

Sector Research: Gas Engine Peakers

by 350 PPM Research Department

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Capitalist Solutions to Climate Change



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Introduction

This report provides a brief introduction to gas engine peakers, a flexible type of electricity generation plant, including the critical role they could play in the fight against climate change.

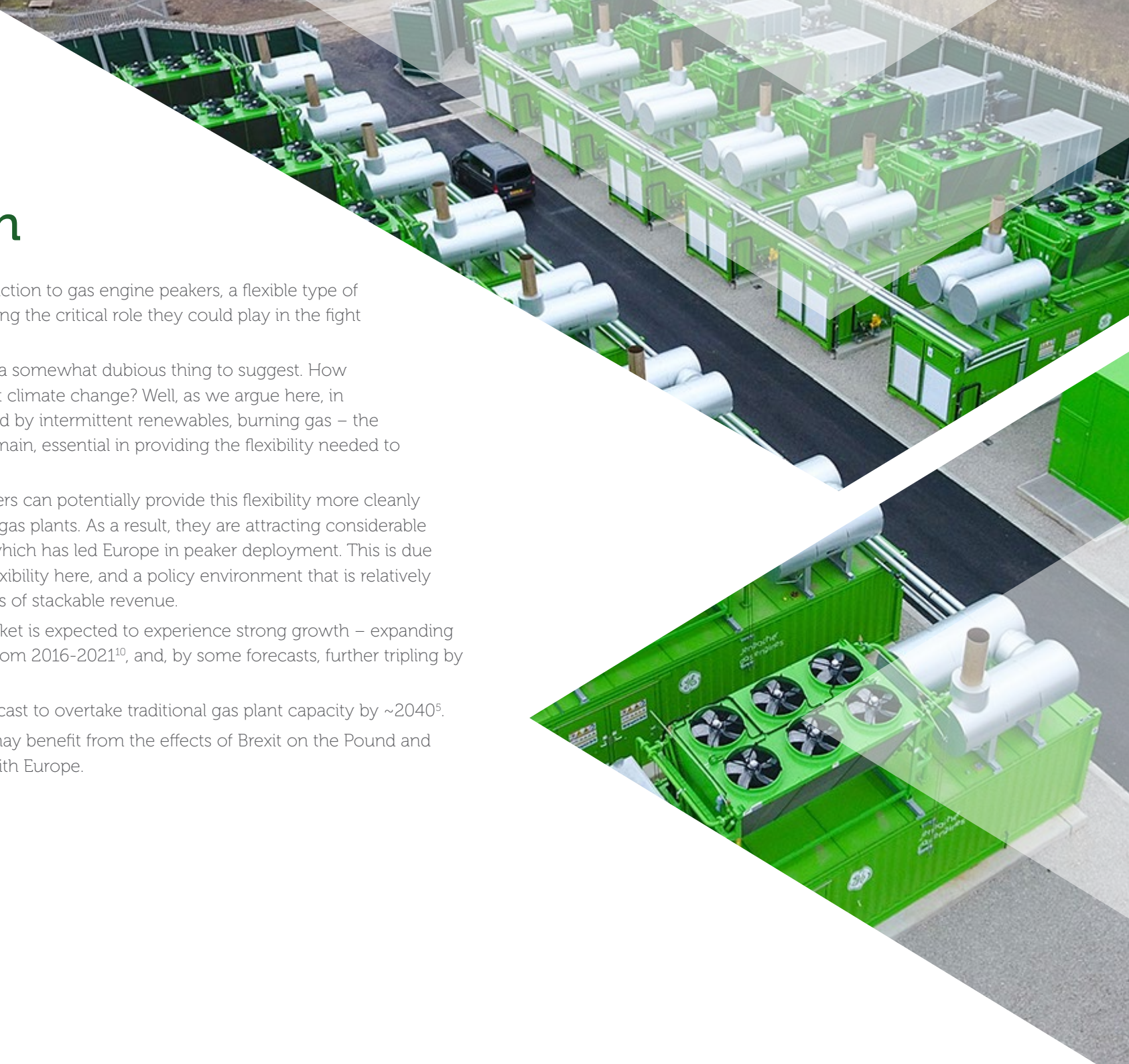
This might, at first sight, seem like a somewhat dubious thing to suggest. How can burning gas possibly help fight climate change? Well, as we argue here, in the transition to a future dominated by intermittent renewables, burning gas – the cleanest fossil fuel – is, and will remain, essential in providing the flexibility needed to keep the lights on.

Small, distributed gas engine peakers can potentially provide this flexibility more cleanly and economically than traditional gas plants. As a result, they are attracting considerable investment, especially in the UK, which has led Europe in peaker deployment. This is due to a particularly strong need for flexibility here, and a policy environment that is relatively favourable in defining clear sources of stackable revenue.

Looking ahead, the UK peaker market is expected to experience strong growth – expanding over five times in capacity terms from 2016-2021¹⁰, and, by some forecasts, further tripling by 2030⁹.

Worldwide, peaker capacity is forecast to overtake traditional gas plant capacity by ~2040⁵.

More immediately, local peakers may benefit from the effects of Brexit on the Pound and electricity trading arrangements with Europe.

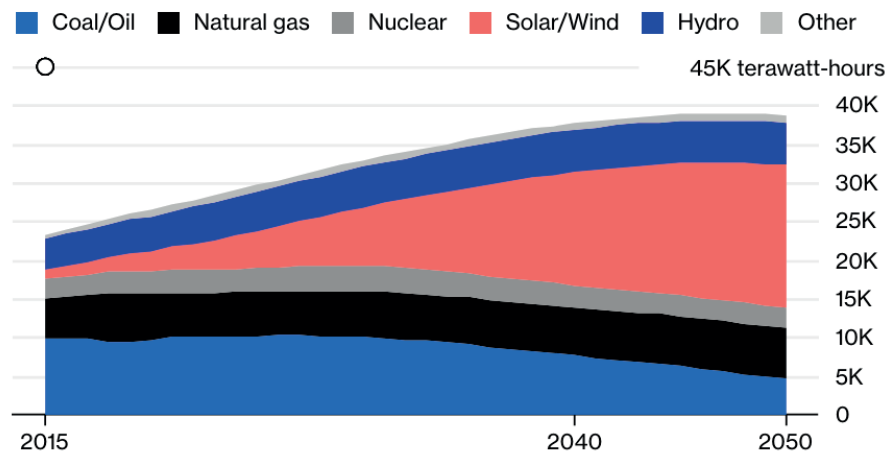


Background

The Problem: The Transition to Renewables

The electricity industry is in the early stages of a well-publicised transition, switching from fossil fuel sources – coal, oil, and, to a lesser extent, gas – to renewable ones, such as wind and solar. This switch is both government-mandated – as governments attempt to meet international climate change targets – and increasingly self-sustaining as the renewables sector gains competitiveness. **Figure 1**, below, shows how this transition could play out worldwide in the coming decades, according to Bloomberg New Energy Finance.

Figure 1 – Evolution of worldwide electricity sources out to 2050.¹



¹ <https://www.bloomberg.com/opinion/articles/2018-06-20/natural-gas-power-forecasts-are-rosy-for-peaker-plants>

As a side effect of this transition, we are expected to move mainly from dispatchable sources of energy – ones whose output we can turn up and down to match demand – to intermittent ones, which only generate electricity when the wind blows or the sun shines etc. At the same time, peak energy demand is expected to increase as we switch to electricity for transport and heating, for example². Therefore, matching supply with demand is expected to become increasingly difficult. This is because this matching must happen in real-time; electricity must be generated largely at the instant in time it is consumed. It cannot currently be stored on a large scale.

Supply and demand imbalance can lead to key system variables, such as frequency and voltage, wandering out of acceptable limits, which can be damaging to equipment. In the extreme case, this can lead to blackouts.

This 'intermittency problem' is potentially a major issue for GB. To name a few reasons:

- GB has relatively high and increasing levels of renewables penetration (~30 GW (gigawatts) of wind and solar installed, out of total generation capacity of ~103 GW, 2017²).
- Coal-powered generation is being phased out by 2025, from ~13 GW operational in 2017³.
- New traditional power plants are struggling to find finance (particularly nuclear, though also traditional gas), even as an increasing number of older plants reach the end of their lives.

² <http://fes.nationalgrid.com/media/1363/fes-interactive-version-final.pdf>

³ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/736152/Ch5.pdf

Flexibility Today: Gas is Critical

In GB, gas-powered generation currently provides the bulk of flexibility required to match supply with demand in the face of increasing intermittency. This is mostly provided by large Combined Cycle Gas Turbine (CCGT) plants, connected to the national transmission network. There are 31.5 GW of operating CCGTs (2017), though some of this is more accurately described as providing baseload (constant output, or approximately so).

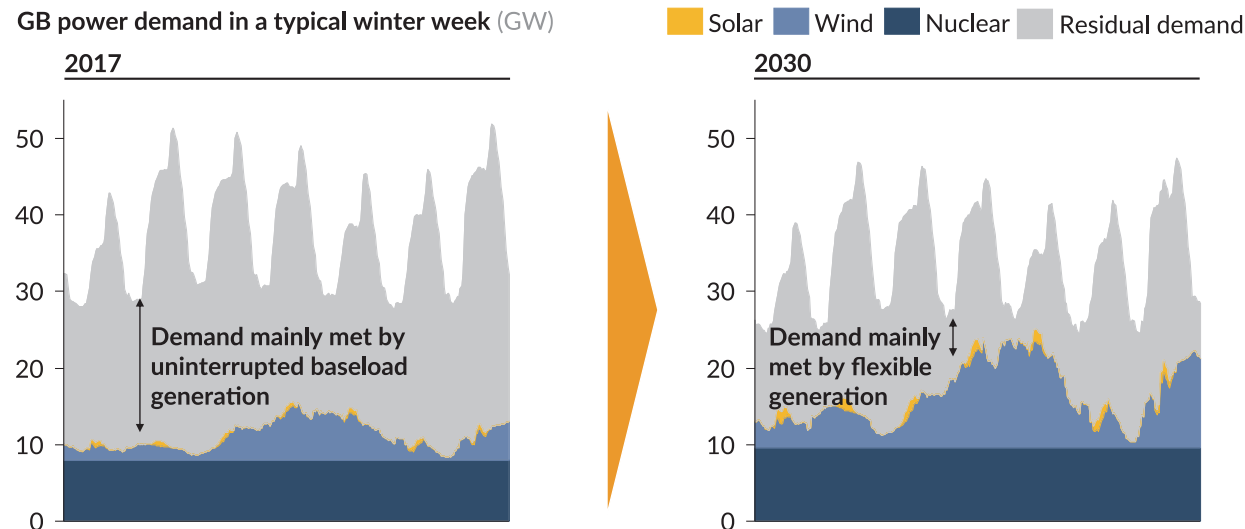
A smaller portion of flexibility is provided by other dispatchable supply – remaining coal, small capacities of biomass and other plants – and by alternative forms of flexibility:

- Interconnectors – importing and exporting electricity from/to neighbouring countries. This method may be impacted post-Brexit; this is discussed later.
- Electricity storage – storing electricity when not needed and supplying it when it is, using technologies such as pumped hydro and batteries.
- Demand side response – adapting electricity consumption to supply (e.g. by briefly turning down an industrial fridge).

Flexibility Tomorrow: Gas is Still Critical

As the switch to renewables picks up pace, so does the associated need for flexibility. **Figure 2**, below, demonstrates this graphically by showing how, in a simulated typical winter week in 2030, GB demand will have to be met by some form of flexibility, rather than uninterrupted baseload generation. As such, Aurora Energy Research, the source for **Figure 2**, sees the flexibility market in GB growing at 7% CAGR (Compound Annual Growth Rate) through to 2040 (excluding CCGTs and interconnectors).

Figure 2 – Growing intermittent renewable generation is materially changing the economics of dispatchable power generation.⁴



⁴ <http://powerresponsive.com/wp-content/uploads/2017/05/Aurora-Energy-Research-Investor-Event.pdf>

The key question for investors is: how will the dynamic between the different forms of flexibility play out over short and long timescales? As the need is significant, all forms will be used to some extent, but to what extent?

350 PPM is a strong advocate for energy storage. In the long-term (2050 and beyond, say) it is hard to argue against dominance of the renewables-storage combination. Effective long-term storage potentially transforms renewables into baseload, making a 100% low carbon future more feasible.

However, the technical and commercial reality is that gas-powered generation will likely remain a key source of flexibility for the foreseeable future in many countries, including GB. **Figure 1**, two pages back, backs this up, forecasting that worldwide gas use will remain approximately at current levels out to 2050. Non-exhaustive reasons for this in GB include:

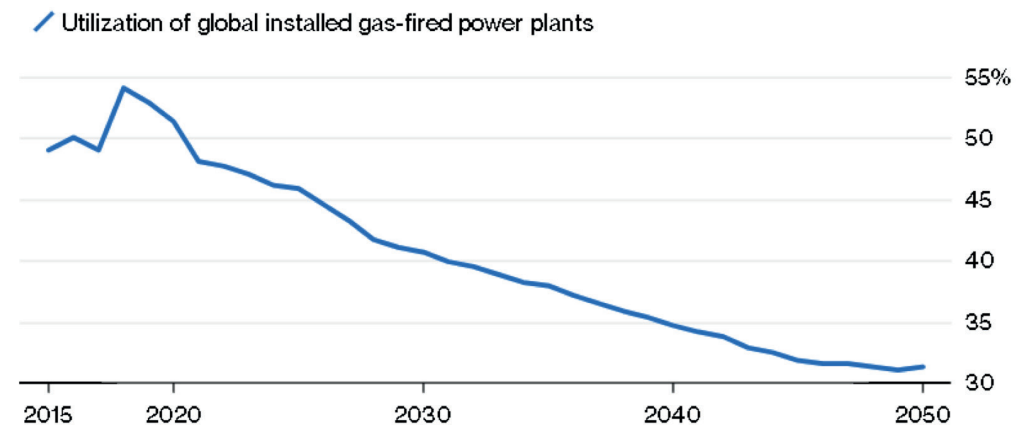
- It is the main source of flexibility role now – this is not going to change overnight. Each of these alternative forms of flexibility mentioned above are growing rapidly, but from a small base, so cannot provide the scale of flexibility needed. In GB, there are currently ~4 GW of interconnectors, ~3 GW of electrical storage and ~1 GW of demand side response².
- There are degrees of flexibility. Modern gas engine peakers can provide high levels of flexibility, see the next section. Technologies such as demand side response and short-duration batteries have, by their nature, limited flexibility.
- The alternative forms of flexibility don't provide flexibility in generation, at least not on their own. Interconnectors and storage allow electricity to be moved around and stored, but something else must generate it.
- Gas is the cleanest, and in some countries the only commercially viable, form of fossil fuel, so if a fossil fuel is going to be used to provide generation flexibility, then it is most likely to be gas.

The Need for Gas Engine Peakers

Having concluded that gas is, and should remain, a critical constituent of the flexibility required to match supply with demand, we now turn our attention to what type of gas plant should be used to provide this flexibility.

Although the need for some baseload gas capacity will remain (at least for now) – which can be provided by traditional Combined Cycle Gas Turbine (CCGT) plants – there is a growing need for gas 'peakers'. By 'peaker', we mean that the plant is used less often, and with a more rapid adjustment of output to meet peaks in demand or drops in supply. The problem is that traditional CCGT plants are not suited to being used like this due to several factors including high fixed costs, reduced efficiency and high start costs. As **Figure 3**, below, forecasts, gas plant utilization is expected to decline considerably out to 2050 as renewables use picks up. This will make the traditional CCGT business model increasingly uneconomic. As a result, some do not see any further CCGT plants being built in GB⁵.

Figure 3 – Forecast percentage utilization of global gas-powered plants¹. Utilization rates are expected to decline significantly.



⁵ <https://www.thenational.ae/business/energy/for-GB-energy-peakers-play-a-blinder-1.756032>

This issue has led to the rise of a new generation of smaller-scale (typically <50MW) plants that use reciprocating engines, rather than the combination of gas-powered and steam turbines used in CCGT plants. We ignore the possible use of Open Cycle Gas Turbines (OCGT) as peakers here. Both diesel and gas engines are used, but in GB, diesel is punished financially for being more polluting.

The advantages of gas engine peakers over traditional CCGT include (stats from footnote⁶, unless indicated):

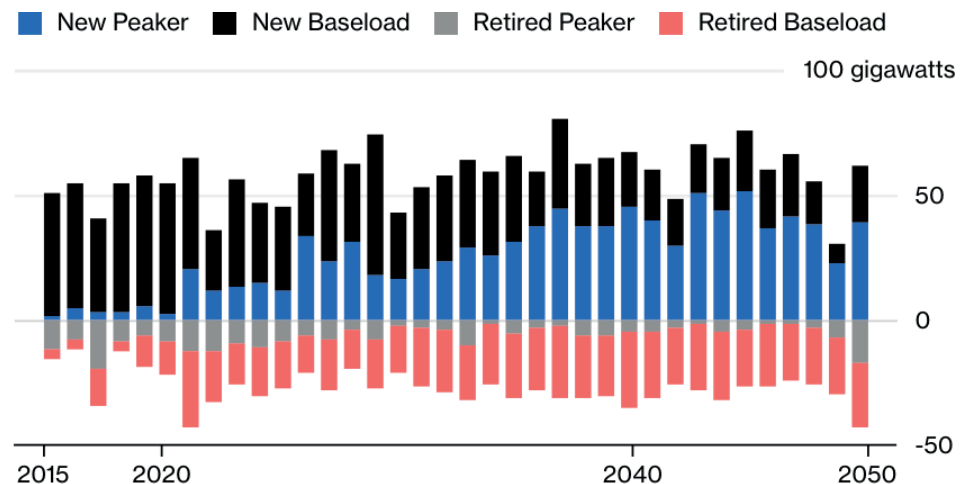
- Significantly lower fixed costs – costs that are incurred even if the plant is not earning money by selling electricity. Fixed costs of CCGTs can be more than 50% higher than those of gas engines (around 25 \$/kW).
- Lower start costs and faster ramp times. Gas engines can be kept off when not needed and started relatively cheaply within short timescales (minutes) when they are. Many older power stations require up to twelve hours' notice before they can generate. As a result, if used to provide reserve, these plants must be kept on 'warm standby', burning gas, but not generating electricity. This is polluting, producing between 300 and 750 tonnes of CO₂ per annum for each megawatt of reserve required⁷.
- Lower capital costs. CCGTs are 45-70% more expensive in terms of \$/KW.
- Shorter economic life, approximately 15 versus 25 years. This reduces the risk of assets becoming uneconomic in later life.
- Can provide local flexibility services, as typically connected to a local distribution network, rather than the national transmission network.
- Relatively quick and easy to build a new plant. Gas engines can come in containerised form which can be installed in relatively small areas of land. Planning permission should also be easier to obtain.

⁶ <https://timera-energy.com/investment-in-flexibility-gas-peakers/>

⁷ <https://www.flexitricity.com/faqs/>

CCGT plants are more efficient at converting gas into electricity, but, overall, gas engines are much more suited to a low utilization environment. Bloomberg New Energy Finance sees baseload gas being replaced worldwide by gas peakers as plants retire at end of life, or as they become uneconomic. They also forecast that peaker capacity will overtake traditional plant capacity by ~2040⁵, see **Figure 4**, below.

Figure 4 – Forecast worldwide capacity evolution of peaker and baseload gas plants. Peakers are expected to dominate over the coming decades.¹



UK Market for Gas Engine Peakers

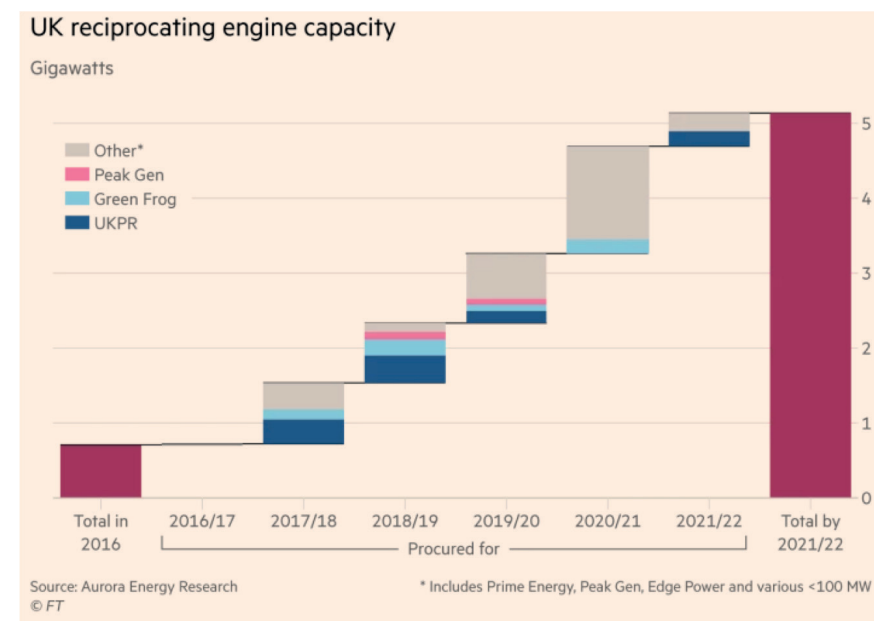
Investment in reciprocating engine peakers has surged over the last 4 years in the UK, driven in part by the introduction of the Capacity Market, a government subsidy, explained in more detail in the next section. As **Figure 5**, right, shows, the market is expected to expand roughly five times in capacity terms from 2016-2022. The companies listed in **Figure 5** specialise in gas engine peakers, or flexibility more broadly, and are building up distributed portfolios of assets. By 2030, Green Frog – one of these companies – expects 11 GW of reciprocating engine peakers to be operational⁸. Aurora Energy Research sees a higher 14.4 GW by the same date⁹. The UK has so far led European peaker investment, due to the chronic need for flexibility highlighted earlier, and a policy environment that is relatively favourable in defining clear sources of ‘stackable’ revenue, see the next section.

Barriers to entry for new participants are arguably not high and are reduced by the existence of aggregator companies, such as Flexitricity, Limejump and Kiwi Power, who dispatch assets on behalf of owners, in exchange for a cut of the profits. Such aggregators can provide access to additional revenue streams, some not currently available to smaller generators going it alone.

⁸ <https://www.greenfrogpower.co.uk/generation>

⁹ <https://www.auroraer.com/insight/distributed-and-flexible-energy-market-scenarios-report-h2-2018/>

Figure 5 – UK reciprocating engine capacity.¹⁰



¹⁰ <https://www.ft.com/content/ba6bd46a-1d75-11e8-956a-43db76e69936>



Economics

GB Revenue

Simply put, gas engine peakers earn money by:

- Directly selling electricity.
- Selling their ability to adjust electricity supply on demand (selling flexibility, in other words).

Within technical and contractual limits, it is possible to access multiple revenue streams 'simultaneously', also called 'stacking' revenues. Depending on market conditions, it may make sense to switch between available revenue streams in real-time. Revenues are likely to be higher in winter, due to high heating demand and the potential lack of both solar and wind.

Available revenue streams can be subdivided into the following categories:

Revenue: Electricity Trading

The bulk of a peaker's revenue comes from directly trading the electricity it generates. Wholesale electricity is sold in advance (at any time up to the point of generation) and can be sold directly to another party or on an exchange. Wholesale electricity is traded across several markets, each with a specific period before physical delivery of the electricity:

- Forward markets – months and years ahead of delivery
- Day-ahead
- Intraday – within the day of delivery
- Balancing Mechanism – minutes before delivery (explained further in the next section)

Peakers may make use all these markets, though most of the revenue is likely to come from the markets closest to the time of delivery.

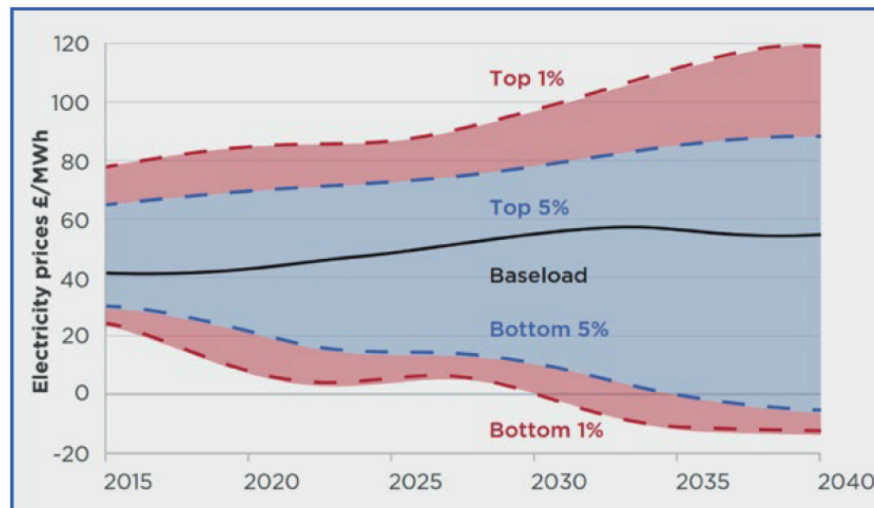


The profit that can be extracted from trading electricity is variable and a function of several factors, including, but not limited to:

- The difference between the wholesale price of electricity and its cost of production using natural gas. Electricity and gas are separate and free-floating markets – so their difference varies – however, they are historically correlated markets. This is because the price of electricity is in part driven by the price of gas.
- Price volatility. This is expected to increase as renewables use picks up, see **Figure 6**, below.
- Balancing Mechanism volumes. These are also expected to increase as renewables use picks up (see footnote³ for example); increased intermittency implies a greater need for balancing.

Brexit has the potential to increase trading revenue for peakers. This is especially true if we leave the EU Internal Energy Market (IEM), the likely outcome of a no deal Brexit. One possible consequence of this happening is that the EU (or UK) imposes tariffs on EU-GB electricity flows, increasing import prices and therefore increasing prices for local peakers. Devaluation of the Pound would amplify this effect.

Figure 6 – Wholesale electricity price variation out to 2040⁴. Volatility is forecast to increase. This should be positive for peaker plants.



Revenue: Balancing Mechanism (BM)

As explained earlier, to maintain grid stability, electricity supply and demand must be matched in real-time. It is the job of the System Operator – National Grid in GB – to make this happen. When generation and consumption are not in balance, National Grid uses the Balancing Mechanism (BM) to purchase last-minute changes in generation and consumption to correct the mismatch. The BM is used 3,000 times per day at a cost of £350 million per year. It has highly dynamic prices which can reach £2,500/MWh (megawatt-hour), compared to around £50/MWh in wholesale markets⁷. Small generators cannot currently access the BM directly but can access it via certain aggregators. Wider access to the BM is expected later this year¹¹.

Revenue: Balancing Services

The Balancing Mechanism serves a just-in-time balancing function. National Grid also procures balancing services more cheaply ahead of time using a tender process rather than an ad hoc market. Gas engine peakers can provide some of these services. Each has its own technical requirements, associated revenue opportunity and tendering procedure. Service providers may be paid both to be available to provide a service and, separately, to provide it. On a MWh basis, providing balancing services typically generates significantly more revenue than the conventional sale of electricity.

¹¹ https://www.nationalgrideso.com/sites/eso/files/documents/Wider%20BM%20Access%20Roadmap_FINAL.pdf

The main categories of service relevant to peakers include reserve and potentially frequency response services. Both involve changing generation as directed by National Grid, but frequency response happens on shorter timescales, and is therefore theoretically higher value.

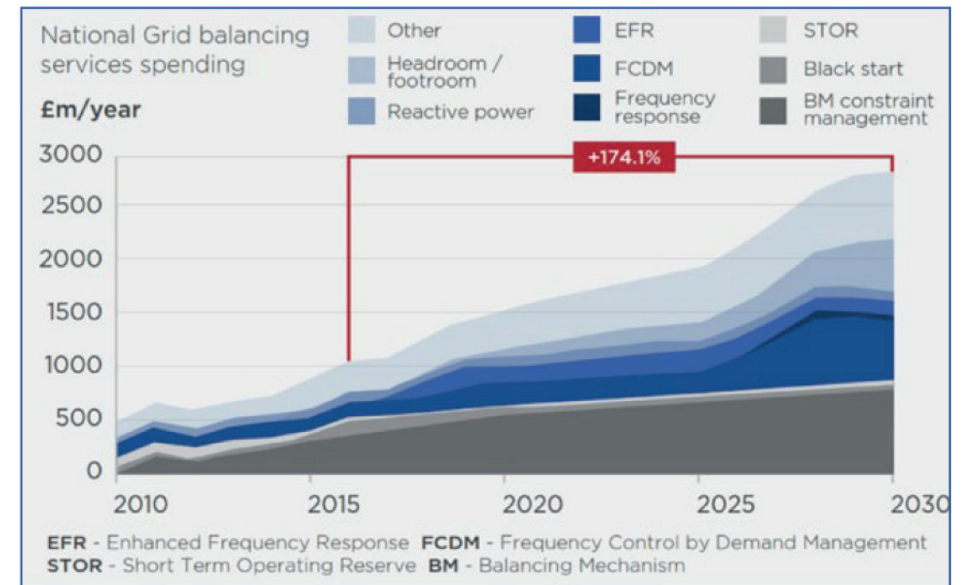
Frequency response services are necessary to keep GB's electricity system operating at a nominal frequency of 50 Hz, or 50 cycles a second (meaning that electrons in electricity wires switch direction this often). National Grid has a licence obligation to keep this frequency within plus or minus 1% and stricter operational limits, thus it contracts out various services to help in this task. The main service is called Firm Frequency Response. This requires a response within 30 seconds, and for that response to be maintained for up to 30 minutes. Tenders with National Grid are held on a monthly basis for this service¹².

Short Term Operating Reserve (STOR) is National Grid's most important source of reserve capacity, necessary in case of breakdown in generation or demand varying from forecasts. STOR is delivered by reducing demand or increasing generation with around 10 minutes' notice and sustaining this for approximately 1 to 2 hours. It is a program with over 1.8 GW being contracted, across all forms of generation, through blind tenders taking place three times each year¹³.

We cannot cover all relevant services here, but it is worth mentioning one more – black start. Black start is a procedure used to restore power in the event of a total or partial shutdown of the national electricity system. This service is being newly tendered in 2019 and offers the potential of ~5-year contracts¹⁴.

Aurora Energy Research forecasts that spending across all balancing services combined will increase significantly over the next decade, see **Figure 7**, right.

Figure 7 – National Grid balancing services spending is forecast to increase as renewables use picks up.⁴



¹² <https://www.nationalgrideso.com/balancing-services/frequency-response-services/firm-frequency-response-ffr?overview>

¹³ <https://www.nationalgrideso.com/balancing-services/reserve-services/short-term-operating-reserve-stor>

¹⁴ <https://www.nationalgrideso.com/balancing-services/system-security-services/>



Revenue: Capacity Market

The Capacity Market is part of GB government's Electricity Market Reform package. It is intended to secure electricity supplies by paying extra for reliable sources of capacity. Gas engine peakers can participate. Under the scheme, participants are paid an availability payment for being connected. The main requirement is to be able to adjust supply within a 4-hour notice period, with a 4-hour maximum event duration.

New build generators can apply for a 15-year contract in the T-4 auction (4 years ahead of contract start), whilst existing generators, or those able to reduce demand, can apply for a one-year contract in the T-1 auction (1 year before contract start). The price paid is determined by an annual auction hosted by National Grid. Prices have been falling, but 350 PPM believes they are likely to rebound. Some older plants did not secure contracts in previous auctions and shut down as a result.

Capacity Market payments are currently suspended due to an ECJ (European Court of Justice) ruling, though new capacity auctions are going ahead, and 350 PPM expects a relatively swift resolution.

Revenue: Other

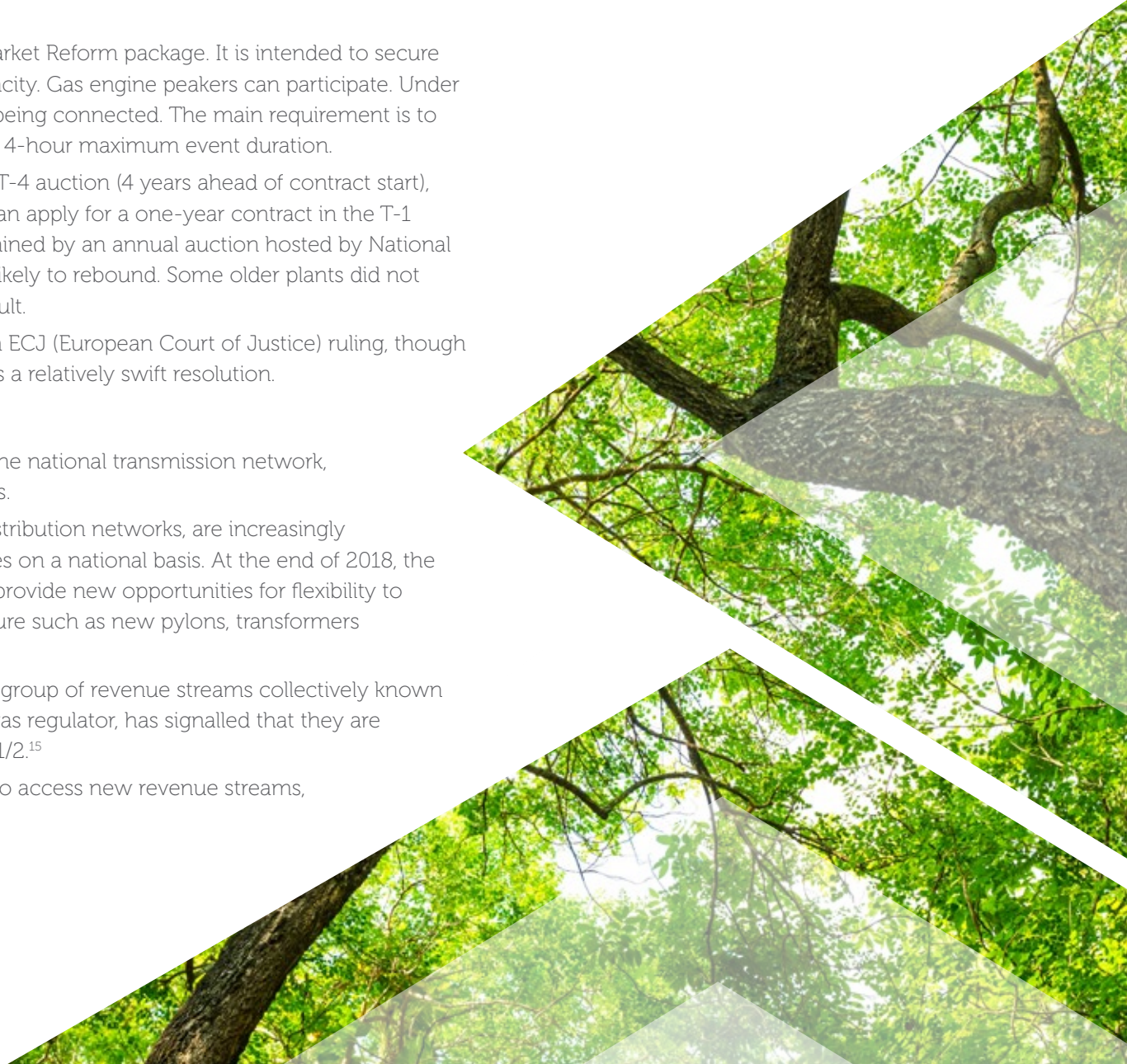
Being connected to a local distribution network, rather than the national transmission network, provides gas engine peakers with other revenue opportunities.

Distribution Network Operators (DNOs), who run the local distribution networks, are increasingly procuring local flexibility services much like National Grid does on a national basis. At the end of 2018, the DNOs agreed to a 'Flexibility Commitment', which is likely to provide new opportunities for flexibility to compete with traditional forms of energy network infrastructure such as new pylons, transformers and substations.

Distribution-connected generation is currently able to earn a group of revenue streams collectively known as 'embedded benefits'. However, Ofgem, the electricity and gas regulator, has signalled that they are 'minded to' to remove virtually all embedded benefits by 2021/2.¹⁵

Finally, a gas engine peaker gains flexibility, and may be able to access new revenue streams, by co-locating batteries on the same site.

¹⁵ <https://www.current-news.co.uk/news/ofgem-proposes-fixed-residual-charges-and-an-end-to-embedded-benefits>



Other Considerations

Costs

As you might expect, the chief operational costs for gas engine peakers are gas-related (fuel and fixed costs). Other costs include:

- Operation and maintenance.
- Tax on emitted carbon.
- Standard overheads – rent, insurance etc.
- Aggregator revenue share, if an aggregator is used.
- Interest on debt finance, if used.

Capital costs vary; a ballpark figure is ~£11.5M for a 20 MW site.

Getting It Built

A gas engine peaker is typically built on a site that is:

- A brown field or agricultural site, ~1.5 acres for 20 MW capacity.
- Near to a suitable point of connection to the grid.
- Near to a suitable gas main.
- At least 250m from residential properties.
- Not on designated land – e.g. Site of Special Scientific Interest or Area of Outstanding Natural Beauty.
- Free from flood risk.

As explained earlier, gas engines can come in containerised form, simplifying construction. A typical 20 MW project takes in the region of nine months to construct.

Like all projects, availability of finance is determined by the level of revenue certainty that can be provided once built. This depends on, for example, success in winning Capacity Market and other contracts. The involvement of an experienced aggregator may reduce the perceived risk from the financiers' perspective, as the aggregator can help secure contracts and should have a proven track record of trading electricity.

Summarising Quotes

"A major transformation is underway in European power markets. Ageing plants are retiring and being replaced to a significant extent by renewable capacity. Loss of existing flexible plants and the inherent intermittency of wind and solar output is driving a requirement for substantial investment in new flexibility."

"...there remains a key system requirement for flexible thermal generation capacity."

Timera Energy⁶

"Peakers are much better placed to deliver than larger traditional gas plants in an economy with lots of renewables."

Bloomberg New Energy Finance⁵





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