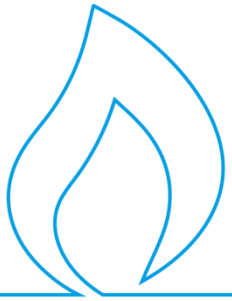
Department of Energy & Climate Change

ANNEX D

Gas price elasticities: the impact of gas prices on domestic consumption – a discussion of available evidence



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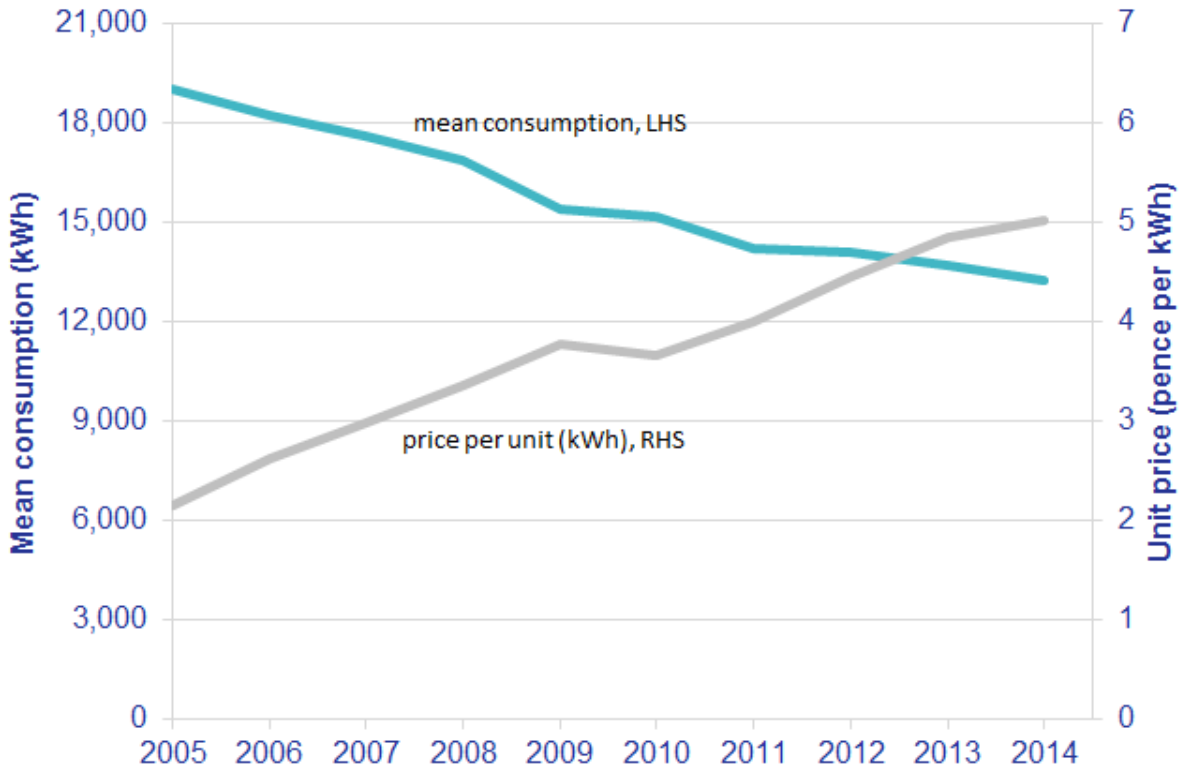
Introduction

This annex investigates the relationship between domestic gas price and demand, by examining existing research which has attempted to estimate the associated price elasticity. An estimate of elasticity is then combined with historical price data to gain an understanding of how much changes in price have contributed to the decline in domestic gas demand observed over the last decade. Finally, the way in which the price elasticity of gas might differ across different household income groups is examined.

Analysis

Figure D1: Mean domestic gas consumption per household and prices over time, 2005-2014



Footnotes:
1. Source: Subnational Gas Consumption Statistics (https://www.gov.uk/government/collections/sub-national-gas-consumption-data), and Quarterly Energy Prices (https://www.gov.uk/government/collections/quarterly-energy-prices)

As Figure D1 shows, mean gas consumption[1] declined by 30 per cent over the last decade[2]. In tandem, over the same period, per unit domestic gas prices more than doubled. While this may suggest an obvious correlation between prices and consumption, there are a number of other factors at play which might complicate this relationship. For instance, over this period around four million cavity walls and five million lofts were insulated driven by government policies aimed at increasing the efficiency of the housing stock[3]. Chapter 4

[1] Among households with a gas supply
[2] Overall energy demand has also declined, by 25 per cent between 2005 and 2014. This decline is less pronounced than that seen for the household mean (30 per cent), as over this period the population has grown, as evidenced by an eight per cent increase in the number of gas meters.
[3] The rise in gas prices over the last decade may have also contributed to the uptake of energy efficiency measures.

of the main accompanying NEED report would indicate that this will have had a downward effect of gas consumption even in the absence of rising gas prices. In addition, consumer behaviour, which research has shown to have an effect on demand (e.g. Haasa et al., 1998) may have changed as people's lifestyles and habits have evolved.

This paper aims to isolate the component of the decline in gas demand that arises specifically due to the increase in prices. In order to disentangle all of the different factors that affect consumption, it is necessary to employ some econometric modelling techniques. An analysis of this type, based on some work done for DECC by NERA Economic Consulting, was published in an annex of the 2012 NEED report[4]. While not the main focus of the work, an estimate of the price elasticity of gas was reported in brief.

The degree to which demand for a good or service changes in response to a change in its price is known as its price elasticity. Price elasticities vary for a number of reasons, but particularly depend on the availability of alternative goods/services that could be consumed (i.e. substitutes).

A distinction exists between short and long-run elasticities. Short-run elasticities isolate only the behavioural changes in response to price, and not the effect of any investments that occur in response to sustained price changes. Long-run elasticities reflect the fact that sustained price movements might trigger investments that create long-term increases/decreases in energy demand.

The NERA report estimated, based on NEED data, that the price elasticity of domestic gas was -0.1 – in other words, for every 10 per cent increase in its price, the amount of it consumed decreases by 1 per cent. The magnitude of this estimate implies that demand for domestic gas is price inelastic, i.e. demand is relatively un-responsive to changes in price, falling proportionately less than the increase in price. The methodology used to arrive at this estimate (discussed further below) considers the average response to prices over the 2005-12 period, indicating that it is more representative of a long-term elasticity.

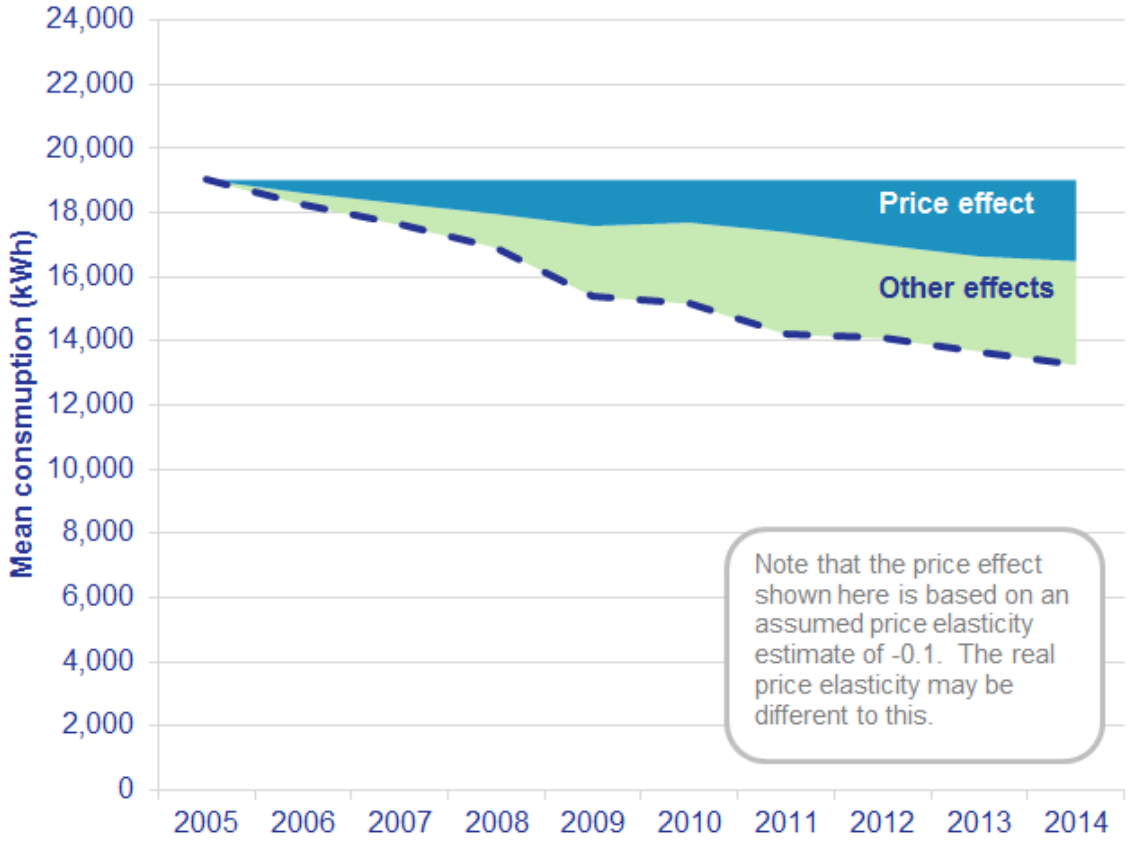
Applying the NERA elasticity estimate to the change in prices seen over the last decade suggests that about 40 per cent of the observed decline in consumption can be attributed to the rise in gas prices[5]. Figure D2 below, shown for illustrative purposes, demonstrates the implied contribution that price rises have made to the fall in gas consumption over time, assuming a price elasticity of -0.1. Note that this contribution is entirely dependent

[4] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65974/6869-need-report-annex-e.pdf

[5] To calculate the implied price related fall in consumption the product of the percentage change in the unit cost over the 2005-14 period and the assumed estimated elasticity (here -0.1) was multiplied by the mean level of consumption at the start of the period. This was then compared to the overall fall in mean consumption over the period.

on the elasticity estimate and a different outturn would occur if the real price elasticity were different.

Figure D2: Illustrative composition of mean gas consumption decline – prices and 'other' effects



Academic literature suggests that understanding the key drivers of gas demand is notoriously difficult; most modelling attempts fail to explain a significant degree of the observed variation in consumption[6]. One of the main reasons for this is that human behaviour plays a very important part, and it is difficult to obtain data that sufficiently represents the nuances of individuals' behaviour within a model. In addition, it can also be difficult to disentangle price influences from other drivers of consumption – e.g. the extent to which prices have influenced lifestyle changes over time, or the ease of take up of measures offered through government policies. This lack of data inevitably introduces a degree of missing variable bias into models, which casts some doubt on the validity of any obtained results. To tackle this, the NERA model takes advantage of the fact that the

[6] Longhi S. (2014) provides a discussion of the proportion of variation (R^2) that previous studies have managed to explain when attempting to model domestic gas demand. (The highest R^2 listed was just 0.4.)

same households are represented in the NEED data in each year, by using a 'panel' approach (explained below).

Analysis is often performed on cross-sectional data, for example on data from a survey of households which gives a snap-shot of information representative of a given time. If a regression is run on this data, the coefficients are estimated based on variation which occurs between the different households. However, repeating the survey after a period of time - with the same respondents - allows a time series dimension to be added to the existing cross-sectional dimension, resulting in a dataset known as a panel. A panel regression can then be run, which makes use of both dimensions when estimating the coefficients, i.e. both the variation between households and the variation over time within households. The functional form of a common panel data regression model looks like:

$$y = a + bx_{it} + \in_{it}$$

where y is the dependent variable, x is the independent variable, a and b are coefficients, i and t are indices for individuals (or households) and time, and $\in$ is the error term. The NEED dataset, which contains observations for all households over a period of time, is effectively a panel, and is therefore suitable for this type of analysis.

Panel regressions are a known remedy to the missing variable bias which, as mentioned above, is likely to be an issue here. This is because they make it possible to control for some types of missing variables even without observing them, by observing changes in the dependent variable over time. This controls for missing variables that differ between cases but are constant over time. Panel regressions can also control for missing variables that vary over time but are constant between cases. Although NERA's price elasticity estimate takes advantage of this approach, it remains prudent to make comparisons with other similar research, in order to provide some verification.

Table D1 below shows a number of gas price elasticities, collected from a number of academic papers which have attempted this kind of estimation.

Table D1: Collated domestic gas price elasticity estimates from academic literature

Study	Geographic Area	Sample	Estimated Elasticities[1]	Methodology
Alberini et al (2011)	USA – household level	1997-2007	-0.56 – -0.69	Several specifications of Static FE model
			-0.65	GMM estimator
Dagher (2011)	Colorado, US	1994-2006	-0.09 (sr) / -0.23(lr)	Autoregressive Distributed Lag
Nilsen et al (2005)	EU	1960-2002	~ -0.25 (sr)	Number of Homogenous estimators
			-0.97 – -1.5 (lr)	
Nilsen et al (2005)	UK	1960-2002	-0.10 (sr)	Shrinkage estimator
			-0.17 (lr)	
Serletis et al (2011)	UK	1980-2006	-0.28	Static Translog Model – NQ Flexible Functional form

Summary of studies compiled by University College London

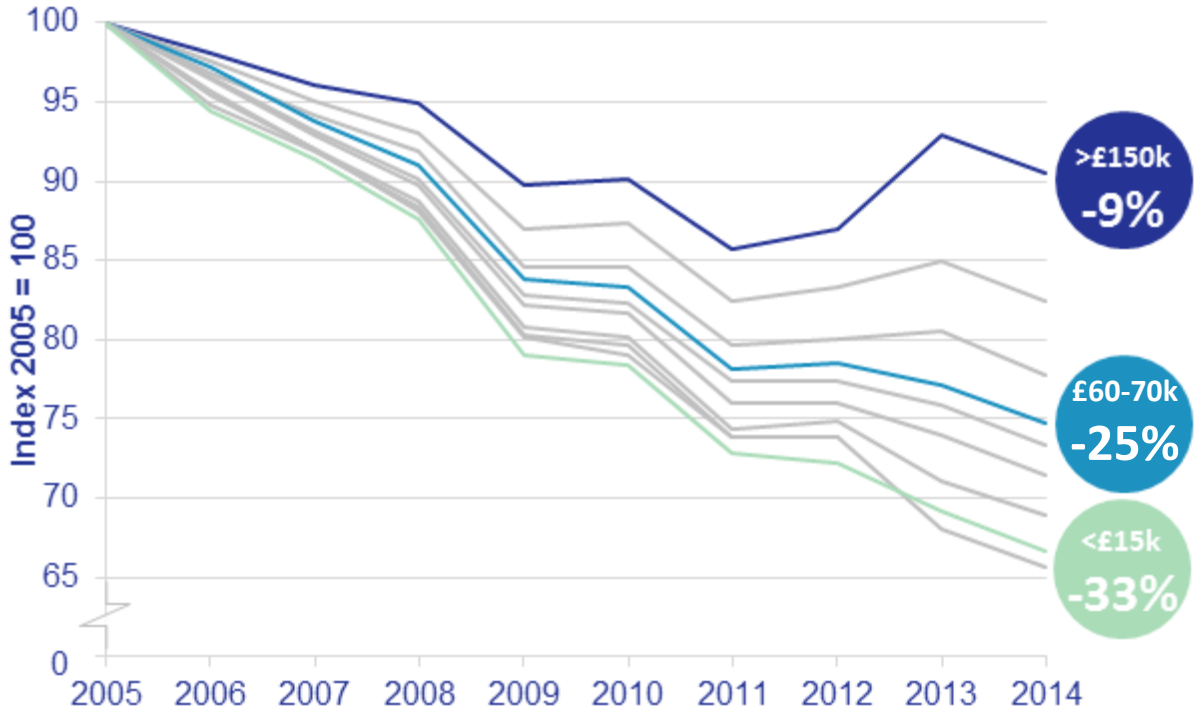
1. Here 'lr' refers to long-run estimates and 'sr' refers to short-run.

As Table D1 shows, there is a degree of variation in the elasticity estimates for the UK (between -0.10 and -0.28) and even more in other parts of the world (-1.5 in the EU). The NERA result is consistent with the lower magnitude end of the UK range, providing some reassurance of this finding. It should be noted that during the periods over which the previous UK studies were based (pre 2006) gas prices were generally more stable than the 2005-2012 period used in the NERA study, which may have led to some variation in the results. Similarly, different methodologies were used in each separate case, which may again explain some of the variation. The higher magnitude end of the elasticity estimate range (-0.28), when applied to historical price movements (2005-14), would imply a much greater decline in consumption than actually occurred. This places some uncertainty around this estimate, although it is possible that other influencing factors might have offset some of associated decline in consumption. It is expected, however, that most of these other factors (e.g. increases in energy efficiency), would have contributed to the decline in consumption, rather than reversed it. This provides additional evidence to suggest that the real elasticity lies towards the lower magnitude end of the range (i.e. closer to the NERA estimate).

An interesting extension to this analysis would be to consider how the price elasticity of demand differs between household income groups. Figure D3 below re-visits the mean

gas consumption time series shown in Figure D1, but here it is shown split by income group.

Figure D3: Mean domestic gas consumption per household by income group, 2005-2014



As Figure D3 shows, the higher income groups have experienced a far smaller decline in consumption compared to the lower income groups. This pattern is consistent for all groups across the whole time period, with the exception of the two lowest income groups, which switch order in the last couple of years[7]. This implies that there may well be a link between price elasticity and income. There are a couple of intuitive explanations as to why the price elasticity might differ between income groups:

1. Energy costs likely comprise a larger proportion of low income households' income, suggesting that their demand might be more sensitive to price changes

2. Some low income groups (e.g. the fuel poor) might already be heating their homes to a very limited extent, leaving less opportunity to reduce their consumption further should prices rise

[7] The data behind this chart is available in Table 11 of Annex F

These two mechanisms work in opposite directions, with the first suggesting a higher price elasticity among lower income households and the second suggesting a lower elasticity. The pattern shown in Figure D3, with the lower income groups exhibiting much greater reductions in consumption over the period of increasing price would imply that the first mechanism appears to be dominant here. However, due to the possible influence of factors beyond price, it is again necessary to employ a full econometric analysis to isolate the true price elasticities of each income group. The NERA analysis didn't explore this theme and research literature in this area is sparse[8]. A very rough attempt to investigate this using a panel regression using NEED data provided initial confirmation that the different income groups did indeed have different price elasticities. The magnitude of the lowest income group's price elasticity was found to be 25 per cent higher than that of the highest income group, providing tentative verification of the indication from Figure D3 that lower income groups are more sensitive to changes in domestic gas prices. Given the provisional status of this preliminary analysis, the full results are not presented here[9].

[8] A similar concept, income elasticity, i.e. the change in demand for domestic gas in response to a change in income *is* explored in research literature (e.g. Bernstein R. and Madlener. R (2011)). Although this is not entirely analogous to the price elasticity by income group cross-section discussed here, it does provide evidence that a relationship between income and demand for domestic gas does exist.

[9] This initial exploratory work was however based on the publically available anonymised NEED dataset, allowing interested readers to explore this in more detail if desired: https://github.com/decc/NEED_panel The index of multiple deprivation (produced by DCLG) was used here as a proxy in the absence of an explicit income variable.

Conclusion

Estimating the impact of prices on gas demand is difficult, as demonstrated by the variation in results when this has been attempted in the academic literature. Most research implies that the domestic demand for gas is inelastic, but the changes in price have been of a large enough magnitude for this to have had an impact on demand levels.

Although there is a lack of established research to support this, initial indications suggest that lower income groups possess higher price elasticities and are more sensitive to changes in price compared to higher income groups.

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