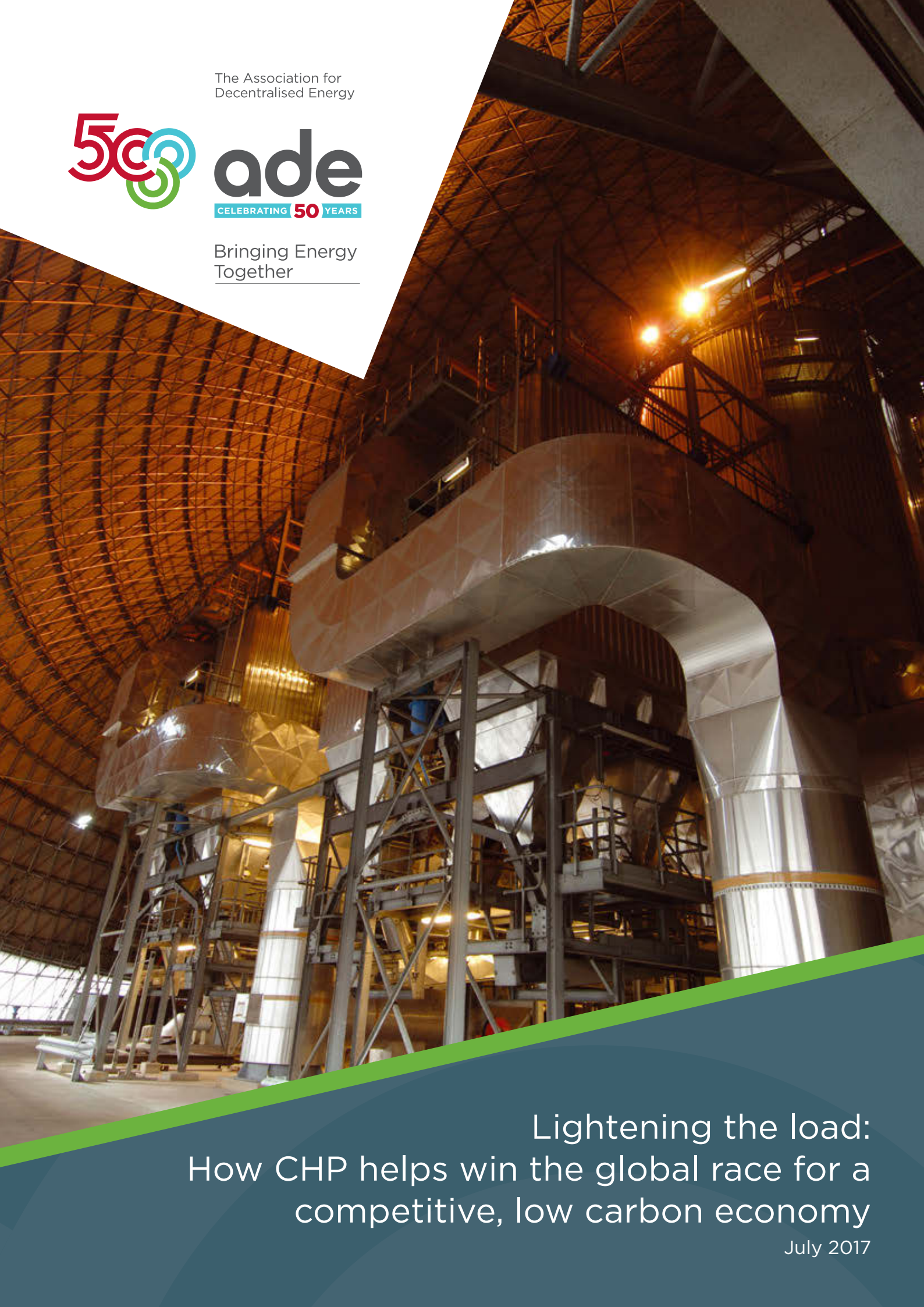


The Association for
Decentralised Energy



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CELEBRATING **50** YEARS

Bringing Energy
Together

A photograph of a large industrial facility, likely a power plant or refinery, featuring massive, curved, metallic ducts and complex scaffolding. The interior is illuminated by warm, orange lights, and the ceiling is a high, arched structure with a grid of steel beams.

Lightening the load: How CHP helps win the global race for a competitive, low carbon economy

July 2017



The Association for
Decentralised Energy



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Executive summary

A concerted global effort is required to tackle climate change, and countries are competing on who can transition most effectively. How each nation adapts to a carbon constrained world will determine its future economic competitiveness and ability to deliver lasting, sustainable growth and prosperity.

Within the Industrial Strategy, the UK Government has set twin aims of delivering a decarbonised economy and strengthening the global competitiveness of British businesses. These twin aims, while aligned with global trends, can also create tensions.

Decarbonising is, on the whole, a benefit to the UK's economy, lowering the UK's energy costs over the long-term. However, some elements of decarbonising the economy can result in higher energy costs, which can fall particularly hard on businesses, with business energy costs having risen by as much as 119% since 2004.

The cost of delivering a new energy system includes more than just the support for increased renewable and nuclear energy generation. The electricity system must meet the challenge of delivering sufficient capacity, balancing the electricity network on a second by second basis, and adapting and expanding power networks.

Meeting these three challenges carries costs. The Capacity Market, balancing services, and electricity networks add nearly £11 billion a year on users' bills today, making up about one third of all UK electricity costs, and will rise to nearly £13 billion by 2021. In addition, meeting these system requirements with higher carbon resources can make it harder to meet our decarbonisation goals.

In order to meet these three energy system challenges, policy to date has focussed on the energy sector to solve them. However, there is a yet-unseized opportunity for businesses energy users to provide benefits to the energy system and lighten the load of this cost rise. By receiving value for their contributions, these businesses will be able to protect their profitability and competitiveness, and support inward investment.

A key tool for businesses to deliver these benefits is combined heat and power (CHP). Combined heat and power is the most efficient way to meet heat and power needs, cutting energy waste by up to 30%.

The benefits of CHP are being felt today. There are more than 2,000 businesses and sites in the UK which use CHP to support their operations. More than 111,000 jobs are located on these sites and CHP is helping to improve manufacturing productivity, control energy costs and protect long-term employment. CHP is also used by hundreds of heat networks, providing heating through a network of pipes to homes and businesses in UK cities.

While historically CHP plants were built and operated to run all the time, and while some industrial users will always have very limited power flexibility, new CHP plants are able to respond to market signals, providing more generation when needed and less when lower carbon generation is available.

CHP enables businesses to provide flexibility, efficiency, and local value, while achieving the Government's strategic energy and industrial policy goals. In addition to its financial benefits, CHP saves carbon as long as it displaces other, higher carbon gas and coal power stations which do not recover their heat.

Recommendation: With National Grid and other market analysts expecting up to 14 GW of new gas generation, and with gas generators continuing to generate for thousands of hours in 2030, the UK should set a clear ambition to ensure as much as possible of this capacity is CHP.

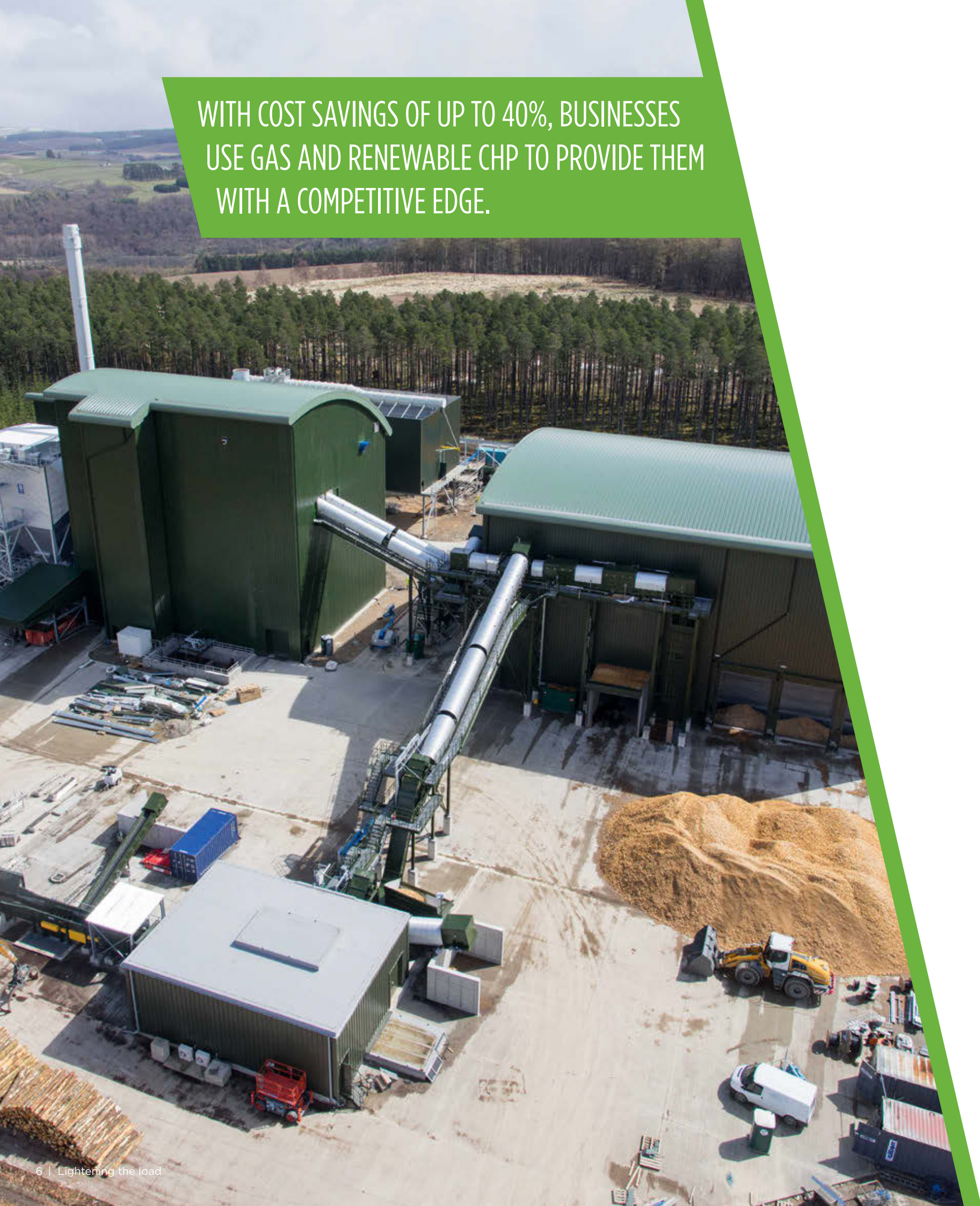
A more productive, low-carbon economy

Businesses with CHP are able to displace more expensive power generation and reduce UK fuel costs, delivering more than £375 million to the UK economy, while removing more than 6.7 million tonnes of carbon per year.

By building new CHPs instead of new, less efficient power-only gas plant, by 2030 carbon savings will slow to 4 million tonnes per year, but system cost savings will increase to between £656 million to £774 million, even as the energy system decarbonises.

Recommendation: CHP's system benefits should be properly recognised and rewarded under the Government's forthcoming carbon taxation review. This can be achieved by continuing Carbon Price Support tax at its current rate until 2025 when coal generation is forecast to close; by maintaining existing CHP reliefs under the Climate Change Levy and the Carbon Price Support; and by relieving CHP from Carbon Price Support for its exported electricity.





WITH COST SAVINGS OF UP TO 40%, BUSINESSES
USE GAS AND RENEWABLE CHP TO PROVIDE THEM
WITH A COMPETITIVE EDGE.

Controlling fast-rising network costs

By generating close to the point of use business users with CHP reduce strain on local and national networks, saving at least £81 million a year, alongside reducing network losses.

Recommendation: The regulator, Ofgem, should provide assurance that distributed generators are fairly rewarded for the benefits they provide to the transmission and distribution networks, including benefits of net demand reductions on long-term network costs.

Below are three additional areas of the UK economy where businesses using CHP are being under-recognised for the value they provide, and how that failure can be best addressed. In doing so the UK will deliver CHP's potential.

Other areas where CHP value is not recognised

- **More competitive businesses**

With cost savings of up to 40%, businesses use gas and renewable CHP to provide them with a competitive edge.

Recommendation: The Conservative manifesto's commitment to deliver a new support scheme for industrial energy efficiency should be implemented, and be available for both new assets and to enable business energy users to connect to existing CHP assets.

- **A more resilient, secure energy system**

The Capacity Market does not currently recognise the value of more efficient generation, encouraging cheap to build but costly-to-run power stations.

Recommendation: In its 2019 review, the Government should reform the Capacity Market to ensure that it better secures long-term value for consumers, recognising the life-time efficiency benefits to consumer value of different power plants. This value recognition could be accomplished by providing a bid price uplift in auctions for lower carbon or more efficient plants.

- **Cost-effective, user-led flexibility**

CHP users are competitive against other forms of controllable generation and demand response in different balancing services and markets. CHP's inertia value, potentially worth up to £150/MWh, goes unrewarded.

Recommendation: National Grid should follow through on its commitment to reform the balancing service markets to make them simple, transparent, competitive, and open to all market participants. National Grid should specifically reward inertia, including recognising the value of already-generating power plants.

By ensuring users with CHP are recognised for the value they provide, the UK will be able to increase the benefits they provide. However, currently, the UK relies on fewer users with CHP than many of its industrial competitors, such as Germany, where CHP-enabled energy users supply 12% of the country's electricity needs.

The UK's current CHP capacity is far below what it should be, with a cost-effective potential to triple CHP's role in the energy economy, located in businesses and on heat networks. Delivering that capacity would bring the UK in line with other industrial competitors and help deliver sustainable growth in a low carbon world.

Full list of recommendations

1. With National Grid and other market analysts expecting up to 14 GW of new gas generation, with gas generators continuing to generate for thousands of hours in 2030, the UK should set a clear ambition to ensure as much of this capacity as possible is CHP.
2. CHP's system benefits should be properly recognised and rewarded under the Government's forthcoming carbon taxation review. This can be achieved by continuing Carbon Price Support tax at its current rate until 2025, when coal generation is forecast to close; by maintaining existing CHP reliefs under the Climate Change Levy and the Carbon Price Support; and by relieving CHP from Carbon Price Support for its exported electricity.
3. In order to ensure gas CHP's long-term carbon savings are recognised across policy, all carbon methodologies should base CHP's carbon value against the emissions of the marginal gas plant, not the average grid emissions, including within SAP and the HM Treasury Green Book.
4. The regulator, Ofgem, should provide assurance that distributed generators are fairly rewarded for the benefits they provide to the transmission and distribution networks, including benefits of net demand reductions on long-term network costs.
5. The Conservative Manifesto's commitment to deliver a new support scheme for industrial energy efficiency should be implemented, and be available for both new assets and business users seeking to connect to existing CHP assets.
6. Government should encourage EII energy efficiency by compensating CHP operators who supply heat to Energy Intensive Industries (EIIs) to replace the competitive advantage lost by EII reliefs.
7. In its 2019 review, the Government should reform the Capacity Market to ensure that it better secures long-term value for consumers, recognising the life-time efficiency benefits to consumer value of different power plants. This value recognition could be accomplished by providing a bid price uplift in auctions for lower carbon or more efficient plants.
8. Government and Ofgem should continue simplifying the Capacity Market to make it easier for CHP users. One example is that regulations currently prevent sub-2 MW, non-exporting CHP from participating in the auctions.
9. National Grid should follow through on its commitment to reform the balancing service markets to make them simple, transparent, competitive, and open to all market participants.
10. National Grid should specifically reward inertia, including recognising the value of already-generating power plants. At the very least, inertia value should be recognised and rewarded in any future voltage market design.

WITH NATIONAL GRID AND OTHER MARKET ANALYSTS EXPECTING UP TO 14 GW OF NEW GAS GENERATION, WITH GAS GENERATORS CONTINUING TO GENERATE FOR THOUSANDS OF HOURS IN 2030, THE UK SHOULD SET A CLEAR AMBITION TO ENSURE AS MUCH OF THIS CAPACITY AS POSSIBLE IS CHP.

Delivering a highly competitive low carbon economy

A concerted global effort is required to tackle climate change, and countries are competing on who can transition most effectively. How each nation adapts to a carbon constrained world will determine its future economic competitiveness and ability to deliver lasting, sustainable growth and prosperity.

Energy is a key part of this challenge. Energy is at the heart of businesses. It powers production lines, computers and industrial processes, and keeps offices lit, warmed and cooled.

Unsurprisingly, this vital resource accounts for up to half of production costs for some businesses.

Within its Industrial Strategy, the Government has set out an ambition to:

- 1. Support UK businesses' global competitiveness by delivering cost-effective energy supply
- 2. Decarbonise energy in line with the Climate Change Act.

The twin aims of delivering a decarbonised economy alongside strengthening the UK's global competitiveness, while aligned with global trends, can also create tensions.

Decarbonising is, on the whole, a benefit to the UK's economy, lowering the UK's energy costs over the long-term. However, some elements of decarbonising the economy can result in higher energy costs which can fall particularly hard on businesses. While household energy costs have fallen since 2004, business energy costs have risen by as much as 119%, with policy costs making up nearly twice as much of business energy users' bills compared to householders¹.

These higher costs make business less competitive and can even encourage them to move offshore, reducing domestic production and increasing global carbon emissions. While UK-based carbon emissions fell by 16% between 1997 and 2013², once the carbon content of UK imports were included, emissions fell by only 6%.

These tensions between the cost of the energy transition and the UK's economic goals are not inevitable. By enabling businesses to use the tools and technologies available today, they can both reduce UK emissions and the costs related to decarbonisation.

The cost of delivering security and flexibility in a decarbonised system

Delivering a low carbon energy system means more than just supporting increased low carbon energy generation.

As the electricity system shifts from one with a few large, controllable gas and coal power plants in the centre of the country to more than 23 GW of intermittent wind and solar³, it faces three further questions:

- How can the UK provide sufficient capacity to meet its energy needs when intermittent renewables are unavailable?
- How can the UK match supply and demand from second to second in an increasingly variable electricity system?
- How can the UK expand and adapt its electricity network infrastructure to meet its new energy demands?

Answering these questions and meeting the challenges they create requires new investment and new power system services. The Capacity Market, balancing services, and electricity network costs currently add nearly £11 billion a year on users' bills, rising to nearly £13 billion by 2021⁴, and making up approximately one third of total UK electricity costs⁵.

A decarbonised economy represents the best long-term value for the UK, but meeting these challenges according to the traditional approaches risks adding unnecessary costs for households and businesses, and losing public support for the low carbon transition. In addition, meeting these requirements with higher carbon resources can make it harder to meet decarbonisation goals.

Below, the report sets out the three challenges created by a decarbonising energy system and the specific cost impacts on all energy users.

3 National Grid, Future Energy Scenarios, 2016. Data for 2015 consistent across all scenarios.
4 Based on projected annual costs of the Capacity Market, Balancing Services and electricity networks.
5 Total value of electricity sold in 2015 was £34 billion. BEIS, 2016. Digest of UK Energy Statistics (DUKES).

1 Committee on Climate Change (CCC), 2017. Energy Prices and Bills: Impact of meeting carbon budgets.
2 BEIS, 2015. 2013 UK greenhouse gas emissions: final figures - data tables.



The first challenge: Provide enough capacity to keep the lights on

Keeping the lights on is always a top priority. To achieve this end, we must provide controllable capacity when wind and solar are unavailable.

Renewable and low carbon generation face very low marginal costs (as an additional turn of a wind turbine is essentially free) and also receive a subsidy, which further encourages them to generate. Conversely, burning an extra tonne of coal has costs for fuel, transportation, and carbon.

The growth of low marginal cost renewables has led to dramatically reduced average wholesale electricity prices. However, it has also meant sharper price volatility between times of high and low wind and sun. As energy market prices become more volatile, revenue for generators becomes much harder to predict.

The more low carbon generation, the harder it is to invest in controllable capacity to secure the system, creating a feedback loop against energy security investments. These new market dynamics make it more difficult to invest in new, efficient generation capacity, which is needed alongside demand response services to balance intermittent renewables.

With 28 GW of coal and gas power plants closing by 2030, analysis by National Grid's Future Energy Scenarios and other organisations estimate the UK

will need between 12 to 14 GW of new gas generation capacity, in addition to significant expansion of demand response, battery storage and interconnector capacity.

To ensure the lights stay on, Government runs annual auctions to purchase capacity from providers of generation, storage, and demand response. By buying capacity up front it seeks to reduce future electricity price spikes by ensuring sufficient capacity at all times, securing better value for consumers. The cost of this auction, called the Capacity Market, varies from year to year, but will be more than £1.2 billion a year in 2020, a cost that is recovered directly from users' bills⁶.

By 2030, 'peaking' power plants and demand response schemes will run for only a few hundred hours a year, while more efficient power stations will run for thousands of hours. Modelling analysis by Aurora Energy found that more than 10 GW of controllable capacity could operate for at least half the year⁷.

The Capacity Market will need to deliver a mix of different providers to deliver the different kinds of capacity needed. However, the Capacity Market has to date delivered limited efficient generation, limited amounts of demand response, and incentivised the construction of more than 8 GW of less efficient and higher carbon gas and diesel engines.⁸

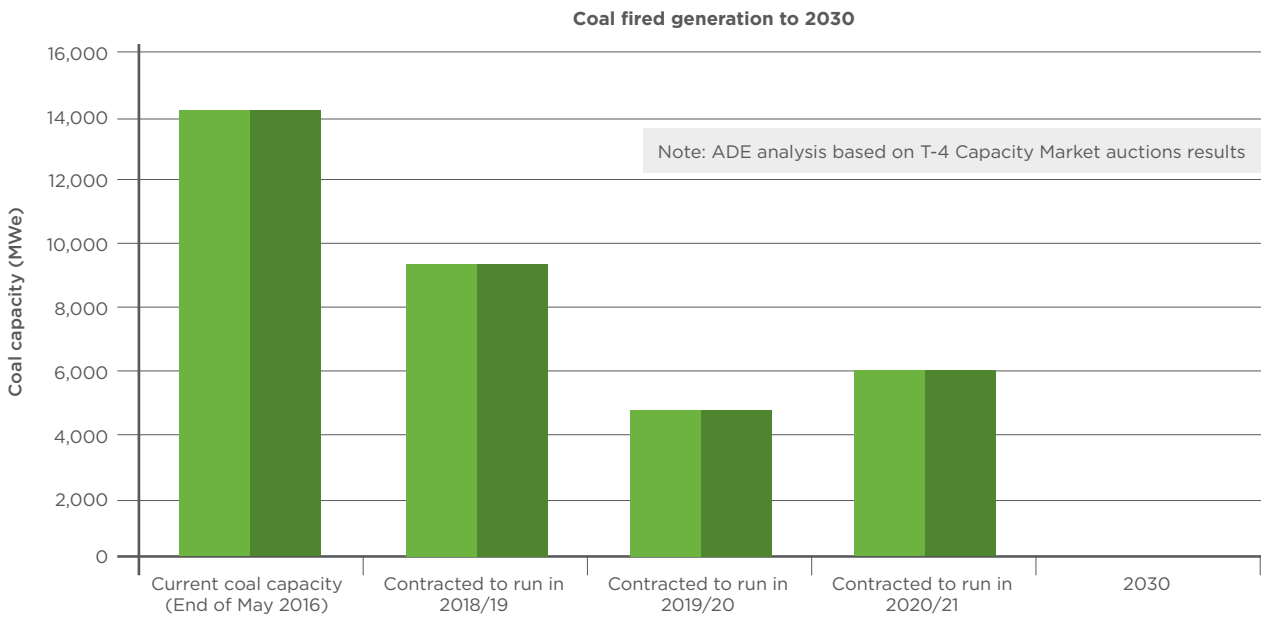


Figure 1: Expected coal-fired generation closure in the next five years.

6 National Grid, 2016. Provisional Auction Results: T-4 Capacity Market Auction 2020/21.
7 Aurora Energy, 2017. Ofgem's embedded benefits reform - minded to decision Summary and Aurora's commentary.
8 ADE analysis based on National Grid Final Auction Results reports for 2014, 2015 and 2016.

The second challenge: Ensuring second by second matching of power use and demand

Because electricity cannot yet be stored on a large scale, power demand and generation must be in complete balance on a precise second-to-second basis.

The growth in intermittent renewables has delivered major reductions in UK emissions but also make it harder to meet customers' power needs at all times of the day and night, whatever the weather.

To keep the system in balance, the Transmission System Operator is paying increasing amounts to generators to turn on or off at the right time. Dependency on coal and higher carbon generation to provide these services can slow decarbonisation and as the amount of centralised capacity falls, balancing costs can rise unless new decentralised providers are used to replace it. Current 'balancing costs' are £1 billion a year, and National Grid estimates they will double to £2 billion by 2020, all of which is added to consumers' bills.⁹

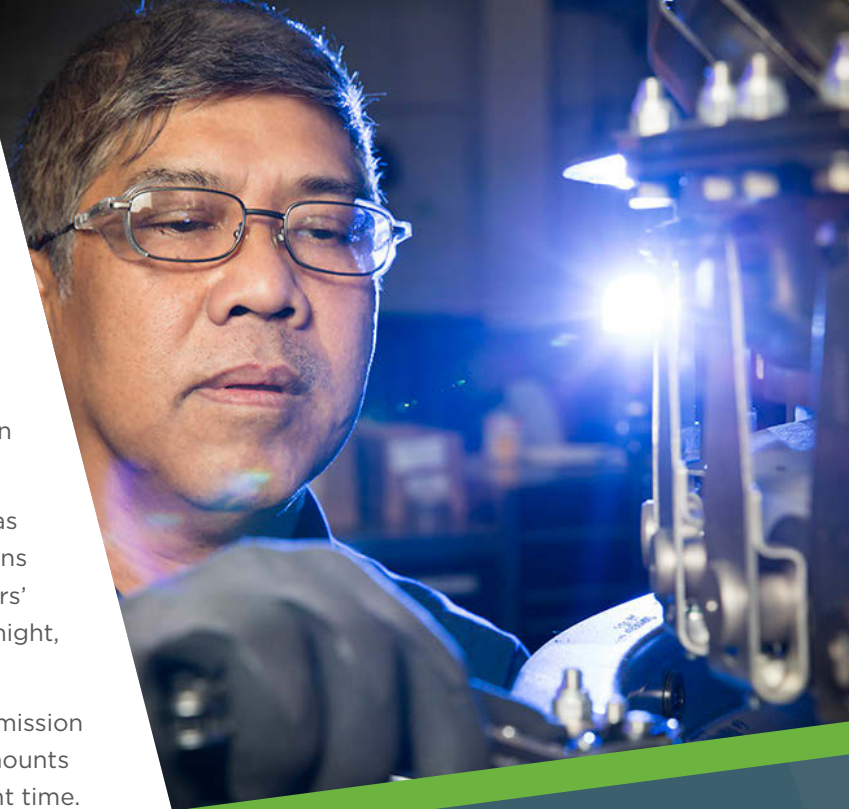
The third challenge: Expand and adapt the electricity network

Finally, Great Britain must expand its electricity network infrastructure to cope with this new energy system.

The result has been significantly increased network investment. Transmission network costs have nearly tripled since 2007, rising from £943 million to £2.7 billion today, and will grow by a further 35% to £3.7 billion by 2021¹¹. Distribution networks cost £6 billion a year.¹²

By expanding the distribution and transmission networks, electricity also has to travel further, resulting in more of it lost along the power lines. Currently about 7.7% of electricity, worth £3.1 billion¹³, is lost in its transportation across these networks.

9 Gosden, Emily, 2016. "Balancing demand 'could cost National Grid £2bn", Daily Telegraph, 27 June 2016.
10 National Grid, 2014. Enhanced Frequency Control Capability: Electricity Network Innovation Competition Full Submission Pro-forma.
11 Pace, Andy; Lord, Jo; Edwards, Tom, 2016. A Review of the Embedded Benefits accruing to Distribution Connected Generation in GB, Cornwall Energy.
12 Gowdy, Johnny, 2016. "Who pays for the grid?", Regen, 30 September 2016.
13 ADE calculations based on DUKES data, Sales and electricity and gas by sector and Electricity commodities balance. The value of electricity sold to all consumers is applied to losses on the transmission and distribution networks.



A key part of the intermittency challenge is the loss of 'inertia'. Traditional power stations have large rotating lumps of copper - the generator. These have rotating momentum which helps stabilise the network when power output from other sources fluctuates. Renewable energy sources tend to connect to the grid using high tech electronics, which have no rotating mass and do not provide this inertia. The closure of large coal and gas generators is leaving the Transmission System Operator at risk of relying on fewer and fewer providers. One estimate by National Grid said addressing inertia could cost between £268 million and £600 million by 2021.¹⁰

Energy users can meet our energy system challenges more effectively

Meeting these challenges to security capacity, system balancing and network adaptation are all necessary parts of delivering a transition to a low carbon economy.

To address capacity, balancing and network adaption challenges, the UK has generally looked to energy providers through the Capacity Market, feed-in tariffs, electricity network and balancing services, with costs passed on to energy users through their bills.

To address the increased costs on businesses, Government has given specific energy intensive industrial sectors reliefs from certain policy costs, such as renewable feed-in tariffs and carbon taxes. However, these reliefs do not apply for all businesses; do not address capacity, balancing and network costs; and reliefs, when delivered alone, are not a long-term, sustainable approach.

Fortunately, there is an unseized opportunity to better address these energy transitions while simultaneously supporting and growing UK businesses' competitive strengths.

Business and industry increasingly view decarbonisation as a requirement for long term prosperity and recognise the advantage of participating in a sustainable pathway that enables businesses to compete in a global, low carbon economy.

Uniting the UK's industrial and energy strategies can not only make the system more cost-effective and lower carbon; it also returns control to users and makes them active stakeholders in the transition. Instead of business energy users paying for a system imposed on them, they can lighten the load of the cost rise and receive value for their contribution, protecting their profitability and competitiveness, and encouraging inward investment. The result is that business, which can sometimes advocate against decarbonisation measures, can become stronger supporters.

Combined heat and power lightens the load of the energy transition

Combined heat and power (CHP) is a process where the heat normally wasted in power generation is captured and supplied to industry, homes or businesses.

In today's coal, gas and bioenergy power stations, up to two thirds of the fuel consumed is lost as heat, often seen as a cloud of water vapour rising from cooling towers. By capturing that heat, CHP cuts energy use by about 30% and so improves efficiency and reduces emissions. Because it generates power, in addition to heat, it can also provide electricity services to businesses and the wider electricity system.

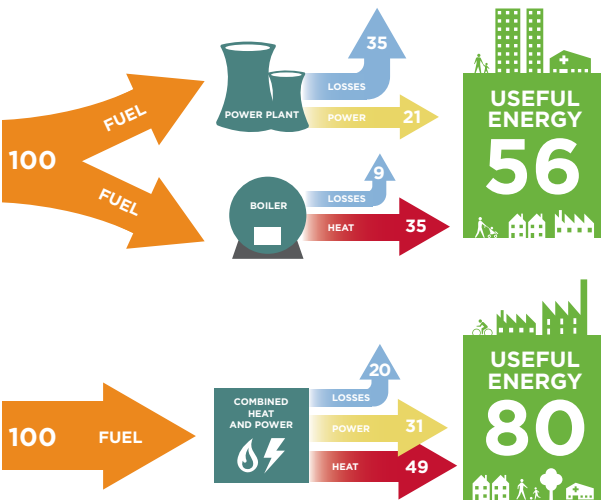
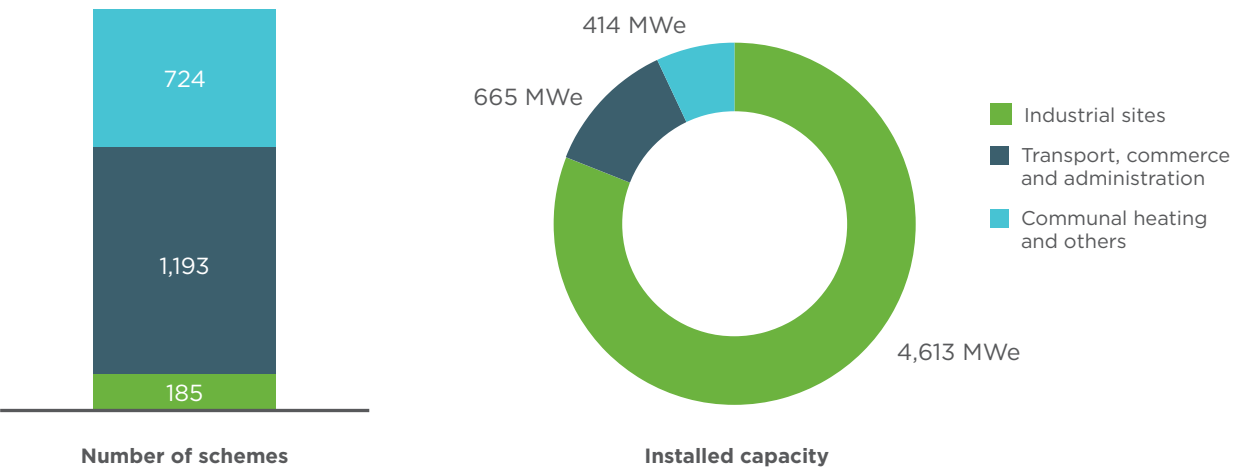


Figure 2: Fuel savings delivered by CHP compared to the separate generation of heat and power

CHP enables businesses to participate in new energy markets, improving economic productivity, delivering power generation capacity, enhancing electricity system resilience, reducing network costs, and cutting business energy bills. All of these benefits help to better achieve the Government's strategic energy and industrial policy goals.

The benefits of CHP are being felt today. There are 2,102¹⁴ businesses and sites in the UK which use CHP to support their operations. More than 111,000 jobs¹⁵ are located on these sites and CHP is helping to improve manufacturing productivity, control energy costs and protect long-term employment. CHP is also located on hundreds of heat networks, providing heating through a network of pipes to homes and businesses in UK cities.



14 Department for Energy and Climate Change (DECC), 2016. Digest of UK Energy Statistics (DUKES), Chapter 8: Combined Heat and Power.

15 The Association for Decentralised Energy, 2016. Backing Industrial Productivity: The combined heat and power opportunity.

Carbon savings today and beyond 2030

In addition to its financial benefits, CHP is also the most efficient form of generation, reducing emissions today and beyond 2030, using both gas and renewable fuels. CHP can make use of natural gas, biomass, biogas, municipal waste, and hydrogen. About 13% of CHP capacity is renewable, a 24% increase since 2011.¹⁶

Gas CHP saves carbon as long as there are other less efficient, gas power stations for it to displace. Large gas power stations are expected to run with relatively high load factors through the 2020s and 2030s¹⁷ and can be displaced with more efficient CHP.

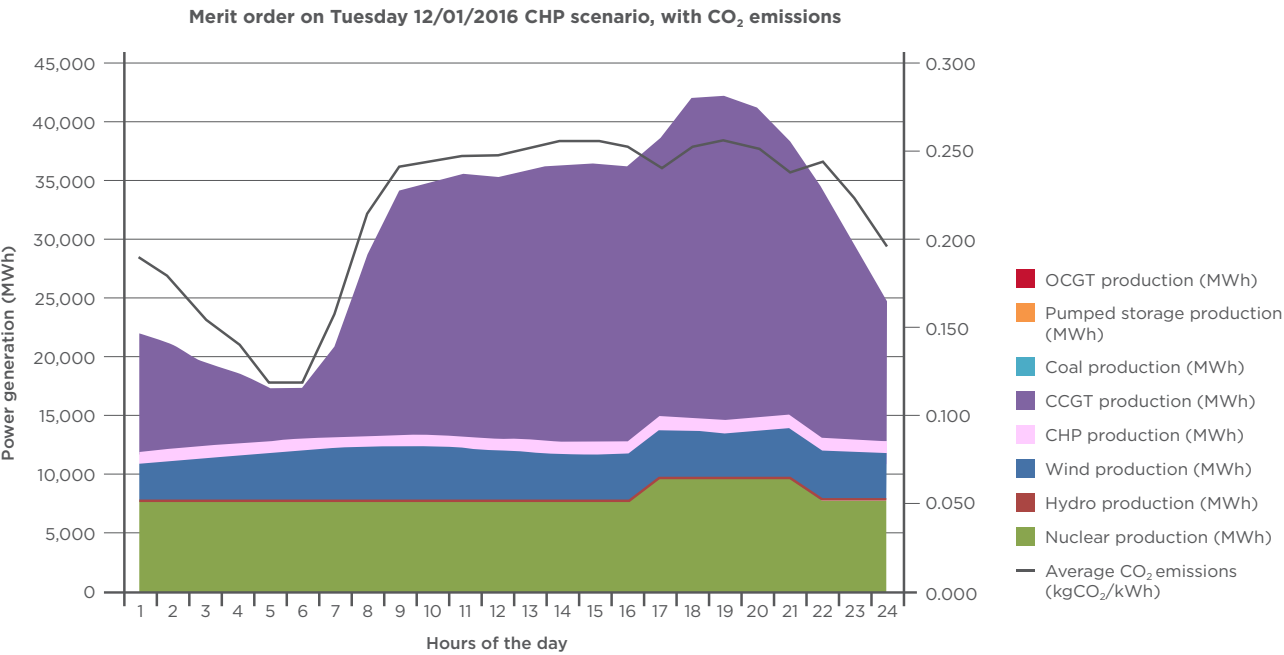


Figure 3: Types of generation providing electricity at different times of the day and the impact on carbon emissions.

As time goes on, these power plants will see their load factors fall, reflecting the increasing saturation of renewable generation and the disappearance of other gas generators during certain hours and certain days¹⁸.

Highly efficient and flexible

While historically CHP was designed, built and operated to run all the time, new CHP plants are able to operate increasingly flexibly, supporting the system with the most efficient form of generation. For example, CHP on district heating schemes can store hot water for when it is needed in thermal stores, which are 100 times cheaper than battery storage¹⁹.

Flexibility for existing CHP on industrial sites is more challenging, due to their need to provide consistent steam demand and for some sectors' highly-valued security of heat supply. While some new industrial CHP will always remain relatively inflexible, industrial users are increasingly able to provide flexibility by switching between CHP-generated steam and boiler-generated steam, depending on market signals.

The challenges in securing these benefits

These benefits make CHP a win-win, and CHP should be the default choice for consumers with a heat and power demand and a default choice for an energy system which requires controllable, higher load factor generation.

However, recent experience demonstrates that CHP's promise has been stifled as businesses, manufacturers, developers and investors have been unable to realise the technology's full system value. Market failures, lack of access to markets, and insufficient recognition for CHP's environmental contribution are keeping the UK from meeting the potential for this valuable energy efficiency solution.

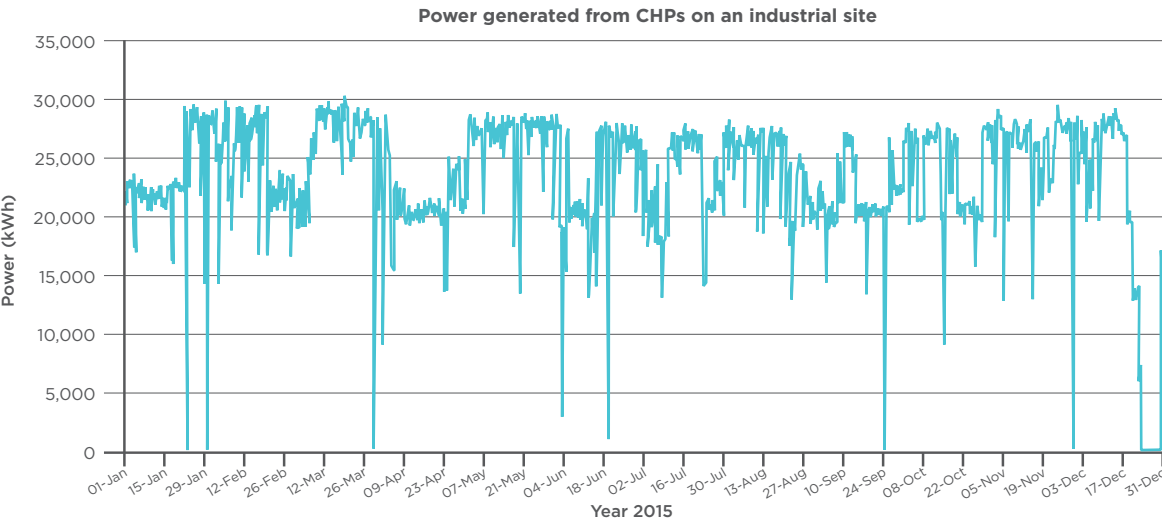


Figure 4: An example of an industrial CHP changing the amount it generates in response to price signals.

¹⁶ Department for Energy and Climate Change (DECC), 2016. Digest of UK Energy Statistics (DUKES), Chapter 8: Combined Heat and Power.

¹⁷ Aurora Energy, 2017. Ofgem's embedded benefits reform – minded to decision Summary and Aurora's commentary.

¹⁸ Please see Annex A for more detail on how gas CHP saves carbon today and beyond 2030.

¹⁹ Connolly, D., Mathiesen, B. V., & Lund, H., 2015. Smart Energy Europe: From a Heat Roadmap to an Energy System Roadmap. Aalborg Universitet.

Recognising CHP's value

With National Grid and other market analysts expecting up to 14 GW of new gas generation²⁰, and gas generators continuing to generate for thousands of hours in 2030, the UK should set a clear ambition to ensure as much as possible of this capacity is CHP.

For CHP to achieve this ambition, energy users need to be fairly rewarded for the energy security, flexibility, and carbon reduction benefits they provide.

To understand the scale of these benefits, the ADE developed an hourly dispatch model which measures CHP's system-wide benefits, both today and in 2030, which analysed existing real-world CHP generation profiles against a fast-changing electricity system.

Below are five areas of the UK economy where business users with CHP provide significant value; the primary reasons that this value is not fully recognised in policy or markets; and how to best address that failure in recognition.

By addressing these failures, the UK would help secure CHP's potential and deliver a market-led, low carbon, business-friendly energy transition.

20 National Grid, 2016. Future Energy Scenarios, Net movement by generation.

A more productive, lower-carbon economy

Value: CHP displaces more expensive power generation and reduces economy-wide fuel costs. Based on the ADE's hourly dispatch model, this combination of benefits delivered more than £375 million to the UK economy in 2016, while removing more than 6.7 million tonnes of carbon.

The dispatch model shows that by ensuring a third of the potential 14 GW in new gas plant is CHP system, cost savings will increase significantly by 2030 to between £656 million to £774 million per year, although as the energy system decarbonises the total carbon savings will fall to between 4 and 6 million tonnes²¹.

Current recognition: Current energy tax policy allows CHP users to secure relief for CHP, reflecting a portion of its system-wide savings.

Policy improvements: CHP's system benefits should be properly recognised and rewarded under the Government's forthcoming carbon taxation review. This can be achieved by:

- Continuing the Carbon Price Support tax at its current rate until 2025, until coal generation is closed;
- Maintaining existing CHP reliefs under the Climate Change Levy and the Carbon Price Support; and
- Relieving CHP from Carbon Price Support for its exported electricity.

In order to ensure gas CHP's long-term carbon savings are recognised across policy, all carbon methodologies should base CHP's carbon value against the emissions of the marginal gas plant, not the average grid emissions, including within SAP and the HM Treasury Green Book.

Controlling fast-rising network costs

Value: By providing controllable local generation, CHP-enabled businesses can reduce strain on local and national networks. The ADE estimates that distributed generators reduce the cost of transmission networks to consumers by at least £27/kW²², with CHP alone saving consumers £81 million a year²³. CHP also reduces distribution and transmission network losses.

Current recognition: While avoided network losses are now to be recognised²⁴, the value of reducing transmission network demand is not. Ofgem plans to reduce the current reward for distributed generators' benefit to the transmission network from £45/kW to as low as £3/kW over three years from 2018.

Distribution networks recognise CHP's value, but undervalue it by £5 to £10/kW²⁵.

Policy improvements: Ofgem should ensure distributed generators are fairly rewarded for the benefits they provide to both the transmission and distribution networks, including both local and national network costs. Ofgem's charging review should specifically consider the long term impact of net demand reductions on transmission network costs.



21 Please see Annex B for the full methodology for the ADE's hourly dispatch model.

22 ADE, 2017. [ADE Response to CMP264/265 consultation](#).

23 Assumes 3 GW of total CHP Capacity eligible for embedded benefits.

24 Ofgem, 2016. [CMA Remedies Implementation Plan](#).

25 [DCUSA Change Proposal DCP283](#) - The calculation of generation credits in the CDCM; [DCUSA Change Proposal DCP287](#) - Generation credits in the EDCM.

Other areas of under-recognition

Below are three additional areas of the UK economy where business users with CHP’s value is not fully recognised in policy or markets; and how to best address that failure to help deliver CHP’s potential and a market-led, low carbon, business-friendly energy transition.

• More competitive businesses

Value: More than 2,000 businesses use gas and renewable CHP to improve their competitiveness, with cost savings of up to 40%. These businesses have their own CHP plant or connect to an existing CHP through a heat network.

Current recognition: More than two thirds of Government support is directed toward renewable energy, with less than a third for energy efficiency²⁶. There is no specific investment support for new business energy efficiency investments.

For business users interested in renewable CHP, poor design of the Contracts for Difference scheme has blocked new investments, despite the technology’s key role in the Government’s Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050.

The reliefs received by Energy Intensive Industries (EIIs) make CHP economics harder by removing a cost driver for industrial sites to use more efficient CHP-generated heat and power.

Necessary improvements: The Conservative manifesto’s commitment to deliver a new support scheme for industrial energy efficiency should be implemented, and be available for both new assets and businesses seeking to connect to existing CHP assets.

Government should encourage EII energy efficiency by compensating CHP operators who supply heat to EIIs to replace the competitive advantage lost by EII reliefs.

By 2020, Government should deliver a new bioenergy CHP support mechanism, to help businesses invest in high-quality, high-efficiency, renewable CHP schemes.

• A more resilient, secure energy system

Value: A CHP plant provides the most efficient form of generation, providing the best long-term value to consumers and returning benefits to businesses. CHP plant can be built in just over half the time of a large power station, and give greater system resilience by spreading many smaller units across the country.

Current recognition: The Capacity Market does not currently reward the long-term value of more efficient generation. The auction encourages cheap to build but costly to run power stations. The results to date have been more than 8 GW of gas and diesel engine farms, but almost no successful new CHP assets. The auction’s design risks delivering higher long-term costs for consumers.

Due to barriers in the Capacity Market rules and regulations, only 51%²⁷ of CHP capacity is currently participating.

Necessary improvements: In its 2019 review, the Government should reform the Capacity Market to ensure that it better secures long-term value for consumers, recognising the life-time efficiency benefits to consumers of different power plants. This recognition could be accomplished by providing a bid price uplift in auctions for lower carbon or more efficient plants.

Government and Ofgem should continue simplifying the Capacity Market to make it easier for CHP users. One example is that regulations currently prevent sub-2 MW, non-exporting CHP from participating in the auctions.

• Cost-effective, user-led flexibility

Value: On a level playing field CHP users are competitive in different balancing services and markets, with users benefitting from these services instead of just paying the costs. On-site generators face challenges in accessing balancing services markets, and receive only 1% of balancing service payments²⁸.

Current recognition: National Grid has proposed reforming balancing services to open different products up to a wider number of market participants.

However, CHP’s inertia value goes unrewarded, even as National Grid estimates a possible cost of up to £150/MWh to increase inertia on the system²⁹.

Distribution network-connected CHPs cannot easily participate in the Balancing Market,

worth up to £6,000 a megawatt hour. In the past, such prices could be seen perhaps once a year but they are becoming more frequent as the need for flexibility increases.

Necessary improvements: National Grid should follow through on its commitment to reform the balancing service markets to make them simple, transparent, competitive, and open to all market participants.

National Grid should specifically reward inertia, including recognising the value of already-generating power plants. At a minimum, a methodology for recognising inertia value should be created and this value should be rewarded in any future design of voltage markets.

28 National Grid, 2016. Power Responsive Annual Report 2016.
29 National Grid, 2014. Enhanced Frequency Control Capability: Electricity Network Innovation Competition Full Submission Pro-forma.

26 ADE analysis comparing spending commitments on the Renewable Heat Incentive, Contracts for Differences, the Renewables Obligation, the Capacity Market, and small-scale Feed-in Tariff with spending commitments on Demand Side Response in the Capacity Market, the Energy Companies Obligation, Green Deal, Climate Change Agreements, and combined heat and power reliefs.
27 ADE analysis comparing CHP and autogeneration capacity in the Capacity Market with Total CHP Capacity in the 2016 Digest of UK Energy Statistics (DUKES).



Securing CHP's value for the UK economy

The CHP market in the UK remains underdeveloped

Despite the large system benefits provided by business users with CHP, their role is lower in the UK than comparable industrialised nations. CHP represents about 6% of gross electricity generation in the UK, and is the fifth lowest among IEA 21 countries, where the average is 16.4%³⁰.

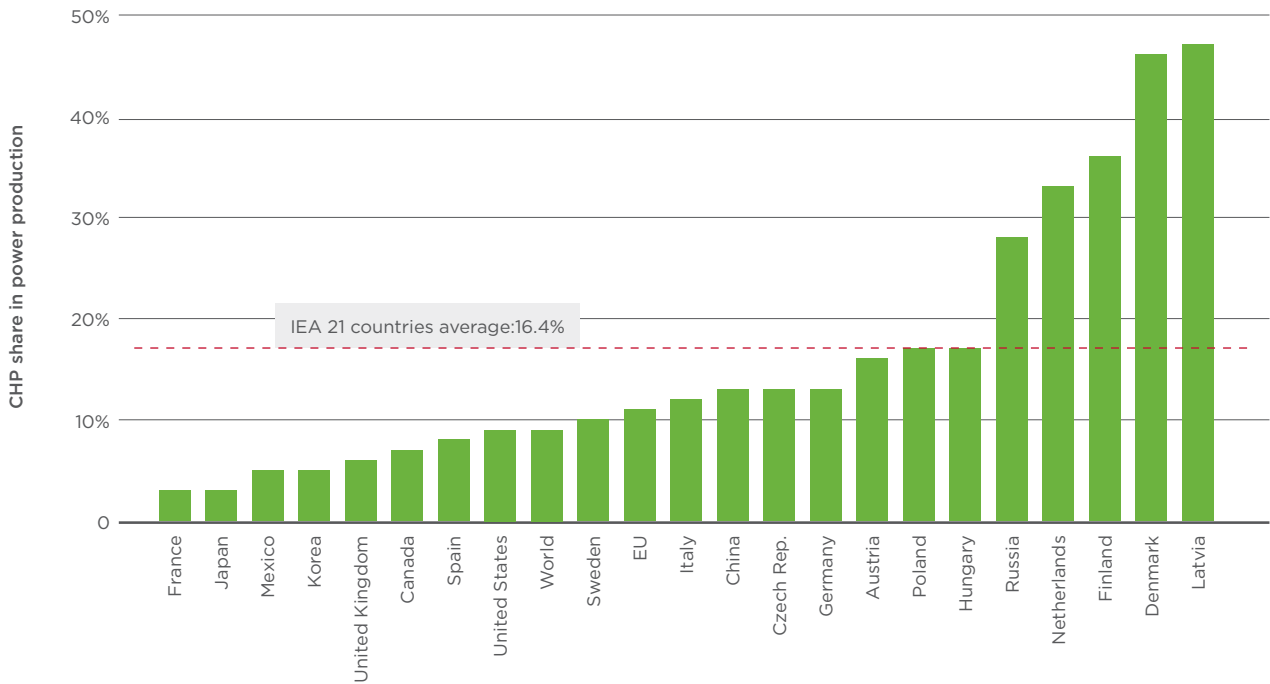


Figure 5: CHP share in power production in IEA countries, 2011.

Germany's CHP-enabled energy users supply 12% of the country's electricity needs³¹ and the German Government has set a goal to double the installed CHP capacity. This approach both gives German industry a competitive economic advantage and helps support their energy transition.

Government predictions regarding the growth of CHP's contribution to the UK energy system have been consistently incorrect, falling from a 2011 prediction of 11.3 GW by 2020, to a 2016 prediction of 7.2 GW by 2020³².

Potential for threefold increase of the CHP fleet by 2025

Clearly, the UK's current CHP capacity is far below its potential. Recent BEIS analysis suggests that by 2025, highly efficient CHP has the technical potential to supply 10 times more heat than present today³³. Even if only a third of this technical potential is commercially deliverable, the UK would triple CHP's contribution to the energy economy, delivering a total of 15 GW of CHP electrical capacity by 2025³³. This level of CHP capacity which would bring the UK in line with other industrial competitors and help deliver sustainable growth in a low carbon world.

30 Tracking Clean Energy Progress report, International Energy Agency, 2014

31 European Commission, Eurostat, 2016.

32 Department for Energy and Climate Change (DECC), 2011 and 2016. Updated energy and emissions projections.

33 "National Comprehensive Assessment of the Potential for Combined Heat and Power and District Heating and Cooling in the UK", Ricardo AEA Energy & Environment report for DECC (former BEIS), December 2015

CHP fleet
5.7 GWe

Potential for highly efficient
additional CHP by 2025
15 GWe

Figure 6: Opportunity for CHP development based on the economic potential

In addition to new CHP capacity, there is an important need to protect the role of existing CHP plants located on more than 375 industrial sites throughout the country. Current industrial CHP sites face market challenges as many were designed to operate as 'baseload generators', limiting their flexibility to respond to market signals and limiting profitability in today's more volatile electricity market.

However, with many of these assets coming to the end of their lives, there is an important opportunity to maintain their productivity benefits and replace them with natural gas and renewable CHP solutions. A failure to protect the value of these assets and encourage their eventual replacement will result in an increase in carbon emissions and a reduction in the UK's economic productivity.

BEIS estimates that its Heat Network Investment Project could deliver £2 billion in new heat network infrastructure by the early 2020s, delivering 4.9 TWh of heat³⁴ which could be met by up to 1 GW of new CHP investments³⁵. CHP's electricity revenues make those heat networks more investable, reducing Government support and delivering lower carbon, lower cost heat and power to businesses and householders.

34 Department for Energy and Climate Change (DECC), 2016. Heat Network Investment Project Consultation: Capital funding for building heat networks.

35 ADE analysis, assuming the heat is delivered by new CHP plants operating 6,000 hours per year.



Annex A - How gas CHP saves carbon emissions through the 2030s

Whatever fuel is used, CHP represents the most efficient energy generation of that fuel. However, CHP’s value as a carbon saving technology varies depending on the source of fuel.

CHP using natural gas saves carbon by generating heat and power up to 30% more efficiently than other thermal power stations, and by pushing higher carbon thermal power stations out of the market.

The carbon emissions factor for grid electricity can vary over the course of the day, depending on the power stations operating at each half hour. Balancing of electricity demand and supply is provided on a daily basis by thermal generators, such as coal and gas power plants.

Government modelling has previously found flexible CHP can help address the high grid carbon intensity periods and the evidence suggests that gas CHP largely only displaces other gas power plants and rarely displaces either intermittent renewables or nuclear³⁶.

This means that CHP will continue to provide fuel and carbon savings against the alternative generator, which will be coal and gas generation until 2025, and then gas only in the late 2020s and through the 2030s.

The Government modelling also found that gas CHP would increase carbon emissions if it displaced gas carbon capture and storage (CCS), based on the assumption that significant amounts of gas CCS would deploy by the early 2030s. The assumption that CCS will be deployed has now been removed in new Government projections³⁷, and therefore gas CHP is not at risk of displacing this technology.

Therefore, while average grid emissions may fall, gas CHP will likely continue to save carbon emissions by up to 30% far into the 2030s, as long as there is other, less efficient gas generation to displace. The expectations from a number of analyses, including National Grid’s Future Energy Scenario, is that gas generation will continue to play a role through the 2030s.

However, in the 2020s, CHP load factors will fall to reflect the increasing saturation of renewable generation during certain hours and certain days, which will push off all gas generators.

Renewable fuels

By using CHP to combust low carbon, renewable fuels we get the best efficiency and produce a lower carbon impact than heat only or electricity only processes.

For biomass specifically, CHP is typically 10 times smaller than large power-only biomass power plants. While larger power plants use wood pellets imported from outside the UK, CHP will typically use local biomass supply chains, with far lower supply chain emissions. A typical biomass CHP plant can achieve a carbon saving of close to 94%, with embedded supply chain emissions of c.30kgCO₂e/MWh³⁸. These emission levels are significantly less than the minimum CO₂ requirements set by Government under the Renewables Obligation. CHPs can also use locally-sourced waste wood fuel stock, which has even lower supply chain carbon emissions.

Energy from waste provides a further carbon saving opportunity, by using this waste resource as efficiently as possible. Of the UK’s 33 energy from waste facilities, only six currently use their heat for the benefit of local businesses and householders due to a lack of heat network infrastructure to connect them.

Finally if the gas grid is decarbonised, then the most effective use of highly valuable green or hydrogen gas will be in CHP, generating both heat and power simultaneously.

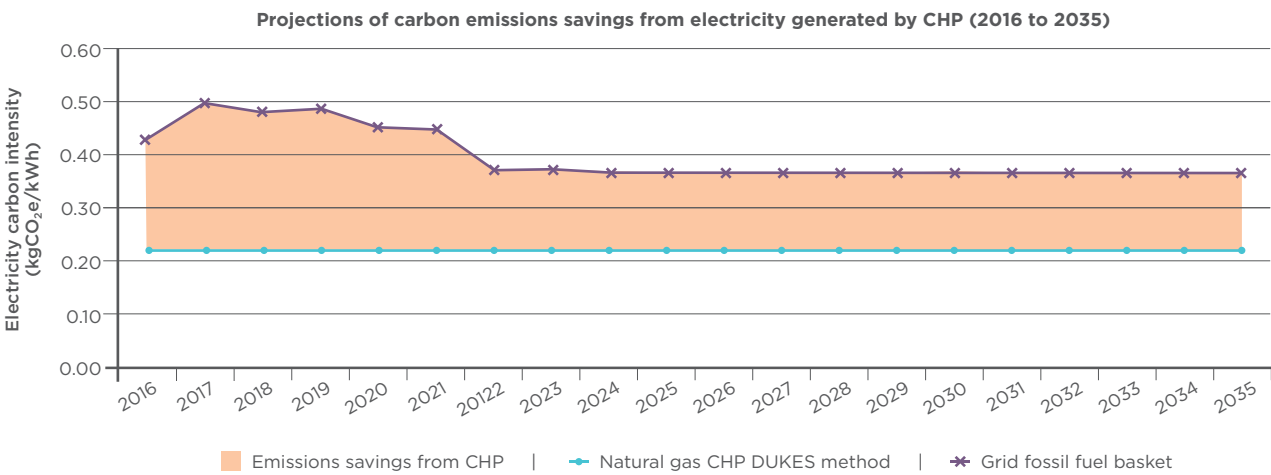


Figure 7: CHP carbon savings compared against the marginal plant over time.

36 Lane Clark & Peacock LLP, 2014. Modelling the impacts of additional Gas CHP capacity in the GB electricity market.
37 Department for Energy and Climate Change (DECC), 2016. Updated Energy and Emission projections:2016



Annex B: How this report modelled CHP's system benefits

Context and objective of the modelling

CHP generates both heat and electricity in a single and efficient generation process. The value of CHP in terms of carbon emissions savings is assessed in government publications such as the Digest of United Kingdom Energy Statistics (DUKES), but it provides no indication of its macroeconomic value despite CHP making up to 6% of all UK electricity supplies.

To address this gap, the ADE developed a simulation model of the UK electricity system to assess the macroeconomic value of the CHP fleet in 2016 and in 2030. 2030 is the midpoint year of the 5th carbon Budget, and an important milestone for the UK on its pathway to meeting its carbon targets. The modelling analysis has been undertaken by ADE with discussions with the industry and policy makers throughout the process.

The ADE modelling looks to address these three specific questions:

- What difference does the CHP fleet make in terms of the wholesale power price?
- How does this affect the wholesale price of electricity paid by all consumers in the UK?
- What are the primary energy savings and carbon emission savings associated with generation from CHP?

The ADE electricity dispatch model matches supply with electricity demand for every hour of the year. It uses an optimisation mechanism based on the economics of the electricity market, which is called the merit order. The merit order is the sequence in which generators are dispatched to meet demand, which is based on their marginal operating costs. Electricity cannot be stored easily in large quantities, so there is a requirement for supply to match demand at all times, both to deliver energy to consumers and to secure the grid network.

The model seeks to replicate the way the electricity system works. In the wholesale electricity market, suppliers with access to several power generation plants will decide which one to purchase from based on their marginal operating costs in order to minimise their overall cost of delivering electricity. For example, if the wind is blowing suppliers will prefer to use electricity from wind farms, which are nearly zero marginal operating cost, to meet as much contracted output as possible before turning to fossil fuel plants.

The effects of the CHP fleet were assessed according to their impacts on:

1. **Wholesale market dynamics:** System price determined for every hour of the year, primary energy use across the generation mix, carbon dioxide emissions.
2. **Impact on generation technologies:** Load factors of generation technologies, operational costs and margins of generation technologies.
3. **Consumer costs:** How consumers are affected by power generation from CHP (via their bill), independently of who pays and receives the money.

Factors which have not been considered include:

1. **Interconnectors:** Determining the price of electricity supplied by interconnectors requires a modelling of the pan-European market, which is out of scope of this work. National demand met by interconnectors is removed from the model, which has the effect of scaling back the overall annual demand by about 15%.
2. **Network costs:** Costs vary depending on locations and are out of scope of this model.
3. **Renewable CHP:** All CHP is assumed to be gas CHP, which will have the effect of underestimating CHP's overall savings by excluding zero-carbon CHP assets.
4. **EU ETS price changes:** Potential EU ETS price growth in future years was not considered.

Model overview, inputs and results

The model compares a baseline scenario, which aims to reflect the current electricity system, against a 'no CHP' scenario, where there are no CHP plants in the UK electricity system and all other parameters remain equal.

In the 'no CHP' scenario, the demand currently met by the CHP fleet is instead met by increased output from the generation mix, as illustrated in Figures 8 and 9 below. Differences in system prices, power generators margins, primary energy use and primary energy costs, and carbon dioxide emissions between these two scenarios lead to the results presented in the main body of this report.

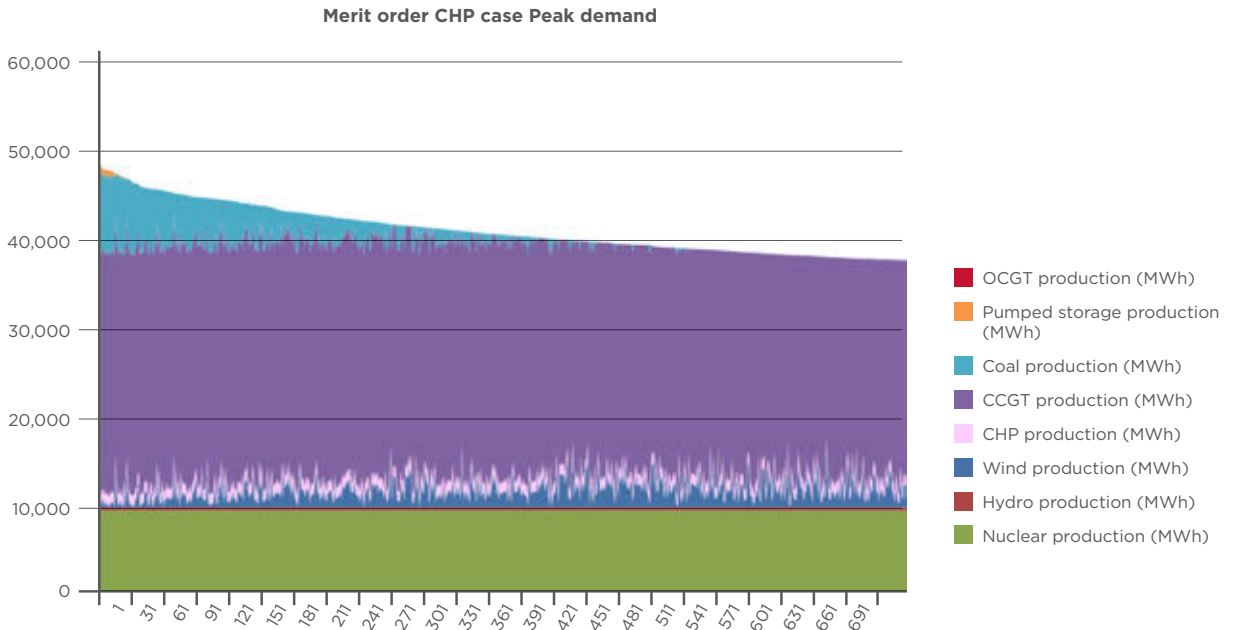


Figure 8: Baseline scenario load duration curve during the hours of highest electricity demand of the year.

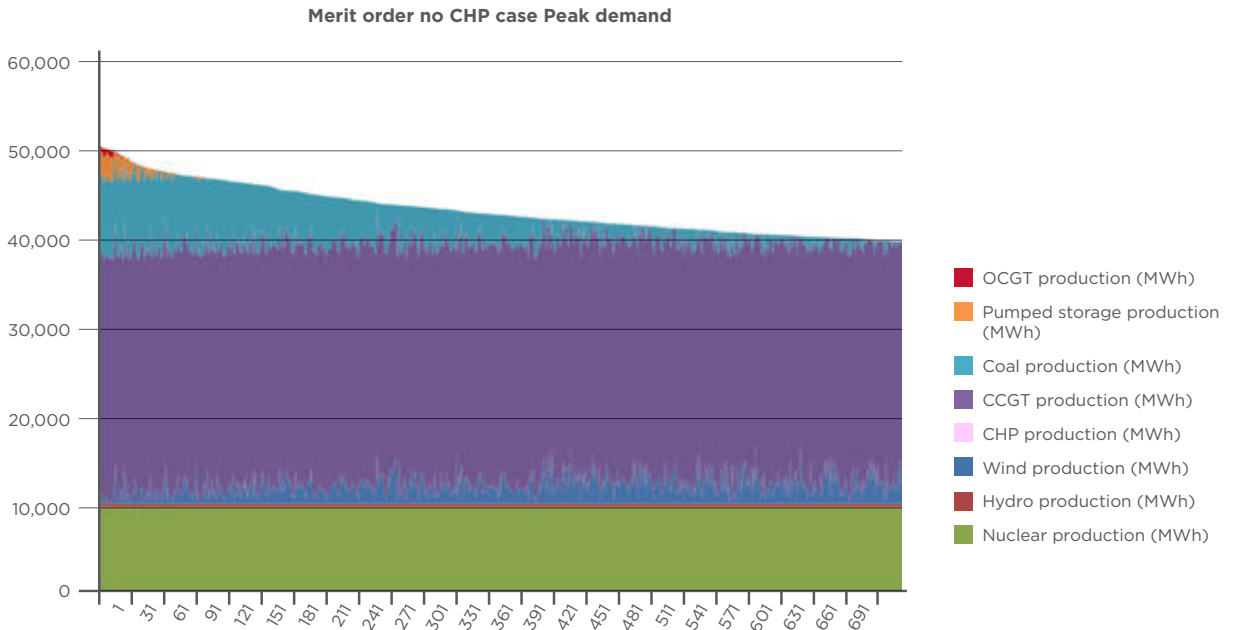


Figure 9: No CHP scenario load duration curve during the hours of highest electricity demand of the year.

Electricity demand

The electricity demand dataset comes from National Grid. National Grid demand data reflects the demand placed onto and taken off of the transmission system (also known as ‘net demand’). The demand data therefore does not include embedded generation, which has the effect of supressing overall transmission system demand.

The national electricity demand includes interconnector flows to the UK as these are meeting local demand, but excludes interconnector flows out of the UK as these are not meeting UK demand.

Electricity losses

Electricity is transported from where it is produced to points of consumption using a network of cables. The distribution system takes electricity from the high voltage transmission system and carries it to population centres. Some electricity is lost on the transmission and distribution cables before it reaches users. To account for these losses, the total amount of electricity generated needs to be higher than

overall consumer demand. Losses on both the transmission and distribution networks are approximately 7% of electricity supplied, based on DUKES.

Heat demand

CHP generates heat alongside electricity, and the amount of heat generated by CHP follows a ratio of 2 to 1. The model uses the assumption that this is the heat demand of consumers. As such, this is the demand that needs to be met by gas boilers when this is not met by CHP.

Electricity generation

The model comprises eight types of power plants, connected to both the transmission and distribution networks. Plants connected to the distribution networks are known as ‘embedded generation’. Each power plant has a maintenance and outage schedule to account for the times when it is not available to run. The eight generation technologies included in this model are wind, hydro, nuclear, gas fired CHP, CCGT, gas oil fired CCGT and pumped storage. The parameters used in the model are given in Figure 10 below.

	Transmission connected generation plants								
	Wind	Hydro	Nuclear	CHP	Coal	CCGT	Oil fired OCGT	Pumped storage	Embedded CHP
Capacity (MWe)	4,921	1,400	9,487	1,976	17,534	30,080	1,333	2,744	3,716
Short run marginal cost (£/MWh e)	2	5	5	32	46	33	93	46	32
Fuel intensity (M Wh th /MWh e)	0	0	0	2	3	2	3	0	2
Carbon intensity (tCO ₂ /MWh e)	0	0	0	0	1	0	1	0	0

Figure 10: Main parameters used in the dispatch model in 2016.

The short run marginal costs of generation are given in Figure 11 and include the commodities prices, commodities delivery costs, carbon prices and carbon levy rates, and short term operation and maintenance costs. The data comes from publicly available sources (commodities trading platforms, National Grid, HMT, BEIS, Ofgem and DEFRA).

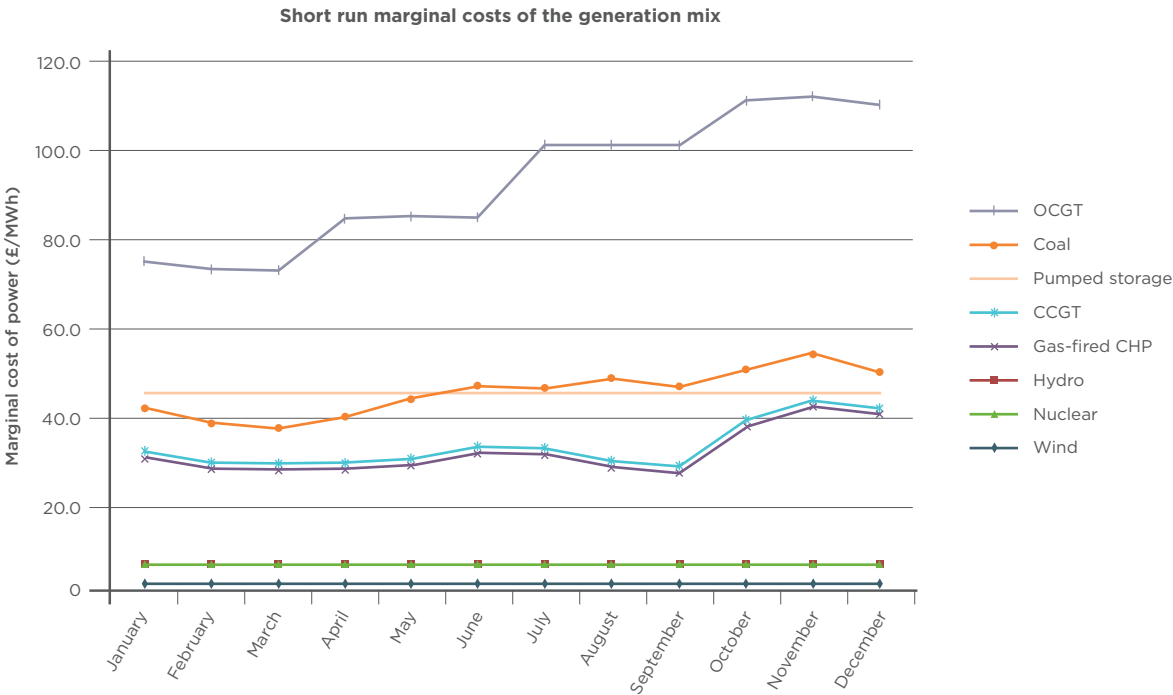


Figure 11: Marginal costs of the generation mix in 2016 calculated on a monthly basis.

Merit order effect on wholesale power prices

The sequence in which generators are dispatched to meet demand is based on their marginal operating costs. All the plants on the system will be paid at the marginal cost of the last generation plant on the dispatch curve. The last generation plant on the dispatch curve sets the system price, which is the wholesale price of electricity.

Without CHP, the price will be set more often at the marginal cost of the next most expensive generation plant. As a result, the price that all consumers pay for electricity will be higher on average. This effect of the merit order on the system price is illustrated in Figures 12 and 13 (right). To note, the variability effect of wind is smoothed by the hourly averaged figures.

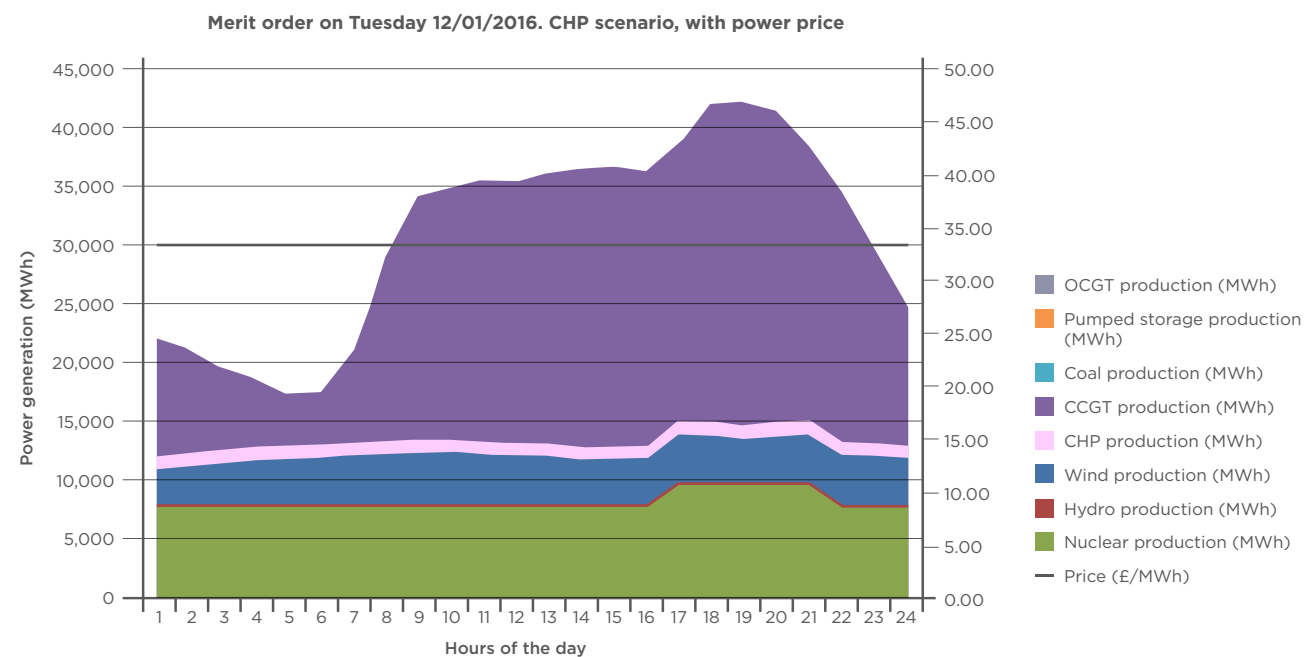


Figure 12: Baseline scenario merit order during a day with hourly power price.

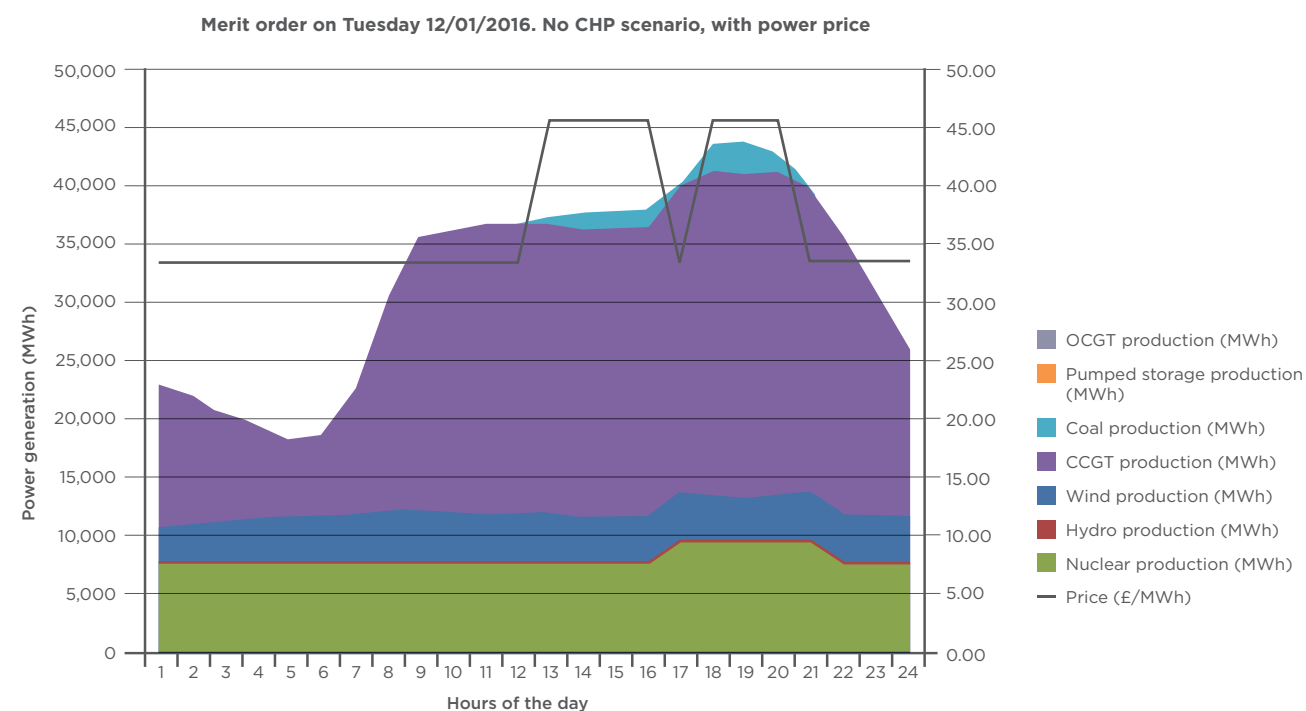


Figure 13: No CHP scenario merit order during a day with hourly power price.

Heat generation

When heat generation is not met by CHP, it is assumed to be provided by an efficient gas boiler.

Projections to 2030

Looking to 2030, significant uncertainties are associated with factors affecting electricity demand and fuel prices. These uncertainties are reflected in the modelling by applying different scenarios.

CHP capacity projections in 2030 are based on the assumption that CHP captures most of expected new gas power generation capacity. The model is based on National Grid's Future Energy Scenarios "Gone Green" and "Slow Progression" as best estimates for the amount of new gas generation required for meeting the electricity demand in 2030.

"Gone Green" is a world in which the UK's 2050 decarbonisation targets are met. The focus on long term environmental goals, high level of prosperity and a harmonised European approach all contribute to this achievement.

"Slow Progression" is a world where economic conditions limit society's ability to transition as quickly as desired to a renewable, low carbon world. This result in some progress towards the UK's decarbonisation target, but at a slower pace.

Although the overall capacity of gas generation remains more or less stable between now and 2030, between 11 and 13 GW of new gas capacity is expected to replace retiring plants according to National Grid's scenarios.

The model assumes a level of development of fuel prices for gas and coal to 2030 which is based on BEIS projections (Updated Energy and Emission projections, Annex M, 2016). Oil price projections are based on BEIS's dataset "fuel prices to major power producers" - and do not include the Climate Change Levy or Carbon Price Support taxes.

The model assumes development of new generation capacity for renewable, coal-fired plants, nuclear plants, oil-fired OCGT and pumped storage based on National Grid's Future energy scenario "Gone Green" and "Slow Progression" (2016). Gas and diesel reciprocating engines are not considered within the model. No gas carbon capture and storage capacity is expected to come forward within the model.



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