The Economic and Environmental Effects of a Low Carbon Future

A report for Ecotricity

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1.2	20/04/15	Philip Summerton	Final report.
1.1	20/04/15	Philip Summerton	Draft report.

Contents

Executive Summary

Background

- In 2014, the European Commission announced its 2030 framework for Climate and Energy. The framework comprises a target for greenhouse gas emissions in 2030 to be 40% lower than 1990 levels and for renewables to make up at least a 27% share of the energy mix in that year. In addition to the EU targets, the UK's own 2008 Climate Change Act has put in place an ambition to reduce emissions by 80% in 2050 relative to 1990 levels.
- To meet these goals, renewables will become an increasingly important part of the energy mix. Investment in energy efficiency measures will also be required, in order to reduce emissions from households, industry and transport.
- In light of this, Cambridge Econometrics was commissioned by Ecotricity to assess the economic and environmental effects of a future with a high share of renewable sources of energy in the electricity generation mix and an ambitious transition to the use of electric vehicles in the UK.
- This report summarises the results from the analysis. Section 1 summarises current trends in fossil fuel expenditure in the UK. The methodological approach used to estimate the economic and environmental effects of a future with ambitious deployment of renewable technologies and electric vehicles is presented in Section 2. The effects on the economy and the environment are presented in Chapter 3 and Chapter 4 respectively.

Key messages

- Economy-wide expenditure on primary fuels (excl. tax) is over £50bn per year and, despite reductions in the volume of demand, high fossil fuel prices have led to an increase in nominal expenditure on primary fuels in recent years.
- Whilst UK production of oil and gas has declined by over 60% in the past 10 years, expenditure on fossil fuel imports has increased. Unless the pattern of energy consumption in the UK changes, further expected declines in UK oil and gas production will lead to greater dependency on fossil fuel imports in the future.
- A commitment to investment in low-carbon energy sources could significantly influence economic and environmental prospects for the UK. A high renewables future, in which 60% of electricity is sourced from wind energy, could lead to a £13bn increase in gross output by 2030, compared to a scenario in which no effort is made to decarbonise electricity generation.

- A rapid transition to the use of electric cars and vans in place of conventional powertrains could also increase domestic output in the motor vehicles sector and its supply chain by a further £30bn.
- Recent studies have found that the employment effects associated with the construction and manufacture of renewable technologies are in the range 5-20 job-years per MW installed. An ambitious renewables scenario could lead to the creation of 70,000 direct jobs in production of renewable technologies, and a further 80,000 jobs in the supply chain in a peak build year.
- In the motor vehicles sector and its supply chain, a future in which all cars and vans sold in the UK are electric by 2030 could lead to the creation of a further 50,000 jobs, due to an increase in advanced vehicle technologies and an expansion of the motor vehicles supply chain.
- Recent evidence from RenewableUK has suggested that the levelised cost for onshore wind could fall to £64-69/MWh by 2020 and for offshore wind, it could fall to £100/MWh in that year. If this rate of learning can be maintained, the levelised cost of new generating capacity in an ambitious renewables scenario could fall to £89/MWh in 2030, which is less than 3% higher than the levelised cost of new generating capacity in a scenario in which the generation mix continues to include high levels of gas and coal.
- A commitment to investment in renewable technologies over the next 10-20 years could lead to a fall in the carbon intensity of electricity to below 50 gCO_2/kWh and annual CO_2 emissions from electricity generation could be over 100 $MtCO_2$ lower than in 2013. A transition in which all new cars and vans sold in the UK are electric by 2030 could lead to further CO_2 savings, of around 40 $MtCO_2$ per year.
- The health benefits of the transition towards renewable energy sources and electric vehicles could also be substantial. The move to the Euro-6 vehicle emission standards coupled with further vehicle efficiency improvements and increased deployment of advanced electric powertrains could reduce the number of hospital admissions by over 3,500 in 2030, due to reductions in local air pollutants. The economic value of the health and environmental benefits over the period to 2030 is estimated at £1.25bn.

Reporting conventions

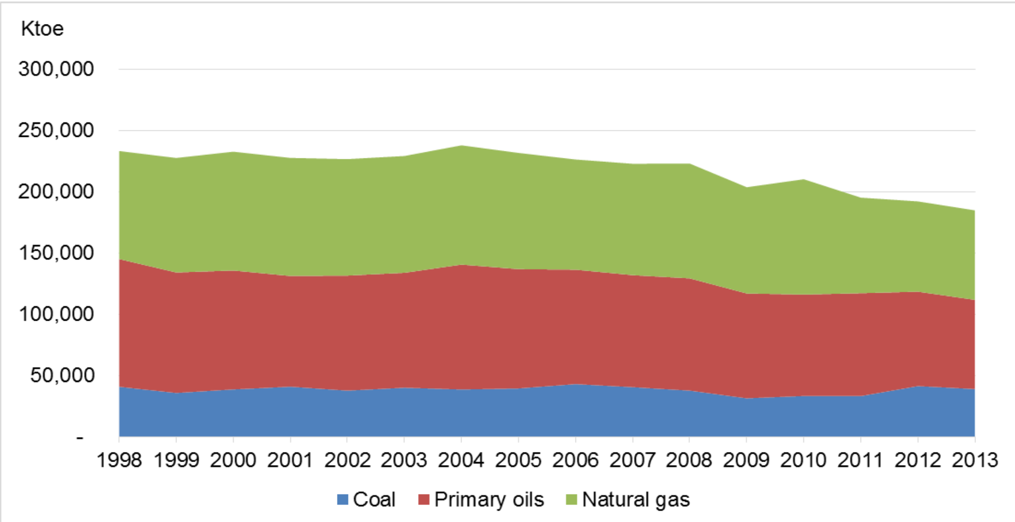
All monetary values referred to within this report have been converted to the 2012 price base, unless stated otherwise.

1 Total Expenditure on Fossil Fuels in the UK

1.1 Historical trends in the supply and consumption of fossil fuels in the UK

Fossil fuels are the dominant source of energy in the UK, accounting for around 86% of primary energy consumption in 2013[1]. Demand for fossil fuels has been falling since 2004 but, in recent years, demand has declined even more sharply. The recent reduction in demand for fossil fuels was initiated by a contraction in industrial output and consumer demand following the onset of the economic recession in 2009. Since then, the transition to renewable energy sources, in combination with energy-efficiency improvements in industry, households and transport, has led to further reductions in demand for fossil fuels.

Figure 1.1 Demand for fossil fuels in the UK



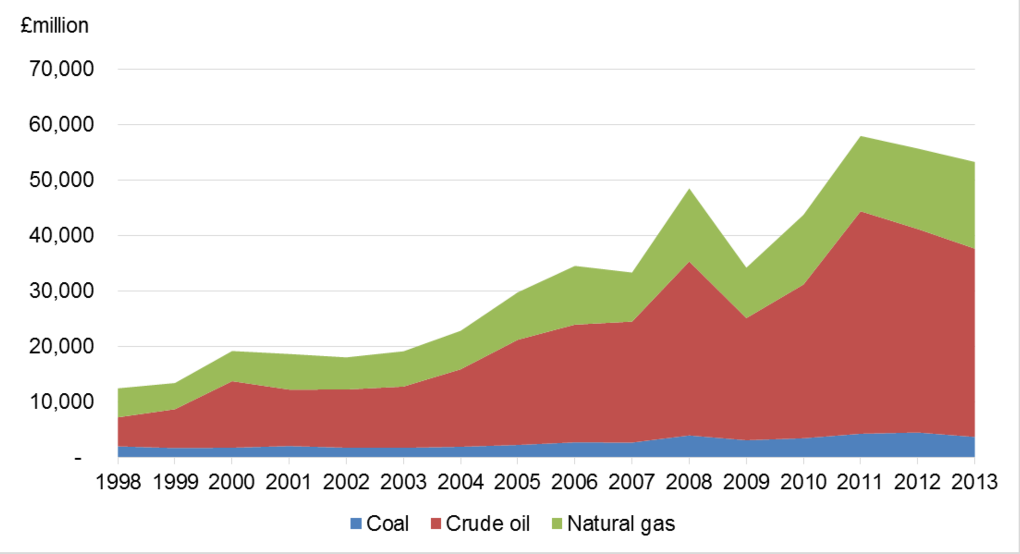
Source: DECC (2014), Digest of UK Energy Statistics.

Despite this fall in the volume of demand, rising oil and gas prices in recent years have led to an increase in economy-wide spending on fossil fuels over the same period. By 2013, the basic value of inland consumption of primary fuels reached £53bn. Including tax and margins, total expenditure on primary fuels was close to £70bn in 2013.

Figure 1.2 shows how total nominal expenditure on coal, oil, petroleum and natural gas has increased over the past decade.

[1] Most of the remaining 14% of primary energy was from low-carbon sources, such as nuclear and renewables. Source: DECC (2014), Digest of UK Energy Statistics.

Figure 1.2 Total nominal expenditure on primary fuels in the UK (net of tax)

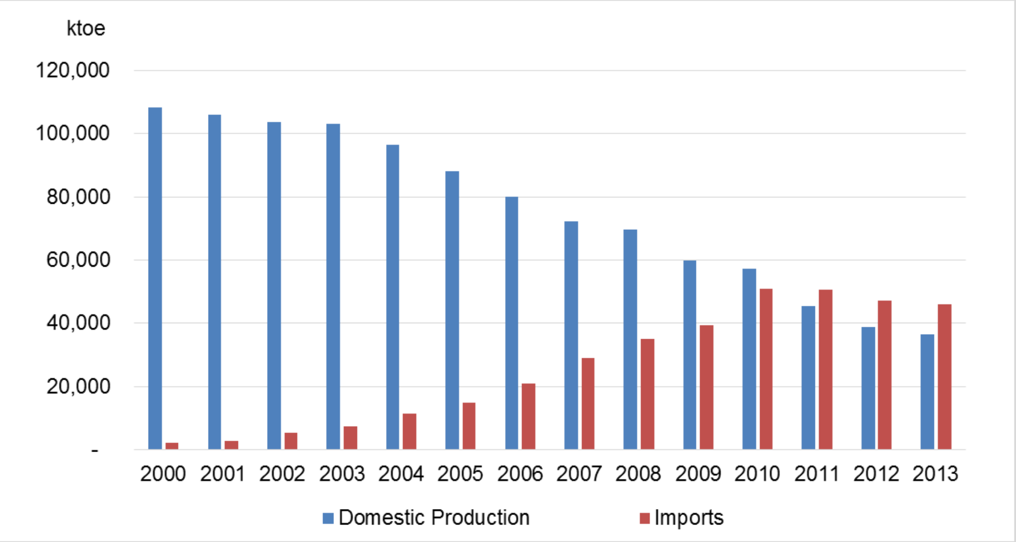


Source: DECC (2014), Digest of UK Energy Statistics.

The UK is becoming increasingly reliant on imports of fossil fuels

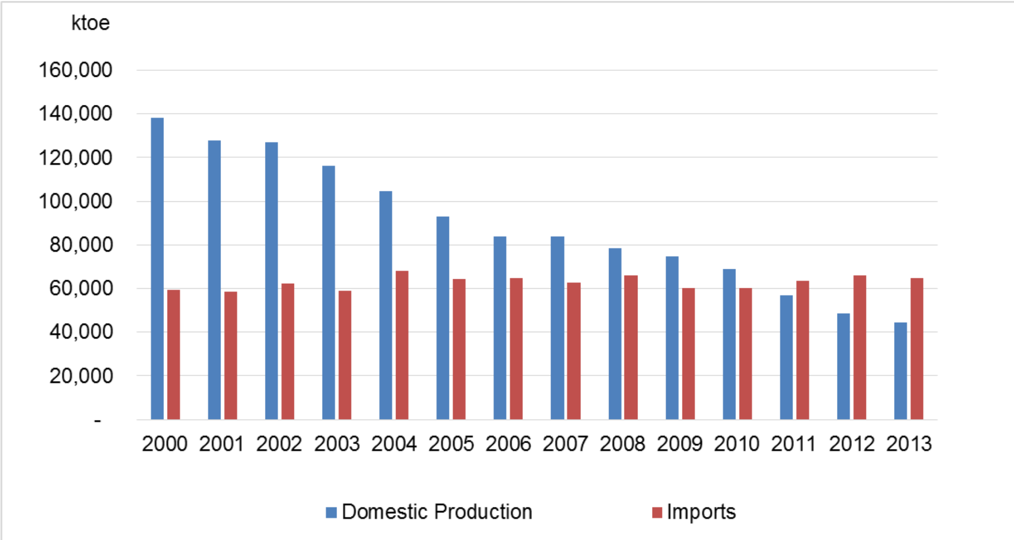
The gradual fall in the volume of fossil fuel consumption in the UK in recent years (as shown in in Figure 1.1), has been outstripped by a faster decline in domestic oil and gas production. This has led to an increasing reliance on fossil fuel imports in the UK. Since 2011, imports of natural gas, oil and coal have continued to surpass domestic production of these fuels. By 2013, imports of natural gas and crude oil reached £30bn and £11bn, respectively. Figure 1.3 and Figure 1.4 below show recent trends in domestic production and imports of oil and gas to the UK.

Figure 1.3 Domestic production and imports of natural gas to the UK



Source: DECC (2014), Digest of UK Energy Statistics.

Figure 1.4 Domestic production and imports of crude oil to the UK



Source: DECC (2014), Digest of UK Energy Statistics.

The UK's import dependency is likely to be exacerbated if the recent fall in the oil and gas price continues, damaging the balance sheets of firms in the oil and gas industry, and forcing some, unprofitable, oil and gas wells in the UK to close. The UK government has projected a 55%[2] decline in UK oil and gas production over the next 15 years and, if we continue on the current path, this will lead to much greater import dependence in the future.

…but total expenditure on fossil fuels has risen over the same period

Expenditure on fossil fuel imports is effectively money following out of the UK economy. If the technology costs are not too prohibitive, the transition towards alternative sources of electricity generation, that have a higher share of their supply chain located domestically, is likely to bring economic benefits for the UK.

Furthermore, despite economic benefits arising from recent falls in the global price of gas and oil, there is considerable uncertainty about how long these low prices will last. Oil and gas prices are inherently volatile and this uncertainty can have adverse effects on business and consumer confidence and on the wider economy.

1.2 Fossil fuel consumption in different sectors of the UK economy

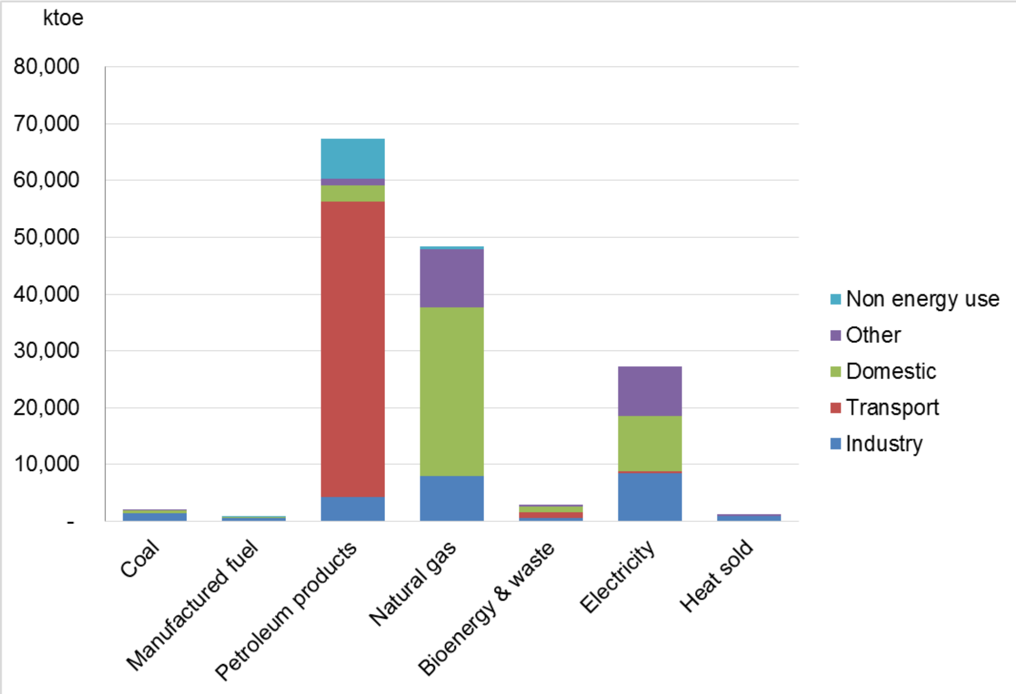
Different sectors of the economy have very different energy needs. In the last thirty years, the UK electricity sector has evolved from a system dependent on coal and gas to a system with an increasing amount of low carbon generation sources. The emissions standards in place due to the European Large Combustion Plant Directive (and subsequent Industrial Emissions Directive) is likely to lead to a gradual phase out of coal-fired power generation over the next decade. This policy effect, coupled with Contracts for Difference, which

[2] Source: DECC (2015), 'UKCS Oil and Gas Production Projections'. Available online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/414172/Production_prjections.pdf

aims to reduce risk for investors in low-carbon electricity technologies, is likely to lead to an increase in renewable capacity in the future.

Figure 1.5 shows dependence on fossil fuels by final users. Whilst demand for petroleum is overwhelmingly derived from the transport sector, widespread deployment of electric vehicles over the period to 2030 could substantially reduce this demand. Domestic users consume the greatest volumes of gas, accounting for around 60% of final gas consumption, with industry and service sectors each accounting for 20% of final demand for gas. Energy efficiency measures have the potential to reduce gas demand from all final user groups.

Figure 1.5 Final energy consumption in the UK, 2013



Source: DECC (2014), Digest of UK Energy Statistics.

2 Analytical Approach

2.1 Future energy scenarios

Overview of energy scenarios

To model the economic and environmental effects of replacing fossil fuels with renewables, we constructed a High Ambition scenario, which combined a high share of renewable sources of electricity generation and ambitious take-up of electric vehicles in the period to 2030.

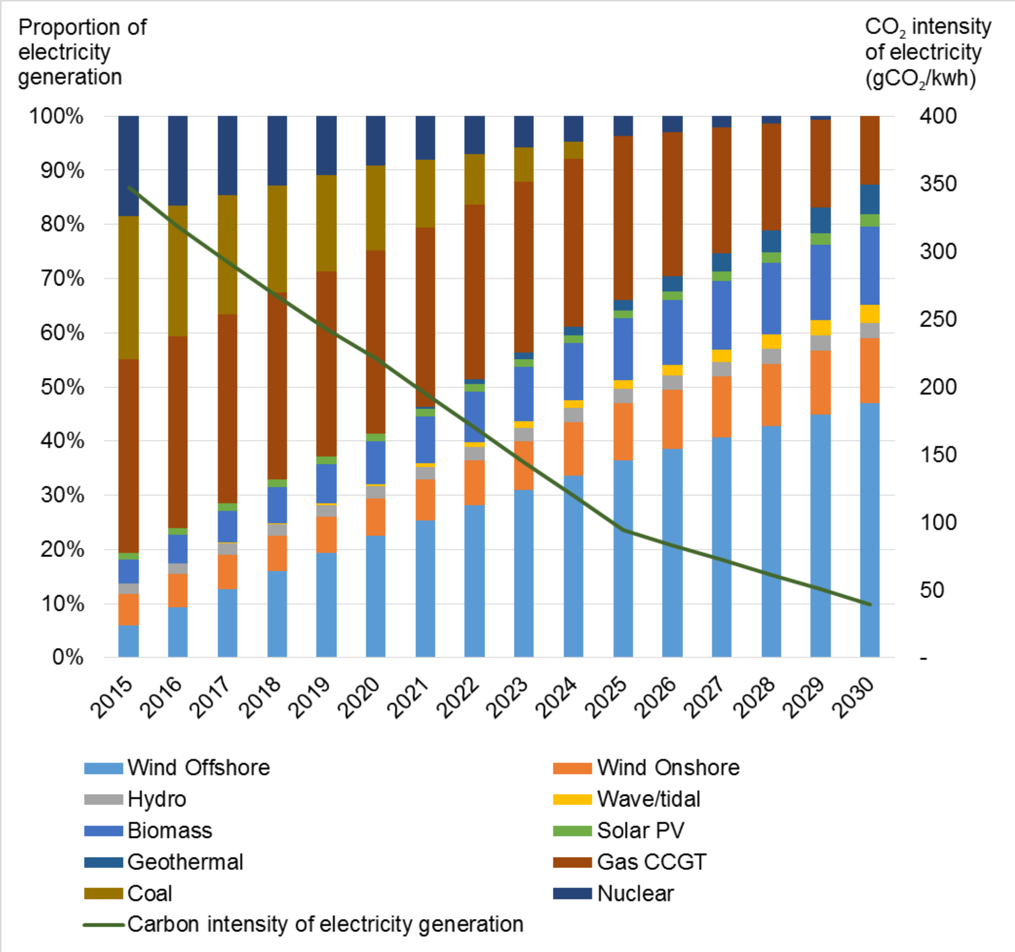
The power sector

The mix of electricity-generating technologies in this scenario was based on the C1 'stretch' scenario from a study by Garrad Hassan[3]. In this scenario, renewables account for 87% of generation by 2030, compared to 19% in 2014[4]. To deal with the intermittency of some renewable sources of energy, there is substantial investment in interconnection, as well as some gas-fired CCGT capacity, which is used as back-up. The additional interconnection capacity also allows for the export of surplus electricity generated by renewables in this scenario. Figure 2.1 below shows the share of different technologies in the electricity generation mix in the High Ambition scenario.

[3] Garrad Hassan (2011), 'UK Generation and Demand Scenarios for 2030'. Note that this scenario has been adjusted slightly in this analysis, for example, to take account of more recent capacity and generation data.

[4] Provisional figure. Source: DECC (2015), 'Energy Trends'

Figure 2.1 Shares of different technologies in the electricity generation mix

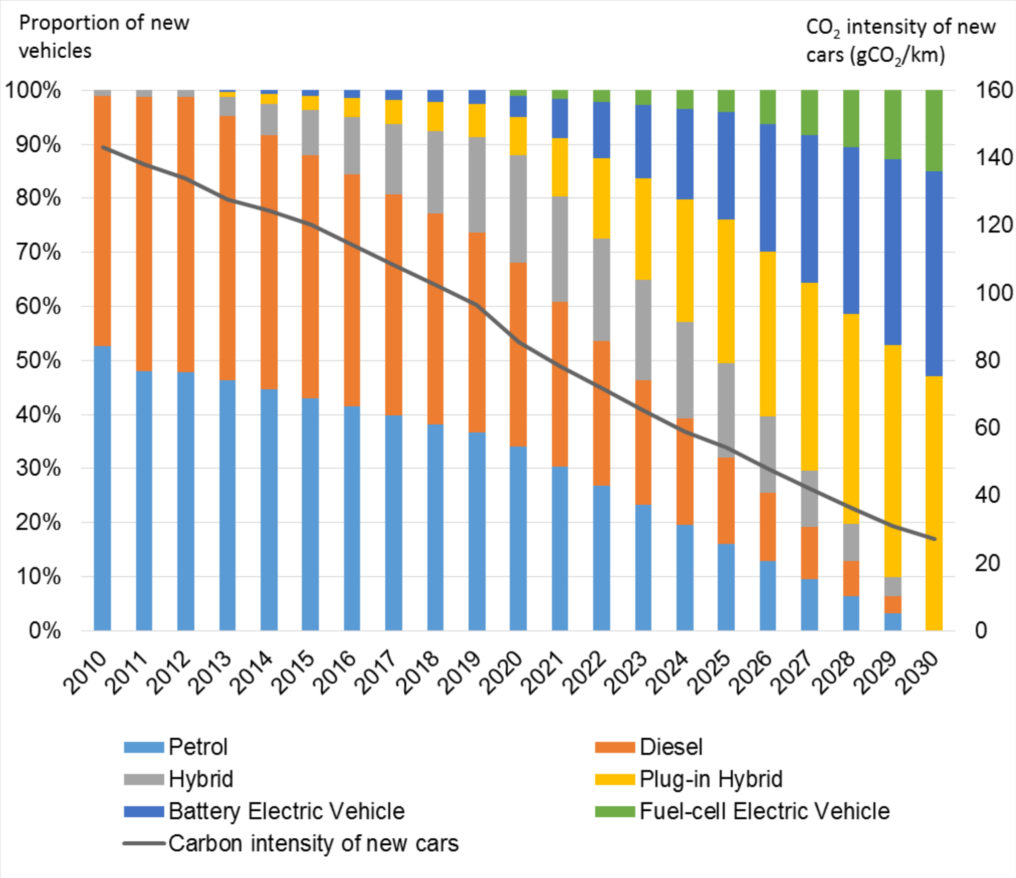


By 2030, around 60% of electricity is generated by offshore and onshore wind. A further 14% is from biomass plants and 13% from other renewable technologies (including solar PV, wave/tidal and hydropower). The high share of renewables in the power sector, complete phasing-out of coal-fired power generation and gradual decline in gas-fired CCGT leads to significant emissions savings. The carbon-intensity of electricity generation falls from 360 gCO_2/kWh today, to under 50 gCO_2/kWh in 2030.

Light-duty vehicles In addition to a low-carbon power sector, the High Ambition scenario includes a high share of electric cars and vans in the vehicle fleet. We assume that the share of electric vehicles in the vehicle sales mix grows rapidly over the next 15 years and, by 2030, all new cars and vans sold in the UK are plug-in electric or fully electric. Over time these vehicles account for an increasingly high proportion of the vehicle stock and the scenario is indicative of a future where all light-duty vehicles on the road are electric by 2050.

Figure 2.2 below shows the characteristics of new passenger car sales. We assume a similar level of electrification of vans over the same period.

Figure 2.2 Characteristics of new passenger car sales



Average tailpipe CO_2 emissions of new car sales surpass the EU target of 95 gCO_2/km in 2021 and continue to fall to under 30 gCO_2/km by 2030 because of the rapid electrification of new cars. In addition, the high renewable content in the power sector means that the 'well-to-wheel' CO_2 emissions of cars are also very low at 33 gCO_2/km.

2.2 Estimating the economic effects of renewables

Estimating the economic effects of an increase in renewable capacity in the power sector

To estimate the gross economic effects of a high share of renewables in the power sector on economic output requires assumptions about:

- the cost of the power-sector technologies and how these costs are likely to change over the period to 2030
- the proportion of each technology's supply chain that is located in the UK
- the size of the multiplier effect

The first two of these assumptions are used to calculate the direct effects of increasing renewables capacity on those industries that manufacture, construct and install the technologies. The multiplier effect is used to model how a demand stimulus in a particular sector would lead to further increases in demand and economic output in the sectors that supply that sector. For example, the direct effect of an increase in offshore wind capacity would include an increase in output in the wind-turbine manufacturing sector. This, in turn, would lead to an increase in demand for steel and electrical components and so output (and employment) in these industries would also increase. This is known as the indirect effect. Some modelling methodologies quantify an induced effect, whereby the additional direct and indirect employment leads to an increase in incomes and consumer expenditure and, as a result, further increases in output. These induced effects are not included within this analysis.

(**Fixed Capital Costs × New Capacity Installed** + **Variable Costs × Electricity Generation**) × **Share of Domestic Production vs. Imports** = **Direct Output Effect**

Direct Output Effect × **Output Multiplier** = **Total Direct and Indirect Effect**

Input-output tables are the framework for modelling inter-industry purchases and it is from these tables that the multiplier effects are derived. The multiplier effects for this analysis were adjusted to take account of the characteristics of the capital cost for each generating technology.

Estimating employment effects

The employment effects were calculated using estimates of job-years per MW for each generating technology from UKERC (2014)[5] and Wei et al. (2010)[6]. To convert these figures into jobs, they were divided by the construction

5 UKERC (2014), Low Carbon Jobs

6 Wei et al. (2010), Putting Renewables and Energy Efficiency to Work: How Many Jobs can the Clean Energy Industry Generate in the US?

period for each technology. This allowed us to model the employment effects dynamically, taking into account the fact that many of the direct jobs relating to an increase in generating capacity are short-term jobs in the construction and manufacturing sectors, typically lasting 2-3 years.

For each generating technology we then applied an employment multiplier to estimate the indirect effects. Again, where sufficient data was available, these employment multipliers were tailored for each technology.

Estimating the economic effects of increasing deployment of electric vehicles

Purchasing an electric vehicle instead of a conventional petrol or diesel car involves a transfer of expenditure. Less money is spent on fuel and more money is spent on the upfront capital cost of the car. The effects of this transfer of expenditure on the UK economy is largely dependent on the location and labour-intensity of the respective supply chains.

An increase in sales of more fuel-efficient electric vehicles and plug-in hybrids leads to an increase in demand for advanced motor vehicle technologies, such as vehicle batteries, electrical components and charging posts. This will create an economic stimulus within the motor vehicles sector and its supply chain. More companies will start producing these technologies and, in doing so, they will need to increase the size of their labour force, which will lead to the creation of new jobs.

To estimate the direct effects on economic output, we calculated the increase in expenditure on the upfront capital cost of cars and vans in the High Ambition scenario, and multiplied this by an estimated 51% share of domestic production (based on the latest data available for 2013). Direct employment effects were then calculated based on the historical labour-intensity of the motor vehicles industry.

We used multipliers to estimate the effects on output and employment in the supply-chain for the motor vehicles industry. The economic effects of the transition to more technologically advanced electric vehicles are particularly high, because the multiplier effects for the motor vehicles industry is relatively large. For each direct job created, another 1.3 jobs are created in the motor vehicles supply chain.

It is to be noted that we did not include estimates of the economic effects of the investment in electric vehicle charging infrastructure and in hydrogen production facilities. We also did not take account of the potential synergies between the electricity grid and electric vehicles. Recent analysis has shown that smart charging can support the electricity grid by storing electricity generated by renewables at times of peak supply and then smoothing out the spikes in electricity demand at certain times of the day, and the value of this is estimated to be in the region of £800 million annually.[7]

2.3 Estimating environmental effects

Estimating the effects on emissions from the power sector

Estimating the effects of the renewables transition on greenhouse gas emissions in the power sector requires assumptions about:

[7] Source: Cambridge Econometrics et al. (2015). 'Fuelling Britain's Future'.

- the fuel efficiency of fuel-based generating technologies i.e. how much fuel input is required for a given level of electricity output
- the emissions coefficients for each fossil fuel

For this analysis we assume that, by 2030, the efficiency of coal and gas CCGT generation are 45% and 59%, respectively. We assume that the CO_2 intensity of gas fuel is 184 gCO_2/kWh and the CO_2 intensity of coal is 333 gCO_2/kWh.

Estimating the effects on emissions from the power sector

For passenger cars and vans, we used a vehicle stock model, to model vehicle sales and stock by type of vehicle. We made assumptions on the annual distance travelled and the fuel-efficiency of different representative vehicle types. This then allowed us to calculate the carbon intensity of the vehicle stock.

2.4 Key assumptions and data sources

Key data sources used to inform technical assumptions in the spreadsheet model are outlined below. More detailed assumptions are reported in the annexes to this report.

The cost of electricity generating technologies

As far as possible, we used estimates provided by DECC for the capital cost of the different electricity generating technologies and learning rates from Arup (2011)[8] and the IEA Blue Map. For onshore and offshore wind, we included an additional sensitivity, with higher learning, based on Renewable UK's latest Cost Reduction Task Force reports.[9][10] Fossil fuel prices were taken from DECC (2014)[11] and additional sensitivities were run on DECC's low and high price variants.

Technical assumptions for motor vehicles

The cost of vehicle technologies were taken from Cambridge Econometric et al. (2013)[12]. We assumed the total number of vehicles sold each year remained constant over the period to 2030 and assumed that the average distance travelled also remained constant over this period, at 12,500km per annum.

Assumptions about output and employment

The employment effects associated with different power sector technologies were based on estimates from studies by UKERC (2014)[13] and Wei et al. (2010)[14]. For the motor vehicles sector, the labour-intensity and import share of production was based on the latest 2013 data from ONS.

For the motor vehicles sector, and for each electricity generating technology, multiplier effects were calculated based on the ONS input-output tables (2010)

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[8] Arup (2011), Review of the Generation Costs and Deployment Potential of Renewable Electricity Technologies in the UK

[9] Renewable UK (2015), Onshore Wind Cost Reduction Taskforce Report

[10] Renewable UK (2015), Offshore Wind Cost Reduction Taskforce Report

[11] DECC (2014), DECC Fossil Fuel Price Projections

[12] Cambridge Econometrics et al (2013), Fuelling Europe's Future

[13] UKERC (2014), Low Carbon Jobs

[14] Wei et al. (2010), Putting Renewables and Energy Efficiency to Work: How Many Jobs can the Clean Energy Industry Generate in the US?

and assumptions on the breakdown of capital costs from the Political Economy Research Institute (2009)[15].

2.5 Limitations of our analysis

The estimates presented in this report, of the economic and environmental effects of a scenario with a high share of renewable technologies and electric vehicles, are based on a simple spreadsheet model. For each technology included in the model there are assumptions about its labour intensity, the domestic content of the supply chain, and the associated multiplier effects. The labour intensity and domestic content assumptions are technology-specific and based on recent literature and peer reviewed studies. Where possible, we also tailored the multiplier effect by technology, but inadequate cost data meant that this was not always feasible.

The key limitation of this analysis, however, is that we only considered the gross effects of the transition to renewables and electric vehicles. As we only quantified the direct and indirect effects in the technology sectors and their supply chain, we exclude any potential induced effects as a result of the low-carbon transition. These induced effects include the macroeconomic outcomes associated with an increase in the level of employment (which would lead to increases in income and spending, increases in income tax receipts and reductions in unemployment benefit payments) and the effects of higher vehicle and electricity prices (which will have the opposite effect, lowering disposable incomes and consumer expenditure). Thus, our results are not reflective of the net macroeconomic effects of the low-carbon transition, but provide an indication of the likely output and employment effects within specific sectors and their supply chains.

[15] Political Economy Research Institute (2009), The Economic Benefits of Investing in Clean Energy

3 Economic Effects

This section of the report presents our analysis of the effects of the transition towards renewables and electric vehicles on economic output and employment.

3.1 The economic effects of replacing fossil fuel-based power generation with renewable sources

The High Ambition scenario is characterised by a high share of onshore and offshore wind, which accounts for around 60% of total electricity generation by 2030. The effect of the transition to renewable technologies on output and employment, however, is crucially dependent on the proportion of the supply chain that is located within the UK, the labour-intensity of the supply chain, and the rate of productivity improvements, or 'learning'. Table 3.1 below shows key results for the onshore and offshore wind sectors under different learning rate assumptions in 2028, which was a peak year for building new wind generating capacity.

Table 3.1: Economic effects of an increase in onshore and offshore wind generation under 'low' and 'high' learning rate assumptions.

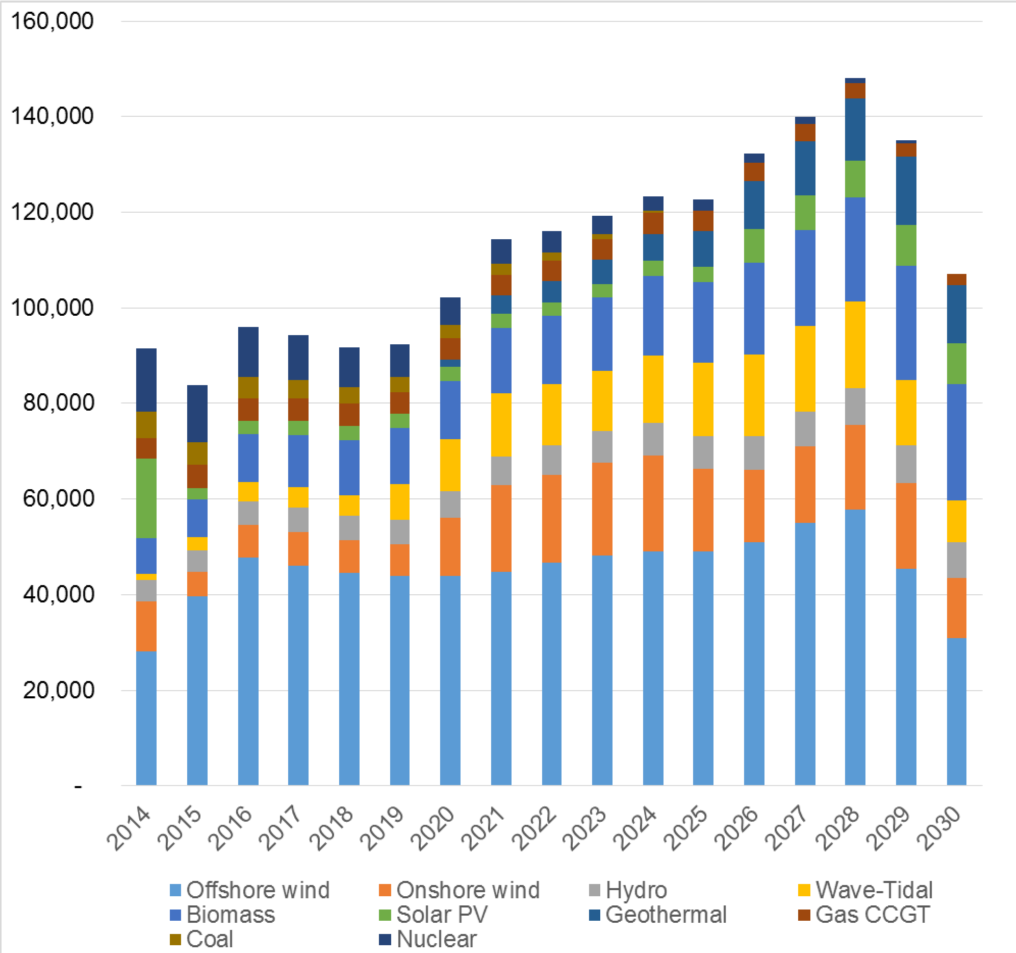
	2028			
	Offshore wind		Onshore Wind	
Capacity (GW)	43.2		15.7	
Generation (TWh)	143.8		38.4	
Load Factor (%)	38%		28%	
Learning rate (cost reduction per doubling of cumulative capacity)	12%	20%	7%	20%
Output multiplier	1.8	1.8	1.8	1.8
Employment multiplier	2.2	2.2	2.2	2.2
Direct output	6,385	5,247	924	793
Total direct and indirect output	11,449	9,408	1,657	1,421
Direct jobs (FTE)	26,386	19,335	8,072	5,796
Total direct and indirect jobs (FTE)	57,738	42,309	17,663	12,683
Levelised cost	107.7	79.0	78.2	56.9

Source: Cambridge Econometrics.
Note: Figures do not always appear to add up in this table due to rounding.

Effects on jobs

Figure 3.1 below shows the effects of the High Ambition scenario on employment in the electricity generation sector and its supply chain, under an assumption of a 12% and 7% learning rates for offshore and onshore wind, respectively. In 2028, the peak year for building new renewable generating capacity, there are 150,000 direct and indirect jobs created in the renewables sector, of which around 30,000 jobs are created in the wind sector and a further 40,000 in its supply chain.

Figure 3.1 Jobs in the electricity sector and its supply chain under the High Ambition scenario (low learning rate assumptions)



Effects on electricity costs

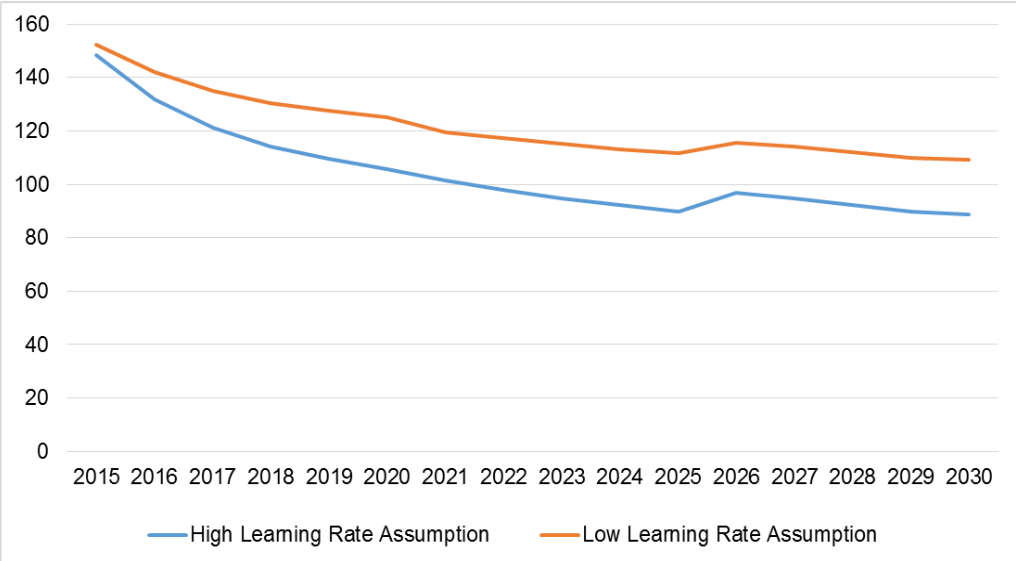
The effects of the High Ambition scenario on the levelised cost of electricity is highly dependent on the assumptions about learning and productivity improvements for each technology. For most technologies, we based the learning rate assumption on those referenced in Arup (2011)[16] and the IEA Blue Map. However, recent evidence from Renewable UK suggests that more

[16] Arup (2011), Review of the Generation Costs and Deployment Potential of Renewable Electricity Technologies in the UK

substantial cost savings could be realised for onshore and offshore wind. The estimates on potential future cost savings for onshore and offshore wind are used as a sensitivity on the learning rate. Under the learning rate assumptions based on Arup (2011), the levelised cost of new electricity generating capacity is £109/kWh by 2030.

However, higher productivity improvements, similar to those implied in the Renewable UK reports, would lead to an average levelised cost of new generating capacity of under £90/MWh, which is cost-competitive with gas generation under central DECC gas price assumptions.

Figure 3.2 The levelised cost of new electricity generating capacity in the High Ambition scenario under different learning rate sensitivities (£/MWh)



Higher electricity costs would impact negatively on the economy by increasing production costs for industry. This would potentially reduce the UK's competitive position in international markets, which would worsen the UK's balance of trade. Furthermore, higher electricity prices would reduce consumers' disposable income, leading to a reduction in consumer expenditure.

Effect on fossil fuel expenditure

Provisional data for 2014 from DECC[17] suggests that total expenditure on coal and gas for electricity generation was around £5.5bn. This reflects a slight fall on the previous year, due to lower fossil fuel prices and a higher proportion of electricity generation from alternative energy sources. A concerted effort to decarbonise the power sector could lead to fossil fuel savings of £3.9bn annually by 2030, relative to 2014 figures.

3.2 The economic effects of ambitious deployment of electric vehicles

Effect on economic output and employment

More sophisticated technologies installed in new vehicles in the High Ambition scenario leads to an increase in the average cost of new vehicles and an increase in real output in the motor vehicles sector and its supply chain. By

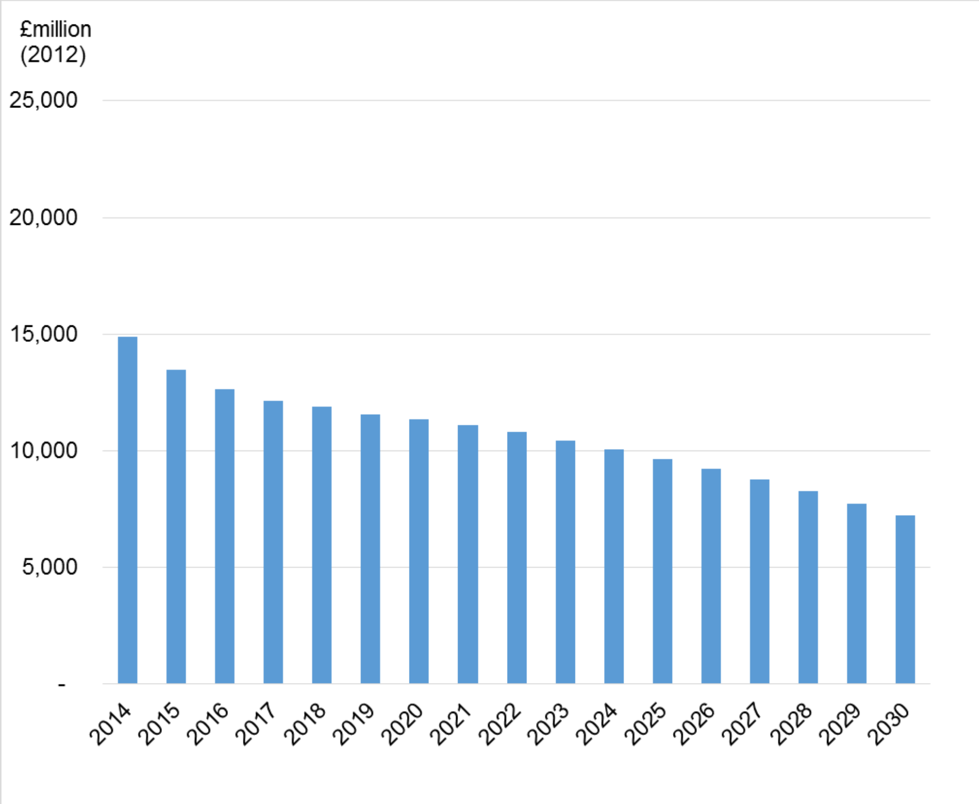
[17] DECC (2015), 'Energy Trends' and DECC (2014) 'Fossil Fuel Price Projections'

2030, there is an £8bn annual increase in economic output in the motor vehicles sector and a further £7bn increase in output in this sector's supply chain. This translates to an additional 50,000 direct and indirect jobs, relative to a scenario in which there are no further improvements to the efficiency of new vehicles.

Effect on expenditure vehicle fuel bills

The High Ambition scenario also leads to a substantial reduction in expenditure on petroleum, as shown in Figure 3.3. By 2030, the total fuel bill savings relative to 2014 are £7.8bn (excluding tax and fuel duty). If tax and fuel duty is included, these fuel bill savings are equivalent to £17.5bn. The increase in volume of electricity demanded is much smaller, because the power ratio for a battery is much greater than that of an internal combustion engine.

Figure 3.3 Expenditure on petroleum by cars and vans in the High Ambition scenario (excluding tax and fuel duty)



This reduction in demand for petroleum translates to substantial vehicle savings in the cost of fuelling cars and vans. After taking account of the reduction in petroleum demand and increase in demand for electricity, annual fuel bills will fall from £1,190 in 2014 to £560 by 2030 for the average car owner in the UK: a saving of £630 per annum.

4 Environmental Effects

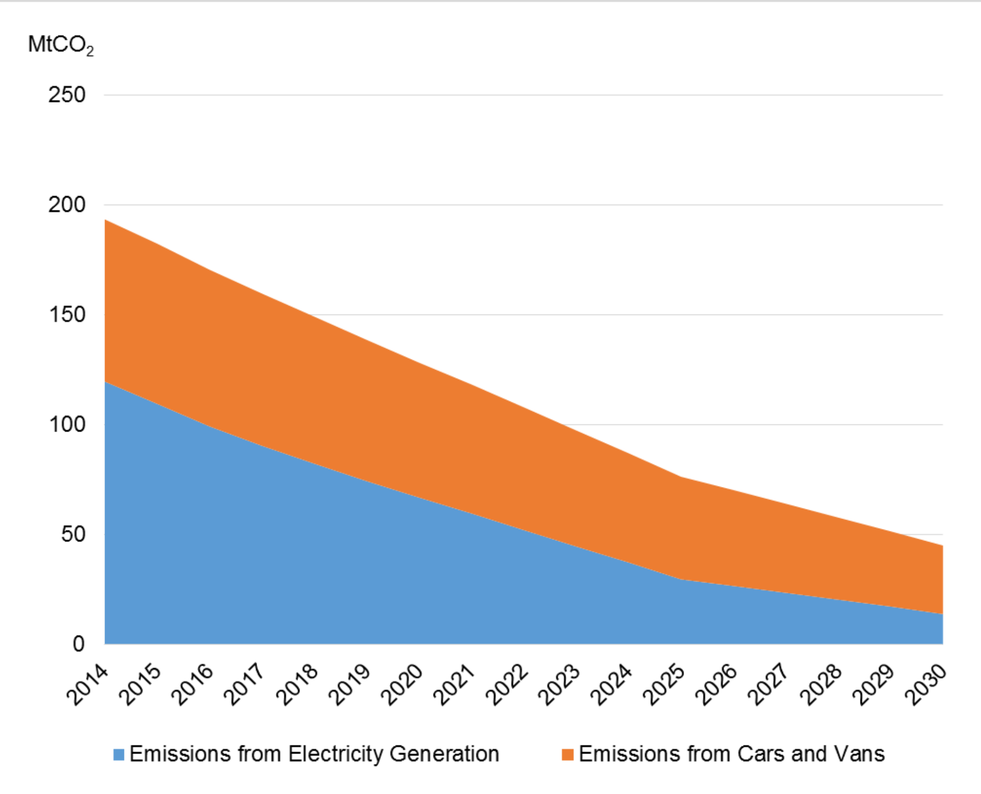
Overall we find that, by 2030, the High Ambition scenario would save 133 $MtCO_2$ annually, relative to a scenario in which there is no change in the mix of power sector technologies and no improvement in the efficiency of cars and vans. Of this total saving, around 94 $MtCO_2$ is due to the transition to renewable technologies in the power sector, and the remaining 39 $MtCO_2$ saving is due to the transition towards advanced electric powertrains in the passenger car and van market.

4.1 CO_2 Emissions

The potential reduction in CO_2 emissions resulting from decarbonisation of electricity generation and passenger road transport is substantial. In the High Ambition scenario, the carbon intensity of electricity falls to 27 g/kWh by 2030 and annual power sector emissions fall to 14 $MtCO_2$, compared to 147 $MtCO_{2e}$ in 2013. Electricity demand increases by 9.2TWh due to the additional demand from electric vehicles but, as there is a high share of renewables in the power sector, this only increases net greenhouse gas emissions by 0.35 $MtCO_2$. Furthermore, by investing in renewable technologies in the power sector, the UK will be locked-in to cleaner electricity generation sources in the future. A commitment to reducing emissions in the period up to 2030 will also bring economic and environmental benefits to future generations.

Figure 4.1 below shows CO_2 emissions from electricity generation and from cars and vans in the High Ambition scenario over the period to 2030.

Figure 4.1 CO_2 emissions in the High Ambition scenario



4.2 Particulate Matter (PMs)

Particulate Matter (PMs) are tiny solid or liquid particles suspended in the air. A number of studies have shown that particulates can have adverse effects on human health, contributing to, or worsening, the effects of heart and lung conditions. The main sources of particulates in the UK are emissions from coal-fired power plants and diesel-fuelled transport. Particulate matter emitted from road transport can have particularly damaging effects in large towns and cities: high inner-city traffic flows can lead to very high concentrations of this pollutant, in areas in which there is also a high population density. The transition to cleaner energy sources in the power sector and road transport sector has the potential to reduce emissions of particulates and improve health outcomes.

In the High Ambition scenario, we find that particulates emitted by cars and vans would fall by over 90% between 2015 and 2030. The complete phase-out of coal-fired power generation and replacement with renewable technologies would eliminate power sector sources of particulates.

4.3 Nitrogen oxides (NOx)

Nitrogen oxides are also potentially harmful for human health. Around 220,000 tonnes of nitrogen oxides are emitted from cars and vans in the UK each year. In the High Ambition scenario, by 2030 electric powertrains make up 45% of the vehicle stock and the annual level of nitrogen oxide emissions from cars and vans falls by 88% to 27,000 tonnes.

4.4 Health and environmental impacts

The effects of particulates and nitrogen oxides on human health include increasing the risk of cardiovascular diseases and worsening the symptoms of respiratory conditions, such as asthma.

Over the period 2015-2030, the cumulative reduction in NOx and PM's due to the electrification of passenger transport would be 1,177,000 tonnes and 34,000 tonnes, respectively. Based on estimates by Defra (2011)[18] of the effects of local air pollutants on hospital admissions for respiratory and cardiovascular diseases, we calculate that, by 2030, this would lead to 3,518 fewer hospital admissions per year.

The UK government has also estimated the total damage costs associated with local air pollutants. The damage costs put a value on the combined health impacts (due to increases in hospital admissions and life-years lost) and environmental impacts (due to damage to materials and buildings). Taking these costs into consideration, the net economic benefit of increasing electrification of cars and vans is £1.25bn over the period to 2030.[19]

[18] Defra (2011), Air Quality Appraisal – Damage Cost Methodology

[19] It is important to note that, even in a scenario where there no improvements to the efficiency of new vehicles, the effects of the Euro 6 standards for new vehicles' emissions leads to a substantial reduction in local air pollutants, as the older, dirtier cars and vans begin to retire from the vehicle stock.

5 Conclusions

In conclusion, it is evident that a commitment to a low-carbon future could lead to substantial growth opportunities in the renewables and motor vehicles sectors and their supply chains. Around 150,000 jobs could be created in the power sector and associated supply chains, with a further 50,000 jobs relating to the motor vehicles industry.

When interpreting the economic results, however, it is important to note that our analysis has only considered the gross effects of the low-carbon transition in the electricity and transport sectors. As we have only considered the sectors that are directly or indirectly affected by this transition, potential induced effects have been excluded. It is unclear whether the net induced effect would be positive or negative. It could be positive, due to the income effects of an increase in employment in the High Ambition scenario, or negative, due to an increases in vehicle and electricity costs. Furthermore, as we have not taken account of the effects on government tax revenues (for example, due to changes in fuel duty and income tax revenue) we ignore another important factor that could affect the net macroeconomic outcome.

There are now a number of studies that suggest that after induced effects are taken into consideration, the net macroeconomic impact of the transition to a low carbon future is positive. Cambridge Econometrics et al (2015)[20] found that in an ambitious electric vehicles scenario and under the assumption that any loss of fuel duty is directly compensated for by an increase in VAT, the transition to electric vehicles would lead to a £2.4bn -£5bn increase in GDP by 2030 and the creation of 7,000-19,000 net jobs. Cambridge Econometrics et al (2012, 2014)[21][22] has also shown that, despite leading to slightly higher electricity prices, investment in renewable technologies in the power sector brings about net macroeconomic benefits due to a transfer of expenditure away from fossil fuel imports and towards investment in domestic industries.

[20] Cambridge Econometrics et al (2015), Fuelling Britain's Future

[21] Cambridge Econometrics et al (2014), The Economics of Climate Change Policy in the UK

[22] Cambridge Econometrics et al (2012), A Study into the Economics of Gas and Offshore Wind

Appendices

Appendix A Modelling Assumptions

A.1 Power sector technology assumptions

Table A.1-A.3 show key assumptions that were used to estimate the power sector results. Power sector generation is broadly based on Scenario C1 from Garrad Hassan (2011), however these assumptions have been updated to take account of more recent electricity sector data and different electricity demand projections.

Table A.1: Characteristics of the power sector

	Generation (TWh) 2030	Load Factor	Technology Lifetime
Wind Offshore	166	38%	22 years
Wind Onshore	42	28%	24 years
Hydro	10	40%	60 years
Wave/tidal	12	26%	120 years
Biomass	51	65%	22 years
Solar PV	8	11%	25 years
Geothermal	19	80%	35 years
Gas CCGT	45	50%	25 years
Gas CCS	0	50%	25 years
Coal	0	80%	40 years
Nuclear	0	91%	60 years

Source: Garrad Hassan (2011), DECC (2013).

Table A.2: Labour intensity of capital costs for different power sector technologies

	Construction, installation and manufacturing jobs (job-years/MW)	Construction period	CAPEX jobs (jobs/MW)
Wind Offshore	7.0	3 years	2.3
Wind Onshore	7.0	2 years	3.5
Hydro	5.7	2 years	2.9
Wave/tidal	17.7	3 years	5.9
Biomass	6.4	1 years	6.4
Solar PV	21.6	1 years	21.6
Geothermal	9.3	2 years	4.7
Gas CCGT	1.0	3 years	0.3
Gas CCS	20.5	5 years	4.1
Coal	4.3	4 years	1.1
Nuclear	15.2	6 years	2.5

Source: UKERC (2014), Wei et al (2010).

Table A.3: Economic assumptions for different power sector technologies

	Domestic Content (2030)	Type 1 output multiplier	Type 1 employment multiplier
Wind Offshore	55%	1.79	2.19
Wind Onshore	49%	1.79	2.19
Hydro	80%	1.79	2.19
Wave/tidal	65%	1.79	2.19
Biomass	80%	1.82	2.03
Solar PV	32%	1.84	2.39
Geothermal	50%	1.45	1.91
Gas CCGT	76%	1.45	1.91
Gas CCS	38%	1.45	1.91
Coal	76%	1.43	1.68
Nuclear	44%	1.45	1.91

Source: Domestic content assumptions from various sources. Multiplier effects estimated using ONS 2010 input-output tables.