconnect in Europe between:
  1. Flex capacity requirement
  2. Returns required to deliver flex.
- This 'policy funding gap' is most acute in Germany, but is Europe wide for some technologies e.g. storage, DSR, hydrogen.
- Flex asset investment needs capacity payments (or equivalent).

Watch for value tailwind from rapid policy evolution

- What if policy doesn't evolve to provide more flex support?
- Price volatility will surge as Europe swings from capacity overhang to deficit… across the next 3 years.
- If it hasn't already happened, this should trigger policy action.
- Flex capacity is set to be remunerated one way or another.

Impact of decarbonising faster?

- More rapid decarbonisation increases the flex capacity deficit.
- Logic? Electrification of other sectors (transport, heat & industry) drives up power demand & flex requirement.

Capacity payment support gathering pace

UK	Capacity market
France	Capacity market
Germany	No capacity payments
Belgium	Strategic reserve
Netherlands	No capacity payments
Spain	Limited cap. payments
Italy	Capacity market

Green = markets with more acute/imminent flex investment need
Blue = markets with ongoing flex investment requirement

Flex capacity support tailwinds (examples)

Capacity price recovery (overhang swings to deficit)
Capacity payment reforms targeting flex
Balancing & ancillary services reform
Sharper balancing price signals
Advantageous network charging reform
New low carbon flex support mechanisms

Case study: German flex investment

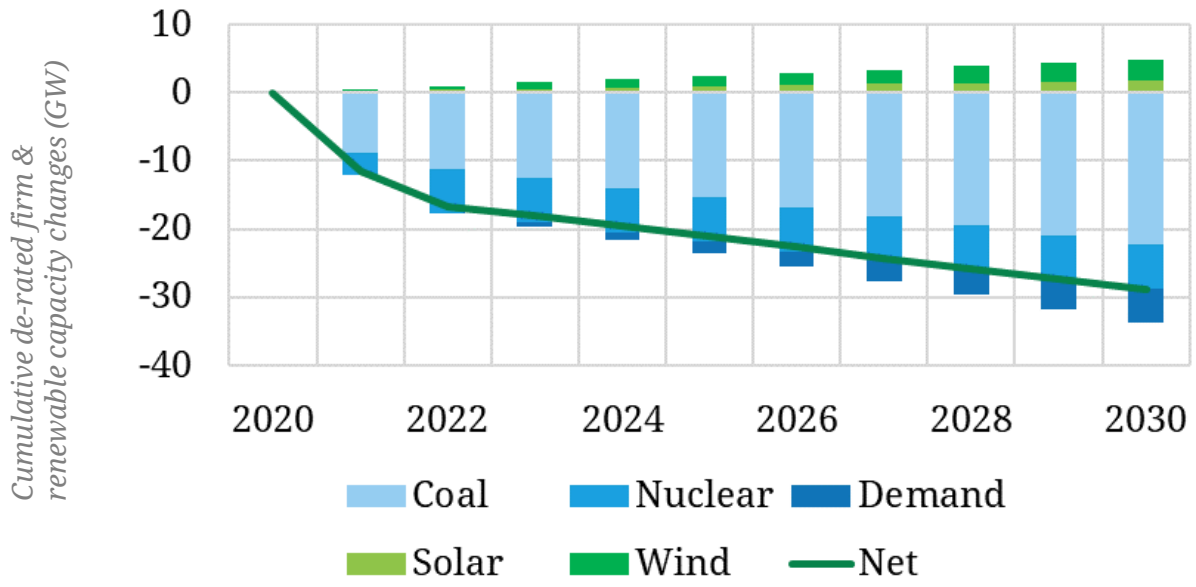
Value proposition

- Historical flex capacity overhang set to swing rapidly into deficit over the next 3 years.
- High wind/solar penetration & rapid deployment to drive sharp increase in price shape & volatility.
- Rapid decarbonisation increases flex capacity gap as other sectors electrify (e.g. transport & heat).
- Targeted policy support mechanisms e.g. CHP.

Challenges

- Historical capacity overhang (dampening price signals).
- No market wide capacity payment mechanism.
- Revenue dependence on 'reserve control' balancing market.
- Rapidly evolving policy support landscape.
- 4 separate TSOs and networks.

Change in German de-rated capacity balance (GW)



German flex investment opportunities

1. Gas CHP / CCGT	e.g. replace coal/lignite CHP & district heating	*Transition flex from gas (needed until at least 2050)*
2. Gas peakers	low capex, low load factor, low carbon	
3. CCGT extensions	cheapest incremental flex e.g. as GTs	
4. Storage	Rising price volatility; shifting policy support	*Low carbon flex*
5. DSR & EVs	Growing policy support & infra build out	
6. Interconnectors	new & upgrades e.g. to CEE, Nordics & Alpine	
7. Hydrogen	green & blue hydrogen pilot projects	

Case study: UK flex investment

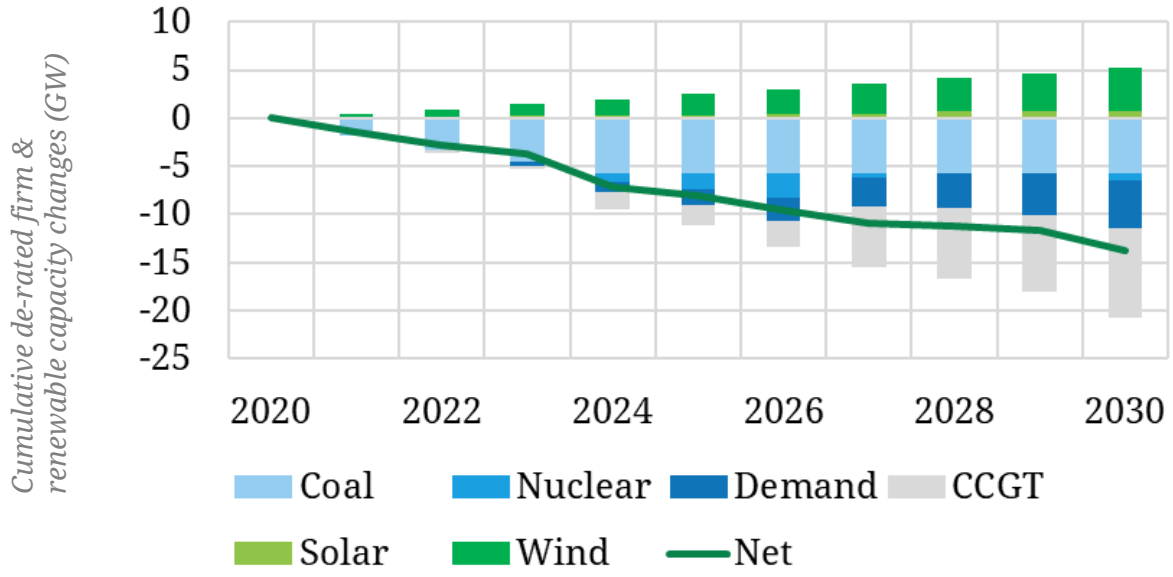
Value proposition

- Rapid scheduled closures of coal & nukes
- Ageing CCGT fleet (some will need to close)
- New capacity requirements to drive near term capacity price recovery
- New higher wind targets driving intermittency
- Evolving EV policy targets supporting demand.

Challenges

- Low recent capacity clearing prices
- Current overhang of coal & CCGT capacity (set to clear over next 2-3 years)
- Transition to increasing focus on BM returns
- Evolving policy support landscape (e.g. for DSR/storage/EVs)
- Carbon price floor uncertainty.

Change in UK de-rated capacity balance (GW)



UK flex investment opportunities

1. New CCGT	2-5GW potential. Need capacity price >£25/kW.	*Transition flex from gas (needed until at least 2050)*
2. Gas peakers	5+ GW potential. Need £15-20/kW cap price.	
3. CCGT extensions	Cheapest incremental flex e.g. as GTs	
4. Storage	Margin focus on BM. Evolving policy support.	*Low carbon flex*
5. DSR & EVs	Evolving policy support. Tech dependency.	
6. Interconnectors	Potential new to IE, DE, FR, Nordics	
7. Hydrogen	green & blue hydrogen pilot projects	

5 key flex investment takeaways

Takeaway	Description
1. Flex requirement	• Structural reduction in flex capacity underway (at least 30GW by 2023, 60GW by 2030). • At least 25€bn flex investment required by 2025, 55€bn by 2030*.
2. Asset types	• New low carbon flex technologies are key, but need policy support & can't plug the gap alone. • Very difficult to construct a scenario where gas flex will not be required until at least 2050.
3. Investment case	• Focus on asset margin distributions i.e. simulation based analysis of markets & asset dispatch. • Sense check with benchmarks & backtesting. Contracting can help manage risk/return.
4. Policy tailwinds	• Current policy support is grossly inadequate to deliver scale of required flex investment. • As overhang swings to deficit, capacity prices will rise & other support tools will be implemented.
5. Opportunities	• 'Sweet spots' where capacity needs overlap 1. market price signals & 2. policy support tailwinds. • First mover advantage with some markets/assets given 1. economies of scale & 2. entry barriers.

**Note: these numbers are much larger if you include 1. other non E-7 EU markets 2. gas plant closures 3. nukes closing to schedule 4. renewable target misses.*

What can Timera do to help?

Timera 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, value monetisation & market analysis

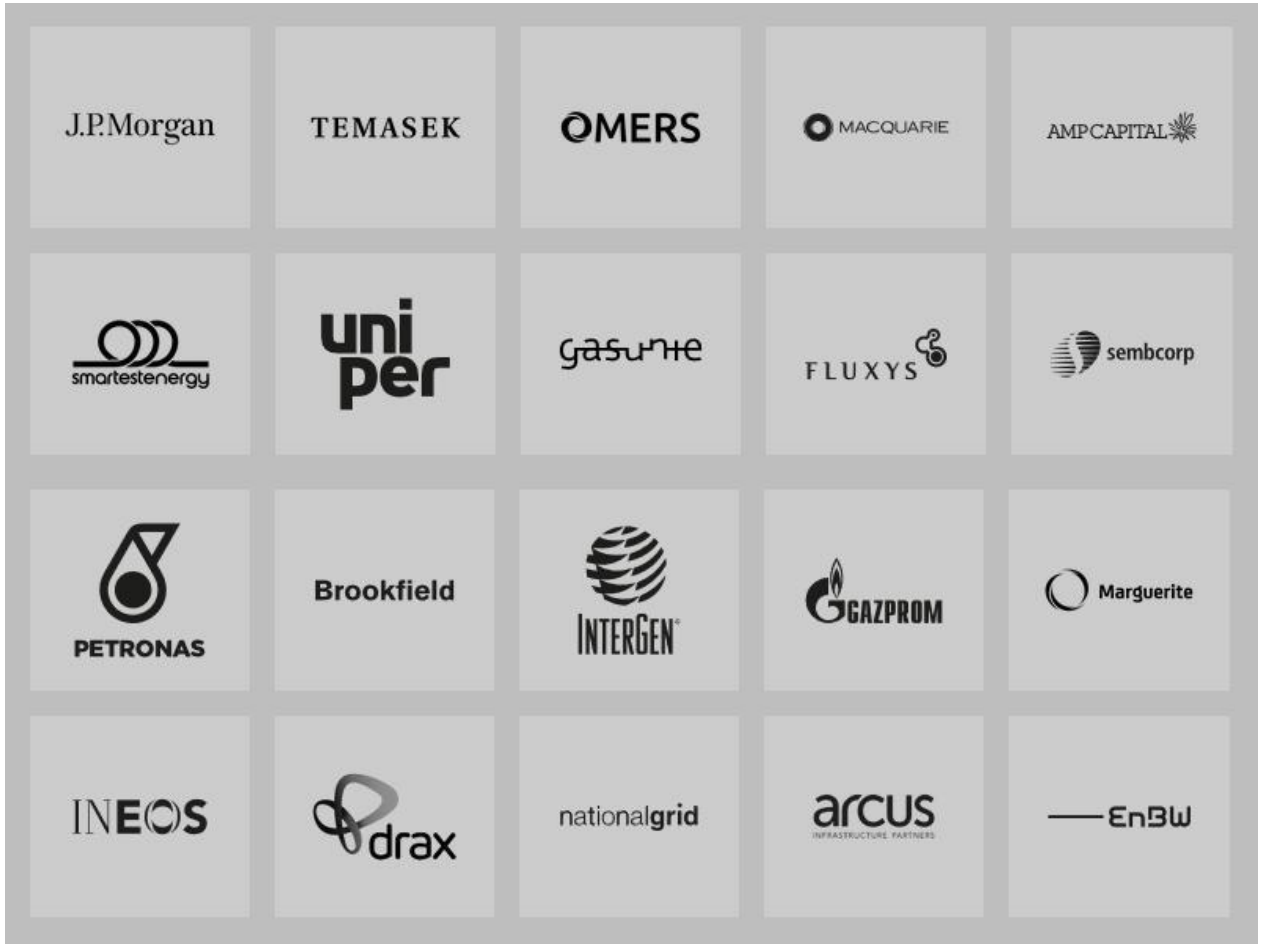
Strong client base

leading energy companies (producers, utilities, funds)

Leading industry blog

15,000+ regular readers, publications, conferences

Our clients include



What does Timera do?

Our power asset class expertise

- Conventional generation
- Battery & hydro storage
- Renewables
- Interconnectors
- Distributed flex / EVs

Our power related services

A. Investment

- asset valuation
- commercial due diligence
- transaction support
- investment targeting
- portfolio strategy

B. Value Management

- flex asset monetisation
- contracting & optimisation
- risk management
- business model structure
- analytical capability development

C. Market Analysis

- scenario analysis
- stochastic stack modelling
- LNG/gas/power integrated modeling
- asset value implications
- capability development

Recent Timera project credentials

A. Investment

- **Thermal:** Due diligence & valuation for DE & NL thermal portfolio acquisition
- **Storage:** Valuation & transaction support for bid on 2GW battery portfolio
- **Gas plants:** Valuation to support bids for multiple NW European CCGT & engine portfolios
- **Renewables:** Valuation & due diligence on multi-asset NW European renewable portfolio
- **Interconnectors:** Market & valuation analysis to support bid for stake in UK-FR interconnector

B. Value Management

- **Flex monetisation:** advised on battery & engine portfolio hedging & optimisation strategy
- **Onboarding:** advised on development of post acquisition portfolio value & risk management
- **Offtake:** supported offtake & market access contract structure design & negotiation
- **Asset closure:** Analysis of coal end of life economics & auction bidding strategy
- **Capability:** developed & implemented an Earnings at Risk based CCGT hedging capability

C. Market Analysis

- **Flex need:** Analysis of evolution of Western European requirement for flex to support decarbonisation
- **Pricing:** Detailed analysis of intermarket linkages across LNG, gas & NW European power markets
- **Shape & volatility:** Deep dive stochastic analysis of evolution of NW Europe price shape & volatility
- **Cannibalisation:** Stochastic analysis of evolution of wind & solar capture prices
- **Power modelling:** Support for client development of stochastic market modelling capability

Timera power team members

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

David Stokes: Managing Director

20+ years energy/commodity market experience
Expert in investment/monetization of flex power assets
Industry roles with Origin, Williams, JP Morgan

Olly Spinks: Managing Director

20+ years energy industry experience
Expert in flexible power asset valuation
Ran BP's gas, LNG & power commercial analytics function

Rosie Read: Director

10 years industry energy industry experience
Optimisation and commercial analysis expert
Analysis, strategy & power trading industry background

Steven Coppack: Senior Analyst

7 years European energy industry experience
Trading, optimisation and fundamental analysis expert
Analysis, operations & trading industry background

Nick Perry: Senior Advisor

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

Tommy Rowland: Analyst

5 years European energy industry experience
Strong power, risk and data analysis expertise
Commercial & risk analysis roles at Smartest Energy

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