Understanding growth rates in primary energy consumption

Summary

This article, aimed at a technical audience, notes that the switch from coal and gas to more renewable generation (wind and solar) has had a significant impact on primary energy consumption. This effect needs to be considered when examining changes in primary energy consumption and in conclusions that can be drawn regarding energy efficiency. In particular, for 2015 primary energy consumption data suggests that on a temperature corrected basis consumption has fallen by 0.8 per cent compared to 2014. However the majority of this effect is due to the different statistical treatment of the input fuels for electricity. However, as GDP has grown in the last year, data still suggest progress is being made on energy efficiency.

Introduction

This article considers the impact that the switch from fossil fuels to renewables has had on primary energy consumption, and looks at the underlying trend in this series once such effects are removed. Annual data on primary supply are available at the end of February each year, one month in advance of the more complete energy balance becoming available. The article is aimed at more experienced users of the data. More detailed explanation of energy statistics concepts are available on the DECC web site[1].

Electricity supply in the UK

In the UK a variety of fuels are used to generate electricity. In 2010, gas and coal together accounted for around 75 per cent of the electricity generated in the UK, with a range of other sources used. In 2015 this combined percentage had fallen to around 52 per cent. For gas and coal the energy content of the fuel entering the power station to be transformed into electricity is measured. The electricity produced by the transformation process (turbines) and sent to the National Grid is subsequently measured. This process involves losses, as not all the energy produced from combustion can be converted to electricity. Typically the thermal efficiency of coal plants is around 36 per cent, whilst gas plants in the UK operate at around 48 per cent thermal efficiency. Data on thermal efficiency are published each year in table 5.9 of DUKES (Digest of UK Energy Statistics[2]).

Nuclear energy accounted for around 16 per cent of generation in 2010, but has increased to around 21 per cent in 2015. For nuclear, the heat from nuclear fission is measured as the input to electricity generation, with the output of electricity also recorded. For the last few years the thermal efficiencies of the nuclear fleet has been just under 40 per cent.

Biomass, which has grown from a 3.1 per cent share of generation in 2010 to 8.6 per cent in 2015, is treated in a similar way to the fuels above, with the energy content of the inputs (wood pellets; waste etc) being recorded as well as the electricity output.

The above treatments are quite different though for three renewable sources: wind; hydro; and solar photovoltaics (pv). For each of these sources, it is not possible to measure the energy input. In particular each day a certain level of wind crosses the UK but only a small portion is used to drive wind turbines – so it is difficult to assign an exact value to the energy input to the turbines. For these fuels the internationally agreed convention in energy statistics is to define the energy input to the process as equal to the electricity generated. There are thus no losses recorded in energy statistics regarding these processes.

In a similar manner the energy inputs used to produce imported electricity is unknown. The statistical convention is again to define the input energy as the same as the electricity imported to the UK.

[1] www.gov.uk/government/publications/energy-balance-methodology-note
[2] www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes

Primary energy consumption

Primary energy consumption is defined as the primary supply of energy to the economy – this is calculated by summing all the energy inputs to the economy: production, plus imports, minus exports, minus energy used in international marine bunkers plus stock change. This measure of supply equals demand plus/minus a small statistical difference. The demand is equal to all final energy consumed by end users, plus industrial energy use, losses in distribution, and energy lost in transformation processes. A pictorial representation of the energy flows in the economy is published annually by DECC[3].

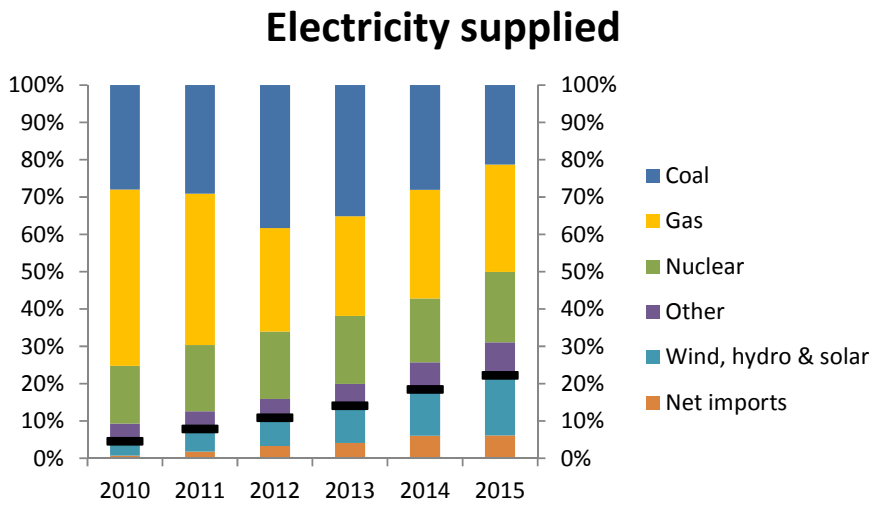
Electricity can not only be produced as a primary energy source but also as a secondary commodity. Primary energy commodities are extracted or captured directly from natural resources. All energy commodities which are not primary but produced from primary commodities are termed secondary commodities. Secondary electricity comes from the transformation of both primary and secondary energy.

Primary electricity is obtained from natural sources such as wind, solar pv, hydro and tidal. Secondary electricity is produced from the heat of nuclear fission and by burning combustible fuels such as coal, gas and biofuels. In producing secondary electricity there are losses as discussed earlier in this article.

More details of the conventions used in producing energy statistics and balances are available from manuals produced by international organisations[4,5].

Effect of switching between sources

The chart below shows the shares of electricity supply in the years 2010 through to 2015. Between these years there has been a reduction in coal and gas use for generation, largely offset by an increase in wind generation and increased net imports.



The share of supply from wind, hydro, solar and net imports, as indicated by the more solid line in the chart above, has increased from 4.5 per cent in 2010 to 22.1 per cent in 2015. This sharp change in these sources with no recorded losses is sufficient to distort messages from looking at primary supply.

[3] www.gov.uk/government/statistics/energy-flow-chart-2014
[4] www.iea.org/publications/freepublications/publication/energy-statistics-manual.html
[5] http://unstats.un.org/unsd/energy/ires/

Estimating size of distortion

To estimate the effect of this change, the fuel use in the latest year was considered against modelled fuel use if the generation shares of 2010 had remained constant.
Data in the table below shows the effect of these changes.

Million tonnes of oil equivalent

	2010	2011	2012	2013	2014	2015
Fuel used for electricity (table 5.1 of Energy Trends)	79.6	77.0	78.2	76.5	70.7	69.0
Modelled fuel use for electricity	79.6	77.2	77.2	76.9	74.1	74.0
Difference	0.0	0.2	-1.0	0.4	3.4	5.0
Per cent difference	0.0%	0.3%	-1.3%	0.5%	4.8%	7.3%

The changes in fuel used can then be considered against the headline primary energy consumption series, and the effect seen on the growth rates.

Million tonnes of oil equivalent

	2010	2011	2012	2013	2014	2015
Primary energy consumption	219.4	203.5	208.0	207.0	193.7	194.6
Annual growth	3.6%	-7.3%	2.2%	-0.5%	-6.4%	0.5%
Temperature adjusted consumption	213.4	209.0	207.9	204.1	199.0	197.4
Annual growth	0.2%	-2.1%	-0.5%	-1.8%	-2.5%	-0.8%
Temperature and electricity fuel mix adjusted consumption	213.4	209.3	206.9	204.5	202.4	202.5
Annual growth	0.2%	-2.0%	-1.1%	-1.2%	-1.0%	0.1%

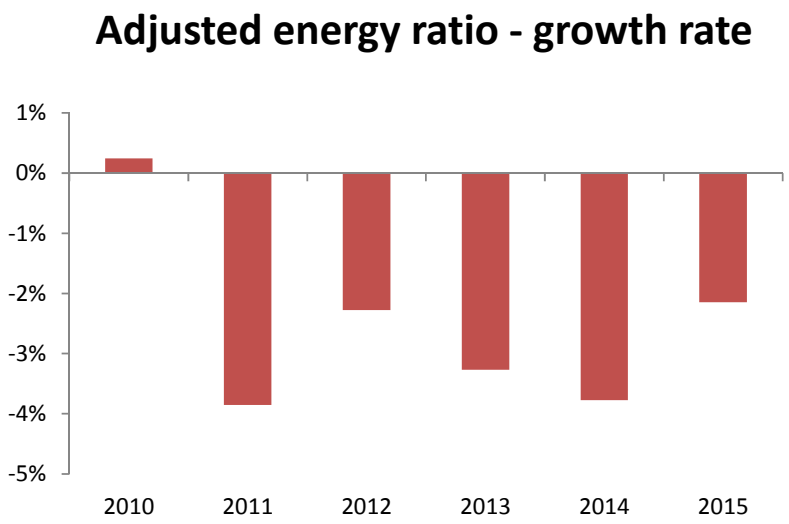
From the table above the growth in primary energy consumption in the UK was 0.5 per cent between 2014 and 2015. As 2015 was a cooler year than 2014 there was an increase in demand for heating fuel. When we look at the temperature adjusted series, with the effect of this additional demand removed, we see that the underlying growth in 2015 was for a reduction in primary energy consumption of 0.8 per cent. However, as less fuel was used for electricity generation due to high wind output, the overall underlying change in primary energy consumption in 2015 was for a growth of 0.1 per cent.

Energy Ratio

The energy ratio is typically calculated by dividing a temperature corrected energy series by GDP (Gross Domestic Product) in constant prices and then indexing so that changes over time can be calculated. In the table below a second energy ratio has been calculated using the temperature and electricity adjusted series.

	2010	2011	2012	2013	2014	2015
Energy ratio	100.0	96.0	94.4	90.7	86.0	83.5
Growth rate of energy ratio	0.2%	-4.0%	-1.7%	-3.9%	-5.2%	-3.0%
Adjusted energy ratio	100.0	96.1	94.0	90.9	87.5	85.6
Growth rate of adjusted ratio	0.2%	-3.9%	-2.3%	-3.3%	-3.8%	-2.1%

Looking in particular at the last four years from 2012 through to 2015 the energy ratio has fallen by an average of 4.0 per cent per year. However, when we examine the adjusted ratio as shown above the ratio has fallen by only 3.1 per cent per year. This still shows a significant improvement, with more output being produced using less energy, but is lower than that derived from the headline energy ratio.



Final energy consumption

The aggregate final energy consumption is produced and published by DECC on a quarterly basis. This data looks at demand from industry, transport, households and the rest of the service sector and is based on more complete administrative and survey data. Losses from energy transformation, and from the own use of the energy industry are excluded. This series can be used as a reliable indication of sectoral consumption and is produced on both a raw basis and in a temperature and seasonally adjusted form. This series is unaffected by the previous issues with changing structure of fuel inputs for the generation of electricity as it just considers the end use of the fuel in its final form. The temperature adjusted series provides the best indicator for changes in energy efficiency.

Between 2014 and 2015, final energy consumption (excluding non-energy use) grew by 1.9 per cent. However, when the effects of temperature are removed the growth rate falls to 0.3 per cent. This rise is due to an increase in transport energy use, likely due to the lower oil prices. Final energy consumption excluding transport still shows a picture of falling energy use, but it's down by only 0.2 per cent compared to a year earlier.

Conclusion

The changing pattern of fuels used in the UK to generate electricity, has meant that greater care is now required in assessing growth rates of primary energy consumption. Reliable estimates can though still be obtained by looking at primary energy consumption, and by making suitable adjustments to ensure more consistent treatment of losses in electricity generation.

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