Wind and solar reducing consumer bills
An investigation into the Merit Order Effect

Executive summary

Concerns over the cost of renewable subsidy schemes have led to significant policy changes and cast doubt over future deployment of renewables. Whilst these support mechanisms ultimately increase consumer bills in the short term, renewables also act to reduce them by driving down wholesale electricity prices – a phenomenon described as the Merit Order Effect.

This report repeats a methodology used by others to quantify the Merit Order Effect of wind and solar in 2014.

Main findings:

- Wind and solar generators reduced the wholesale cost of electricity by **£1.55 billion** in 2014
- In net terms, the cost of supporting wind and solar generation in 2014 was **£1.12 billion – 58% less** than the cost reflected in the Levy Control Framework
- The value of the Merit Order Effect will **increase with further renewable deployment** – the current level of savings suggest that, if renewable support was viewed in net terms, the projected future overspend of the Levy Control Framework may not be a reality
- If existing savings are maintained, **future planned renewable development may deliver net benefit** (in cost terms) to the consumer

Introduction

The last few years have seen rapid deployment of renewable technologies in the UK. Current renewable capacity stands at 28.4GW[1] – a threefold increase in just five years. Renewables are playing an increasingly important role in generating the UK's electricity. Latest figures show that, in the second quarter of 2015, 25.3%[2] of electricity was generated by wind, solar, hydro and other renewable generators.

Solar, more so than any technology, has epitomised this dramatic growth. Spurred by rapidly decreasing costs (a doubling of solar capacity leads to prices falling by around 20%[3]), solar capacity in the UK has increased from just 96MW in 2010 to over 8,200MW today[1]. Wind, whilst not quite matching this increase in capacity, has also seen significant growth. The UK now boasts more offshore wind capacity than the rest of Europe combined[4].

Emissions from the generation of electricity currently account for around a third of the UK's annual greenhouse gas emissions[5]. Renewable technologies will play a key part in helping the UK achieve its ambitious carbon reduction targets – at least 80% in 2050 from 1990 levels[6]. Decarbonising electricity provides one of the quickest paths to emission reduction. Other major contributors to emissions, particularly transport and heat, are harder to tackle and methods to do so are themselves heavily reliant on greener electricity.

Alongside decreasing costs and the need to meet emissions reduction targets, renewable deployment has been supported by various subsidy schemes paid for through consumer bills. The Feed-in Tariff and Renewables Obligation are two such schemes, and make up the majority of the support. Both pay a fixed amount per unit of renewable generation, irrespective of wholesale electricity prices or other market metrics.

1 DECC, Energy Trends 6.1, **https://www.gov.uk/government/statistics energy-trends-section-6-renewables**

2 DECC, Energy Trends: September 2015, **https://www.gov.uk/ government/statistics energy-trends-september-2015**

3 R. Swanson, A vision for crystalline silicon photovoltaics, 2006

4 EWEA, The European offshore wind industry - key trends and statistics 2014, 2015

5 DECC, 2013 UK Greenhouse Gas Emissions, Final Figures, **https://www.gov.uk/ government/statistics/final-uk-emissions-estimates**

6 **https://www.theccc.org.uk/ tackling-climate-change/the-legal-landscapeglobal-action-on-climate-change/**

7 DECC, Energy Trends 6.3, **https://www.gov.uk/government/statistics/ energytrends-section-6-renewables**

8 Based on the average home using 4,115kWh of electricity a year

9 DECC, Monthly feed-in tariff commissioned installations by month, **https://www.gov.uk/government/statistics/ monthly-small-scale-renewabledeployment**

10 Ofgem, Renewables Obligation Annual Report 2013-14, **https://www.ofgem.gov. uk/publications-and-updates/renewables-obligation-roannual-report-2013-14**

11 Ofgem, Feed-in-Tariff Annual Report 2013-14, **https://www.ofgem.gov.uk/publications-and-updates/feed-tariff-fit-annual-report-2013-14**

12 **https://www.gov.uk/ government/news/ controlling-the-cost-of-renewable-energy, inflated to 2014/15 prices**

13 **https://www.gov.uk/ government/speeches/ levy-control-framework-cost-controls**

Box 1: Renewable support in the UK

Renewables Obligation (RO) – the RO was launched in 2003. It places an obligation on suppliers to source an ever increasing proportion of their electricity from renewable sources. Renewable Obligation Certificates (ROCs) are issued to certified renewable generators for each unit of electricity that they produce. ROCs are then sold to suppliers, who use them to meet their obligations. Those failing to meet the obligation pay an equivalent amount into a buy-out fund, which is then distributed proportionally amongst those suppliers who have complied. In 2014/2015, over 70 million certificates were issued[7] supporting the generation of 56TWh of electricity (enough to power 13.5 million homes[8]).

Feed-in Tariff (FiT) – the FiT scheme was launched in 2010 with a view to supporting smaller scale generation (<5MW). This could include anything from a domestic rooftop solar installation to a small solar farm. To date, the scheme has supported over 700,000 installations with a combined capacity of 4GW[9].

The table below gives the annual cost of these support schemes in 2013/14 and 2014/15.

£m	2013/14	2014/15[12]
Renewables Obligation (RO)	2,596[10]	2,983
Feed in Tariff (FiT)	691[11]	790
	3,287	**3,773**

Despite the apparent success of renewables in the UK, concerns over the cost of support schemes have cast doubt over any future development. The Levy Control Framework (LCF), announced in 2010, was designed to limit the cost of these schemes to the consumer (as well as the cost of the Warm Home Discount). Since May, the government has announced significant changes to existing support schemes, citing a projected future overspend under the LCF[13].

Whilst the direct cost of supporting renewables is clear, many of the benefits they deliver are difficult to quantify directly. Energy independence, improved air quality and green jobs, whilst no doubt valuable, are difficult to attach an objective monetary value to. However, some of the benefits they deliver are clear and quantifiable. Renewables positively impact electricity bills by reducing the wholesale price of electricity. A long recognised benefit, this has been quantified by various reports abroad and is a consequence of the Merit Order Effect (MOE). This describes the mechanism by which, at times of renewable generation, electricity from these sources will be cheaper than those from others (e.g., fossil fuel power stations) as renewable generators don't have fuel costs.

Box 2: Merit Order Effect

In order to meet the UK's electricity needs, there must be enough generating capacity to meet demand at any one moment in time. National demand fluctuates throughout the year and throughout the day (demand is higher in the day than at night and higher in the winter than in summer). Electricity can be produced from a variety of sources – from fossil fuel power stations burning coal or gas, to renewable generators powered by the wind or sun. Each of these will have a marginal cost associated with them – that is, the cost of generating an additional unit of electricity at any moment in time. For fossil fuel power stations, this is predominately the cost of fuel. For renewable generators, which have no fuel costs and very low maintenance costs, the marginal cost is practically zero.

As generating capacity needs to exceed demand, there are multiple combinations of generators that could be used to provide electricity. In order to reduce the cost of this electricity, it is logical to meet demand with the cheapest generators available at the time, i.e., those with the lowest marginal cost. A list of generators in ascending order of marginal cost is known as a Merit Order. Generators will be called upon according to the Merit Order to meet national demand. The Merit Order can be viewed graphically as a dispatch model.

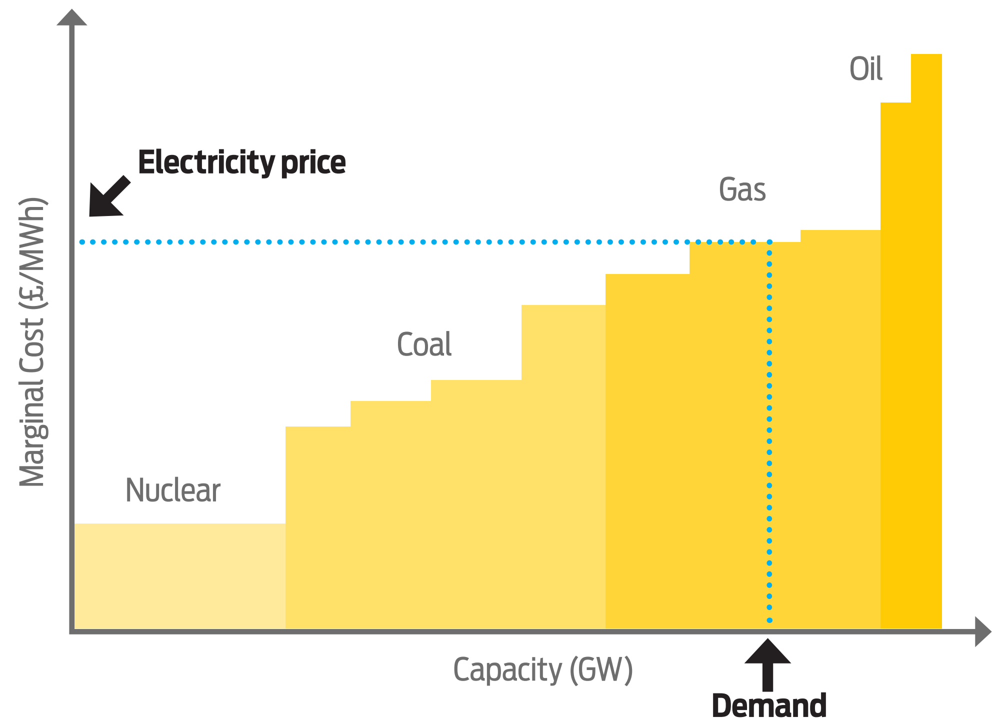

Figure 1: A dispatch model

The price received by all those generating is equal to the highest marginal cost of all them. This is because in a purely competitive market, equilibrium between supply and demand is met when price equals marginal cost.

13 https://www.gov.uk/ government/speeches/ levy-control-framework-cost-controls

Box 2 continued: Merit Order Effect

When they are generating, renewables enter the Merit Order at the very bottom (or furthest to the left on a dispatch model). This has the effect of pushing conventional sources of generation to the right on a dispatch model, thus lowering the highest marginal cost and therefore the overall price paid to all generators. This is known as the Merit Order Effect. The price paid to generators is the wholesale electricity price. Thus, the Merit Order Effect reduces the wholesale electricity price.

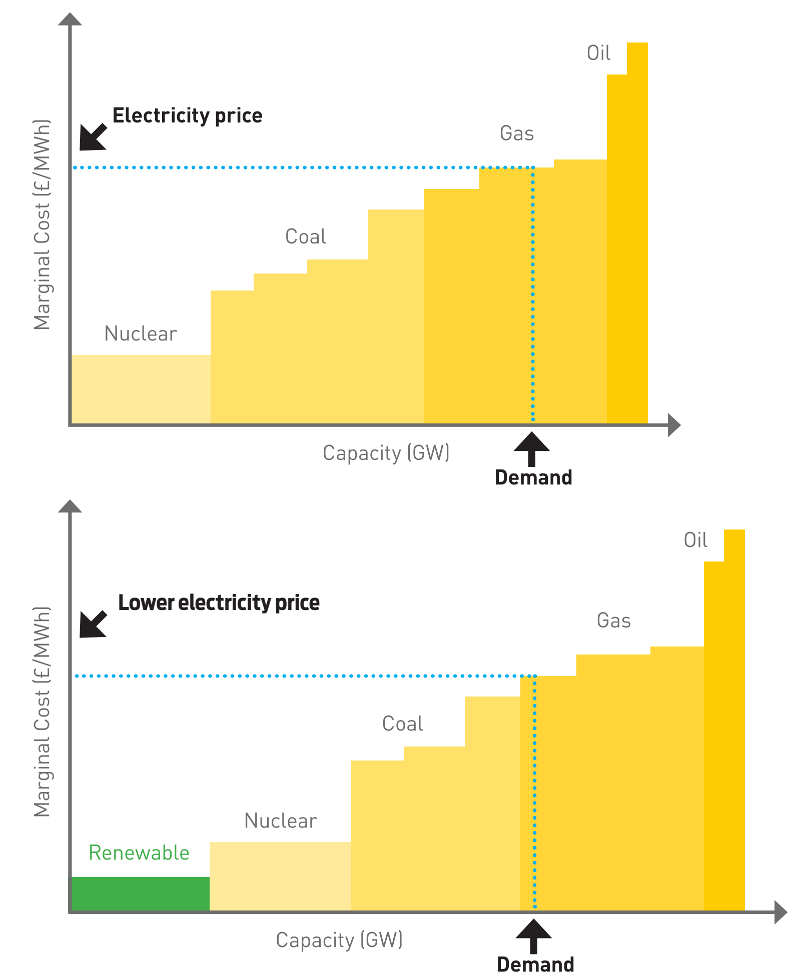

Figure 2: A dispatch model with and without renewables, demonstrating the Merit Order Effect

Not all electricity is bought on wholesale markets, instead being contracted months or years in advance at a fixed price via mechanisms such as Power Purchase Agreements (PPAs). As such, it is not immediately obvious how savings in the wholesale price will be passed through to the end user. However, even the prices paid through long term contracts (e.g. PPAs) will be based to some extent upon the wholesale price of electricity. Whilst savings may not be passed through immediately, the reduced wholesale price will impact when these instruments re-contract.

This report seeks to quantify the reduction in wholesale prices achieved by wind and solar as a result of the Merit Order Effect in 2014.

Methodology

To measure the value of the Merit Order Effect in 2014, this report repeats a methodology used by others[14]. By creating a dispatch model and using national demand data adjusted for wind and solar generation, it is possible to estimate what wholesale prices would have been had these technologies not been present.

A dispatch model was created by comparing historical demand to wholesale prices. Demand data was taken from the National Grid[15]. Wholesale price data uses Day Ahead Market prices from APX[16]. Prices were plotted against demand and a step curve of 'best-fit' overlaid to create a dispatch model. In doing so it was noted that there was a significant difference between prices in summer and winter. As such, two separate dispatch models were created.

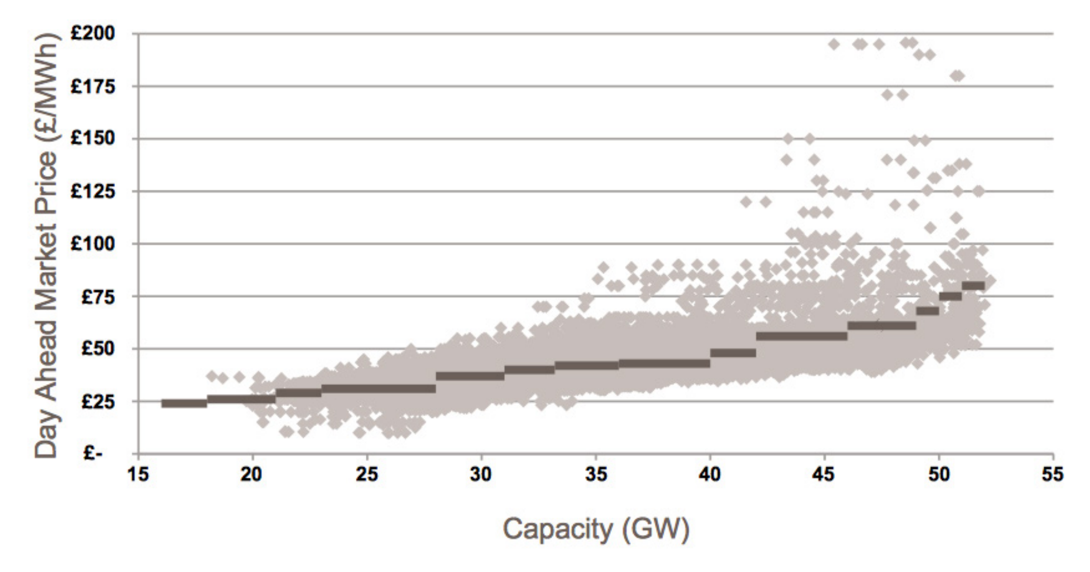

Figure 3: 2014 data with dispatch model overlaid

Using the dispatch model, it is now possible to simulate wholesale prices P given a specific demand D. The Merit Order Effect of a particular technology is the difference between the simulated electricity spending of a market without this technology and the observed spending for electricity consumed.

$$MOE = \sum (P_{simulated} - P_{observed}) \times D_{observed}$$

Dividing the total value of the Merit Order Effect by the generation of the technology provides another metric, the Merit Order Price (MOP). A Merit Order Price can be viewed as the amount of money that would be paid to a generator per unit of generation if all the benefit of the Merit Order Effect was to be returned to those who had caused it. Crucially, if the Merit Order Price is greater than the level of support provided to the generator per unit of generation, there is a net benefit to the consumer.

To estimate what national demand would have been without the presence of a specific technology, it is simply a case of adding the generation of that technology to the existing demand profile. Technology specific generation data was taken from Elexon[17]. This was then scaled up to match annual generation figures from DECC[18].

Box 3: Merit Order Effect of wind and solar in 2014

Generation type	Overall saving (MOE)	Mean MOP (£/MWh)
Solar	£150 million	£36.50
Total wind	£1,400 million	£43.50
Total solar and wind	**£1,550 million**	**£43.50**

In addition to exploring the past value of the Merit Order Effect, it is possible to estimate any future savings by running different demand profiles through the dispatch model. Technology specific generation is scaled up from the existing data to reflect increased deployment.

The 2014 Merit Order Effect values reflect average installed capacity of 12.1GW for wind and 4.1GW for solar. Installed capacity at the end of June 2015 stood at 13.7GW for wind and 8.2GW for solar[1].

Box 4: Estimated Merit Order Effect of wind and solar in 2015

Generation type	Overall saving (MOE)	Mean MOP (£/MWh)
Solar	£300 million	£36.00
Total wind	£1,600 million	£43.00
Total solar and wind	**£2,000 million**	**£43.00**

14 M. Carton et al., Quantitative Analysis of the Merit Order Effect from Photovoltaic Production in Italy, 2013

15 **http://www2.nationalgrid. com/uk/Industry-information/Electricity-transmission-operational-data/Data-Explorer/**

16 **https://www.apxgroup. com/market-results/apx-power-uk/ukpx-auction-historical-data/**

17 **https://www2.bmreports. com/bmrs/?q=actgenration/actualaggregated**

18 DECC, Digest of United Kingdom Energy Statistics 6.4, **https://www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes**

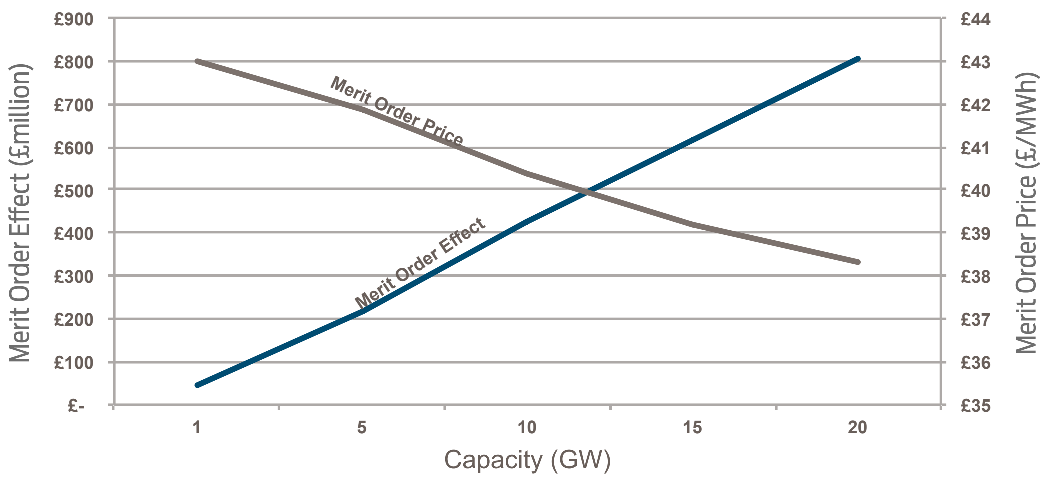

Figure 4: Forecast Merit Order Effect of solar at different installed capacities

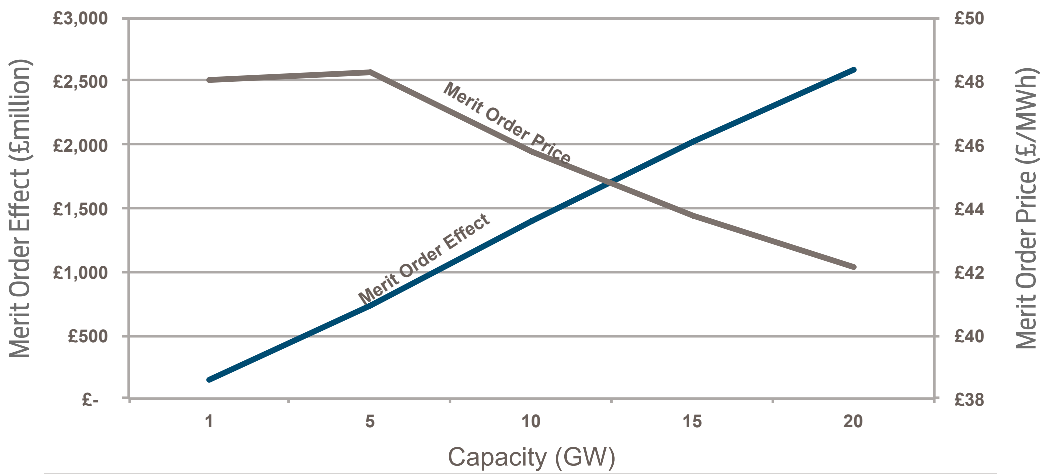

Figure 5: Forecast Merit Order Effect of wind at different installed capacities

Conclusion

This report aimed to quantify the reduction in wholesale prices achieved by wind and solar as a result of the Merit Order Effect in 2014. The report highlights the valuable contribution these technologies play in driving down consumer bills.

In 2014, it is estimated that wind and solar reduced the wholesale cost of electricity by £1.55 billion.

Box 5: Net cost of wind and solar in 2014

£m	Support (RO and FiT)19	MOE	Net cost
2014	2,668	1,550	**1,118**

The value of the Merit Order Effect will grow with increased deployment. The value in 2015 is estimated at £2 billion.

The report has highlighted the importance of viewing renewable support in 'net' terms. Subsidy schemes supporting renewable generation are paid for by consumers and increase bills. However, renewables also decrease bills by reducing the wholesale cost of electricity. When this is considered, the cost of supporting these schemes in 2014 was reduced by 58%.

Viewing renewable support in net terms may have a significant impact on the Levy Control Framework (LCF) – the mechanism designed to limit consumer spending on energy policies. Recent, dramatic policy changes have been driven by a projected future overspend of £1.5 billion under the LCF[13]. However, this report suggests such an overspend may not even exist.

The report also explored the value of the Merit Order Price for wind and solar – the reduction in overall electricity spending achieved for each additional unit of wind or solar generation. The report suggests that, if current Merit Order Prices are maintained, new large-scale renewable generation will deliver a net benefit to consumers[20].

19 See Annex

20 Based on the results of the first CFD auction, **https://www.gov.uk/government/statistics/cfd-auctionallocation-round-one-abreakdown-of-the-outcomeby-technology-year-andclearing-price**

Annex: Cost of wind and solar support in 2014

DECC data shows that in 2013/14 and 2014/15, 69.1% and 65.0% of ROCs issued were to wind or solar generators[7].

Combining with the cost of RO and FiT as shown in Box 1 gives an estimate for the cost of supporting just wind and solar. 99.8% of FiT installations support wind or solar[9], so this value has not been adjusted. Data is only made available for financial years. An estimate was made for 2014 by taking a weighted average of the 2013/14 and 2014/15 value (25% and 75% weighting respectively).

Box 6: Cost of supporting wind and solar generation in 2013/14, 2014/15 and 2014

£m	2013/14	2014/15	2014
Renewables Obligation (RO)	2,668	1,939	1,903
Feed in Tariff (FiT)	691	790	765
	2,485	**2,729**	**2,668**