Less Waste, More Growth: Boosting energy productivity

Methodology of calculations

Context

This document provides an overview of the calculations used to develop the report Less Waste, More Growth: Boosting energy productivity.

The report was produced and published by a coalition of 14 organisations, which represent a range of interests, from environmental advocates to large-scale industrial energy users, to building service providers. To read the report, please visit http://www.lesswastemoregrowth/report

A) Electricity system

1. Electricity system losses

The report's electricity system calculations are based on the total amount of electricity generated in the UK and imports from other countries. The data source is the Digest of United Kingdom Statistics (DUKES) 2015, Chapter 5.[1] The base year for all the analysis in the report is 2014.

The report's analysis on existing electricity system efficiency includes the heat recovered through the CHP fleet. The CHP heat generation assumptions are based on data found in DUKES, Chapter 7[2].

The electricity fuel mix includes fossil fuels and renewables. The report follows the approach found in DUKES Chapter 5, which assumes there are no conversion losses for wind, solar and hydro.

In addition to the electricity generation conversion losses, the report calculates the additional losses from transmission and distribution networks.[3]

2. Economic value of electricity system losses

The report values the conversion losses (fuel to power losses) using the wholesale prices of fuels in the UK electricity fuel mix. The cost data comes from DECC's Average prices of fuels purchased by the major UK power producers and of gas at delivery point[4]. The prices are for the fuel delivered.

For electricity generated from thermal renewable and other alternative thermal fuel sources, it is not possible to identify every fuel sources in the mix and their respective prices. Therefore, the report's analysis assumes that thermal renewable and other alternative thermal fuels have the same price as natural gas. Natural gas is one of the cheapest fuels in the UK electricity fuel mix.

The report's analysis values the electricity transport losses (transmission and distribution) at the wholesale price of electricity. The report's calculations use the annual average wholesale price of electricity, based on APX Power UK's monthly average spot price of electricity between August 2014 and July 2015.[5]

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[1] DECC, 2015, *Digest of United Kingdom Energy Statistics*, Chapter 5
[2] DECC, 2015, *Digest of United Kingdom Energy Statistics*, Chapter 7
[3] DECC, 2015, *Digest of United Kingdom Energy Statistics*, Chapter 5
[4] DECC, 2015, *Average prices of fuels purchased by power generators and of gas at UK delivery points*
[5] APX, 2015, APX Power UK Spot

3. Cost of the power system losses to households

The report calculates the annual cost to households from electricity system losses. The number of households in the UK is based on data from the Office for National Statistics. The report's analysis compares the value of electricity system losses to a household's standard domestic electricity bill, the value for which is based on DECC's Average annual domestic electricity bills by home and non-home supplier.[6]

4. CO_2 emissions from electricity system losses

The report uses DEFRA's carbon intensity of the electricity fuel mix to calculate the carbon dioxide emissions (CO_2) associated with UK power generation, and includes the CO_2 emissions of electricity imported through interconnectors.

The report's analysis follows the methodology set out by DEFRA for greenhouse gas emissions reporting.

For the carbon intensity of uranium used in nuclear power plants, the report's analysis is based on data from the Parliamentary Office of Science and Technology ("Carbon footprint of electricity generation", 2006)[7].

The report's analysis calculates the proportion of thermal losses in the overall energy used by power generators and applies it to the overall CO_2 emissions to determine the CO_2 emissions associated with thermal losses.

In addition, the report calculates the CO_2 emissions associated with transporting electricity through networks and the emissions of losses on those networks. These calculations are based on DEFRA's grid-average emission factor.

Based on the overall emissions from the electricity system losses, the report determines how many miles are travelled by an average petrol fuelled car to release the same amount of CO_2. Using the average annual mileage of a car, the report calculates the number of cars that would run that many miles in a year, and compares it to the number of cars licensed in the UK. The data for carbon emissions per mile driven by a petrol car and the number of average miles per car are from the Department of Transport.[8]

B) Electricity and heat system

1. Gas sector losses

In addition to the power system losses, the report examines heat system losses. Heat generated from other sources than gas is not considered in this report.

DUKES Chapter 4 underpins the heat system losses calculations[9]. The report factors in both the gas produced in the UK and the imports from other countries. It is important to note that the report removes the gas supplied to power stations from the gas consumption figure in order to avoid counting gas losses in both the electricity system and the gas system.

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[6] The average domestic electricity bill is £592 in 2014, for a consumption of 3,800 kWh per year. DECC, 2015, *Average annual domestic electricity bills by home and non-home supplier (QEP 2.2.1)*

[7] Parliamentary Office of Science and Technology, 2006, *Carbon footprint of electricity generation*

[8] DEFRA, 2014. *Greenhouse Gas Conversion Factor Repository* and DFT, 2014, *Vehicle Licensing Statistics*.

[9] DECC, 2015, *Digest of United Kingdom Energy Statistics*, Chapter 4

The report works out the distribution losses and the conversion losses, where gas is converted into a useful stream of energy (heat). The report uses DECC's figure for the efficiency of an average domestic gas boiler.

2. Impact of electricity and heat system losses on land and infrastructure

The UK could tap in to the socially cost-effective opportunities to reduce electricity and heat system losses for meeting its energy needs, or alternatively it would need to build more infrastructure. The more energy infrastructure the UK builds, the larger the impact on land.

To calculate the land area covered by bio-energy crops and onshore wind farms, the report uses the "power per unit of land area" ratios caclulated by former DECC Scientific Adviser David MacKay in his book *Sustainable energy without the hot air*.[10]

In terms of bio-energy crops, the power per unit of land area ratio reflects both the calorific value of bio-energy crops and their conversion efficiency.

For the nuclear power plants, the report calculates the number of Hinkley point C plants that would be needed to produce the same amount of energy than the power and heat system losses.

C) Energy productivity

1. Energy productivity

The report's analysis uses DUKES' data on UK energy productivity since 1970 to determine the energy productivity trend over time.[11]

The efficiency of power generators and networks is also based on DUKES data. The analysis includes in the calculations of the overall efficiency of the power system the heat recovered from CHPs.[12]

2. Government's budget for energy productivity

The report calculates the difference in funding between generation policy and efficiency policy.

For generation spend, the total annual spend by HM Treasury, including the Levy Control Framework, is based on the cost of the Renewable Heat Incentive, Contracts for Differences, the Renewables Obligation, the Capacity Market, small-scale Feed-in Tariff and Carbon Capture and Storage.

For efficiency spend, the total annual cost is based on the Electricity Demand Reduction scheme, Demand Side Response in the Capacity Market, the Energy Companies Obligation, the Green Deal, Climate Change Agreements, and combined heat and power reliefs.

For ECO and CCS, the analysis has annualised the multi-year spend under their programmes. For CfDs, RO and RHI, the spend is based on estimated costs in 2019.

D) Ways to improve energy productivity

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[10] David MacKay, 2008. *Sustainable Energy Without the Hot Air*.
11 DUKES, 2015
12 DUKES, 2015

Looking at solutions for improving power generation efficiency, the report uses international organisations, consultants and DECC's reports to determine the amount of cost-effective opportunities to reduce energy losses from power stations, power networks and business users.

The report calculates the value of the overall savings by analysing the value of the cost-effective savings across three sectors: power generation, networks and businesses.

1. Opportunities to improve productivity in power generation

For generation productivity potential, the report's calculations are based on the CHP potential. The report uses Ricardo AEA's cost-effective CHP deployment potential figure, found in *Projections of CHP capacity and use to 2030* to work out the cost-effective opportunities to cut thermal losses from power generation[13].

The report follows the methodology set out in DUKES Chapter 7 to determine CHP heat generation. The report determines the potential annual heat that could be supplied by additional CHPs, which is the opportunity to cut waste in the power generation sector. The heat-to-power ratio is based on the ADE's register of CHP. The CHP load factor comes from DUKES Chapter 7[14].

Gas boilers are the main source of heat in the UK. The report calculates the quantity of gas that would be needed to produce the same amount of heat as the potential CHP production. The report factors in the wholesale price of gas to work out the economic value of the potential savings in power generation.

For CO_2 savings, the report applies DECC's methodology for the carbon savings from CHP-generated electricity's displacement of grid electricity. The calculations are based on UK electricity (fossil fuels) carbon intensity provided in DUKES Chapter 1[15].

2. Opportunities to improve productivity in electricity networks

For power networks opportunities, the report considers the efficiency improvements which would be needed to achieve the same efficiency than Germany, which has the most efficient electricity networks in the world.

The report's analysis of network efficiency in other countries is based on data from the World Bank. The base year for the data is 2012.

The report uses the wholesale price of electricity to determine the economic value of the potential savings in electricity networks.

In addition, the report looks at the potential economic savings if half of the current centralised thermal generation was instead directly connected at the distribution level. The cost of avoided transmission losses is based on the wholesale price of electricity. The transmission losses are based on DUKES Chapter 5. This figure is not included in the report's overall calculation of the economic value from savings across power generation, networks and businesses.

3. Opportunities to improve productivity for businesses and other energy users

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[13] Ricardo-AEA, 2013. *Projections of CHP capacity and use to 2030*. Report for DECC. Cost effective potential based on a discount rate of 15% over 10 years.

[14] DECC, 2015, *Digest of United Kingdom Energy Statistics*, Chapter 7

[15] DECC, 2015, *Digest of United Kingdom Energy Statistics*, Chapter 1

The report uses a consistent approach to value the potential for improved energy productivity across the board. Potential savings in power generation and networks are valued at the wholesale price of the commodity because this is the real cost of the losses to the major UK power producers and power grid operators.

However, for business users, the energy savings that can be achieved would lead to savings on their energy bills. Therefore, the report uses the retail prices of electricity and gas to value the potential business energy savings.

Looking out to 2020, the report's calculation for potential savings is based on the 69 TWh socially cost-effective potential savings identified by DECC in the Energy Efficiency Strategy, Annex E, 2012.[16]

The report annuitises the 69 TWh figure over the 8 year period between 2012 to 2020 to determine the annual potential energy savings.

The report determines the proportions of electricity and gas in the total energy consumption of businesses, based on DUKES data on "Energy consumption by final users, energy supplied basis"[17]. The proportions are then used to work out the potential savings for businesses' consumption of gas and electricity.

The report multiplies the potential savings for gas and electricity respectively by the retail price of gas and the retail price of electricity, based on DECC's data "Prices of fuels purchased by non-domestic consumers in the UK, including Climate Change Levy".[18]

4. Potential savings on householder's annual energy bills

By adding up the cost-effective energy saving opportunities across the board, the report calculates the total savings that could be achieved by power generators, power transport networks and businesses. The report divides the overall potential savings by the number of households in the UK to determine the size of the cost-effective saving from increased energy productivity relative to each household in the UK.

E) Cheapest options to improve energy productivity

The report factors in calculations for the cost of carbon abated under the domestic RHI scheme from July to December 2014, based on Ofgem's data, with gas as the counterfactual. The figure is based on Ground Source Heat Pumps at current grid carbon intensity.[19]

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[16] DECC, 2012. *Energy Efficiency Strategy, Annex E,* page 87

[17] DECC, 2015, *Energy consumption by final users, energy supplied basis*

[18] DECC, 2015, *Prices of fuels purchased by non-domestic consumers in the UK, including Climate Change Levy*

[19] ADE analysis. The cost of carbon abated under the domestic RHI scheme from July to December 2014, based on data published by Ofgem, with gas as the counterfactual. The £800/tCO_2 figure is for Ground Source Heat Pumps. Biomass is the least expensive technology and has a cost of £202/tCO_2 abated.