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Estimating the Carbon Impact of the UK's Energy Price Guarantee

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In this technical note, we aim to provide a detailed overview of the methodology, analysis, and sources used to obtain the numbers and results presented in the associated blog, The Wrong Kind of Net Zero.

What is the carbon impact of the Energy Price Guarantee?

The United Kingdom launched the Energy Price Guarantee (EPG) as a way to protect consumers from rapidly rising energy costs. But what is the carbon impact of the introduction of the EPG?

To calculate this we estimate the price effect of the EPG, which functions as an energy consumption subsidy, the price elasticity of energy demand of UK consumers and consequently its effect on energy consumption. From this energy consumption effect, we calculate a carbon cost of additional energy consumed as result of the subsidy, and compare this to the effect of the UK's funding for climate mitigation through official development assistance (ODA), drawing on previous CGD research. The remainder of this note goes through each stage of this process.

Table 1. Summary table

	Electricity	Gas
% of Fossil Fuel	38%	100%
Cost of subsidy (p/Kwh)	32.36	6.76
Elasticity	0.26	0.18
Demand effect of subsidy	12.74%	7.40%
Avg Household consumption in KWh (during subsidy)	1740	7800
Counterfactual consumption in KWh (without subsidy)	1543	7262
Additional energy consumption (in kwh)	197 Of which: 74.86 from Fossil Fuels	538
Unit impact of Carbon (as kg of Co2 per Kwh)	0.193	0.183
Cost of carbon * extra energy consumed	14.45	98.45
Multiplied by number of Households in the UK	408,935,000.00	2,786,135,000.00

Total Carbon cost of subsidy in kg of CO2:	3,195,070,000.00
Total Carbon cost of subsidy in tn of CO2:	3,195,070.00
Total Impact of UK mitigation ODA during the EPG in tn of CO2:	1,666,666.66

Step 1: Calculating the value of the subsidy

To calculate the carbon impact of the subsidy, we first calculated the cost of the subsidy. The EPG rates in Great Britain were 34.0p/kWh for electricity and 10.3p/kWh for gas. Cornwall Insight, an energy research consultancy firm in the UK,[1] estimated the market price without the cap for electricity was 66.36 p/kWh, and for gas it was 17.06 p/kWh.[2] Thus the difference between these prices is **the value of the subsidy: 32.36 p/kWh for Electricity and 6.76 p/kWh for gas**.

Step 2: Calculating the effect of the subsidy on energy demand

Next, we estimated the effect is of lower energy prices on domestic consumption. Energy demand is relatively price inelastic: that is, responses to price changes are fairly muted, so demand does not shift very strongly in response to higher or lower prices. However, it is not completely price inelastic, and at the margin a lower price will mean that demand increases relative to the higher price counterfactual. We used the price elasticity of energy demands estimates developed by Bobbio et. al. (2022), using data from July 2020 to June 2021.[3] They estimated that a **one percent increase in price reduces demand by 0.26 percent**. For the price elasticity for Gas, we used the summary of studies compiled by University College London which includes Nilsen et al (2005), and Serletis et al (2011). The estimated elasticities of gas of these papers are: -0.1, -0.17, -0.28. We uses the average of these 3 estimates which means that **a one percent increase in price of gas reduces demand by 0.183 percent**. [4] Given our estimate of the subsidy value, the reduction in the price is about 49% for electricity and 40% for gas, suggesting an increase in the demand of energy of **a 12.74 percent for electricity (49*0.26), and 7.4 percent for gas (40*0.183)**. Average household consumption in kWh is 2,900 per year for electricity and 12,000 per year for gas. According to National Grid, 60% of the average household consumption in kWh is done during the 6 months covered by the EPG, and 65% of the average consumption of gas (which equals 1,740 for electricity and 7,800 for gas). If we use the numbers on elasticity previously mentioned this means that without the subsidy household consumption would be 1,543 kWh for electricity and 7,262 kWh for gas. The extra energy consumed for the subsidy is then **197 kWh for electricity and 538 kWh for gas per household**.

1 Though their methodology is not public, they are considered a credible source. Cornwall Insight estimates are also used by the Institute of Fiscal Studies (IFS) on their estimates of the impact of the Energy Price Guarantee.

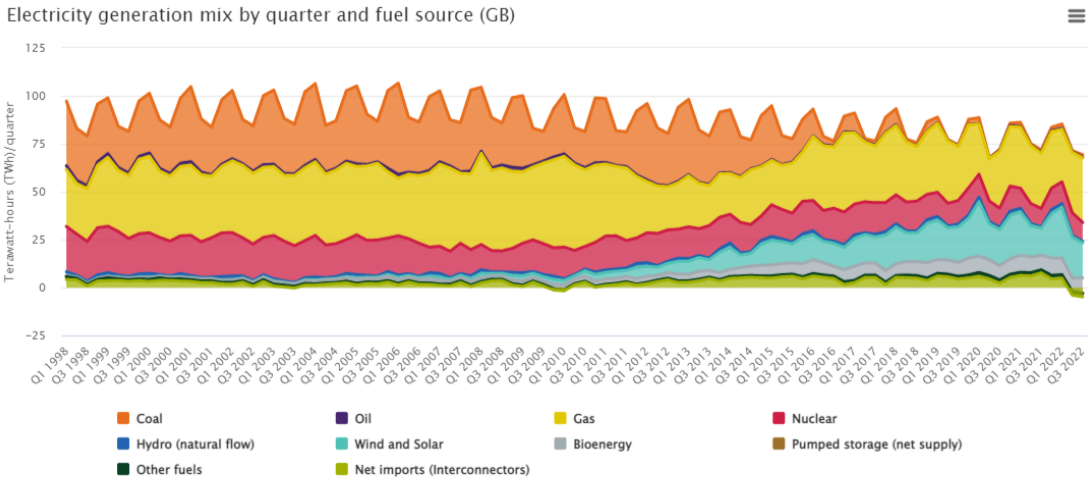
2 The estimates from Cornwall Insight are forecasts using wholesale market data. The price of the estimate is for the first quarter of 2023 (January-March). For simplicity, we assume the price is the same for the fourth quarter of 2022 (October-December).

3 https://www.ofgem.gov.uk/energy-data-and-research/data-portal/wholesale-market-indicators. The paper uses rich, real-life data from residential consumers: the exact group targeted by the energy subsidy. The paper measures how responsive consumers are to price in Britain from July 2020 to July 2021 with half-hourly individual-household data. It includes customers with a dynamic rate that tracks wholesale cost, as well as flat-rate customers used to control for weather and other factors.

4 Even using the lowest estimate of elasticity (-0.1), the carbon impact is still 0.5 million tonnes higher than the UK climate mitigation ODA.

Step 3: Calculate the additional fossil fuel energy consumed

Only a portion of this extra electricity used because of the subsidy will come from fossil fuels, so to calculate what the carbon impact of this is, we only focused on the extra energy that emits CO2. The mean consumption of fossil fuels per day during the months where the subsidy is in operation is approximately 38% of total consumption (national grid).[5] Thus, if the effect of the subsidy made increase the electricity demand and 38% of this consumption came from fossil fuels this means that there was an **extra consumption of 74.86 kWh coming from fossil fuels** due to the subsidy.



Information correct as of: February 2023

Source: BEIS Energy trends section 5: Electricity (ET 5.1)

Step 4: Calculate the carbon impact of additional fossil fuel consumption

To calculate the amount of CO2 this represents, we took as reference the data provided from Bulb on the volume of carbon as kg of CO2 per kWh. **In 2022, these figures were 0.193kg of CO2 emissions per kWh of electricity, and 0.183 kg per kWh of gas**.[6] Then, we multiplied the extra energy consumed in kWh because of the subsidy per the cost of carbon which gives us a carbon impact of 14.45 for electricity, and 98.45 for gas. Since this is household consumption, we multiplied this with the number of households in the UK (28.3 million—source) and this gave us the total carbon impact of the subsidy in kg of CO2: 3.195 billion (then we divided this by 1,000 to get the carbon impact in tonnes of co2). Thus, **the United Kingdom subsidy increased carbon emissions by 3.195 million tonnes of CO2 in a six-month period**.

5 We acknowledge that the mix of energy sources vary depending on how much of renewable energy is generated, and our optimal calculation would focus on the marginal energy source rather than the average, but the mean consumption provides a decent starting point to calculate the carbon impact. In addition, this is an extremely conservative estimate because normally when there's extra energy electricity demand, it tends to come most of it from fossil fuels.

6 The emissions for electricity are higher due to the impact of coal in the energy mix.

Step 5: Comparing this to the impact of UK climate mitigation ODA

The United Kingdom spent **£1 billion on climate-mitigation specific aid** abroad during 2019–2021[7] . Juden & Mitchell suggest the median cost effectiveness of mitigation options across the world at **around £100 per tonne of CO2 mitigated**.[8] We divided the mitigation spent of the UK (£1 billion) with the median price per tonne of CO2 mitigated (£100), which gave us that the impact of UK aid on mitigation **during 2019–2021 was of 10 million tonnes of CO2**, around **3.3 million tonnes per year**, or around 1.66 million tonnes each six months, **1.52 million tonnes less than our estimate of the UK's subsidy**.

Annex: Upper and lower bounds of the estimates

To calculate upper and lower bound of the estimates we looked at 3 potential variables that could potentially affect the consistency of our results (Table 2):

- **Percentage of fossil fuels used in electricity:** As mentioned in the footnote, we acknowledge that the mix of energy sources vary depending on how much of renewable energy is generated, and our optimal calculation only focused on the marginal energy source rather than the average, but the mean consumption provides a decent starting point to calculate the carbon impact. However, this is an extremely conservative estimate because normally when there's extra energy electricity demand, it mainly comes from fossil fuels. So the upper bound would be that all extra energy being consumed comes from fossil fuels, and the lower bound would be that only 10% of the extra energy being consumed comes from fossil fuels (that is the minimum percentage of fossil fuels being used for electricity generation during the EPG months, on the 26th of December 2022).

- **Elasticity of gas demand:** In the technical note we used the average of 3 different studies. In this case, the upper bound would be the higher elasticity among these 3 papers (-0.28), and the lower bound would be the lower one (-0.1).

- **Cost effectiveness of mitigation options:** In the technical note, we used the median cost effectiveness of evaluations which is a cost of £100 per tonne of CO2 mitigated. The upper estimate will be the mean average of these studies instead of the median which yields to £200 per tonne of CO2 mitigated, and the lower bound would be £50 per tonne of CO2 mitigated, i.e. half the median cost per tonne mitigated.

7 According to the Creditor Reporting System dataset by the OECD. Only Official Development Assistance where mitigation was the principial component is counted.

8 We used the median of the real evaluations from figure 2: Cost effectiveness of mitigation options from 50 global economic studies be. The median cost in US$ per tonne of CO2 mitigates is $120, and the average is $240. Using 0.83 exchange rate on 3rd of March 2023, $120 equals £100.17. Using a cost effectiveness of mitigation of £50 per tonne of CO2 mitigation (i.e. half the median cost-effectiveness estimate, effectively assuming a highly cost effective portfolio of projects) would give an impact of 3.3 million tonnes for the 6 months covered by the subsidy—around the same estimate of the UK's subsidy.

Table 2. Summary table upper case scenario, lower case scenario

	Technical note estimate	Lower bound	Upper bound
% of fossil fuels	38%	10%	100%
Elasticity of gas demand	-0.183	-0.1	-0.28
Cost effectiveness of mitigation	£100	£50	£200

On table 3, we calculated the impact using all lower bound scenarios: 10% of electricity demand from fossil fuels, elasticity of gas of -0.1 and £50 per tonne of CO2 mitigated. The results are: an impact of 1.6 million tonnes of CO2 emitted because of the Energy Price Guarantee, and a total of 3.3 million tonnes of CO2 mitigated due to UK's ODA during the same time.

Table 3. Summary table lower case scenario

	Electricity	Gas
% of Fossil Fuel	10%	100%
Cost of subsidy (p/Kwh)	32.36	6.76
Elasticity	0.26	0.1
	12.74%	4.00%
Avg HH consumption in KWh (during subsidy)	1740	7800
Counterfactual consumption in KWh (without subsidy)	1543	7500
Additional energy consumption (in kwh)	197 Of which: 19.7 from Fossil Fuels	300
Unit impact of Carbon (as kg of Co2 per Kwh)	0.193	0.183
Cost of carbon * extra energy consumed	3.8	54.9
Plus number of HH	107,599,430.00	1,553,670,000.00
Total Carbon cost of subsidy in kg of CO2:	1,661,269,430.00	
Total Carbon cost of subsidy in tn of CO2:	1,661,269.43	

	Price per tonne of CO2	Total Carbon cost of ODA mitigation in tn of CO2:
Climate mitigation ODA	**50.00**	**3,300,000**

On table 4, we calculated the impact using all upper bound scenarios: 100% of electricity demand from fossil fuels, elasticity of gas of -0.28 and £200 per tonne of CO2 mitigated. The results are: an impact of 5.1 million tonnes of CO2 emitted because of the Energy Price Guarantee, and a total of 0.833 million tonnes of CO2 mitigated due to UK's ODA during the same time.

Table 4. Summary table upper case scenario

	Electricity	Gas
% of Fossil Fuel	100%	100%
Cost of subsidy (p/Kwh)	32.36	6.76
Elasticity	0.26	0.28
Demand effect of subsidy	12.74%	11.20%
Avg HH consumption in KWh (during subsidy)	1740	7800
Counterfactual consumption in KWh (without subsidy)	1543	7014
Additional energy consumption (in kwh)	197 Of which: 197 from Fossil Fuels	786
Unit impact of Carbon (as kg of Co2 per Kwh)	0.193	0.183
Cost of carbon * extra energy consumed	38.021	143.838
Plus number of HH	1,075,994,300.00	4,070,615,400.00

Total Carbon cost of subsidy in kg of CO2:	5,146,609,700.00
Total Carbon cost of subsidy in tn of CO2:	5,146,609.70

	Price per tonne of CO2	Total Carbon cost of ODA mitigation in tn of CO2:
Climate mitigation ODA	200.00	833,333