



Cutting the bills: UK households profit from clean power

Deploying renewables at speed brings bill savings for UK households, while also boosting the economy and increasing security.

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About

In this report Ember evaluates two possible futures for the UK power system, showing that keeping renewables deployment on track brings both cost of living and energy security benefits. The study uses Ember's open power system model with all input data publicly available.

Highlights

£300

Annual average household bill saving in 2030 compared to today, leading to UK consumers saving a total of £8.7 billion.

49 TWh

UK could export 49 TWh of electricity in 2030, compared to importing 4 TWh if renewables deployment lags behind

98%

UK could achieve 98% clean power by 2030 if commitments are delivered on time

Executive Summary

A clean power system saves UK households £300 per year

Delivering the government's own commitments would save money for UK citizens. Falling behind on renewables deployment would drive costs up and miss the opportunity for the UK to profit from power exports.

The UK is capable of producing 98% of its electricity from clean sources by 2030, if existing commitments are delivered on time. This would bring cost savings for consumers, as well as increasing energy security and helping the UK reach its net zero targets. A clean power system minimises the UK's exposure to imported gas prices and instead turns it into a net exporter of electricity. However, the government is lagging behind and urgent action must be taken if UK climate ambition is to be met.

01 Average household saves £300 on electricity bill in 2030

A cleaner power system would bring cost savings for households. The annual electricity bill for an average household would decrease by £300 in 2030 compared to today under a pathway with ambitious delivery of the renewable commitments. This could save UK households £8.7 billion in 2030 compared to today. A falling short scenario where regulations, administrative and network barriers sabotage renewables targets leads to double the reliance on volatile gas imports and puts the UK at risk of losing clean investment and falling behind other countries. On top of that, the low ambition pathway results in UK consumers missing out on more than £1 billion in electricity bill savings, costing each household an additional £40 per year by 2030.

02 Wholesale costs go down, network costs go up

Electricity bills are made up of different components. Currently, the largest component is the wholesale cost of electricity, followed by the costs required to maintain the power network. A shift towards clean power cuts wholesale electricity costs by around two thirds in 2030 compared to today as cheap renewables dominate the system. Investments in the grid increase network costs, but this is outweighed by the wholesale cost decrease.

03 UK becomes net exporter of electricity

Historically, the UK has been a net importer of electricity. A 98% clean power system would reverse this thanks to a relative increase in cheap wind and solar compared to neighbouring countries. This would result in the UK exporting 49 TWh of electricity in 2030 compared to importing 4 TWh in a falling short scenario.

The longer the UK relies on fossil fuels, the longer households will feel the pinch. A clean power system will save households hundreds of pounds a year off bills, but lagging government action risks blocking those benefits

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UK power bills

Clean power lowers cost of living

The UK is capable of producing 98% of its electricity from clean sources by 2030 if existing commitments are delivered on time. However, the current government is lagging behind, and the UK risks missing out on opportunities to cut consumer bills and become a net exporter of electricity to the EU.

In some ways, the UK has been at the forefront of energy transition. Over the last two decades, the UK [quickly transitioned](#) from a power system that relied heavily on coal to generating just 2% of its power from coal last year. Meanwhile clean power expanded, with wind power growing rapidly to provide a quarter of the UK's power in 2022. A mix of conditions enabled this staggering shift: ambitious short term power sector targets; new regulations putting a price on air pollution and emissions from fossil fuels; stable and consistent policy support for offshore wind power that gave confidence to industry; and reforms to the energy market. This looked set to continue: in 2021 the UK committed to generating all electricity from [clean sources by 2035](#), targeting 95% clean power in 2030 according to the [British energy security strategy](#).

However, the UK now risks ceding its advantage in the clean power transition. The government has allowed key enablers to meet energy transition targets to slip. The latest warning sign was a renewable auction round that [failed to secure any offshore wind capacity](#), a critical technology for the UK's clean power ambition. With the 2030 offshore wind target of 50 GW now highly at risk, the government must heed this warning and take immediate action to ensure future auctions secure sufficient capacity. Targets have to be implemented for benefits to be felt; if the UK can prioritise hitting its ambitious goals, households and the UK economy stand to reap the rewards. If not, the costs of fossil fuel reliance will continue to fall on households.

Delivering on these power sector targets is feasible, according to multiple modelling studies. This includes reports by the British transmission system operator [National Grid](#), the independent [Climate Change Committee](#), as well as Ember's own [modelling](#). However, inadequate government progress stands in the way, including poor [renewable auction results](#)

and limited improvements to [onshore wind permitting regulations](#). The more that focus wavers away from a coordinated, committed approach to power sector transition, the steeper the trajectories become to hit targets.

Building on the existing research, we show that if the UK can reach its targets, ambitious decarbonisation of the power sector will substantially bring down household bills. These benefits are not some distant promise: by the end of the decade clean power can deliver savings, lowering costs of living compared to a future in which the government's plans are not delivered on time.

The scenarios

The more ambitious 'Delivering commitments' scenario assumes that the government delivers its own commitments on time. However, given slow progress over the last few years, this will now require a significant step up in delivery. Current government plans include reaching 50 GW of offshore wind by 2030, 70 GW of solar by 2035, 10 GW of low carbon hydrogen production capacity by 2030 and more than 2 GW of [carbon capture, usage and storage projects](#) by 2030. The scenario combines these government commitments with the National Grid's most ambitious 'Leading the way' pathway from the [Future Energy Scenarios 2023](#) which sees gas power plant capacity fall, interconnection increase and onshore wind double from 2022 levels.

The 'Falling short' scenario is based on National Grid's 'Falling short' pathway and describes a pathway in which the government does not reach net zero by 2050, failing to address some of the key barriers standing in the way of its own plans. For example: delays in onshore wind permitting, solar grid connections and inadequate support for offshore wind expansion. Failure to address these barriers results in higher reliance on fossil gas and electricity imports in this scenario.

Both scenarios are largely based on capacity and demand values provided in National Grid's Future Energy Scenarios 2023 report. This report translates these numbers into household bill savings, calculating the impact different energy transition pathways might have on consumer electricity bills.

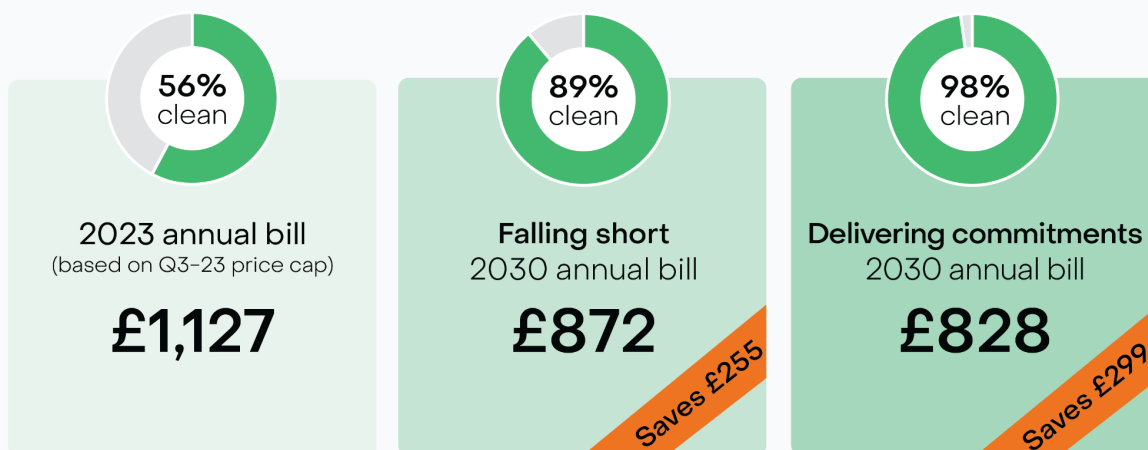
Average household saves £300 in 2030

Our latest modelling shows that delivering ambitious renewables deployment in line with existing government commitments (the 'Delivering commitments' scenario) would result in an average household electricity bill £300 cheaper than the Ofgem price cap in [Q3 2023](#). Lagging on renewables (the 'Falling short' pathway) would cost households more, with bills £40 per year more expensive than the ambitious scenario. In total, the 'Delivering commitments' scenario could save UK households £8.7 billion in 2030 compared to today.

In addition to cheaper bills, the 'Delivering commitments' scenario reaches 98% clean electricity generation by 2030. The lower ambition 'Falling short' scenario would put the UK at 89% in 2030, placing more pressure on delivering the country's clean power commitment by 2035 and delaying the economic benefits of the transition. This scenario also results in 73 TWh of expensive fossil gas imports, double that in 'Delivering commitments', with associated increased exposure to volatile global pricing. The risks of this have already been seen: in January 2023 at the peak of the crisis, soaring gas costs resulted in UK consumers paying four times more for their electricity than two years before under Ofgem's price cap.

More clean power will save households £300 per year

Average annual household electricity bill (£) and clean share of electricity (%)



Source: EMBER-PyPSA modelling, Ofgem

Note: 'Delivering commitments' is modelled on National Grid's most ambitious 'Leading the way' pathway with updated latest solar and offshore wind targets. 'Falling short' is based on National Grid's 'Falling short' pathway, where the UK fails to meet renewable capacity targets.

Although grid investment costs increase in the 'Delivering commitments' pathway to accommodate more renewable deployment, household bills still drop compared to the 'Falling short' scenario as the lower costs of electricity generation outweigh this increase.

However, unlocking these savings by 2030 will only be possible if renewables and the related infrastructure are delivered at speed. At the moment it takes [five to six years](#) to secure all permits for a wind farm and two years for a solar farm, and the Norway-UK interconnector is already delayed by three years due to cable manufacturing capacity issues. In addition to this, the three future renewable auction rounds must each secure [8 GW](#) of offshore wind if the UK is to reach its 2030 target, a steep task given the average across the first four auctions was 4 GW, and amidst current supply chain pressures and high inflation.

However, research shows project development times could be [cut in half](#) by streamlining permitting procedures, reducing grid connection times, and ensuring renewables are appropriately prioritised. For example, through a more permissive planning regime on onshore wind which goes beyond the latest changes recently announced by the government, and ensuring future auctions recognise the increased costs facing renewable developers.

UK can become a net exporter of electricity

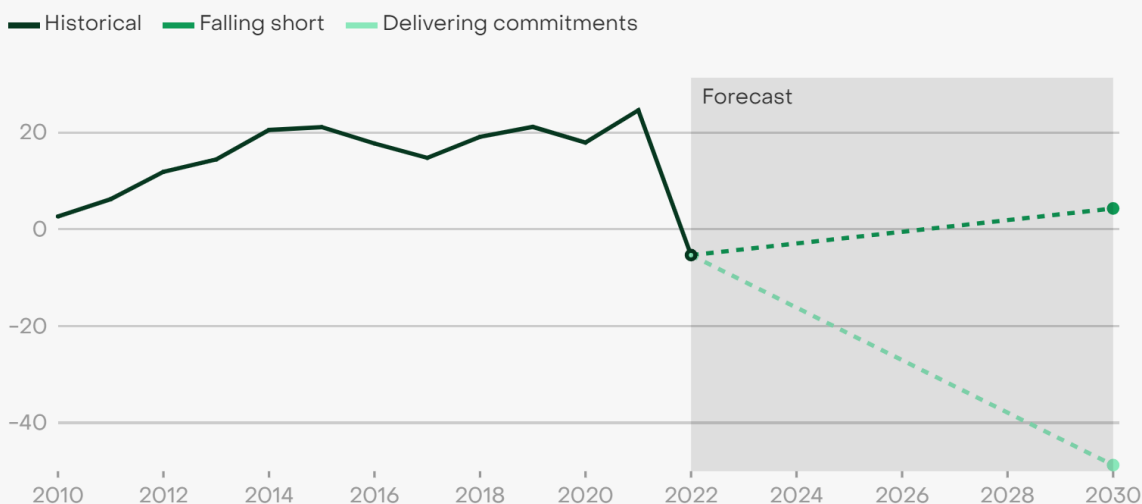
The UK economy as a whole stands to benefit from more renewables on the power grid. Unlike the 'Falling short' scenario, the more ambitious 'Delivering commitments' puts the UK on a pathway to net zero, a path which promises hundreds of thousands of newly created jobs in green industries and access to billions in private capital injected into the UK economy, as outlined in the [UK Net Zero Strategy](#). More renewable power also has the [potential to lower inflation](#).

Compared to the 'Falling short' scenario, the 'Delivering commitments' pathway sees reliance on imported fossil gas reduced by half, equivalent to 4 bcm lower imports. This is another major upside, not only from a security perspective, but also offering [protection against economy-wide damage](#) from volatile prices and supply disruption as seen in the last two years due to a global gas crunch.

The UK can go even further than reducing reliance. In fact, if existing renewables commitments are delivered, the UK could produce a surplus of electricity, turning the country from a historical importer into an exporter of 49 TWh of power annually in 2030. These exports will be possible because the UK's clean power will be cheaper than abroad. This would serve to make the economy more competitive, with the country becoming an attractive location for new foreign investment, alongside the benefits to economic resilience from the clean domestic power supply. If the government falls short on renewables deployment as described in the 'Falling short' pathway, the UK will remain a net importer of electricity - relying on neighbours for around 4 TWh of power a year in 2030 and making the economy less competitive in European markets. As neighbouring countries race towards a clean power system, the UK risks falling behind and [losing investment opportunities](#) which come with the transition.

Delivering existing renewables commitments can turn UK from a power importer to an exporter

Net yearly electricity imports under different scenarios (TWh)



Source: DUKES, Ember's PyPSA-UK model
 'Delivering commitments' is modelled on National Grid's most ambitious 'Leading the way' pathway with updated latest solar and offshore wind targets. 'Falling short' is based on National Grid's 'Falling short' pathway, where the UK fails to meet renewable capacity targets.



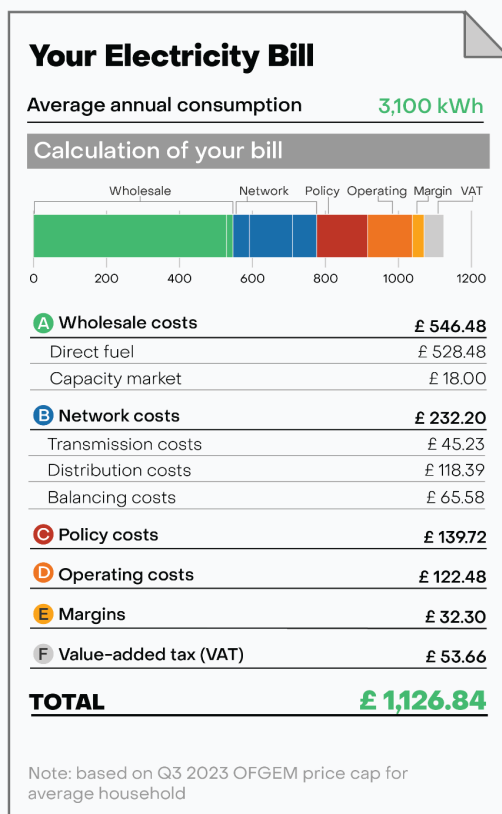
This surplus of electricity has other advantages: it can be turned into hydrogen, contributing to the decarbonisation of other economy sectors such as industry and transport. In fact, in the 'Delivering commitments' scenario the UK produces 34 TWh of green hydrogen, more than 30 times the current level. This is not possible in the 'Falling short' scenario in which green hydrogen production is negligible and the UK would therefore have to import or use existing carbon intensive production methods.

How would a clean power system affect household electricity bills?

To understand how cost savings from renewables will reach households, it is important to first understand how electricity bills work. These bills can be complex, with multiple components determining final costs. It is also highly likely that certain elements could change in the future, as the energy transition affects the structure of electricity generation and what is charged to consumers.

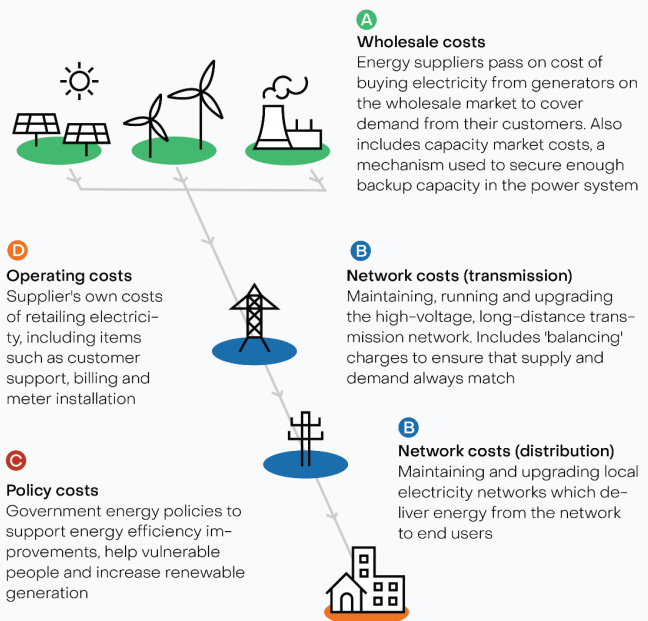
What makes up an average household electricity bill in the UK

Average UK household electricity bill (£)



How the power grid works

Electricity flows from generators to consumers across a network with many different components. Electricity bills are made up of costs associated with the different parts of this system.



Source: Ofgem

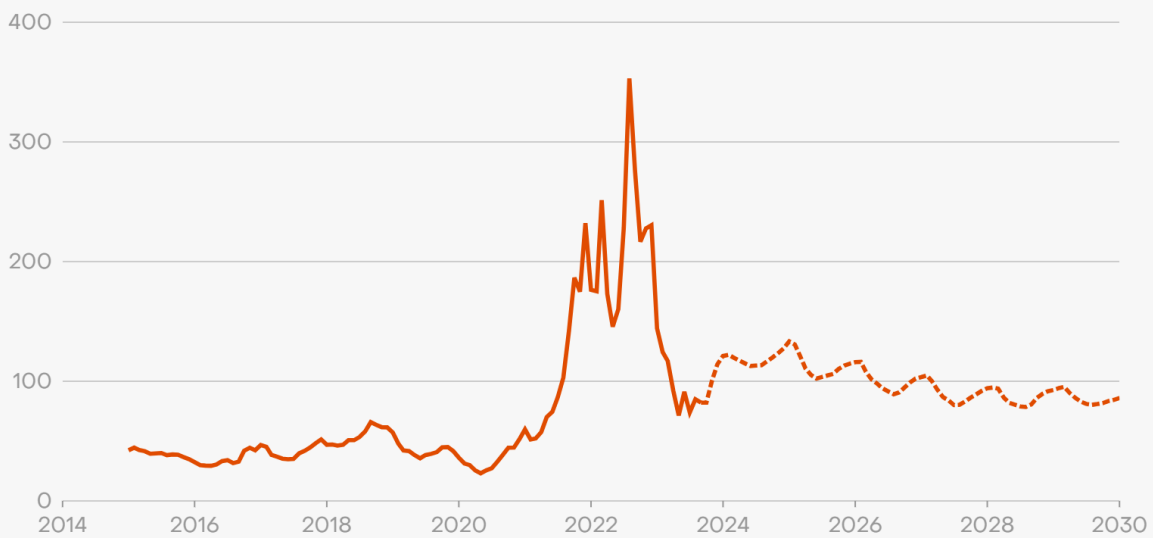
The largest contributor to a UK electricity bill is the wholesale cost of electricity production, currently dictated by the price of running gas power plants. Wholesale components usually

account for approximately one third of an average bill, but as gas costs rose during the recent energy crisis, this peaked at around 70%. Whilst fossil fuel generators continue to set the wholesale electricity price, it is unlikely to fall below £100 per MWh in the foreseeable future.

Fossil gas prices down from peak but set to remain high

Short run marginal cost of gas-fired generation (£/MWh)

Dotted lines are futures prices; solid lines are spot prices



Source: Montel, ICE
 NBP monthly gas prices; EUA and UKA December ETS prices. All data from ICE via Montel. Front month gas prices used before 2023/09; future prices as of 2023/09 used after. SRMC calculation includes costs of fuel, maintenance, emissions allowances, and CPS price.



Meanwhile, the latest auctions for renewable energy producers saw bids significantly cheaper than anticipated future wholesale power prices, which currently closely track fossil gas prices. This emphasises the savings to be made through the deployment of more renewables. The latest auction bids came in at around [£61 per MWh for solar and £67 per MWh for onshore wind](#) [£(2023) prices], with these low-priced projects due to come online between 2025 and 2027. In the previous auction round, offshore wind recorded a record low strike price of £45 per MWh [£(2023) prices]. However, given the lack of capacity allocated in the latest results, there have been warnings over promoting a ‘race to the bottom policy’ and demands that future auctions correctly set their parameters to ensure projects are viable in today’s market.

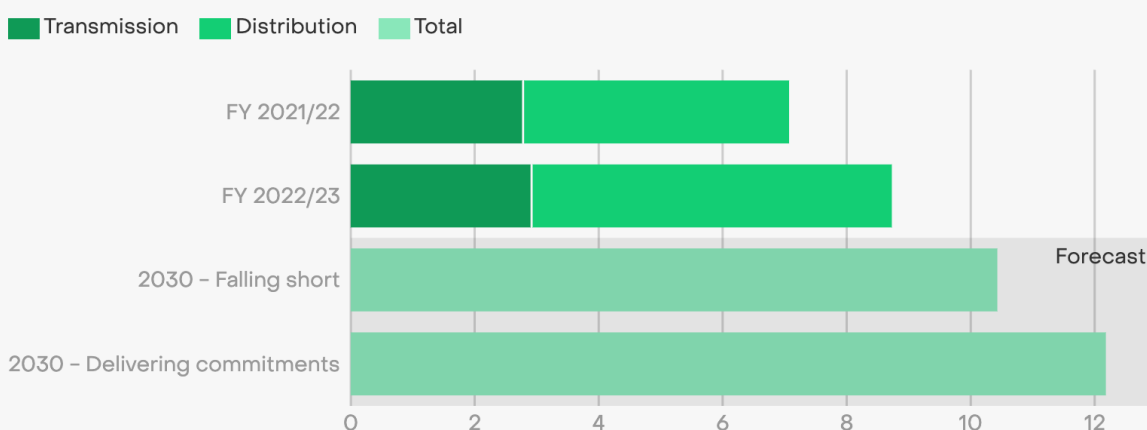
In the 2030 'Delivering commitments' scenario, the wholesale component of household electricity bills drops to £65 per MWh, a staggering two thirds lower than the £176 per MWh in Ofgem's Q3 2023 price cap and 25% less than the 'Falling short' scenario - which contains double the gas generation.

After wholesale costs, the second key component of an average electricity bill is network costs, which usually make up around 20%. Network charges are expected to increase because of the investments needed to reduce grid congestion as more distributed renewables come online, along with higher maintenance costs. Currently, grid expansion is not keeping up with the deployment of renewables, resulting in [£1.5 billion](#) worth of wasted wind electricity since 2021, primarily due to the congestion on the Anglo-Scottish border.

The UK's electricity system operator National Grid plans to increase transmission investment to around [£2.3 billion per year](#) between 2022 and 2026 (double the average investment of the last two years) whilst also increasing distribution investment by 20%. In total, National Grid's Pathway to 2030 states around [£30 billion](#) is needed for grid infrastructure to reach 50 GW offshore wind by 2030.

Increased grid investments are needed to decarbonize the UK power system

Annual grid investments (billion £)



Source: National Grid, Ember's PyPSA-UK model
 'Delivering commitments' is modelled on National Grid's most ambitious 'Leading the way' pathway with updated latest solar and offshore wind targets. 'Falling short' is based on National Grid's 'Falling short' pathway, where the UK fails to meet renewable capacity targets.

Due to these investments, both of the analysed scenarios see network charges increase compared to current prices, from around £75 per MWh in Q3 2023, to £89 per MWh in 'Falling short' and £100 per MWh in 'Delivering commitments'. However, these higher network charges are more than offset by a larger fall in wholesale electricity costs. Compared to 2023, in the 2030 'Delivering commitments' scenario, wholesale costs fall by £112 per MWh whilst network costs increase by only £26 per MWh.

Conclusion

Timely deployment of renewables brings benefits to UK households and the economy

The government needs to ensure its own commitments are met and barriers to renewables are removed.

Delivering the wind and solar targets that are already in place will lower household electricity bills, create jobs, increase energy security, make the UK more competitive on global markets and generate a power surplus that can be used to produce hydrogen and decarbonise transport and industry. However, in spite of ambitious targets, the UK government is failing to live up to its clean power commitments, allowing key technologies such as offshore wind to slip behind and failing to unblock broader obstacles to decarbonisation.

Meeting the UK's clean power ambition will only be possible if a mix of existing barriers are addressed. Permitting procedures must be simplified and accelerated, to tackle grid connection queues and slice wind and solar project lead times to one to two years instead of the current five to seven years. Adequate support is required for grid expansion. Sufficient funding must be allocated for the contract for difference (CfD) scheme for large-scale renewables projects, along with support for strong representation of storage technologies within capacity and other markets.

Recommendations

A grid fit for clean power

Grid development often takes longer than deploying wind and solar, with some renewable projects facing grid connection delays of 10 to 15 years. Tackling slow grid expansion must be a priority to enable new renewable generation and storage to connect to the network. The recent [Electricity Network Commissioner's report](#) outlines 18 recommendations for accelerating the deployment of strategic electricity transmission infrastructure, ranging from urgent updates to the National Policy Statements to a focused public information campaign on the need for a grid refresh.

National Grid also [released an action plan earlier this year](#) to enable the UK grid to meet its clean power targets. Steps outlined include: reforming the planning system to shorten the consenting process for major energy projects; creating a 'Strategic Spatial Energy Plan' by 2025 that sets out future grid investment requirements; shifting from the current 'first come, first served' grid connection process to 'connect or move'; and clarifying roles and responsibilities across the institutions accountable for the energy transition. National Grid also highlights the importance of putting communities at the forefront of the transition and network development should be carried out alongside a wider focus on environmental and social issues.

Support for renewables contracts for difference auctions

The UK's CfD scheme has secured substantial volumes of renewable energy projects and seen prices drop sharply since its first round in 2015. However, the latest auction round failed to secure any offshore wind capacity as, despite warnings, the auction's parameters ignored current market conditions. The government must now rebuild investor confidence and confirm that future auctions will take this into account, ensuring the budget and parameters for auctions enable bids at sustainable prices. With the EU and US announcing their own green industrial strategies and growing global competition, the UK must not be left behind.

Bring consumers onboard

The transition to a clean power system will require buy-in from citizens, through engagement with technologies such as smart metres and participation in demand side response.

[Octopus Energy are demonstrating this is already possible](#), trialling the UK's first customer demand response programme last winter and offering customers free energy when there is excess clean energy on their local grid. Schemes such as these, which provide balancing services to the grid, should be expanded to enable more customers to capitalise on the benefits of a clean power system.

Increased interconnection capacity

With increasing volumes of variable renewable energy, interconnection will be a crucial form of flexibility to ensure that the UK can trade clean electricity with its neighbours at times of high and low demand. Interconnectors are significant infrastructure projects, and future requirements should be planned well in advance, whilst also taking steps to mitigate potential blockers such as the [cable market congestion](#) which delayed the Viking Link.

Scaling up the clean power workforce

The huge expansion of renewable energy and associated infrastructure will require an equally important increase in the number of green, skilled jobs. Plans must be put in place to up- and re-skill a workforce (especially considering workers who will be at risk of losing their jobs as fossil fuels are phased out), ready to undertake jobs across the clean energy sector.

Methodology

Ember's power system model

The analysis presented in the report uses Ember's in-house power system optimization model [EMBER-PyPSA](#), that is publicly available along with all input data under the [MIT](#) licence, allowing for all analysts to replicate our results or build their own scenarios for the UK's future energy system. EMBER-PyPSA is based on the [PyPSA](#) framework, a Python-based 'open source toolbox for simulating and optimising modern power systems', used globally in research and policy applications.

The base assumptions and methodology are described in the ['Path out of the gas crisis'](#) report from 2022, but several updates have been made - such as taking into account National Grid's latest [Future Energy Scenarios 2023](#), adding in a hydrogen demand profile, as well as combining Ember's UK and EU models (described in ['In it together'](#)) to provide a comprehensive overview of the internal and external factors influencing the UK's power system.

The model is run for each hour of the year, with 12 nodes representing the regions of the UK and 28 nodes representing all EU countries except Luxembourg, Malta and Cyprus, plus Norway, Switzerland, Turkey and Russia.

Current and planned power station locations are used (based on [DUKES](#) data, [planned hydro pumped-storage units](#), the [REPD](#) database, among others), with some generators being decommissioned and some replaced e.g. gas turbines being replaced/equipped with carbon-capture and storage units (CCS). For countries outside of the UK, generation units and installed capacities are based on the [latest national announcements](#) and official plans, including the [updated National Energy and Climate Plans](#) or coal phase out commitments.

The model runs the capacity projections against 'worst case scenario weather years', following a methodology used by European grid operators in their planning. The European Network of Transmission System Operators (ENTSOE) prepares *Ten Year Network Development Plans* ([TYNDP](#)) and the European Resource Adequacy Assessment ([ERAA](#)) to assess the safety of the European power system, the availability of generators against the demand, grid expansion needs, etc. Both processes use the Pan-European Climate Database ([PECD](#)) to estimate the demand and variable renewables feed-in under different

climatic conditions, with the TYNDP pathways checked against 1995, 2008 and 2009 (the baseline year) weather profiles as the worst case years. Using the ENTSO-E's methodology ensures the model maintains energy security, with supply matching demand on an hourly basis, even in high stress situations (for example, dunkelflaute, or mid-winter wind lulls).

A merit-order scheme is resembled, in which the dispatching is optimised based on short-run marginal costs. Fuel and CO2 price forecasts were estimated based on latest forward contracts. The running costs of non-fossil generators were set to represent their dispatching priority in the merit order.

The model was calibrated using historical weather and demand data to ensure the cost assumptions correctly represent reality. CHP units were set to run following hourly country temperature profiles derived using the [Atlite](#) tool. A minimum load of 40% for nuclear plants was assumed based on [ENTSO-E's ERAA](#) input data. No ramp up/down limits were introduced due to their impact on model solving times, but these can be added by the user if needed.

The outputs produced by the model give an indication of the resources needed to fulfil the power demand in the future, as well as the emissions intensity, load balancing needs across regions, storage requirements, among other metrics.

All model input files as well as the Python code are available on [Github](#).

Calculating future bill costs

There are several different components that make up a household electricity bill and different approaches have been used to estimate how they might change in 2030. Current average household electricity bill costs are taken from OFGEM's default tariff cap level for 'Other payment', single-rate metering households in [Q3 2023](#). OFGEM's default tariff cap was introduced to protect households by capping the amount customers on standard variable and fixed term default tariffs could pay. However, due to the energy crisis, a [large majority of households](#) are now on standard variable tariffs and therefore OFGEM's default tariff cap is taken to represent the UK average.

Wholesale costs

The EMBER-PyPSA model outlined above was used to estimate the average price of UK power in 2030, assuming the short run marginal cost of plants acts as a proxy for day ahead

prices. Ofgem includes CfD costs in this component along with direct fuel costs. It is assumed that the majority of these CfD costs will come from offshore wind, and an estimate of the [interim levy rate](#) (the cost required to cover payments for the scheme per MWh) is calculated based on the methodology described in a [recent report on UK CfDs](#). The difference of the hourly price returned by the model and the average strike price (taken from a weighted average of existing prices, assuming future capacity secures the same price as auction round 4) is multiplied by the proportion of offshore wind generation assumed to be under a CfD (75% in the 'Falling short' scenario and 84% under 'Delivering commitments'). This number is then divided by electricity demand in 2030.

Network costs

National Grid forecast expected capital investments in their transmission and distribution grids. For the 'Delivering commitments' scenario, this is taken from National Grid's [latest investment proposition](#). The 'Falling short' scenario assumes [investment](#) announced prior to the British Energy Security Strategy when offshore wind and solar targets were increased. The ratio of future to current National Grid investment is used to scale total grid investment (capital and operating costs) across all distribution and transmission operators from 2022/23 to 2030, using the distribution and transmission use of system charges given by Ofgem in the Q3 2023 price cap. Balancing charges are assumed to remain at similar levels to the Q3 2023 price cap given higher investment in the transmission and distribution grid should reduce curtailment costs.

Operating costs

A small decrease in operating costs due to a successful rollout of smart meters by 2025 is assumed in the 'Delivering commitments' scenario. Otherwise, operating costs are assumed to remain the same as the Q3 2023 Ofgem price cap.

Policy costs

Policy costs are made up of (in descending order of magnitude): Renewables Obligation, Warm Homes Discount, Energy Company Obligation, Feed in Tariff and assistance for areas with high electricity distribution costs. Although several of these schemes have ended, they have payment obligations past 2030, and it is therefore assumed the policy cost component of bills will remain the same.

Margins & VAT

Margins (EBIT and headroom) are calculated based on Ofgem Q3 2023 price cap percentages of total bills. An additional 5% is added to the total bill for VAT.

Total household savings are calculated by multiplying expected household bill savings by the projected number of households in the UK in 2030. The latter number is derived by applying the [national population projection](#) increase to [ONS 2022 household data](#).

Fossil gas avoided cost calculations

A gas plant efficiency rate of 50% (gross calorific value/higher heating value) has been used and a conversion factor of 1 bcm = 9.7 TWh has been applied.

Acknowledgements

Model

Ember's power system model is based on the PyPSA framework: T. Brown, J. Hörsch, D. Schlachtberger, [PyPSA: Python for Power System Analysis](#), 2018, Journal of Open Research Software, 6(1), arXiv:1707.09913, DOI:10.5334/jors.188

Reviewers

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Cover photo

A person opens their energy bill in London, UK in 2022.

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