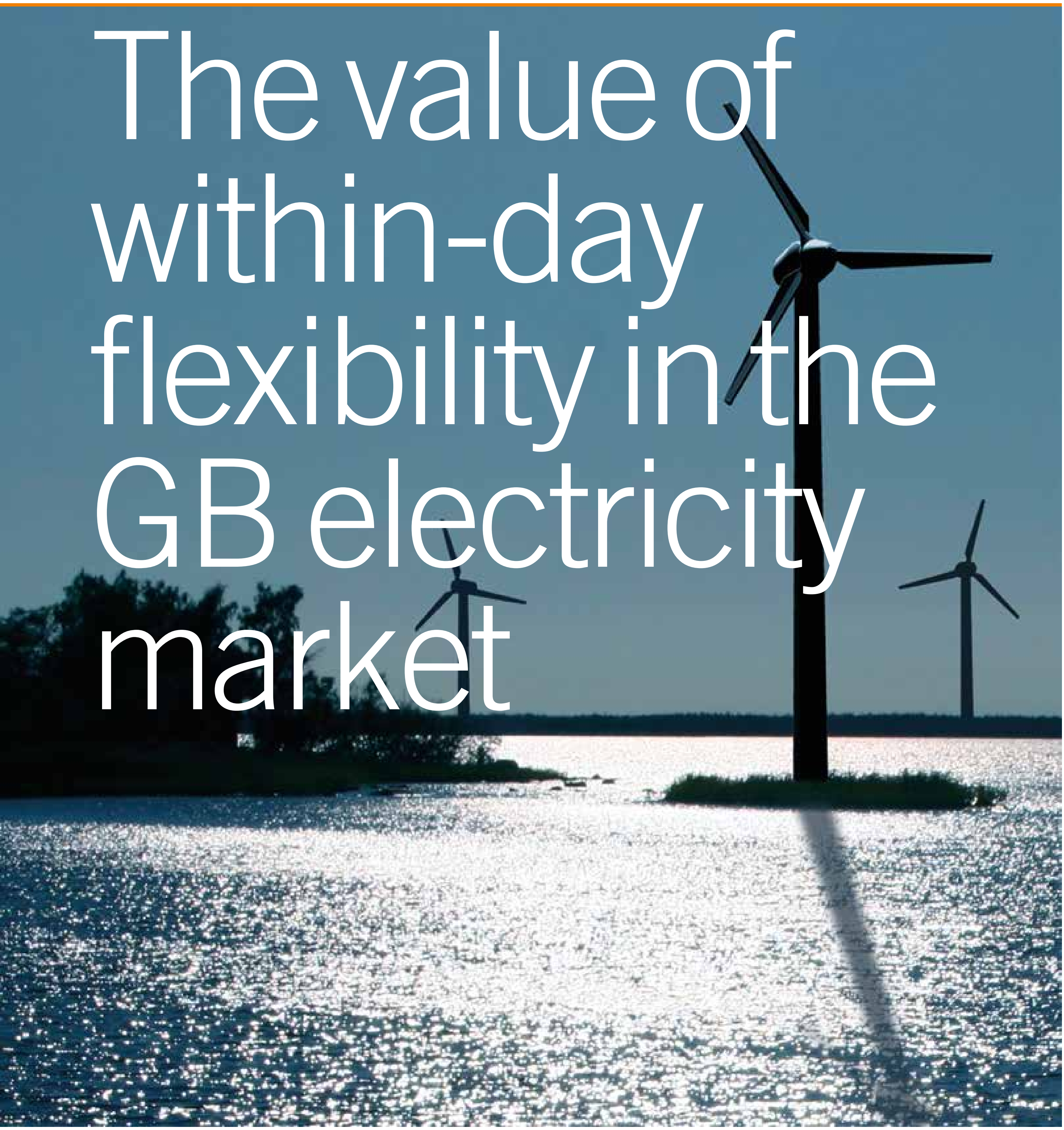
PÖYRY POINT OF VIEW:
SHAPING THE NEXT FUTURE



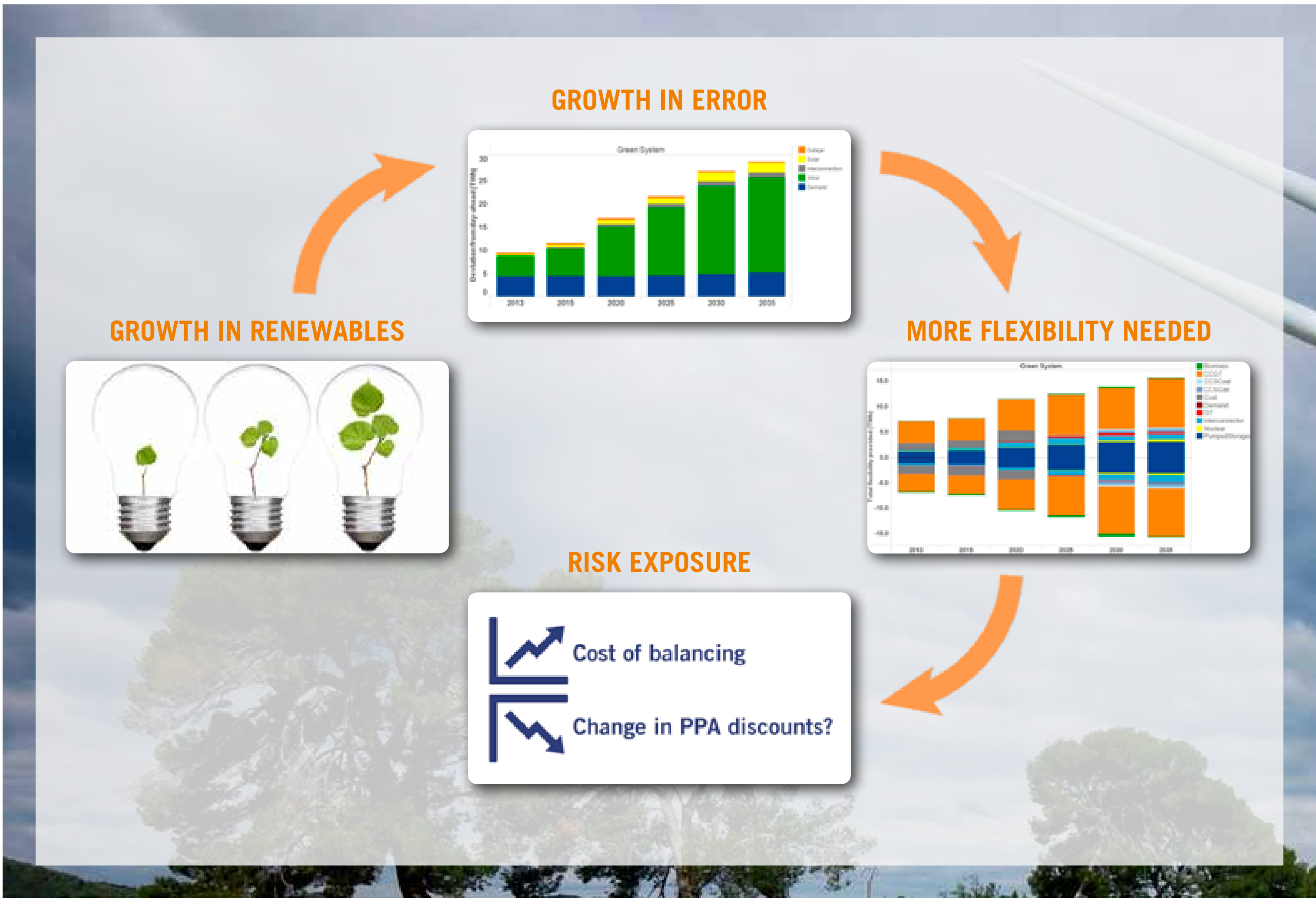
The value of within-day flexibility in the GB electricity market

Introduction

The integration of renewable generation on the GB electricity system leads to a greater need for flexibility, whilst risks for wind generators increase

The electricity system in the UK is facing unprecedented change. As a result of the European 2020 renewable energy targets, the UK is planning to build approximately 15 GW of new wind generation (above current levels) by 2020, and the aspiration of the government is to continue the development of low carbon generation beyond then, with a likely continued growth in wind generation, as well as solar. In addition, the closure of thermal plants due to the EU Large Combustion Plant Directive (LCPD) and the Industrial Emissions Directive (IED) means that flexible plants which could have been used to balance[1] the system will no longer be available.

FIGURE 1 – UNDERSTANDING THE RISKS ASSOCIATED WITH RISING LEVELS OF RENEWABLES



Output from wind and solar is inherently variable, and is also difficult to forecast accurately. As shown in Figure 1, this substantial growth in intermittent renewable generation will lead to a growth and variability in forecast error – as wind and solar generation cannot be forecasted perfectly. As a result, greater flexibility will be needed to manage the unpredictability and variability of intermittent generation (wind and solar) and new plants will be needed to replace the existing thermal capacity which is being shut down. How this flexibility will be provided depends on the market and regulatory structure available to incentivise new plants and/or new players to enter the market. Finally, the risk exposure for new and existing intermittent generators will also change and this risk needs to be understood.

During 2013, Pöyry ran a major multi-client study to understand the risks and opportunities associated with rising levels of renewable penetration on the system for all plant types. This was a major computer modelling exercise; simulating the future electricity system including the impact of weather patterns and plant characteristics such as ramp up and down rates. In addition, the trading behaviour was simulated; focusing on the fine tuning of trading positions in the within-day period.

To understand the future of the electricity system, we created a ‘Green System’ scenario consistent with the Government’s aspirations for renewable and low-carbon development. This is a world where the 2020 renewables targets are met and the carbon intensity of generation in Great Britain falls from 480gCO_2/kWh currently to 100gCO_2/kWh in 2030. Commodity prices remain broadly flat, but the carbon price rises swiftly to £75/tonne by 2030 in real terms. In addition, the electricity market reform proposals are modelled including a capacity payment which delivers 3 hours of loss of load[2].

TERMINOLOGY UNCOVERED:

Within day period – Between day ahead (T-24 hours) and gate closure (T-1)

Balancing period – Between T-1 hour and outturn (T_0)

Within day re-trading – All market actions taken between T-24 hours and T-1 by various generators/portfolio players to fine tune their positions (the aim is to be balanced, therefore be neither long nor short)

Balancing – All actions taken from gate closure (T-1 hour) to outturn by the Transmission System Operator (TSO) to ensure supply meets demand at all times (the TSO takes over from the market and the objective is to balance the system at outturn at the lowest possible cost)

[1] Ensure that the supply of electricity meets consumer demand at all times

[2] Average number of hours in relation to interruption of supply for customers in a year resulting in brown outs (reduction in the quality of supply for customer) or black outs (lights go out).

FIGURE 2 – OVERVIEW OF GREEN SYSTEM SCENARIO

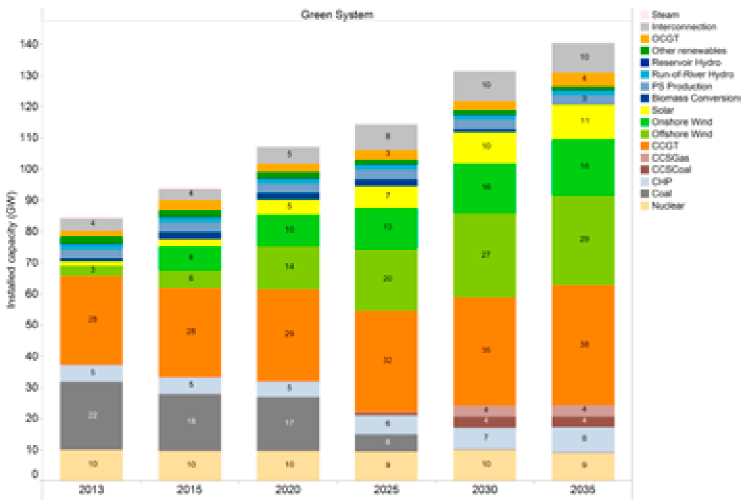
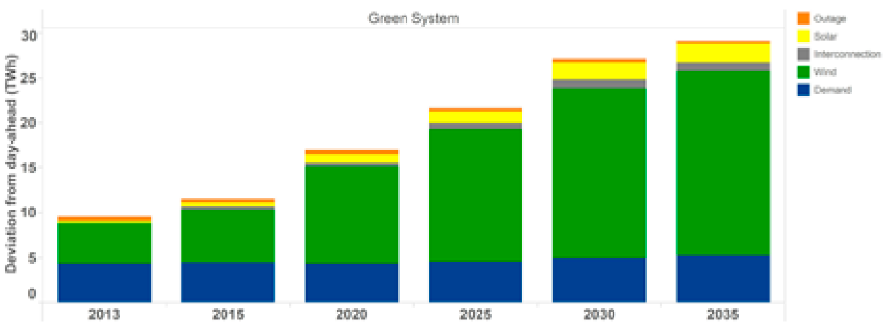


FIGURE 3 – FORECAST ERROR BETWEEN DAY AHEAD AND OUTTURN



REGULATORY AND MARKET CHANGES UNDERWAY AFFECT THE NEED AND SUPPLY OF FLEXIBILITY

The EU 2020 renewable targets are a combined target for energy used in electricity, heat and transport which will deliver a significant level of wind and other intermittent renewable generation in the UK, resulting in a fundamental change in the workings of the current electricity market. As wind and solar become more dominant, greater flexibility will be needed to manage the unpredictability and variability of intermittent generation and new plants will be needed to replace the existing thermal capacity which is being shut down through the LCPD and the IED closures.

In addition, a number of regulatory factors affect the procurement and value of various flexibility providers. These include the introduction of the capacity payment which may or may not value flexibility, the review of the balancing market, the implementation of the EU target model and therefore its effects on intraday trading, as well as the cash out reform which impacts on imbalance costs for generators/demand providers.

INCREASING WIND PENETRATION LEADS TO WIND BECOMING THE DOMINANT SOURCE OF ERROR ON THE SYSTEM IN THE FUTURE

The increased deployment of wind and other intermittent renewable generation will introduce additional variability and unpredictability to the GB electricity system.

Figure 3 shows the annual volumes by source of imbalance between day ahead and outturn.

Historically, demand has been the dominant source of forecast error, driven by errors in temperature forecasts and varying use of electricity by end-consumers. As a result of the recent growth in wind capacity to 2013, the system level errors in wind output forecasts were of a similar order of magnitude to demand errors. However, by 2020, wind becomes the dominant source of error within-day in GB, with solar imbalances also increasing over time. By 2035 the total forecast error is 300% higher than in 2013. These greater volumes of imbalances require a higher level of flexible capacity on the system as well as generating more re-trading of positions; traders refine their positions when updated wind/solar forecasts are available. Whilst it is possible that this error could be reduced somewhat through improvements in forecasting, this is by no means certain (and hence has not been assumed here).

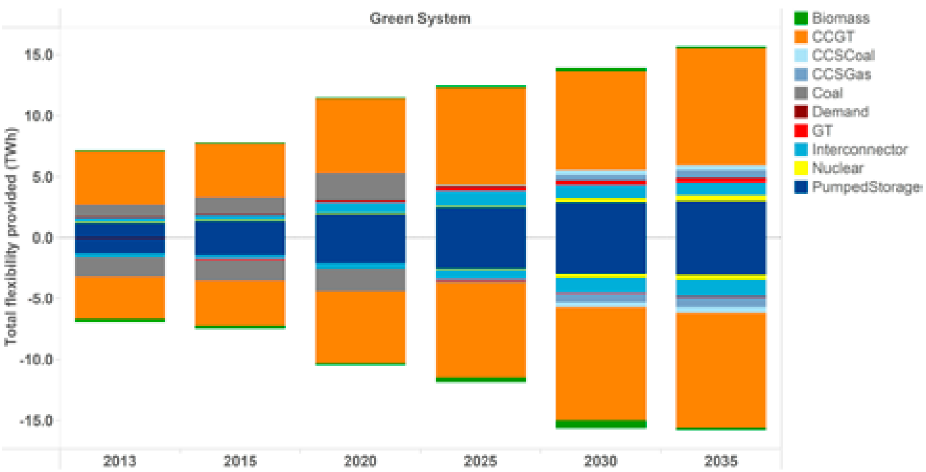
WITHIN-DAY FLEXIBILITY IS PROVIDED PRIMARILY BY CCGTS[3] AND PUMPED STORAGE[4]

Within day error is mitigated using flexible sources of output such as CCGTs and pumped storage, which are able to respond within the required time frames. The increased volumes of imbalances lead to a marked increase in the amount of flexibility required in the GB

market. Figure 4 shows the annual volumes of flexibility required.

The flexibility needed increases substantially from 2013 to 2035, with an equal amount of both upwards and downwards flexibility required. Coal plants provide some flexibility with their output in 2015 and 2020, but the volumes decrease over the years with the coal phase out and the introduction of the carbon floor price. As a result, CCGTs, pumped storage, and Demand Side Response (DSR) provide the majority of the flexibility requirements within-day. With rising levels of renewable penetration, the volume of flexibility provided by OCGT[5] also

FIGURE 4 – ANNUAL VOLUMES OF FLEXIBILITY BY TECHNOLOGY WITHIN-DAY (TWH) IN GB



increases. As these plants are unlikely to be scheduled to run at the day-ahead stage, they generally provide positive flexibility only. Nuclear, being less flexible, is unable to contribute meaningfully to the flexibility requirements.

[3] Combined Cycle Gas Turbine
[4] Pumped storage is a type of hydroelectric power generation used by some power plants for load balancing. The method stores energy in the form of potential energy of water, pumped from a lower elevation reservoir to a higher elevation.
[5] Open Cycle Gas Turbine

Within-day revenues not significant for majority of plants

OUTTURN PRICE VOLATILITY[6] INCREASES MUCH FASTER THAN DAY-AHEAD PRICE VOLATILITY – HENCE THE MOST EFFICIENT AND FLEXIBLE PLANT COULD TAKE ADVANTAGE OF THIS VOLATILITY

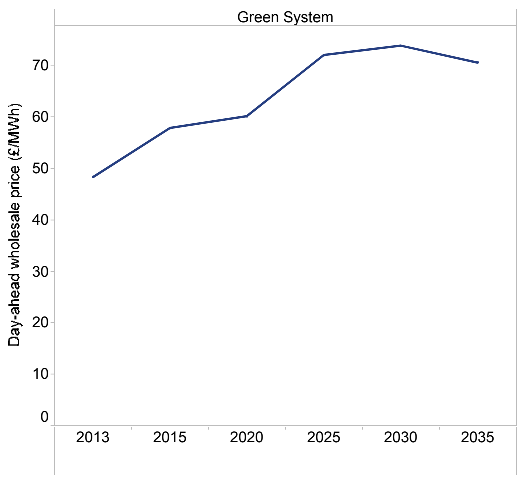
The wholesale price and any subsidy regime available for various technologies are are key determinants of the type of flexibility available to manage the system.

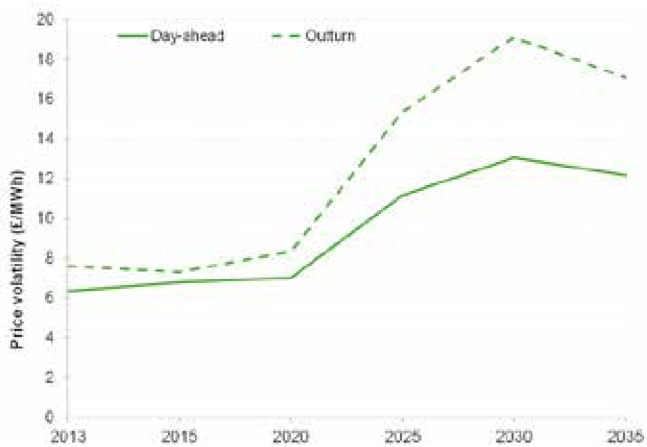
Figure 5 shows the annual Time Weighted Average (TWA) wholesale price projections at the day-ahead stage as well as the price volatility at the day ahead stage and at outturn. There is a general trend of increasing day-ahead expected TWA prices in the future due primarily to the rising carbon floor price. However, increasing levels of renewable penetration and the introduction of the capacity payment in Britain push the prices down. As wind generates primarily during periods when only the most efficient thermal plants are running or when renewable or other low carbon are at the margin, the wholesale price signal which wind generators have access to does not always include the full carbon cost.

Day-ahead price volatility increases somewhat over time, as a result of increasing wind penetration – the classic day-night cycle of prices is increasingly overlaid with a high-low wind pattern. However, this effect is dampened by the development of the capacity mechanism. As a result of the capacity mechanism, we assume that there is less bidding above short-run marginal cost by generators (due to more capacity being on the system), which leads to flatter prices than would otherwise have been the case. However, as the Green System scenario is assumed to include some loss of load (3 hours), we can see an increase in price volatility from 2025.

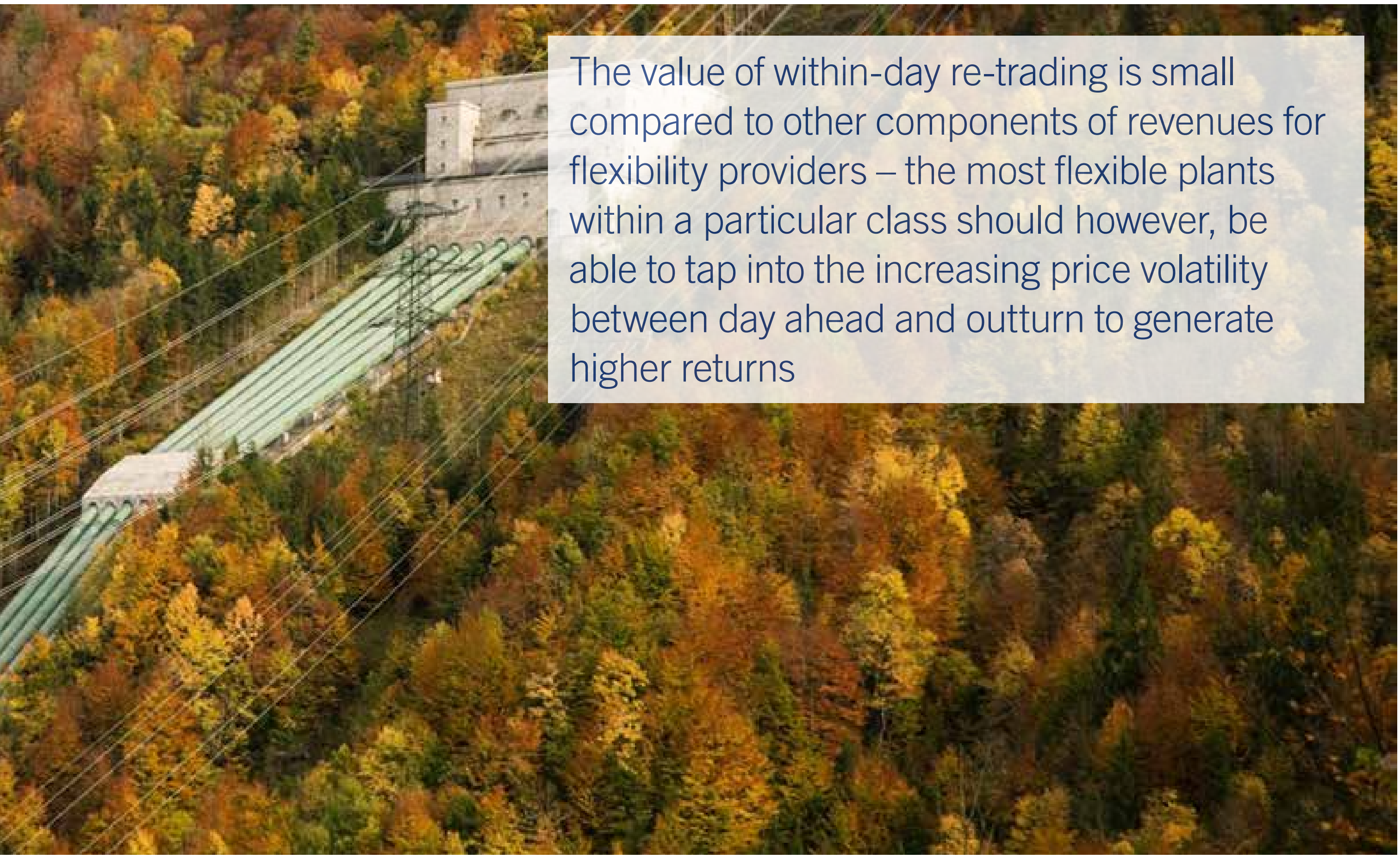
Outturn price volatility rises rapidly from 2020 and is much higher than day-ahead price volatility. This is because the increase in forecast error and the need to balance positions leads to more expensive plant being offered into the market at short notice. In general, the more flexible plant (i.e. more flexible technologies, and more flexible plant within a particular class) could take advantage of this price volatility as they are able to bid in to provide the additional flexibility needed. For those plants which are most flexible within their class, the revenues which could therefore be captured through this price volatility could be higher than for other plants.

FIGURE 5 – DAY-AHEAD ANNUAL TWA PRICE AS WELL AS DAY AHEAD AND WITHIN DAY PRICE VOLATILITY





[6] Price volatility is defined as the absolute difference between two consecutive hourly prices averaged out on an annual basis



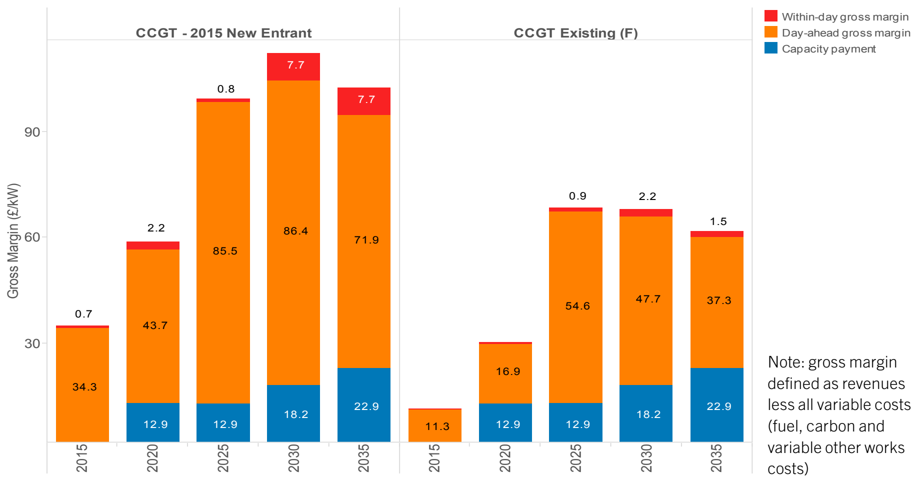
The value of within-day re-trading is small compared to other components of revenues for flexibility providers – the most flexible plants within a particular class should however, be able to tap into the increasing price volatility between day ahead and outturn to generate higher returns

DESPITE THE INCREASING WITHIN-DAY PRICE VOLATILITY, WITHIN-DAY RE-TRADING REVENUES ARE LOW ON AVERAGE COMPARED TO ENERGY AND CAPACITY PAYMENT REVENUES

Figure 6 shows the gross margins for CCGTs in our modelled scenario. The chart shows the breakdown of the gross margins between the capacity payment, energy revenues and additional revenues from within-day re-trading.

Within day re-trading revenues on average are therefore insignificant compared to expected day-ahead energy market revenues and the capacity payment. However, as above, the most flexible plant within a certain class could access a greater portion of the within day revenues.

FIGURE 6 – GROSS MARGINS FOR CCGTS



Note: gross margin defined as revenues less all variable costs (fuel, carbon and variable other works costs)

FiT CfD basis risk

THERE IS A REDUCED MARKET RISK UNDER THE FIT CFD COMPARED TO THE RO; ALL OTHER COMPONENTS OF THE BASIS RISK ARE PRESENT UNDER THE TWO REGIMES. The objective of the FiT CfD is to improve the incentive to undertake low carbon generation investments by increasing certainty for investors, in particular in reducing/removing the long term market risk for investors. The FiT CfD effectively reduces the level of market risk for the generator by providing a top-up to the electricity revenues up to the level of a pre-determined strike price.

We have examined how the risk for offtakers and developers changes under the new FiT CfD compared to the current Renewable Obligation.

The risks faced by generators under the FiT CfD are anticipated to be in some cases similar to the ones under the RO regime. Independent generators under the FiT CfD will not be required to enter into a Power Purchase Agreement (PPA), but we consider this will be likely in order to manage their basis risk exposure.

A PPA contract generally represents the market value of a range of services. If an independent generator attempted to finance and trade their generation without a PPA, then it would likely cost them more than the discount offered by a PPA offtaker. The advantages include:

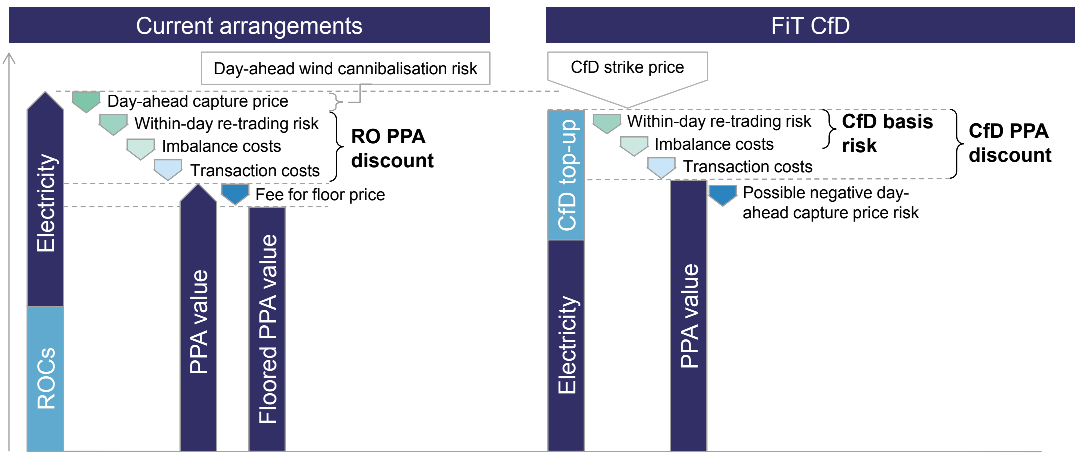
- revenue underwritten by a bankable balance sheet;
- guaranteed access to market; and
- trading and administration services, which an offtaker is likely to be able to provide at a lower cost than a small merchant operator.

Figure 7 below compares the PPA discount under a FiT CfD to the PPA discount under the RO. The market price risk under the RO leaves the generator open to price volatility, however this is substantially reduced under the FiT CfD. The within day re-trading risk, imbalance costs and transaction costs are common to both the RO PPA discount and the FiT CfD PPA discount.

The PPA discount in the case of the FIT CfD therefore consists of the following:

- a FiT CfD basis risk which in turn comprises:
- the within-day re-trading risk – any price and volume risk accrued through adjustments to the generator's positions through market actions up to gate closure (T-1);
- the imbalance costs if the generator is unable to meet its contractual positions and is therefore either long or short at outturn;
- risk related to the possibility of negative market prices which has been termed negative day-ahead capture price risk. While the FiT CfD provides a top-up to the electricity revenues up to the level of the strike price, the FiT CfD payment will not be higher if the reference price is less than zero, hence, a potential risk to both offtaker and the generator; the likelihood of negative reference prices increases with rising levels of wind generation on the system; and
- transaction costs.

FIGURE 7 – PPA ARRANGEMENTS UNDER THE FIT CFD FOR A WIND GENERATOR



- **Market price risk:** RO day-ahead PPAs leave generator exposed to day-ahead price volatility.
- **PPA discount** includes within day re-trading, imbalance and transaction costs.
- **Floor prices** in some RO, PPAs partially mitigate market price risk, but at a greater discount.

- **CfD basis risk** consists of within day re-trading risk and imbalance costs.
- **PPA discount** likely to include the CfD basis risk and the transaction costs.
- If day-ahead price falls below zero, the wind farm will not receive more than the strike price for such periods, hence negative day-ahead capture price risk

FiT CfD EXPLAINED:

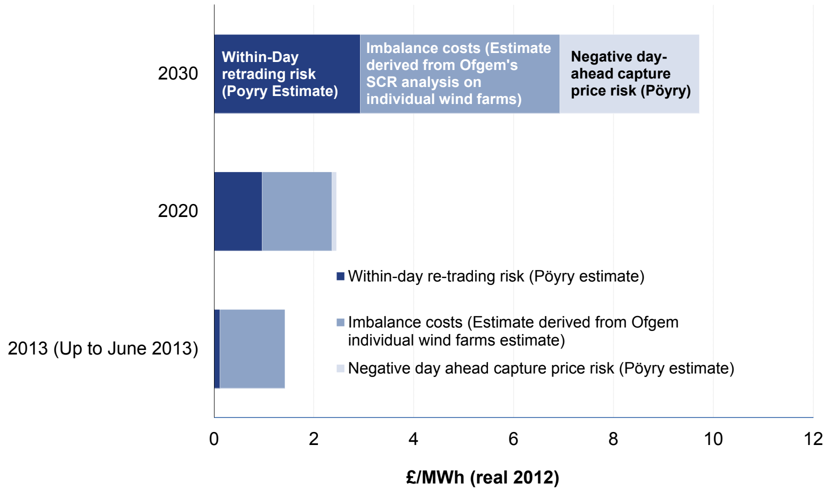
The Feed in Tariff Contract for Difference (FiT CfD) is intended to replace the Renewable Obligation (RO) as the primary support mechanism for large scale renewable/low carbon generators. The aim of the FiT CfD being to support low carbon generation capacity in the UK.

The FiT CfD is a long-term contract which remunerates low carbon generation at a defined strike price. The generator is expected to sell its output into the wholesale electricity market and receive a portion of its revenue from this. In addition, the generator may receive (or pay) top up payments between a defined electricity market index (the market reference price) and the strike price.

If the wholesale market reference price is below the contract strike price, then the generator receives a difference payment and if the reference price is above the strike price, the generator makes the difference payment.

The FiT CfD basis risk increases with rising levels of renewable penetration

FIGURE 8 [7] – FIT CFD BASIS RISK AND NEGATIVE DAY AHEAD CAPTURE PRICE RISK – GREEN SYSTEM



The extent of discount offered to a generator by a counterparty with respect to the PPA is a significant factor in determining whether any particular investment goes ahead or not, with discounts of 9% to 20% common in the market today under the RO. In the Green System scenario, the within-day re-trading cost will rise with increasing levels of wind penetration as will the negative day-ahead capture price risk and imbalance costs. While the FiT CfD basis risk will increase in the future, the market price risk is still likely to be lower than under the RO.

Figure 8 shows how the various components of the PPA (within day re-trading, negative day ahead capture price risk and imbalance costs) and therefore costs to the generator or the offtaker rise in the future for an individual wind farm. This is based on the results of our analysis as well as derived from Ofgem's draft decision paper on Electricity Balancing Significant Code Review.

It can be seen that all quantifiable components of the CFD price risk are due to increase over time with rising penetration of renewable energy production. We have, however, not quantified the transaction costs – generators should take account of PPA transaction costs in addition to the quantified costs already mentioned.

[7] The estimated imbalance costs are derived from Ofgem's SCR draft decision paper. We have tailored the value to our methodology of calculating the within-day re-trading risk. There is some uncertainty in those values as there might still be some overlap between Ofgem's figures and Poyry's. In addition, consideration of DSR, unsupported wind on the system and generation mix will affect these numbers in the future.

We therefore anticipate offtakers to take account of those rising components when determining future PPA discounts. Transaction costs in the future are likely to reflect the same factors as in today's PPAs: the external and internal costs of taking on the PPA as well as the offtaker's perception of future regulatory and market risks. We also anticipate generators to take into account those risks and expected costs when negotiating their FiT CfD contracts with the Government.

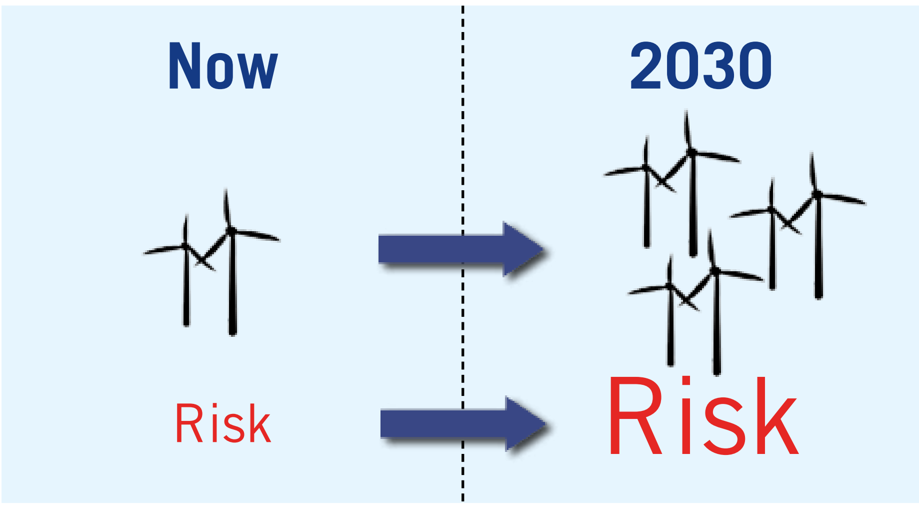
OTHER FACTORS AFFECTING PPA DISCOUNTS

In addition to the changes anticipated in the quantified aspects of the PPA discounts, the changing market and regulatory landscape in the UK is also likely to change the risk premium and the risk perception which offtakers build into the transaction costs as part of the PPA discount.

Some of the regulatory risk is uncertain. For example, the Future Trading Arrangements project Arrangements project was initiated by Ofgem in May 2013, the aim of which is to agree a high level design and roadmap for the arrangements which govern trading designs in GB. These trading arrangements are a long term vision which is likely to allow consideration of the various network codes being created by ENTSO-E (The European Network of Transmission System Operators for Electricity). These changes could affect the longer term contracting strategies for both PPA providers and generators.

Ofgem's Significant Code Review which was published in July 2013 proposed fundamental changes to the cash out regime which are likely to be more punitive for generators and offtakers in an imbalance position. The Significant Code Review also changes the risk whether a generator is part of a portfolio or is an independent player.

These regulatory changes could therefore alter the risk premium in PPA contracts.



Conclusions

Our analysis has shown that increasing penetration of renewable generation on the system leads to rising levels of imbalances. There is a resulting increase in flexibility needed to manage the system. This increase in flexibility requirements translates to additional revenues for flexible plants on a within-day basis, but these are not significant for the majority of plants when compared to other sources of revenue.

In relation to renewable generators, our assessment shows that the move from the RO to the FiT CFD will result in some improvement in overall risk (due to the substantial removal of market price risk). However this will be offset in the longer term – with the CFD basis risk and the negative day ahead capture price risk increasing alongside the growth in renewables penetration.

ADDITIONAL SCENARIOS

As part of this multi-client study, Pöyry also modelled a further two scenarios and three sensitivities.

We modelled a scenario which assumed a capacity payment with no loss of load (compared to 3 hours LOLE in the Green System scenario). The effect of this would be to further dampen wholesale prices compared to a world with a less effective capacity mechanism, as there would be additional capacity available in the system and therefore fewer spikes in prices.

Another scenario simulated the effects of a less ambitious renewable target for 2020 and beyond which delivered higher average annual wholesale prices compared to the worlds with more ambitious targets.

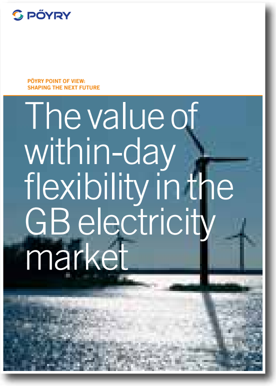
One of the sensitivities included increasing flexibility in the form of increased demand response and pump storage as well as different ramp rates etc. (again, compared to the central case). A world where more flexibility is available reduces the number of low and negative price periods which will be correlated with the highest levels of wind output. In addition, additional flexibility will tend to reduce prices at peak when demand is highest. The TWA base load price may go up but the demand weighted customer price will be lower.

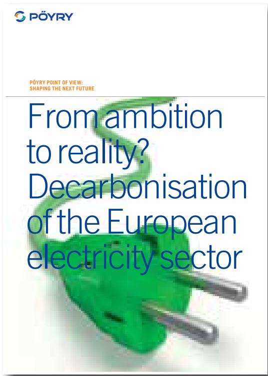
Across all scenarios and sensitivities, there is a substantial increase in the requirements for within-day re-trading, driven primarily by wind generation.

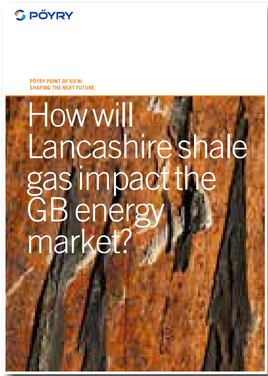
The capacity payments to generators are lowest in the Green System scenario with revenues from the energy market much higher than all other scenarios and sensitivities due to the price spikes caused by load loss and a tighter system. In addition, the capture prices for wind are higher in this world as the market needs to rely on higher prices overall to deliver enough supply to meet demand.

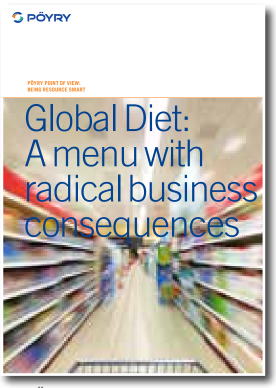
Finally, we also ran a "Low Flexibility" sensitivity which resulted in greater risk for wind generators. The "negative day-ahead capture price risk" is especially high as less flexibility (e.g. storage) is available in the system leading to more negative price periods.

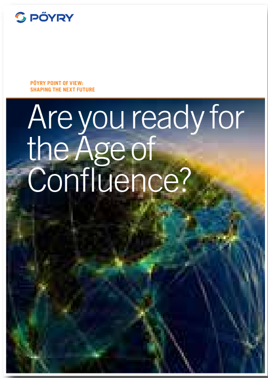
Pöyry Point of View











Staying on top of your game means keeping up with the latest thinking, trends and developments. We know that this can sometimes be tough as the pace of change continues...

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