Existing power plants sharing grid access with new resources can lower costs and double UK's generation capacity

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Working Paper

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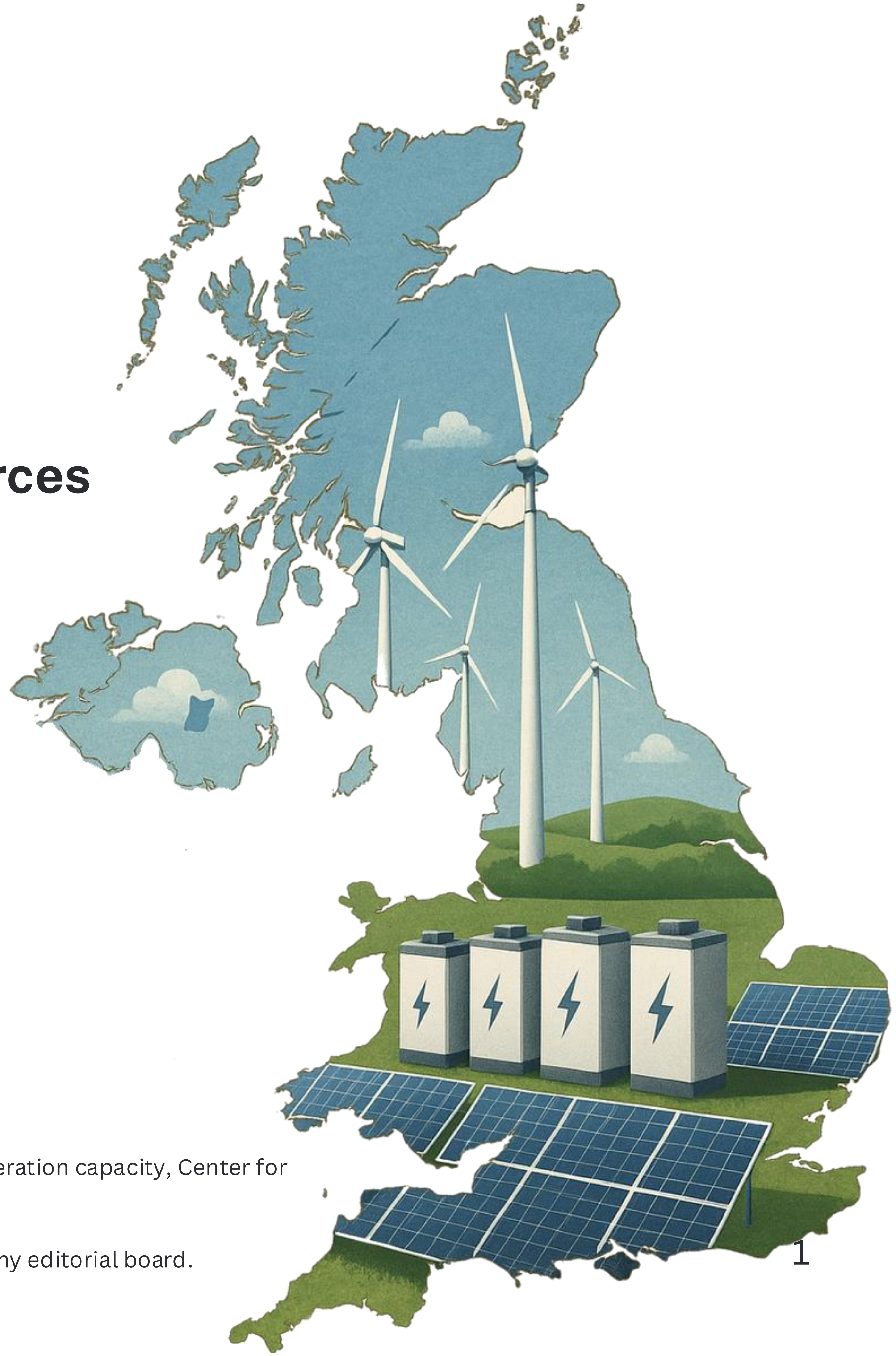


Unlocking 93 GW Clean Energy: £9 Billion Savings, 5x Faster Deployment

The Challenge

- UK electricity demand is projected to grow by 40% by 2030, driven by the electrification of transport and the expansion of data centers, placing significant strain on the grid.
- Low-cost renewable energy projects face excessive 5-7 year delays for grid connections, with 474 GW of capacity currently stranded in grid connection queues, threatening clean energy goals.
- T-4 Capacity Market prices have surged to near-record levels of £60/kW, signaling a systemic shortage of firm, dispatchable capacity and increasing costs for consumers.
- The UK needs to double its installed capacity to meet its 2030 clean power targets, requiring a 2-3x acceleration in the current rate of renewable deployment which is hampered by connection delays.

The Solution

- The UK's 37 GW of gas-fired thermal capacity operates at only a 35% capacity factor, leaving nearly 65% of their grid-connection capacity idle. Similarly, solar plants (9.4%) and wind plants (27.7%) use only a fraction of their available grid connections due to intermittency.
- Deploying new generation and storage at these existing, underutilized grid connection points can provide cost-effective energy and capacity without building new transmission infrastructure, bypassing the congested queues.
- The UK can add 93 GW of clean energy capacity through consolidated connections, including 55 GW of solar, 17 GW of wind, and 21 GW of energy storage at existing power plant sites.
- This 93 GW of surplus grid-connection potential can meet all of the UK's additional Clean Power 2030 requirements for solar, onshore wind, and battery storage, dramatically accelerating deployment timelines from 5-7 years to 1-2 years and saving over £9B in grid connection costs.

Policy Recommendations

- Ofgem and the National Grid ESO should establish clear rules and a streamlined process for consolidated connections, defining it as a distinct category and clarifying the rights of secondary resources to use existing grid connection points up to the agreed capacity limit.
- Create an expedited modification process for surplus connection applications that do not require major network upgrades. This 'Surplus Capacity Connection' pathway would fast-track projects that share grid access at existing thermal and renewable plants.
- Adapt network charging (e.g., TNUoS) to avoid penalizing shared connections. Review market rules, such as the Capacity Market and Contracts for Difference (CfD), to ensure they support and incentivise hybrid projects and co-location.
- Require robust, automated control schemes at co-located sites to ensure the combined output never exceeds the site's connection limit, protecting grid reliability and building trust in the technical viability of shared connections.

Renewable Capacity Expand as Coal gets Retired

Capacity Transformation

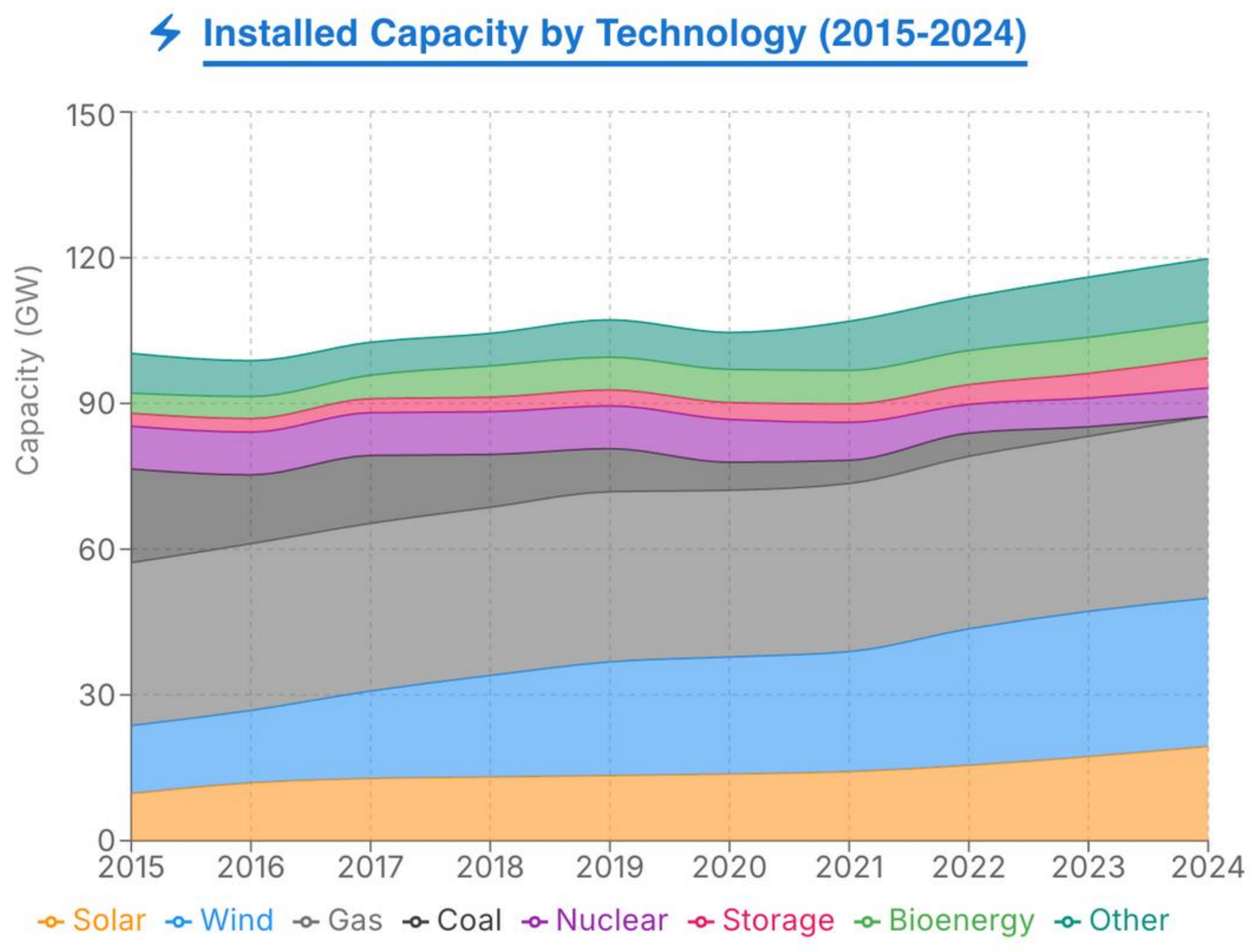
The UK has dramatically transformed its electricity capacity mix in the last decade, with renewables experiencing significant growth while coal capacity has been completely eliminated.

Solar Capacity Doubled
Solar grew from 9.7 GW to 19.4 GW (2015-2024), with 5.7 GW added in recent years (2020-2024)

Wind Expansion
Wind capacity grew from 24.1 GW to 30.5 GW (2020-2024), adding 6.4 GW in four years

Coal Phase-Out Complete
Coal capacity eliminated entirely: 19.3 GW reduction from 2015 to zero in 2024

Gas Capacity Stable
Gas capacity remained fairly constant from 33.5 GW in 2015 to 37.4 GW in 2024, providing grid stability



Source: BNEF 2024, New Energy Outlook

60% of electrcity generation comes from clean sources

Generation Portfolio Evolution

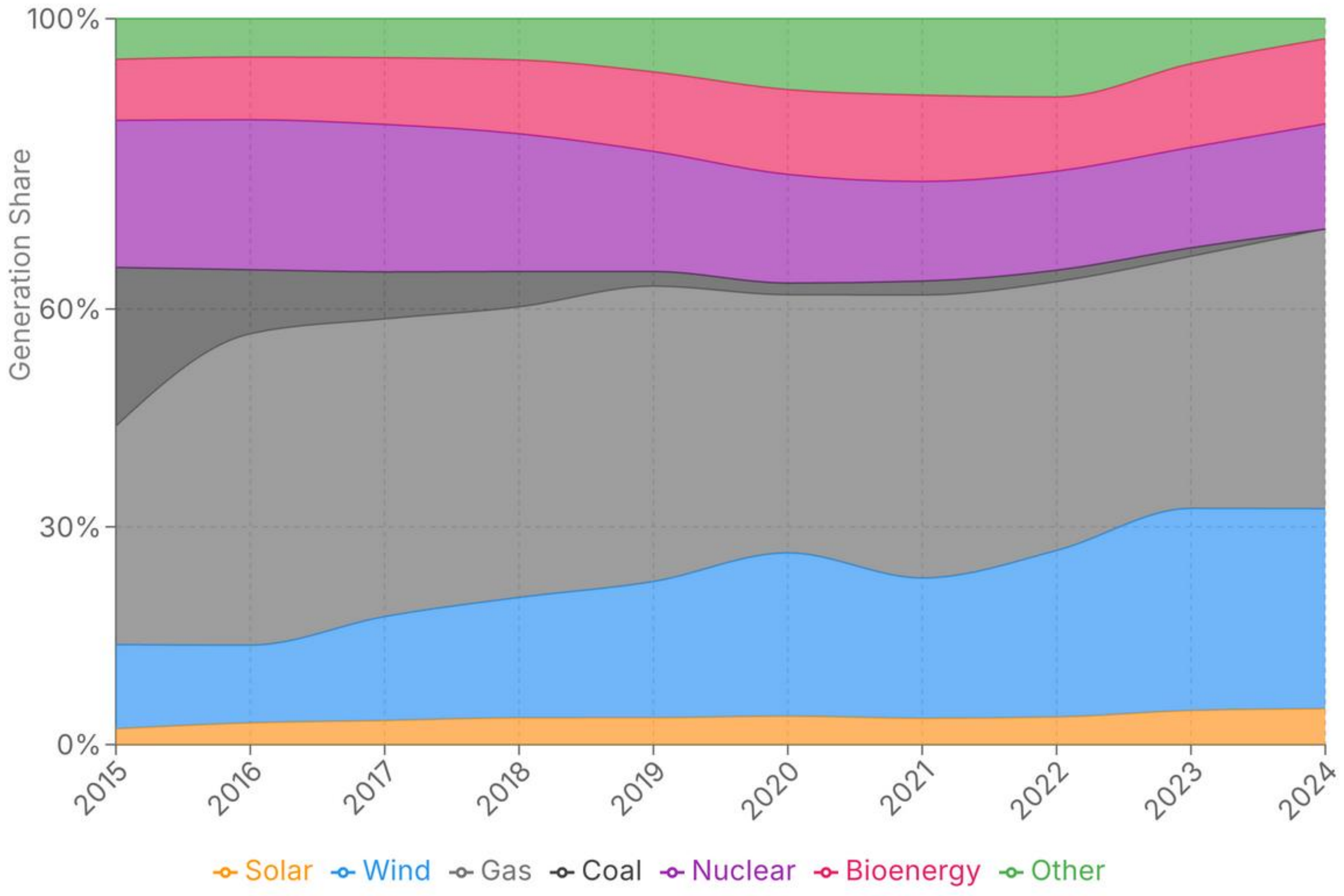
Renewables now provide 44.2% of UK electricity generation in 2024, marking a historic transformation from fossil fuel dependence to clean energy leadership.

Wind Becomes Dominant
Wind generation share grew from 11.6% to 27.6% (2015-2024), now the largest source

Solar Share Doubles
Solar generation rose from 2.2% to 4.9% (2015-2024), more than doubling its contribution

Coal Eliminated
Coal generation fell from 21.9% to 0.0% (2015-2024), completely phased out

Electricity Generation Share (2015-2024)



Source: BNEF 2024, New Energy Outlook

Load expected to grow by 40% up to 2030

20-Year Demand Transformation

Total UK electricity demand declines to 292 TWh by 2025, then surges to 406 TWh by 2035. Historical decline (2015-2025) reverses into massive projected growth (2025-2035), driven by electrification.

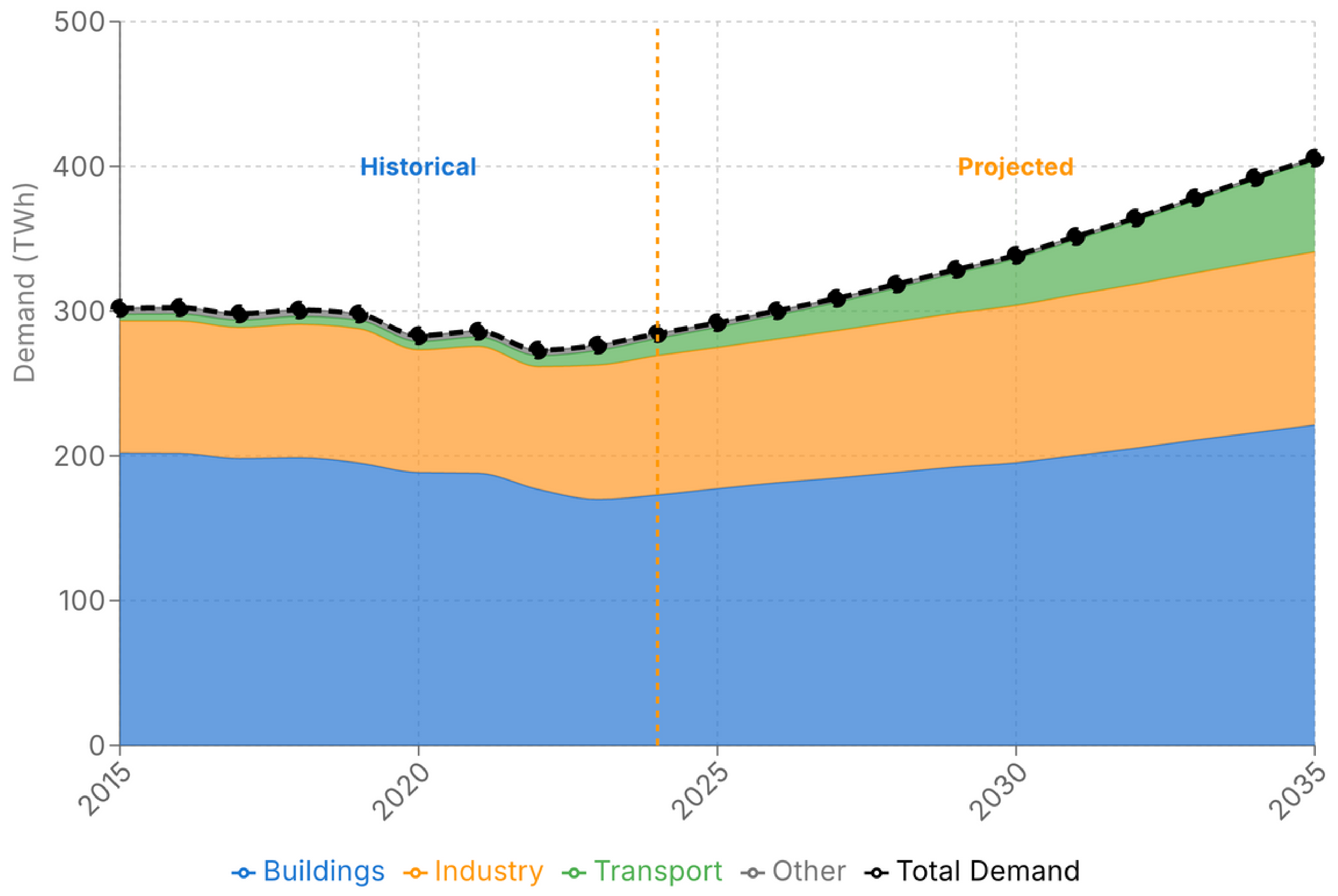
Historical: Buildings Decline
202 TWh to 177 TWh (2015-2025), -12.4% from efficiency improvements

Historical: Transport Emergence
4.6 TWh to 13.9 TWh (2015-2025), +202% early electrification signal

Projected: Buildings Recovery
177 TWh to 221 TWh (2025-2035), +25% from heat pump adoption

Projected: Transport Explosion
13.9 TWh to 63.0 TWh (2025-2035), +354% from mass EV deployment

Electricity Demand by Sector (2015-2035)



Source: BNEF 2024, New Energy Outlook

AI and EVs are major drivers of load growth

AI and EV-Driven Load Growth

Artificial intelligence deployment and electric vehicle adoption emerge as the primary catalysts for electricity demand growth, contributing 113.7 TWh of additional consumption by 2035 across multiple sectors.

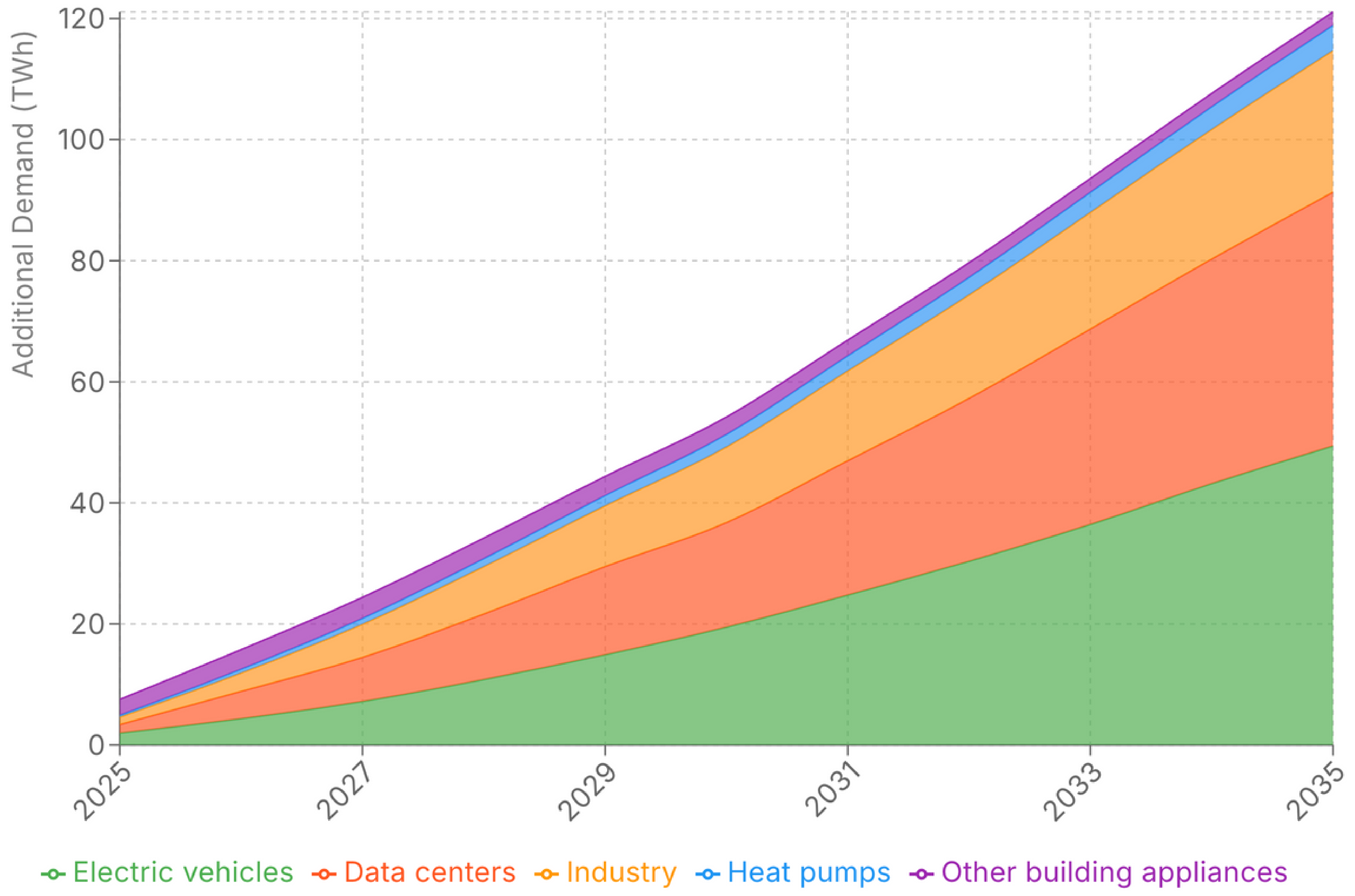
Electric Vehicle Adoption
49.4 TWh incremental demand by 2035, largest single driver

Data Center Expansion
41.9 TWh incremental demand by 2035, AI and cloud driving expansion

Industrial Electrification
23.4 TWh incremental demand by 2035, green hydrogen and steel processes

Heat Pump Deployment
4.2 TWh incremental demand by 2035, gas boiler replacement

Incremental Electricity Demand Growth by Driver (2025-2035)



Source: BNEF 2024, New Energy Outlook

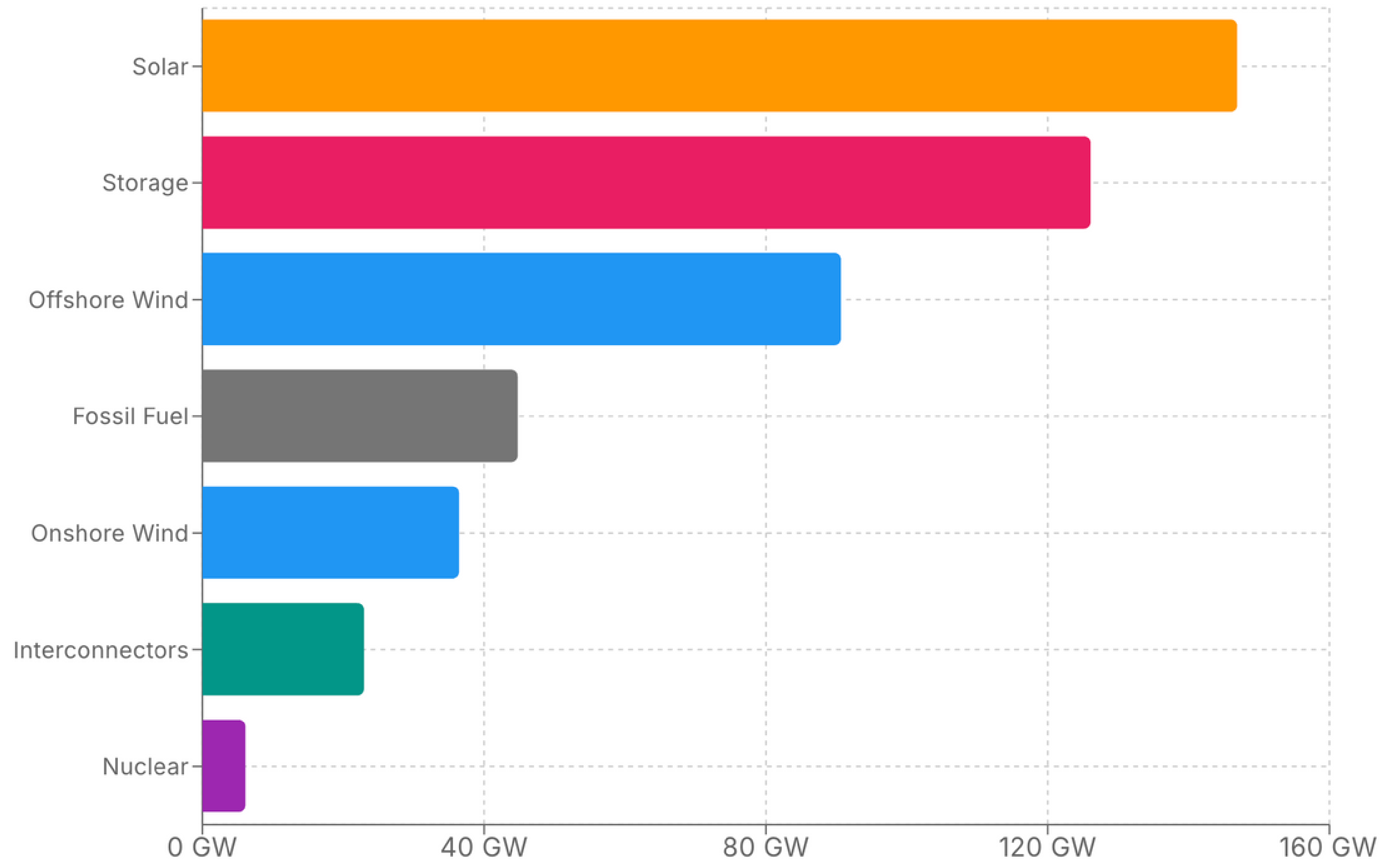
Grid connection wait times have spiked to 5-7 years

474 GW
Total Queue

400 GW
Renewables + Storage

5-7
Years Wait Time

UK Grid Connection Queue by Technology (GW)



Source: Clean Power Action Plan

Crisis Indicators & Root Causes

Worst in Europe
5-7 years vs 1-3 years in Germany/France - massive competitive disadvantage

Grid Congestion
Transmission and distribution networks heavily congested requiring costly upgrades

Assessment Bottleneck
Statement of Works process adds 10+ months, overwhelmed by application growth

Prohibitive Costs
Up to £0.35/W connection costs (51% of solar capex) making projects unviable

Coordination Failures
Poor coordination between distribution and transmission operators

Clean Power 2030 Risk: Queue has sufficient projects but delivery timeline is the critical constraint

Capacity Market Prices Hit Near-Record £60/kW Levels

Capacity prices are surging as the market tightens

The 2024 T-4 capacity auction demonstrates continued market tightening, with clearing prices approaching historical maximums while exhibiting significant shifts in technology composition and contract structures.

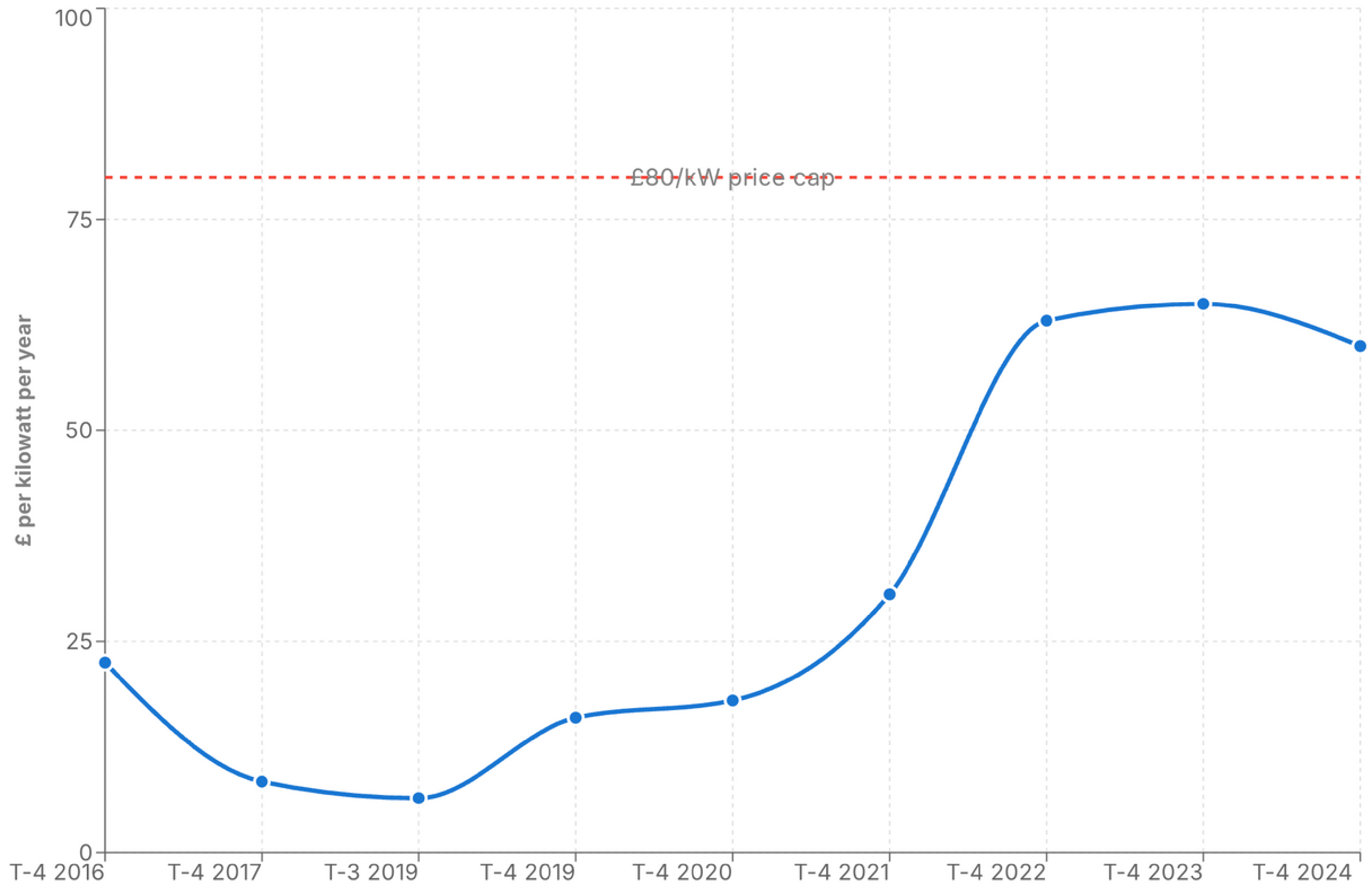
T-4 Capacity Auction Mechanism
The T-4 capacity auction secures electricity generation capacity four years in advance through a descending clock, pay-as-clear format. This market mechanism ensures future security of supply by incentivizing generators and flexible resources to maintain availability when needed.

Price Discovery Outcomes
Clearing price of £60/kW/year represents 92% of the £65/kW historical maximum and 75% of the £80/kW regulatory price ceiling

Firm Capacity Scarcity Signal
Elevated capacity market clearing prices indicate systemic shortage of firm capacity resources, as intermittent renewable deployment outpaces dispatchable generation availability

Capacity Shortage Drivers
Firm capacity shortage results from projected CCGT retirements eliminating grid-scale dispatchable resources, compounded by grid connection queue backlogs preventing new capacity deployment

UK Capacity Market T-4 Auction Clearing Prices (£/kW/year)



Source: BloombergNEF T-4 Capacity Market Auction Outlook

Installed capacity needs to double to meet Clean Power 2030 goals

Installed capacity need to double by 2030

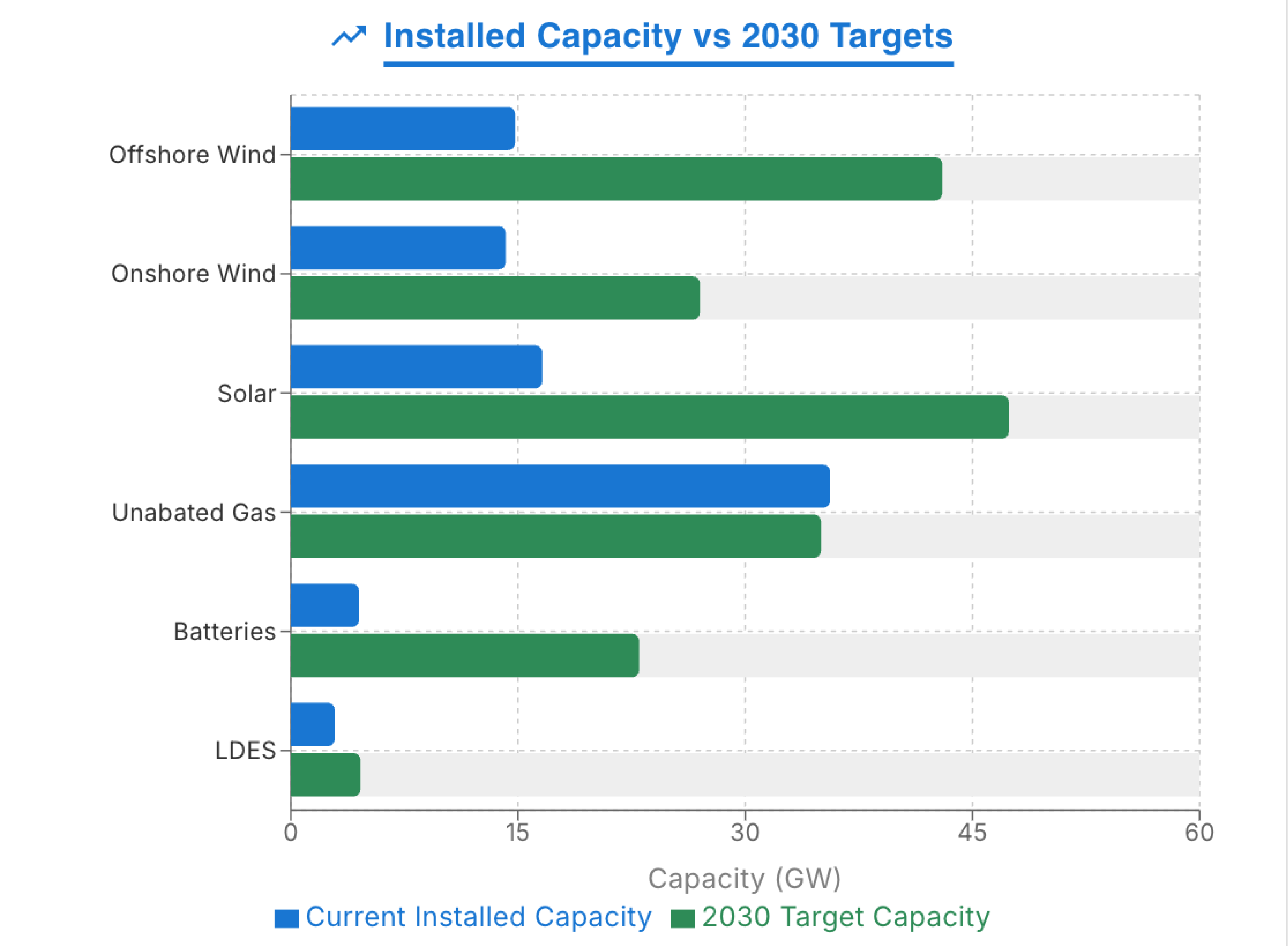
Offshore Wind Capacity
Expansion from 14.8 GW to 43 GW represents 2.9-fold capacity increase by 2030

Solar PV Deployment
Planned increase from 16.6 GW to 47.4 GW through distributed and utility-scale installations

Battery Storage Integration
Storage capacity expansion from 4.5 GW to 23 GW to provide grid flexibility services

System Capacity Growth
Total installed capacity increase from 110 GW to 207 GW while ensuring supply security

£40 billion per year investment required (2025-2030), mostly private sector



Source: Clean Power 2030 Action Plan

Clean Power 2030 Plan requires 2-3x the current RE deployment rate

Installation Rate Requirements Summary

Technology	Current Capacity (GW)	2030 Target (GW)	Addition Needed (GW)	Recent Rate (2022-23) GW/year	Required Rate (2024-30) GW/year	Acceleration Needed
Solar	15.1	**47.4**	32.2	1.0	4.6	2.7×
Batteries	4.7	**22.6**	17.9	1.5	2.6	3.3×
Onshore Wind	13.7	**27.3**	13.6	0.5	1.9	1.7×
Offshore Wind	14.7	**43.1**	28.4	1.7	4.1	3.6×

Data Source: Clean Power Action Plan

Thermal plants are underutilizing their grid connection capacity

Grid-Connection Capacity Underutilization

Gas plants operate at only 35.3% capacity factor, meaning **64.7% of the time grid-connection capacity sits idle**. This massive underutilization reflects the UK's planned transition of gas from daily generation to strategic backup role.

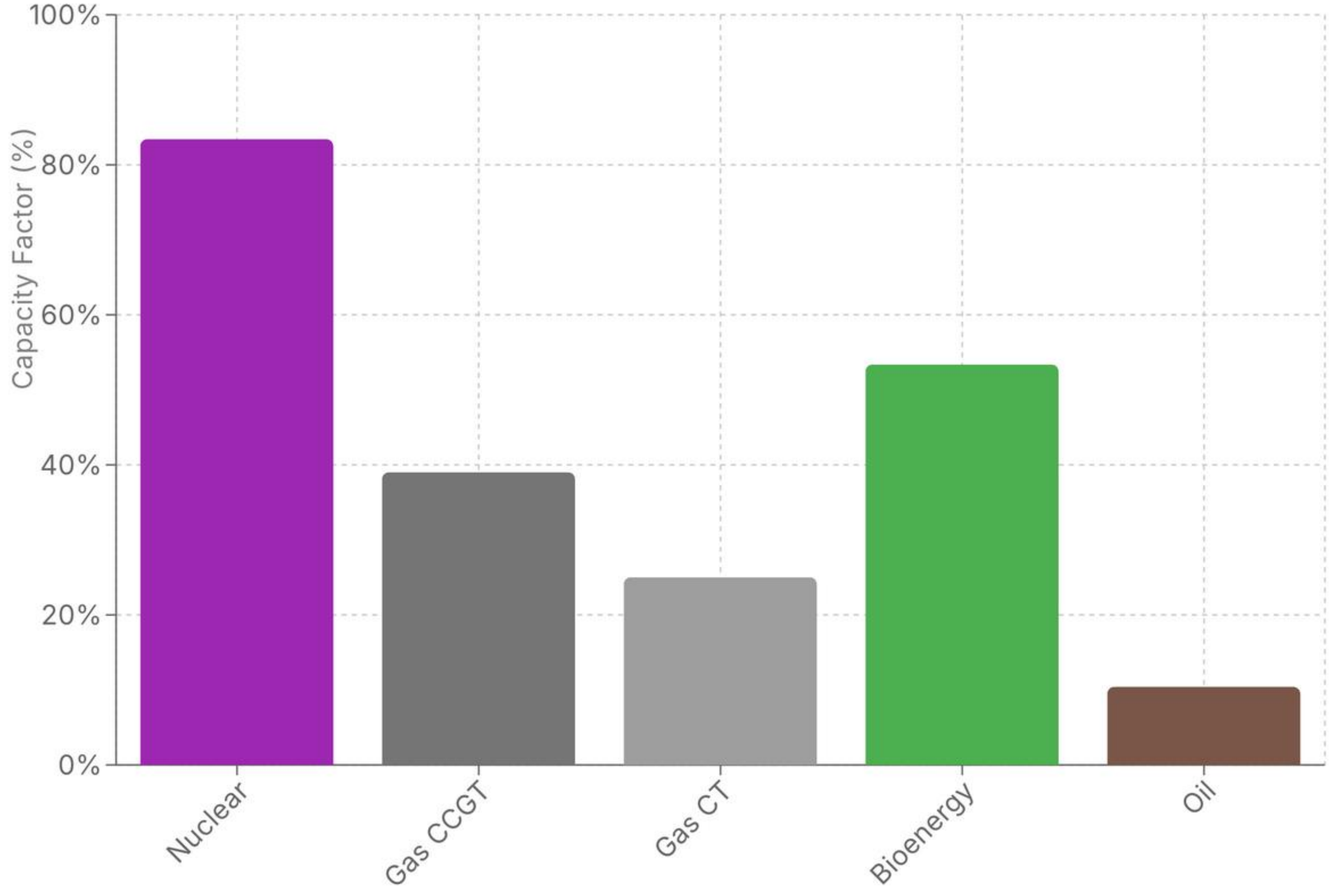
Current Underutilization
65% of the time gas grid-connection capacity unused despite maintaining 35 GW of unabated gas capacity for security

Backup Transition
Gas transitioning "from generating almost every day of the year, to important backup used only when essential"

Generation Reduction Target
Clean Power 2030 plan reduces gas use to "no more than 5% of total generation" from current levels

Future Outlook: Gas will "increasingly move to a reserve role, called upon as a last resort to meet peak demand" while maintaining 35 GW capacity for security of supply.

Technology Capacity Factors (2024)

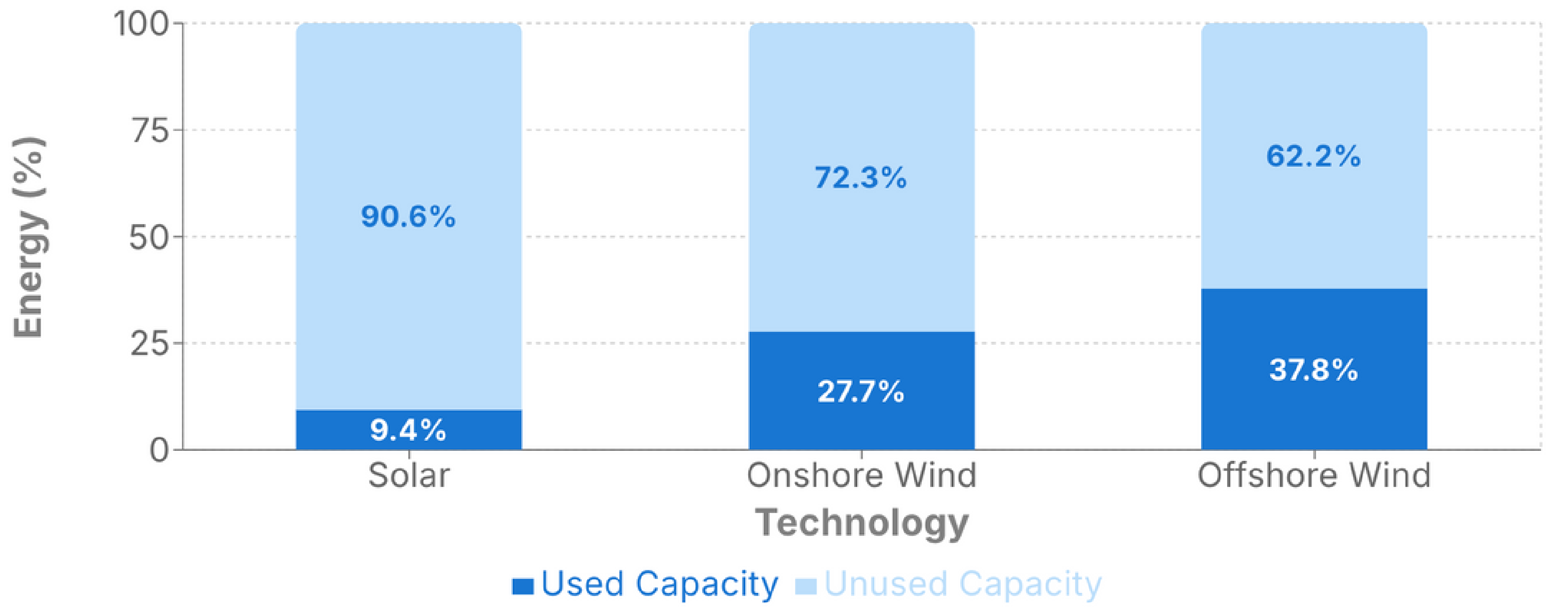


Source: BNEF 2024, Clean Power 2030 Action Plan

Renewables are underutilizing their grid connection capacity

Energy

Renewables utilize only **26.5%** of their grid-connection capacity on average. **73.5%** of the time grid-connection infrastructure sits idle.

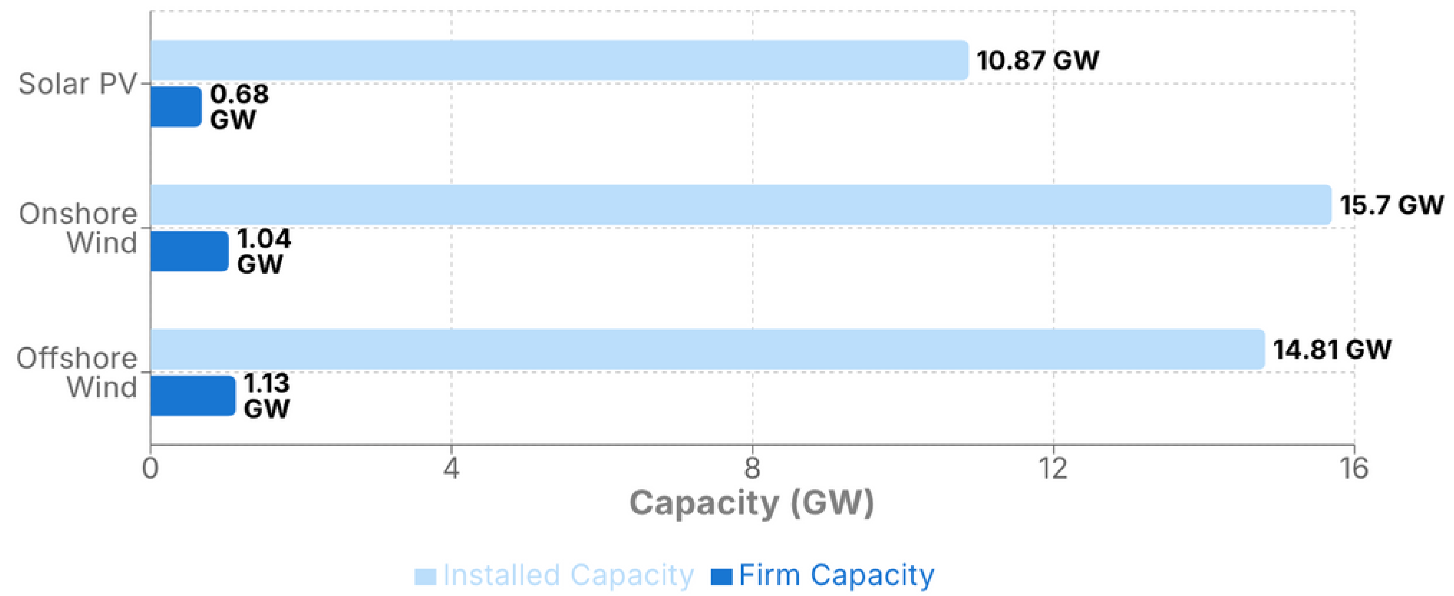


Idle Interconnection Capacity

- Solar (10.9 GW): Grid connection idle 90.6% of the time
- Onshore Wind (15.7 GW): Grid connection idle 72.3% of the time
- Offshore Wind (14.8 GW): Grid connection idle 62.2% of the time
- Massive grid-connection infrastructure underutilized

Firm Capacity

Despite **41.4 GW** of renewable installations, only **2.85 GW** (6.9%) provides firm, reliable capacity becuase of the intermittency of renewables.

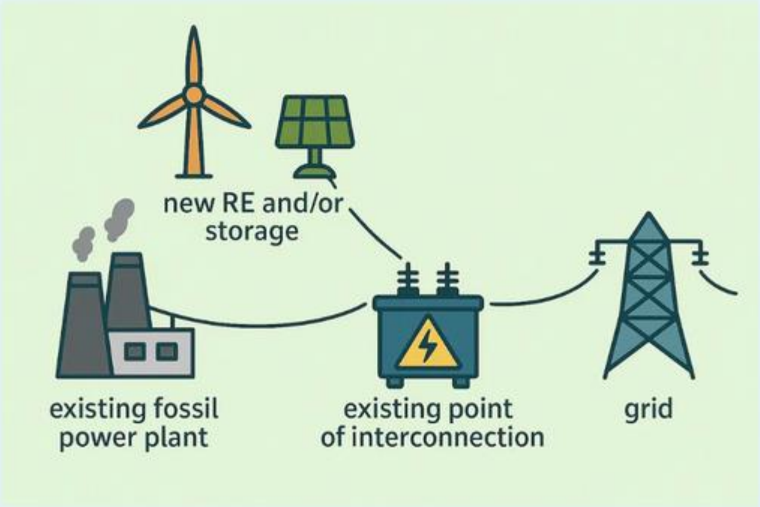


Derating Factors

- Solar PV: 6.25% derating factor
- Onshore Wind: 6.64% derating factor
- Offshore Wind: 7.62% derating factor
- **CCGT: ~85-90% derating factor**

Maximizing efficiency of existing assets: Consolidated Connections

Renewables at Thermal Plants

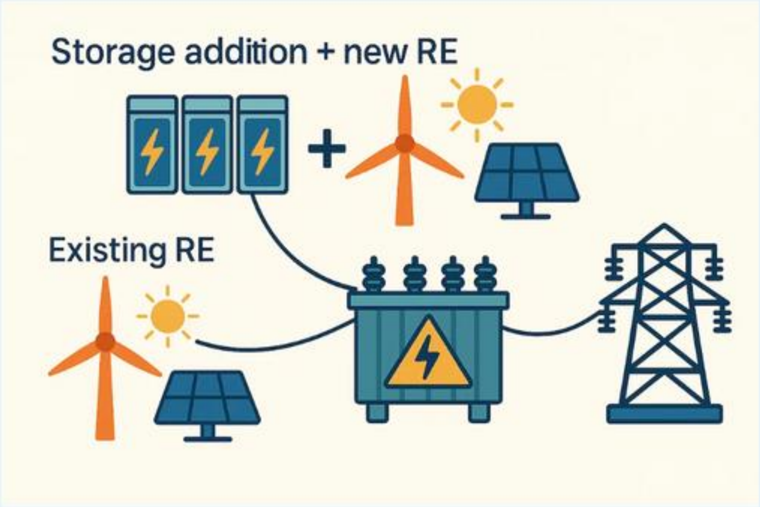


Existing thermal plants have underutilized grid-connection capacity that can be leveraged for renewables

Key Implementation Points:

- Thermal plants, especially peakers, significantly underutilize their grid-connection capacity
- Reduced costs through shared infrastructure and site development
- Creates transition pathway beyond fossil generation assets
- Bypasses lengthy grid connection queues for faster deployment

Storage at Renewable Plants



Current renewable plants use only <30% of their grid-connection capacity due to intermittency

Key Implementation Points:

- Battery storage can be added using surplus grid-connection capacity
- Batteries absorb excess generation that would otherwise be curtailed
- Energy dispatched even when renewables aren't generating, smoothing output
- Batteries shift generation from low-value to high-value hours
- With batteries managing generation profiles, more renewables can be added

Examples

Parc Cynog Hybrid

Wales • Vattenfall

Operational

Original: 11 Wind Turbines (3.6 MW)

Added: 4.99 MW Solar PV (2016)

First major UK wind+solar hybrid. 18,500 solar panels on 8 hectares sharing existing grid connection. Investment: £4.2M, 30-year lifespan.

Solar@Swinford

England • Vattenfall

Consented

Original: Existing Wind Farm

Added: 5 MW Solar Extension (2021)

Solar extension to existing onshore wind farm, following the Parc Cynog model of shared grid infrastructure.

Solar@Kentish Flats

Kent • Vattenfall

Planned

Original: Kentish Flats Offshore Wind

Added: 20 MW Solar Farm (Planning)

Co-located solar farm sharing offshore wind farm's onshore grid connection and infrastructure, reducing network build-out needs.

Whitelee + Battery

Scotland • ScottishPower Renewables

Operational

Original: 539 MW Wind Farm (UK's largest onshore)

Added: 50 MW/50 MWh Battery (2022)

Battery charges during high wind output, discharges later to optimize transmission export capacity utilization.

Methodology Summary

Resource Assessment

- Assessed RE resource availability within a 6 mile buffer zone around each thermal and renewable plant in the UK
- Applied 50+ exclusion criteria including physical constraints (land cover, slope, etc.) and environmental protections, protected areas, national parks, etc.)
- Estimated local solar and wind potential using suitable area and average solar and wind generation density

Economic Analysis

- Estimated local hourly solar and wind generation near each power plant in the UK using meteorological data from ERA5
- Developed custom software tools to simulate solar and wind generation using meteorological parameters like solar irradiance, wind speed, temperature, etc.
- Estimated local solar and wind LCOE using capital cost data from BNEF and compared with the variable costs of thermal plants to identify economic crossover points

Portfolio Optimization

- Estimated optimal mix of solar, wind and storage which maximizes grid-connection use while limiting curtailment below 5%
- For thermal plants, estimated optimal solar and wind capacity that can be added, and for renewable plants, estimated additional solar and wind capacity that can be enabled by adding 4-hour storage.
- Selected high-quality resources with capacity factors above 30% for wind and 20% for solar to ensure economic viability

Load Growth Analysis

- Compared surplus grid-connection potential with the UK's Clean Power 2030 Action Plan targets for renewable energy deployment by 2030
- Estimated grid-connection utilization increase for renewable plants through battery storage and renewable additions
- Quantified avoided grid connection and network upgrade costs based on historical cost data from National Electricity System Operator

Case Study: RWE Goole Fields Wind Farm

Facility Information

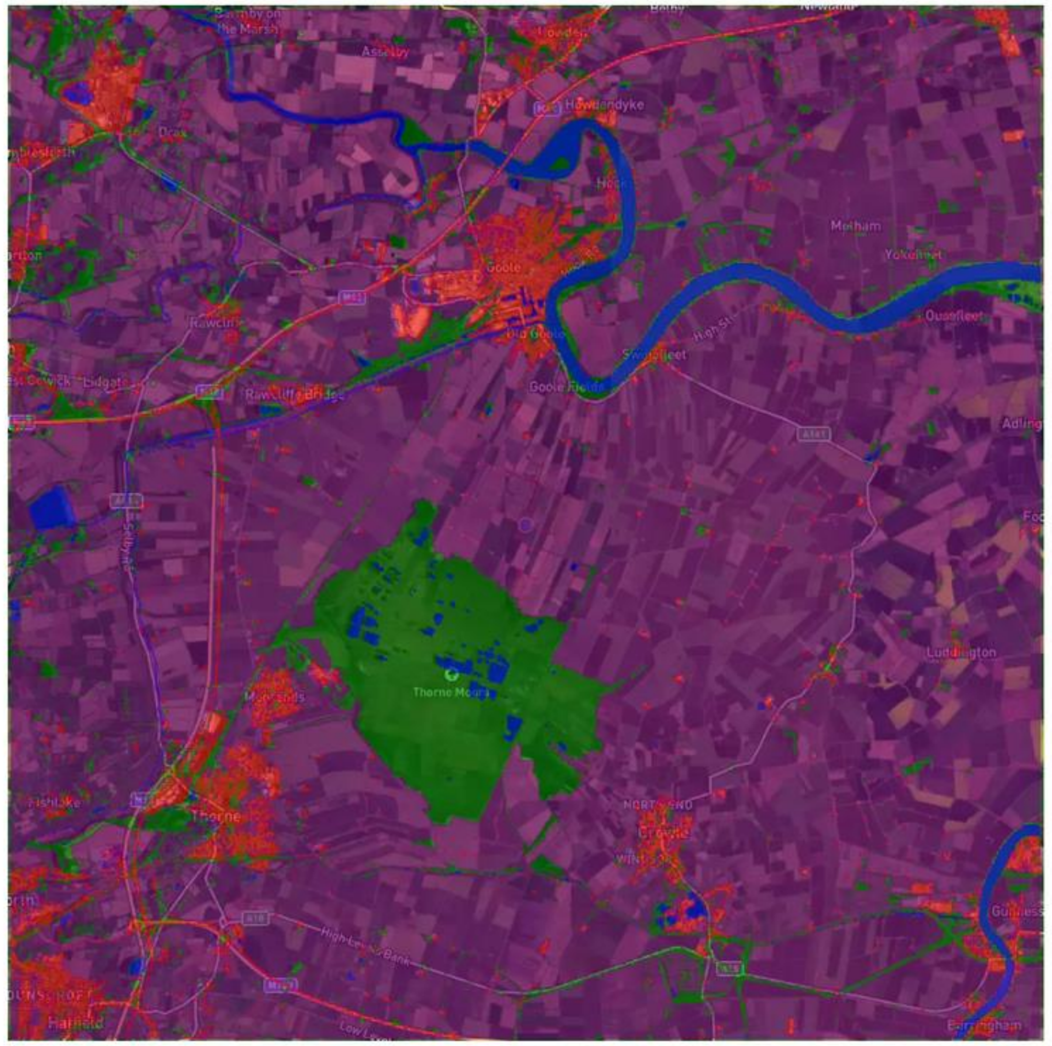
LOCATION	INSTALLED CAPACITY	OWNER	COD
East Riding of Yorkshire, England	**67.65 MW**	**RWE**	**2014**

Satellite View of Wind Farm

6×6-Mile Buffer Zone

Goole Wind: Solar and Wind Potential

Classification Map



Sensitive Habitat · Water/Ice Covered · Urban Area · Unfavorable Topography · Buildable · Other

RE Potential within 6 miles of Goole Wind Farm

- Assessed RE resource availability within a 6-mile buffer zone around the Goole Wind Farm
- Applied 50+ exclusion criteria including physical constraints, environmental protections, and local ordinances
- Estimated local solar and wind potential using suitable area and generation density analysis

79.9% of area within this 6 mile square is buildable

18 GW Solar Potential

1.8 GW Wind Potential

5 TW of solar and wind potential near existing connection points

Thermal Plants

85
Facilities

36,682
MW Capacity

Technology Breakdown

- **72** — Gas Combustion Turbine — 85% of total
- **11** — Oil, Gas, Steam — 13% of total
- **2** — Coal Plants — 2% of total

Plants in Urban Areas

3
Facilities
3.5% of Total

275
MW Capacity
0.7% of Total

RE Potential Near Thermal Plants

408
GW
Solar Potential

41
GW
Wind Potential

Total Potential: 449 GW

Renewable Plants

683
Facilities

21,042
MW Capacity

Technology Breakdown

- **298** — Solar Plants — 44% of total
- **385** — Wind Plants — 56% of total

Plants in Urban Areas

4
Facilities
0.6% of Total

197
MW Capacity
0.9% of Total

Additional RE Potential Near Renewable Plants

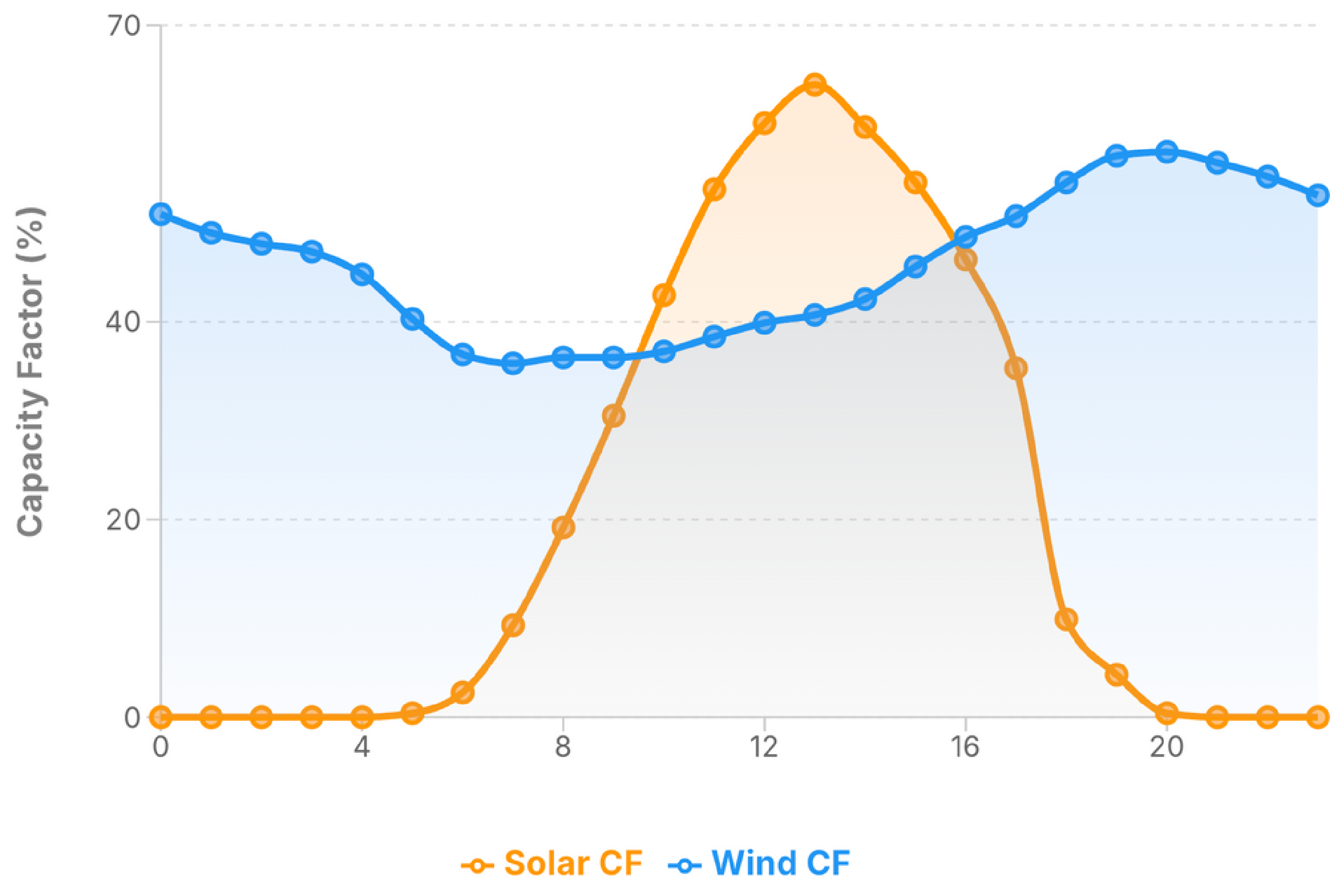
4073
GW
Solar Potential

407
GW
Wind Potential

Total Potential: 4480 GW

Goole Wind: Local Solar and Wind LCOE

Diurnal Capacity Factors at Goole Wind Farm Location



Hourly average capacity factors showing solar peaks during midday and wind's higher nighttime generation in UK

Capacity Factors

Solar (AC)	Wind
20.5%	45.8%

Levelized Cost of Energy

Solar

$23/MWh (2025) → **$21/MWh** (2030)

Wind

$45/MWh (2025) → **$36/MWh** (2030)

44 GW of RE can be added at UK thermal plants

Integration Potential by Technology

UK can integrate 44.3 gigawatts of renewable capacity near existing thermal plants

36 GW	37 GW	7 GW
Thermal Capacity	Solar Integration Potential	Wind Integration Potential

Integration Potential by Fuel Type:

Gas Plants Integration

Current Capacity	Solar Capacity	Wind Capacity
33 GW	34 GW	6 GW

Coal Plants Integration

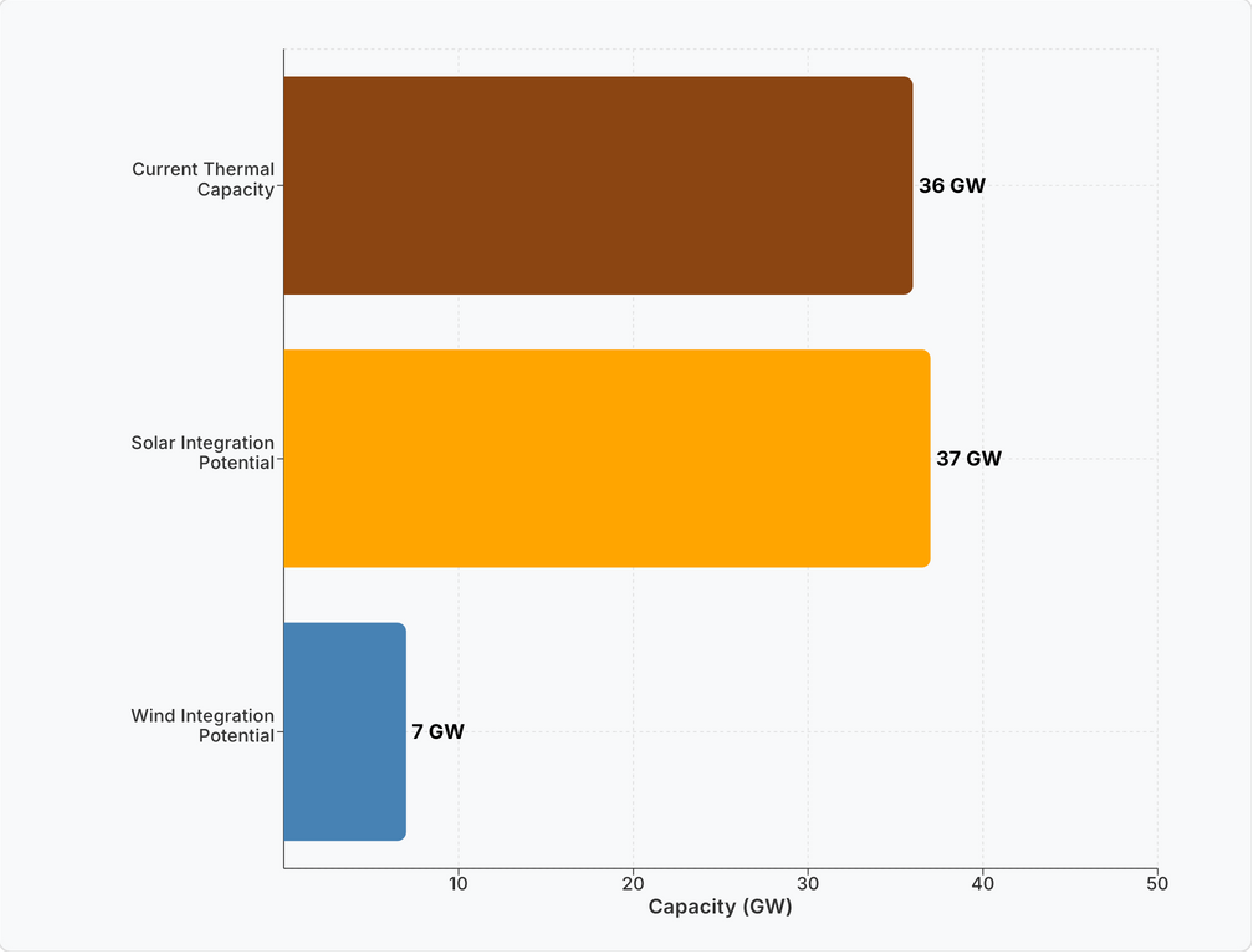
Current Capacity	Solar Capacity	Wind Capacity
2.3 GW	2.6 GW	0.2 GW

Oil Plants Integration

Current Capacity	Solar Capacity	Wind Capacity
0.8 GW	0.5 GW	0.7 GW

Capacity Comparison

Integration Potential vs. Current Capacity



28 GW of RE enabled by 21 GW of storage can be added at existing RE plants

Integration Potential by Technology

UK can integrate 49 gigawatts of additional renewable and battery capacity at existing renewable sites

21 GW	18 GW	10 GW	21 GW
Renewable Capacity	Solar Integration Potential	Wind Integration Potential	Battery Capacity

Integration Potential by Technology Type:

Solar Plants Integration

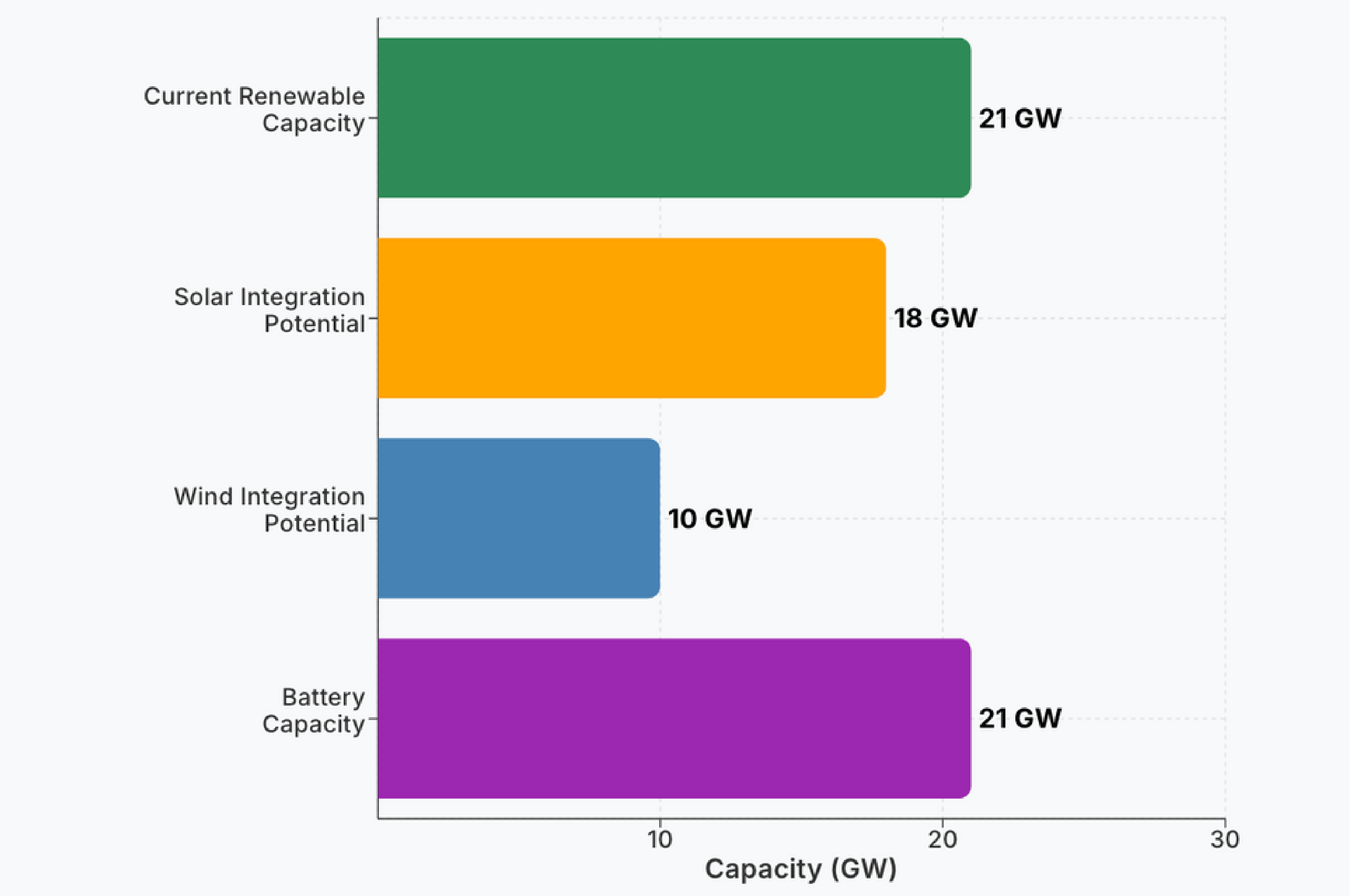
Current	Solar	Wind	Battery
6.3 GW	1.7 GW	7.5 GW	6.3 GW

Wind Plants Integration

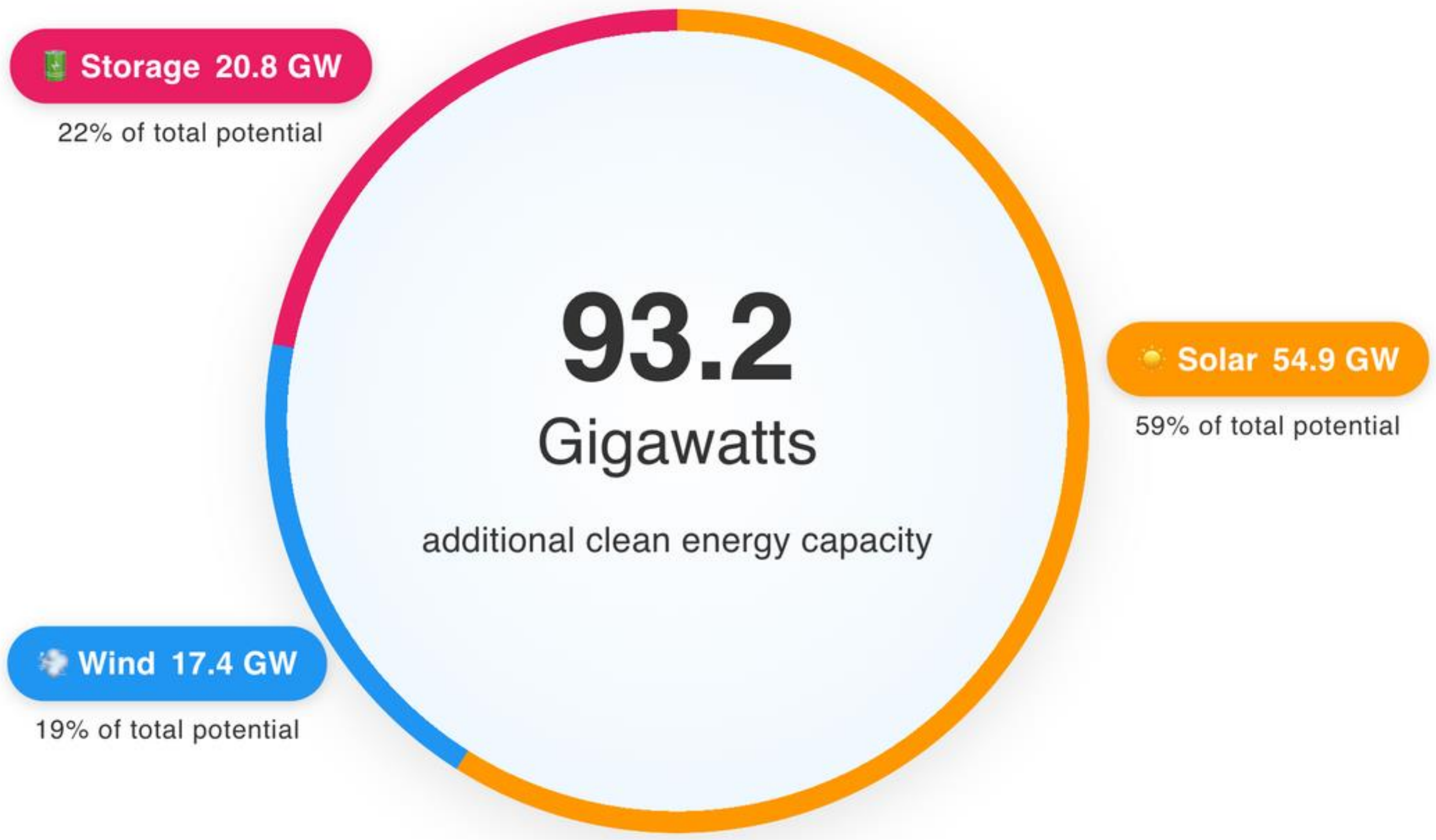
Current	Solar	Wind	Battery
14.5 GW	16.2 GW	2.7 GW	14.5 GW

Capacity Comparison

Integration Potential vs. Current Capacity



93 GW of RE + Storage can be added at existing power plants in UK



54.9 GW of additional solar capacity near existing renewable and thermal plants

17.4 GW of additional wind capacity through grid connection sharing

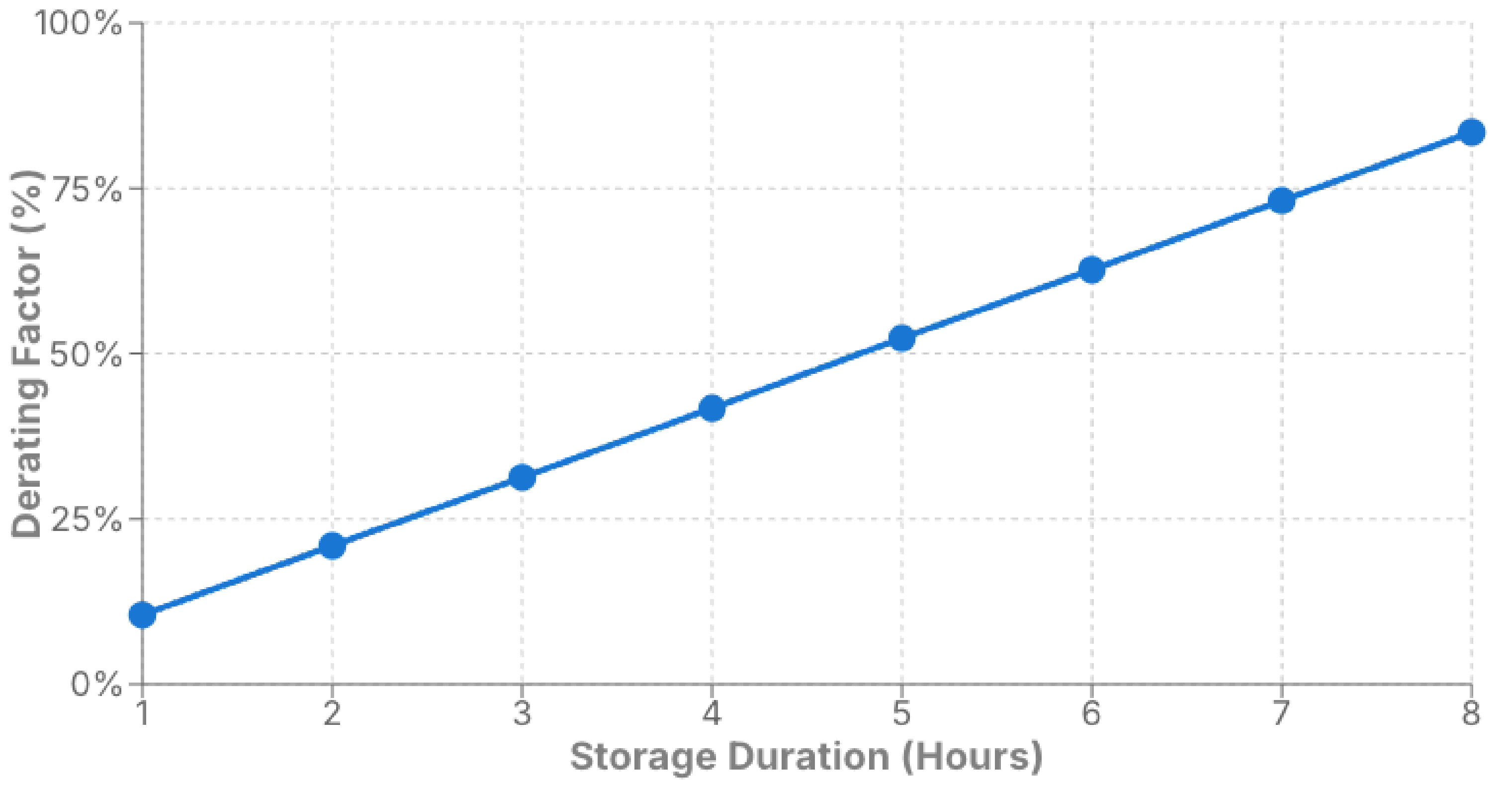
20.8 GW of storage enables higher penetration of renewables

Storage make intermittent renewables to firm assets

Battery Storage: Enhancing Capacity Value

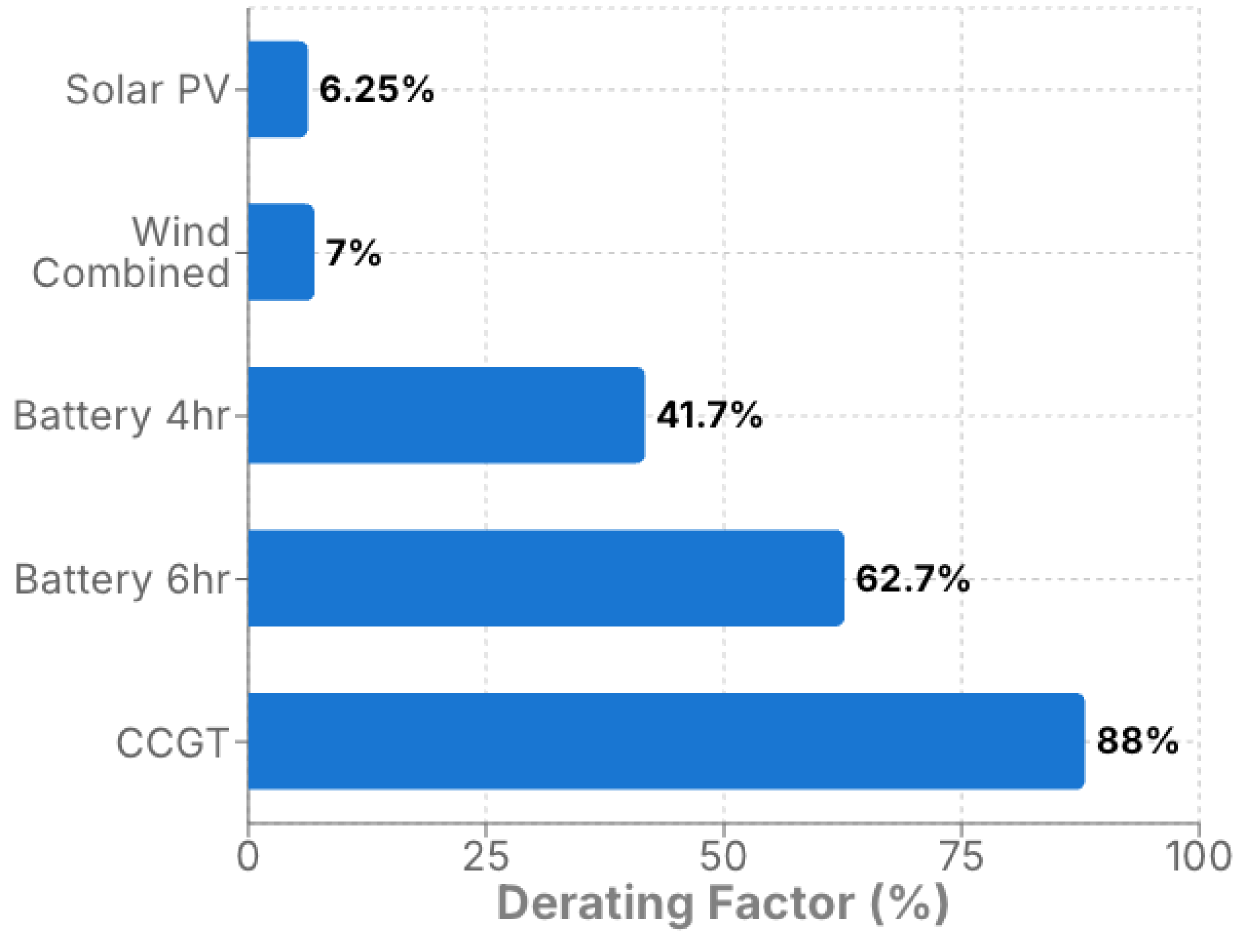
Adding battery storage significantly increases the capacity value of renewable assets:

- 4-hour storage: **41.7%** derating factor
- 6-hour storage: **62.7%** derating factor
- 8-hour storage: **84.2%** derating factor



Derating Factors Comparison

Battery storage bridges the **massive gap** between renewable intermittency (6-7%) and conventional reliability (88%).

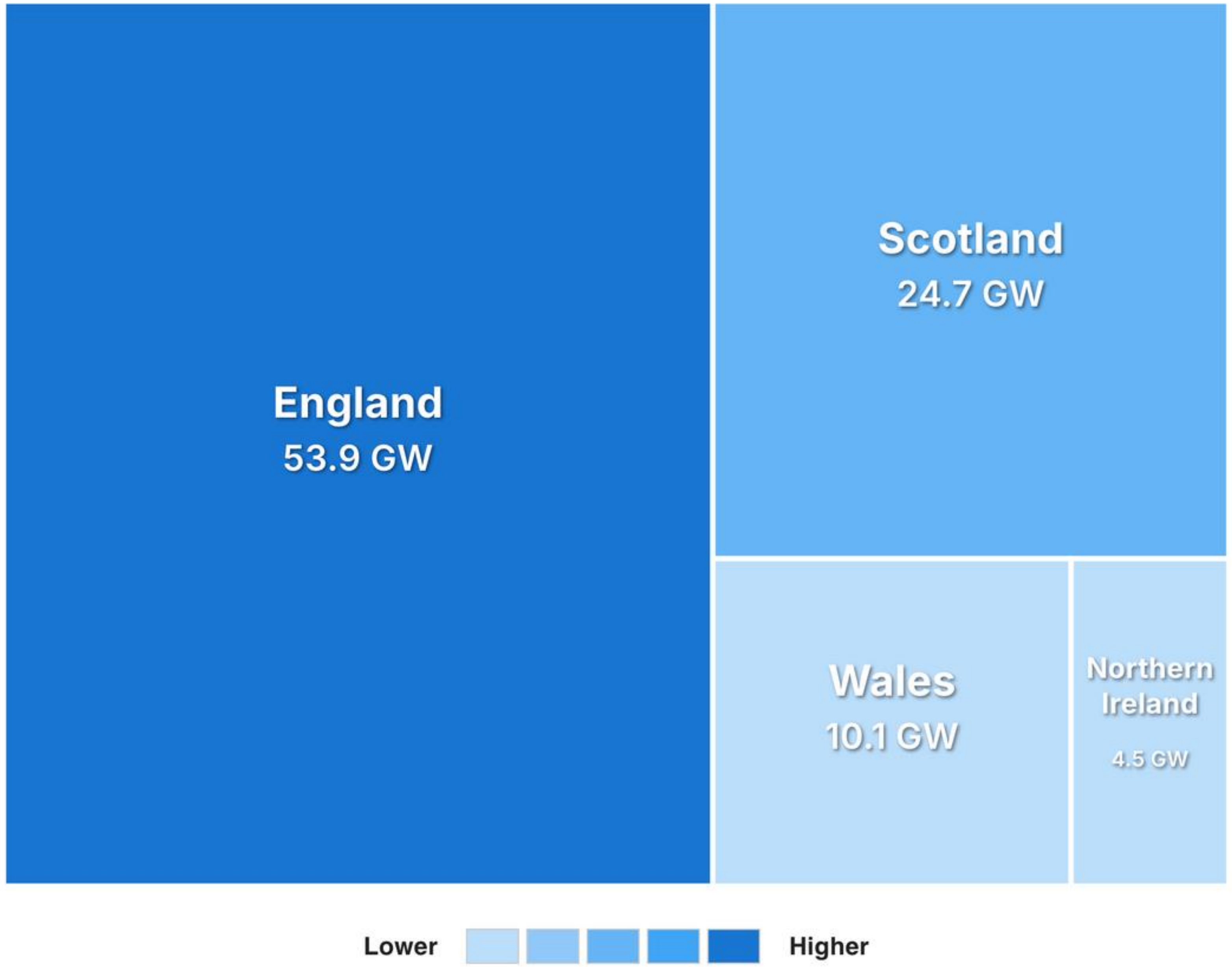


Source: ECR 2024 Derating Factors, National Grid ESO, UK Energy Analysis 2024

Geographical Distribution of Integration Potential in UK

UK Regional Integration Potential

Integration Potential by Region



Regional Breakdown

Total: 93.2 GW

54.9 GW
Solar

17.4 GW
Wind

20.8 GW
Battery

Regional Breakdown

Region	Plants	Current Capacity	Surplus Grid-Connection Potential (GW)			
			Solar	Wind	Battery	Total
England	413	35 GW	33	12.2	8.6	**53.9**
Scotland	212	12.3 GW	12.7	3	9.1	**24.7**
Wales	86	7.4 GW	6.6	1.7	1.8	**10.1**
Northern Ireland	50	2.5 GW	2.6	0.5	1.3	**4.5**
Total	**761**	**57.3 GW**	**54.9**	**17.4**	**20.8**	**93.2**

Consolidated Connections can help meet Clean Power Plan 2030 Goals

Clean Power 2030 Additional Requirements

All additional 2030 Clean Power requirements for solar, onshore wind, and batteries can be met through consolidated connections

Additional Capacity Required by 2030

Solar: **32.2 GW**

Onshore Wind: **13.6 GW**

Battery: **17.9 GW**

Total: 63.7 GW

Surplus Potential Available

Solar: **54.9 GW**

Onshore Wind: **17.4 GW**

Battery: **20.8 GW**

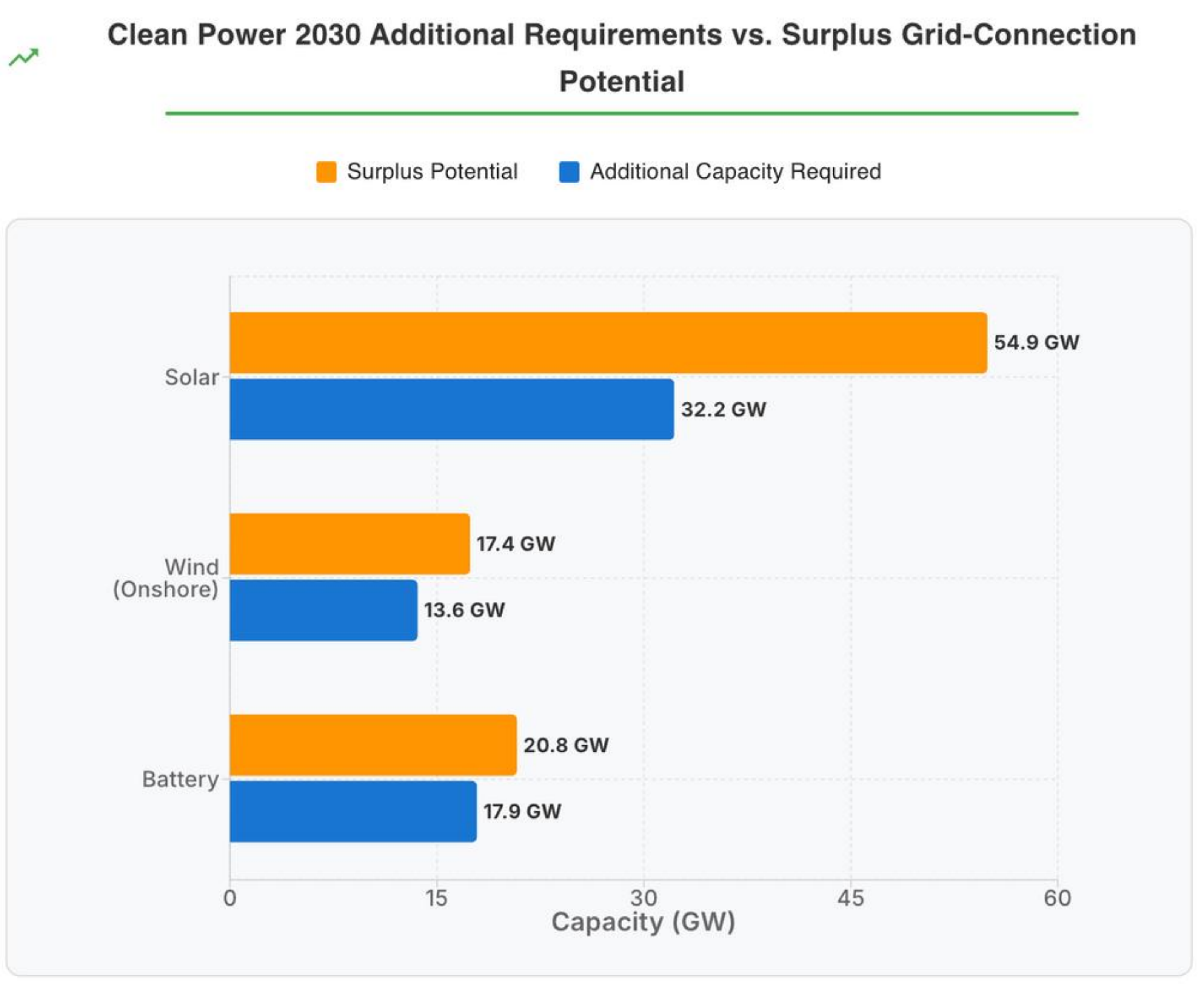
Total: 93.2 GW

Delivery Capabilities by Technology

- **Solar:** 54.9 GW available → Covers **170%** of 32.2 GW needed
- **Onshore Wind:** 17.4 GW available → Covers **128%** of 13.6 GW needed
- **Battery:** 20.8 GW available → Covers **116%** of 17.9 GW needed

Note: Surplus capacity applies to onshore wind only. Offshore wind (46.5 GW) requires separate development.

Implementation Potential



Surplus grid-connection potential compared to Clean Power 2030 additional capacity requirements

£9B of savings in grid connection costs

$ Total Potential Savings

£9.3B

By leveraging existing infrastructure

£328
Savings per UK household

- Reduces interconnection costs
- Reduces new transmission infrastructure requirements
- Cost savings from faster deployment of cheaper clean energy and replacing generation from expensive thermal plants

ⓘ This £9.3B is a conservative estimate that only accounts for interconnection cost savings. Additional benefits from co-location of solar, wind, and batteries would significantly increase the total value but are not included in this figure.

Shared Benefits Across Stakeholders

Adding storage and renewables to existing renewable plants creates value for all stakeholders:

Stakeholder	Benefits
RE Developer	Tax Credit; Reduced Interconnection Costs; Faster Development
Existing Plant Owner	Additional Revenue Streams; Diverse Portfolio
Consumer	Low Cost Electricity; Tax Revenue; Less Pollution
Power System	Reliability; Higher Tx Utilization; Low Capacity Prices
Economy	Reliable Supply; Faster Supply; Low Cost Power

UK Regulatory Landscape for Consolidated Connections

Regulatory Coordination Required

No single actor can implement consolidated connections alone. Success requires coordinated action: Ofgem must adjust rules and incentives, ESO/TOs must create processes and technical standards, and developers must bring forward co-location proposals. The regulatory landscape is aware of the need to "unlock the capacity of the networks" but is still developing concrete policy frameworks.

Ofgem
National Regulator

Office of Gas and Electricity Markets

- Approved major Connections Reform package (TM04+) in April 2025 to overhaul project queue prioritization - culling inactive projects and fast-tracking 'ready' ones
- Eliminated upfront distribution charges in 2023 making connections 'shallower' - removing prohibitive costs for upgrading network capacity
- Supports innovative connections via regulatory sandbox and encourages flexible connection offers for co-located projects

Could direct code changes to formalize co-location rights or adjust charging to reward shared infrastructure use

NESO
Transmission System Operator

National Energy System Operator (NESO)

- Manages transmission connection queue and capacity allocation (TEC) - must study and approve additional generation at existing connection points
- Published Technical Guidance for Co-located Technologies (June 2025) defining 'Consolidated Connections' - new units added to existing station's grid connection point
- Developed 'Gate 2' readiness criteria treating hybrids as single application preventing unfair delays

Actively developing technical and process toolkit for consolidated connections

Transmission Owners
Network Infrastructure Owners

NGET, SP Transmission, SSEN Transmission

- Own and build high-voltage networks - any connection changes (new circuits, uprating transformers, switchgear) fall under their remit
- Facilitate connection modifications for co-located projects - provide design studies and install infrastructure like new 400kV switchgear
- Ensure system integrity by maintaining total export within agreed capacity - requiring control schemes to automatically limit output

Critical implementers with proven track record (e.g. Larks Green solar+battery at Iron Acton substation)

DNOs
Local Network Managers → Distribution System Operators

Distribution Network Operators

- Pioneers in Active Network Management (ANM) systems allowing multiple generators to share limited feeder capacity under dynamic limits
- Proven co-location track record: Tesla 6MW battery at Clayhill Solar Farm (2017) sharing existing grid connection
- Becoming Distribution System Operators (DSOs) with mandate to actively manage local capacity and coordinate with ESO

Distribution-level innovations provide proofs of concept that inform transmission-level thinking

Current Reform Progress and Innovations

Current Status: Building Momentum

The regulatory landscape is **actively evolving** to support consolidated connections. Recent reforms have eliminated key barriers, while innovative connection models are being proven at both distribution and transmission levels. However, **specific guidance for consolidated connection sharing at transmission level is still needed** to unlock the full potential of existing infrastructure.

Recent Regulatory Reforms

2023 - Distribution Charge Elimination

Ofgem eliminated upfront charges for reinforcements at distribution level, making connections 'shallower'

Impact: Aids co-located projects by removing prohibitive costs for upgrading network capacity

April 2025 - Connections Reform (TM04+)

Major overhaul approved by Ofgem to prioritize projects in the queue

Impact: Focuses on culling inactive projects and fast-tracking 'ready' ones

June 2025 - Co-located Technologies Guidance

National Grid ESO published technical guidance for combined configurations

Impact: Standardizes how hybrid projects connect and comply with Grid Code

Ongoing - Regulatory Sandbox Programs

Ofgem encourages innovative connections through regulatory flexibility

Impact: Enables testing of new connection models and surplus capacity sharing

Proven Innovation Models

Active Network Management (ANM)

Provider: DNOs

Dynamic limits allow multiple generators to share limited feeder capacity

Example: Tesla 6 MW battery at Clayhill Solar Farm (2017) sharing existing grid connection

Timed Connections

Provider: Distribution Networks

Generators can only export during certain hours if another has priority

Example: Flexible scheduling prevents capacity conflicts at shared connection points

Consolidated Connections

Provider: National Grid ESO

New generating units added to existing station's grid connection point

Example: Modification of existing Bilateral Connection Agreement (BCA) without increasing export limit

Policy Recommendations: Foundation Framework

Establish Clear Definitions and Rights

Introduce consistent definition of 'co-located' or 'hybrid' projects in grid codes and policy to eliminate current ambiguity

- Define adding battery/solar to existing grid connection (without exceeding export limit) as distinct category in Connection Codes or Ofgem guidance
- Clarify rights of secondary resource - equal priority up to shared capacity or subordinate priority as decided contractually
- Create standard consolidated connection agreements to replace current case-by-case negotiations
- Give developers confidence through standardized legal and technical frameworks

Streamline Connection Application Process

Develop expedited modification process for surplus connections without major network upgrades

- Create 'Consolidated Connection' request category evaluated quickly since total output at grid connection point remains unchanged
- Implement via CUSC modifications allowing existing grid customers to add secondary unit by Supplemental Application
- Incorporate special pathway for hybrids in ESO's Gate process ensuring co-location projects don't lose queue position
- Formalize at distribution level that adding storage/generation behind existing connection preserves original queue position

Adequate Connection Assessment Procedures

Maintain grid reliability with appropriately scoped system impact assessments for co-located additions

- Create tailored study procedures for hybrid sites considering flexible operation and whole-system benefits
- Ensure battery additions don't trigger extensive reinforcement studies if mainly charging from on-site renewable
- Update Grid Code compliance regime with reduced set of tests when new unit operates in tandem with existing one
- Coordinate protection systems and control schemes that automatically respect combined export limit

Review and Adapt Network Charging

Ensure charging methodology doesn't disincentivize capacity sharing between co-located assets

- Tailor TNUoS and distribution charges so two generators sharing one connection don't pay twice for same capacity rights
- Explore aggregated charging or discounts for proven complementary profiles (e.g. solar + wind where combined peak never exceeds single technology)
- Reward flexibility providers using surplus capacity with reduced charges when absorbing energy that would otherwise be curtailed
- Align economic signals with efficient infrastructure use rather than penalizing shared connections

Policy Recommendations: Implementation Framework

Enable Multi-Party Connection Agreements

Remove legal barriers for different entities sharing connections and create transparent frameworks

- Develop standard tripartite connection agreements for situations where different entities own existing plant and new plant (e.g. third-party developer adding solar to utility's gas plant)
- Allow transfer of part of connection's rights to new party - concept akin to 'TEC splitting' rather than complex joint venture arrangements
- Create transparent registry of available surplus capacity at existing sites (voluntarily provided by asset owners) to connect developers to opportunities
- Define 'primary' and 'secondary' user frameworks or create Capacity Trading system between co-located parties

Protect Grid Reliability with Smart Controls

Mandate robust control schemes at co-located sites to ensure safe operation within capacity limits

- Require automation to ensure combined output never exceeds connection limit (e.g. 500MW connection hosting 400MW gas + 100MW solar must have controls preventing 500MW exceedance)
- Update operational codes to clarify how curtailment is managed in hybrid sites and how co-located units participate in balancing services
- Mandate coordination of protection systems and control schemes with grid operators potentially utilizing them to optimize output
- Build trust in control technology as foundation for allowing consolidated connections with updated operational rules for hybrid dispatch

Market and Policy Alignment

Align other policy areas to support surplus connections and remove remaining market barriers

- Streamline planning consent processes for co-location (some authorities already treat battery added to solar farm as minor amendment)
- Review Contracts for Difference (CfD) program with guidance for generators wishing to add storage without jeopardizing contracts (separate metering, no double support)
- Adjust Capacity Market rules to allow sites to offer joint capacity from hybrid or split between components to maximize value
- Evolve ancillary services procurement to treat hybrid plants as integrated or cooperative units, removing metering complexity barriers for grid services

Behind-the-Meter Data Centers: Leveraging Consolidated Connection

Innovative Behind-the-Meter Solution

Configuration Setup

Data center is located behind-the-meter of an existing gas peaker plant, with new oversized solar arrays + 16-hour battery storage added on-site

How It Works

95% of the time: Data center receives power from solar + battery storage.
5% of the time: When solar/battery unavailable, gas plant provides backup power

Gas Plant Dual Role

1) Provides electricity to grid during peak demand when needed
2) Acts as backup power source for data center (5% of time)

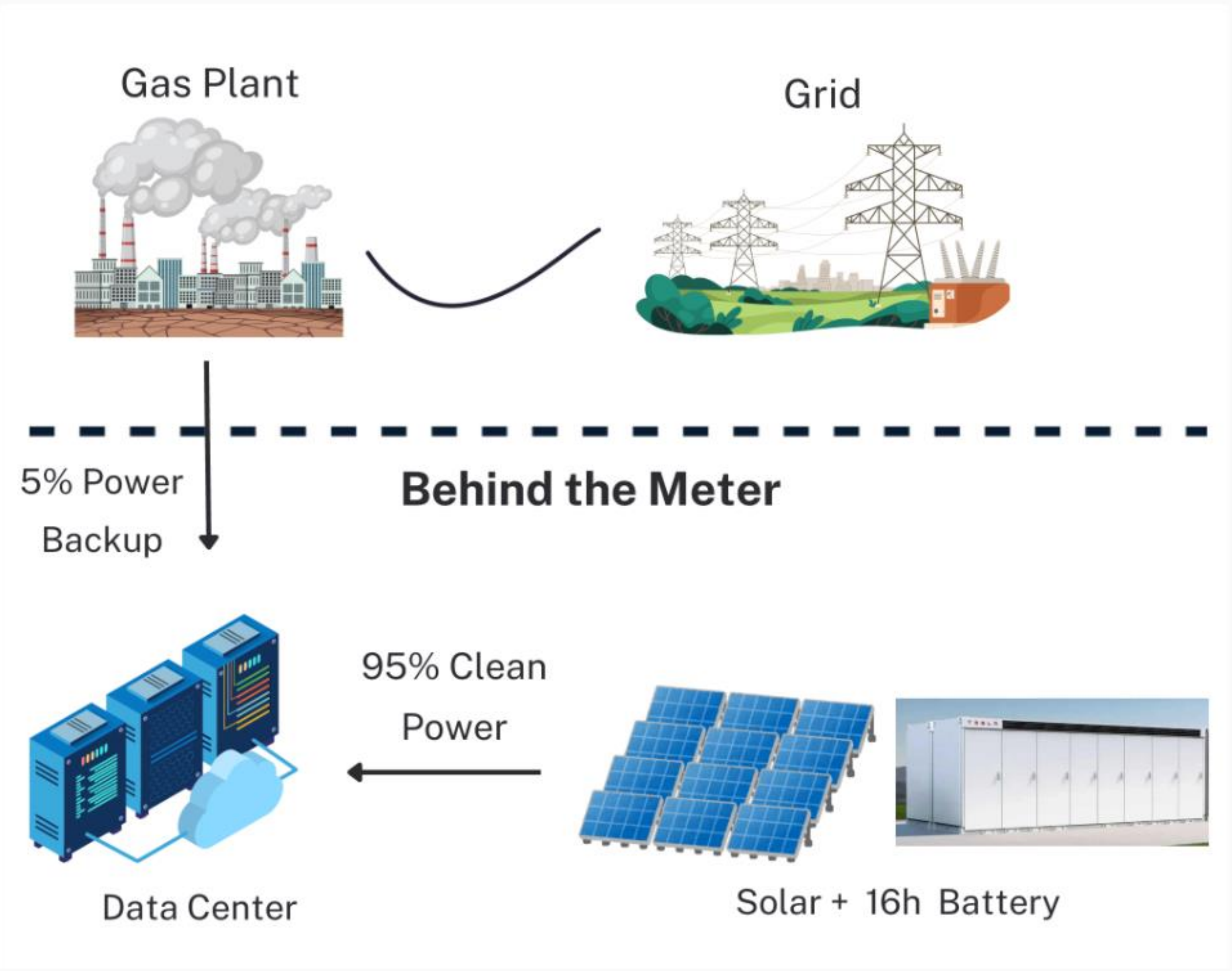
Fast Implementation

Complete build in 1-2 years (vs 5-6 years for new gas plant or grid connection)

Key Benefits

- Uses existing gas plant interconnection (no new transmission)
- 95% carbon-free operation with solar + battery
- Gas plant remains available for grid emergencies

Consolidated Connections to Power Data Centers



Thank you!

Data center electricity demand expected to double up to 2030

Data Center Demand Growth

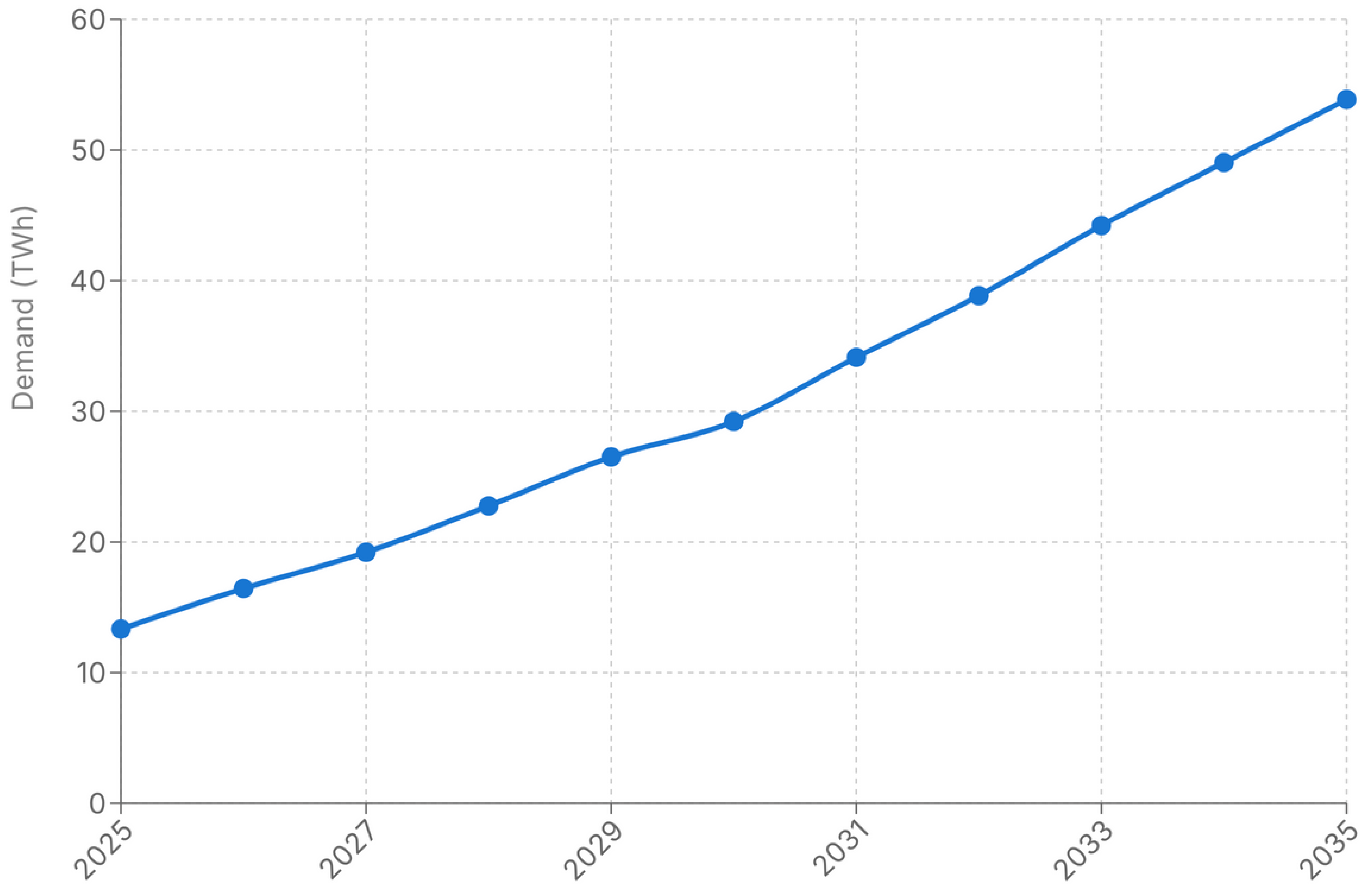
UK data center electricity consumption is projected to increase from 13.3 TWh in 2025 to 53.9 TWh by 2035 (+304%), driven primarily by artificial intelligence deployment, cloud computing expansion, and enhanced digital infrastructure requirements.

Capacity Expansion
Projected 40.6 TWh increase over decade, behind EVs the largest driver of electricity demand

AI Infrastructure Growth
Peak growth 2031-2035: 19.7 TWh addition (+57%) driven by machine learning

System Impact
By 2035: 53.9 TWh equals 13% of total UK electricity demand

Data Center Electricity Demand Projection (2025-2035)



Source: BNEF 2024, New Energy Outlook

Rising Grid Connection Costs Threaten Project Viability

Systemic Barriers Driving Cost Crisis

Grid Connection Cost Burden
33kV connections average £0.10/W with maximum £0.35/W observed, while 132kV connections average £0.07/W with maximum £0.12/W observed

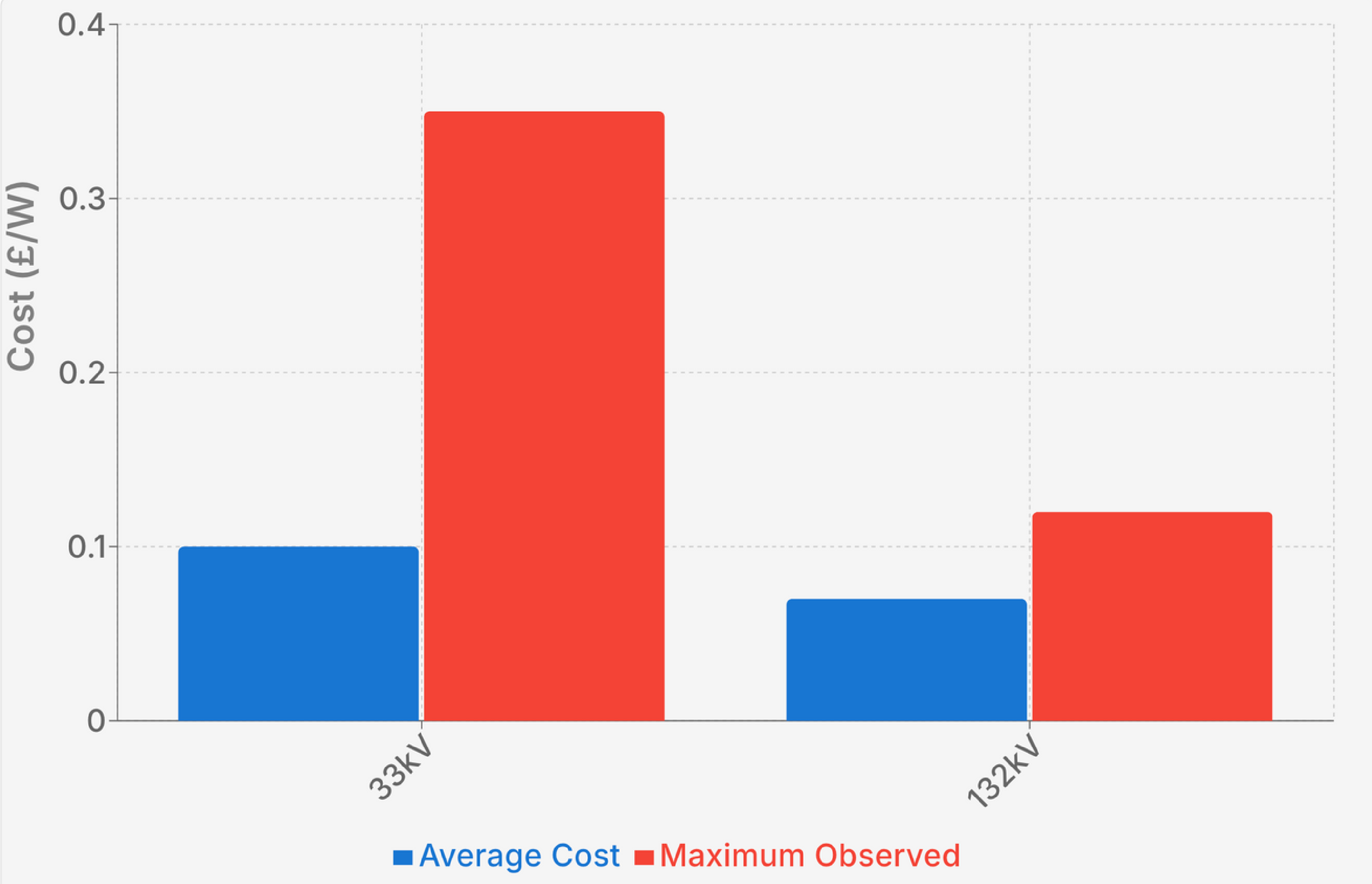
Escalating Cost Crisis
Connection costs have increased significantly, with extreme cases reaching 51% of total solar project capital expenditure making projects completely unviable

System Design Mismatch
Process designed for "fewer, larger connections" now overwhelmed by distributed generation explosion

Extreme Cases: Two 33kV projects exceeded £0.35/W (51% of solar capex) making them completely unviable

UK Grid Connection Costs by Voltage Level

Average vs Maximum Observed Costs (£/W)



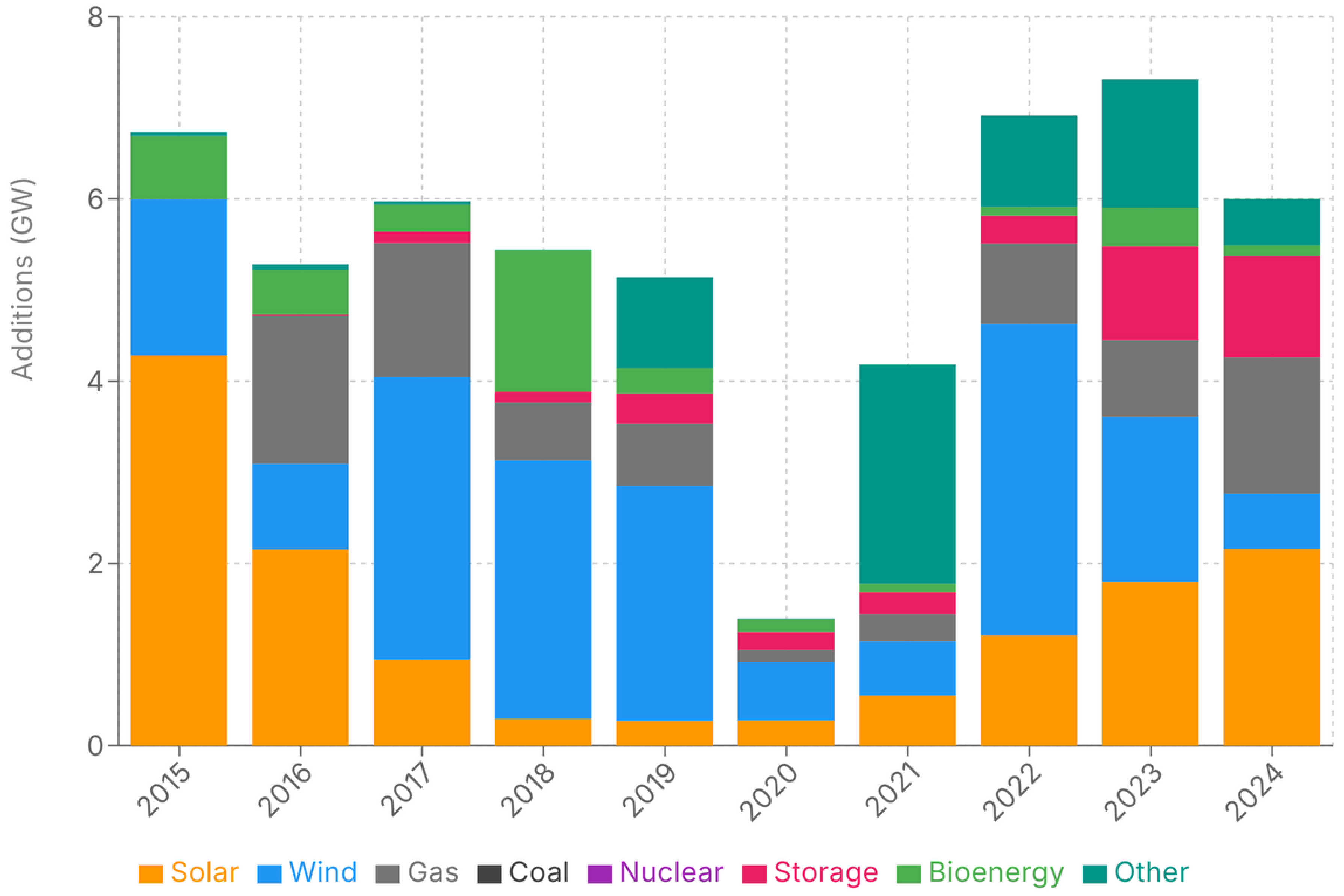
32 GW of new RE capacity was added in last decade

Future Energy Infrastructure

The UK has added 32.1 GW of renewable capacity over the past decade, with 13.9 GW solar and 18.2 GW wind dominating the expansion (2015-2024).

- **Wind Leads Additions**
  18.2 GW wind added over 10 years, with 7.1 GW in recent 5 years (2020-2024)
- **Solar Build-Out**
  13.9 GW solar added over 10 years, with peak additions of 4.3 GW in 2015
- **Recent Acceleration**
  Combined 13.1 GW renewable additions in last 5 years: 6.0 GW solar + 7.1 GW wind
- **Storage Emergence**
  3.6 GW storage capacity added over 10 years, with 2.1 GW in recent 2 years (2023-2024)
- **Gas Infrastructure**
  8.0 GW gas capacity added over 10 years, providing grid reliability during transition

+ Annual Capacity Additions by Technology (2015-2024)



Source: BNEF 2024, New Energy Outlook

23 GW of firm capacity set to retire by 2030

Legacy Infrastructure Phase-Out

The UK is systematically retiring aging fossil fuel plants from 2020-2030, with major phase-outs already completed and future retirements planned to maintain grid reliability during the clean energy transition.

Future Retirements (2025-2030):

Total Capacity: 25.3 GW

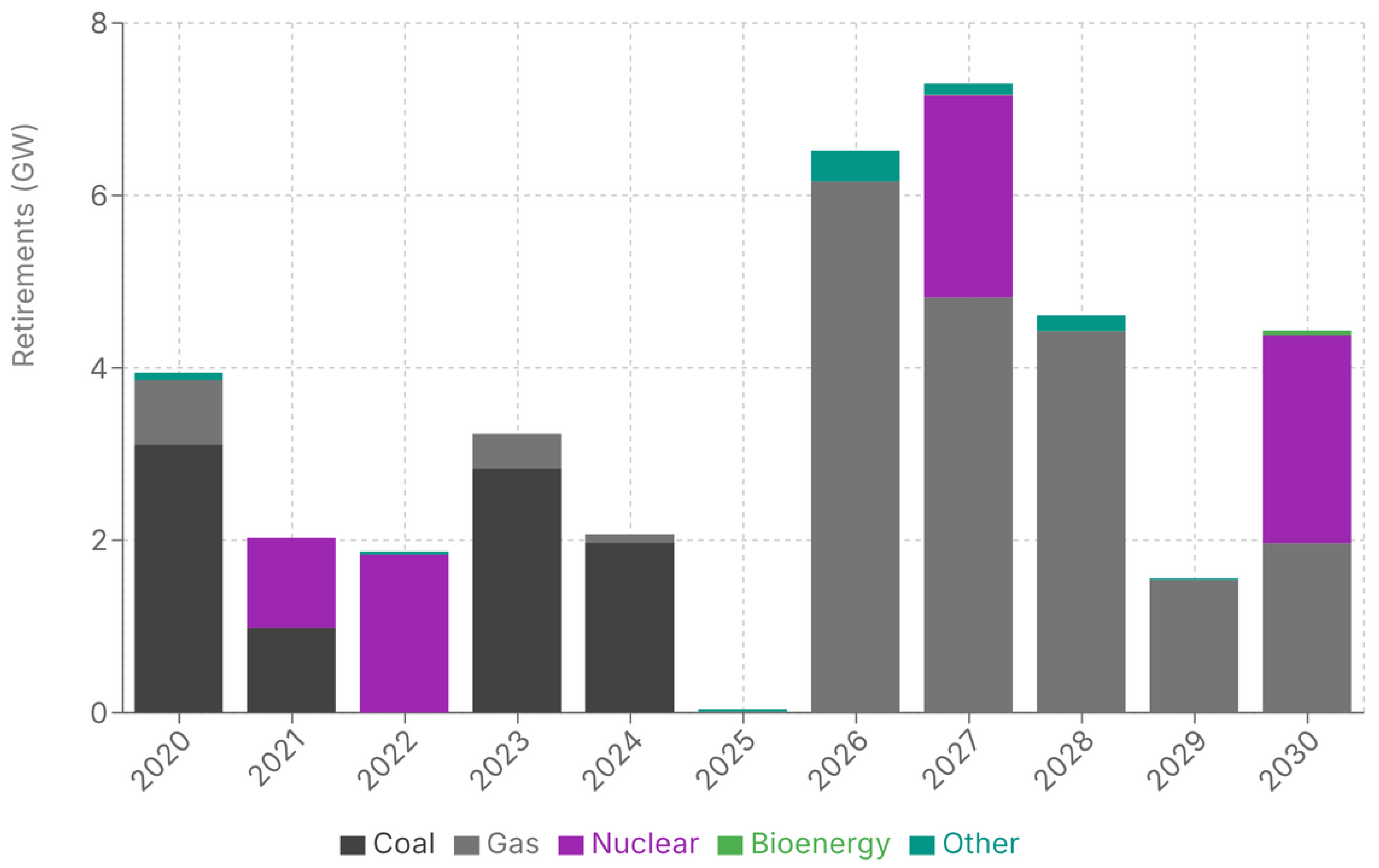
- **Gas:** 18.9 GW (74.8%)
- **Nuclear:** 4.8 GW (18.8%)
- **Wind:** 0.8 GW (3.3%)

Coal Phase-Out
Major coal retirements from 2020-2024, with complete elimination achieved

Future Gas Retirements
Major gas plant closures planned 2026-2030, totaling 18.9 GW capacity

Clean Replacement
Retired capacity being replaced by renewable and flexible resources like battery storage

Annual Plant Retirements by Technology (2020-2030)



Source: BNEF 2024, New Energy Outlook

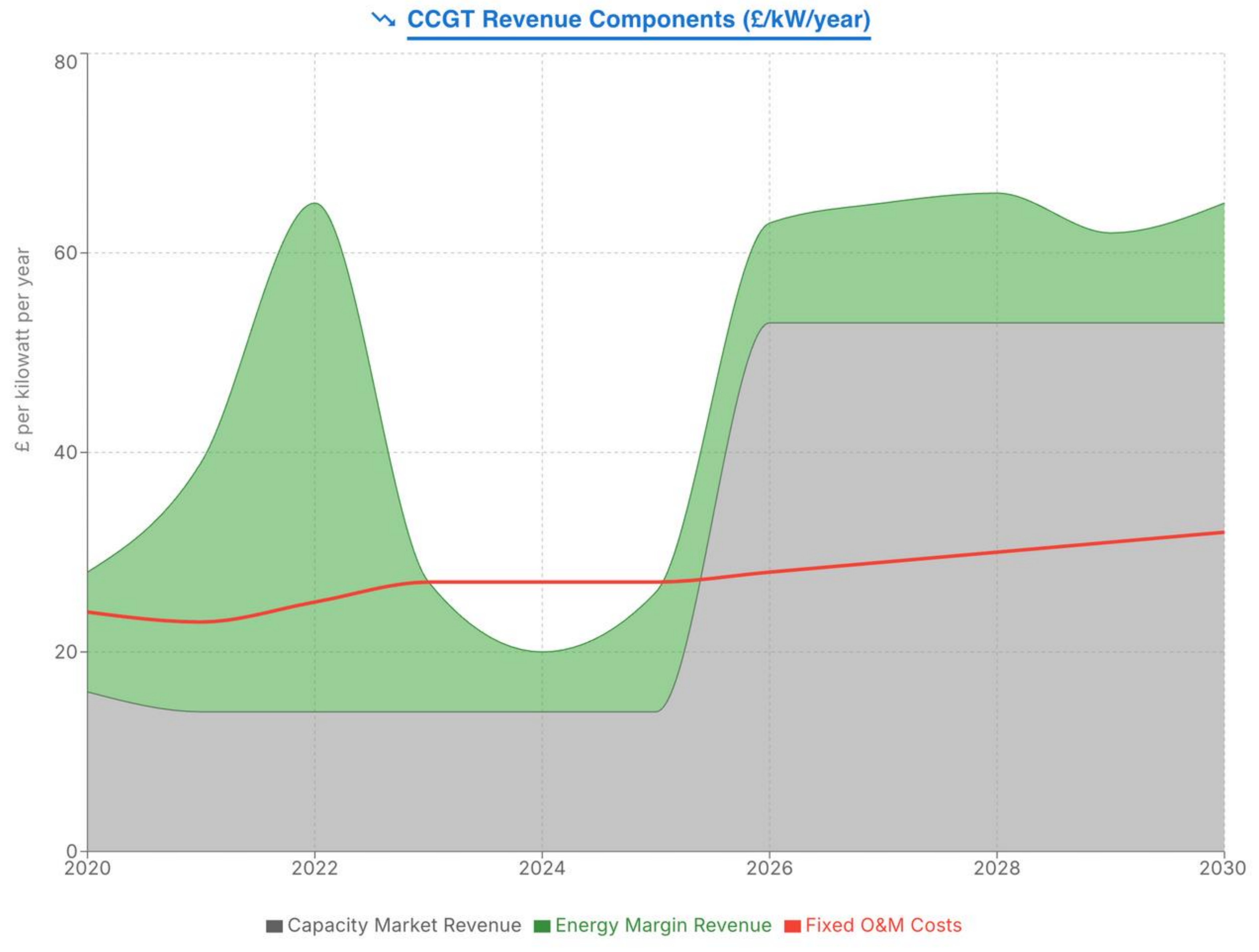
Gas Plants: From Baseload to Backup Assets

Gas Plant: From Baseload to Backup Assets

The deployment of zero marginal cost renewable generation fundamentally alters the economic position and operational profile of combined cycle gas turbines within the UK electricity system.

- **Grid-Connection Capacity Underutilization**
  As zero marginal cost renewable generation expands, CCGT capacity factors decline further from already low levels, worsening grid-connection infrastructure underutilization as plants shift to infrequent backup operation
- **Merit Order Effects**
  Renewable capacity expansion systematically displaces CCGT generation, reducing wholesale market revenue streams and increasing reliance on capacity mechanisms
- **Revenue Structure Change**
  Traditional energy-based revenue models become insufficient as zero marginal cost generators capture baseload market share
- **System Function Evolution**
  CCGTs transition from baseload generators to peaking resources, providing backup capacity during periods of low renewable output

Economic Dependency Shift: As CCGTs transition to backup-only operation relying primarily on capacity payments for economic viability, their grid-connection infrastructure becomes increasingly underutilized - creating stranded transmission assets that remain idle for growing periods while still requiring capital recovery



Source: BloombergNEF CCGT Revenue Outlook