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Gas-fired power in the UK: Bridging supply gaps and implications of domestic shale gas exploitation for UK climate change targets

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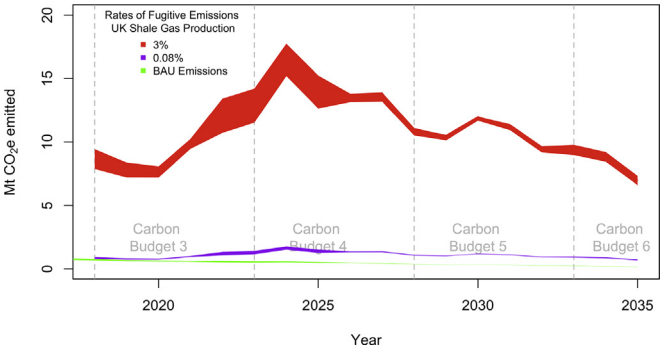
HIGHLIGHTS

- UK domestic natural gas supply will decline −5% yr^{-1} after 2020.
- UK will need natural gas imports or domestic shale gas to meet supply gaps.
- Domestic shale gas industry will increase overshoot on carbon budgets.
- Grid emissions intensity targets can be met regardless of gas supply origin.

GRAPHICAL ABSTRACT



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ABSTRACT

There is a projected shortcoming in the fourth carbon budget of 7.5%. This shortfall may be increased if the UK pursues a domestic shale gas industry to offset projected decreases in traditional gas supply. Here we estimate that, if the project domestic gas supply gap for power generation were to be met by UK shale gas with low fugitive emissions (0.08%), an additional 20.4 Mt CO_2e[1] would need to be accommodated during carbon budget periods 3–6. We find that a modest fugitive emissions rate (1%) for UK shale gas would increase global emissions compared to importing an equal quantity of Qatari liquefied natural gas. Additionally, we estimate that natural gas electricity generation would emit 420–466 Mt CO_2e (460 central estimate) during the same time period within the traded EU emissions cap. We conclude that domestic shale gas production with even a modest 1% fugitive emissions rate would risk exceedance of UK carbon budgets. We also highlight that, under the current production-based greenhouse gas accounting system, the UK is incentivized to import natural gas rather than produce it domestically.

1. Introduction

The United Kingdom (UK) is legally bound by 'The Climate Change Act' to reduce greenhouse gas (GHG) emissions by 2050 to 80% below a 1990 baseline (UK Parliament, 2004). The Climate Change Act also empowers an independent body, The Committee on Climate Change (CCC), to advise the Government on progress towards the 2050 goal. The CCC recommends reduction targets in 5-year budget periods. The UK met its first carbon budget (CB1: 2008–2012) of 3018 Mt CO_2e, and is likely to meet the second and third carbon budgets, covering the years 2013–2022 (DECC, 2014a, 2015a). However, the Department for Energy and Climate Change (DECC - now the Department for Business, Energy,

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[1] Megatonne carbon dioxide equivalent (Mt CO_2e).

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and Industrial Strategy - BEIS) suggests that the UK may fail to meet its fourth carbon budget (CB4: 2023–2027) by as much as 146 Mt CO_2e (BEIS, 2017a; DECC, 2014a, 2015a). The DECC projections indicate a 7.5% overshoot in CB4, with an uncertainty range of 6–13%. This projected overshoot (DECC, 2015a) increases into the fifth carbon budget (CB5: 2028–2032), which the UK is at risk of exceeding by more than 14% (BEIS, 2017a).

Major Power Producers (MPPs), companies whose primary activity is electricity generation (DECC, 2012), produce 94% of all electricity in the UK. In 2015 over half of this production was from the combustion of coal (120 Terawatt Hours - TWh) and natural gas (71 TWh) (DECC, 2015b). GHG emissions from MPPs are traded within the European Union Emissions Trading Scheme (EU ETS), and are capped by UK emissions allowances granted by EU ETS. These emissions do not affect the UK's ability to meet carbon budgets directly, however, the continued use of fossil fuels by MPPs maintains a domestic demand for fossil fuels, which can create emissions in other non-traded sectors of the economy (e.g. coal and gas extraction). UK electricity production is projected to shift away from coal generation towards gas power, to supplement growing renewables and nuclear capacity (BEIS, 2016a, 2017a; European Parliament and the Council on Industrial Emissions, 2010; UK House of Commons, 2013). Yet, domestic production of natural gas will continue to fall (OGA, 2016). If the UK shifts the source of this gas from domestic North Sea gas to imported liquid natural gas (LNG), associated UK gas production emissions will fall while production-phase emissions elsewhere in the globe would increase. Conversely, a domestic shale gas industry could provide increased energy security for the UK, but would create a new source of domestic industrial emissions that is not yet fully accounted for within planned UK carbon budgets.

The CCC has stated that a UK shale gas industry is not compatible with UK climate change targets unless three test criteria are met: (1) production emissions are strictly limited; (2) UK gas consumption declines, remains in line with carbon budgets, and displaces imports; (3) production emissions are offset elsewhere in UK carbon budgets (CCC, 2016a, 2016b). The first test can be met by strict regulation of practices associated with shale gas production, many of which are agreed upon by industry (UKOOG, 2015). The second test may be met by maintaining or lowering UK gas consumption, while measuring and prioritizing the lowest carbon footprint gas to be consumed in the UK. The third test will require national coordination of sectoral GHG emissions to accommodate any additional emissions associated with domestic shale gas production.

In addition to the shale gas criteria, the CCC recommended a grid electricity emissions target of 50 g CO_2e kWh^{-1} by 2030 in the fourth carbon budget report (CCC, 2010), but have since relaxed that goal to below 100 g CO_2e kWh^{-1} by 2030 (CCC, 2015). The CCC projects this goal will be met by a combination of renewables, natural gas, carbon capture and storage (CCS), and nuclear power. DECC/BEIS has projected several scenarios which illustrate pathways to a 100 g CO_2e kWh^{-1} target by 2030. This study aims to quantify the emissions associated with gas consumption in the UK for electricity generation under scenarios projected by DECC/BEIS, and identify 'CCC-test' limits on emissions for a domestic shale gas industry.

1.1. DECC & BEIS projections

DECC/BEIS produce annual projections for *Updated energy and emissions scenarios* (BEIS, 2017a; DECC, 2014a, 2015a) which incorporate GHG-reduction policies, fossil fuel prices, and economic growth projections. The *Reference Scenario* is based on central estimates of economic growth and fossil fuel prices - it is therefore treated as the central estimate in this study. It contains all agreed-upon policies and planned policies. DECC's *Low Growth*, *High Growth*, *Low Prices*, and *High Prices* projections assume the same policies as the *Reference Scenario* but incorporate variance on fossil fuel prices and economic growth. Their *Existing Policies* projection contains central estimates, but excludes planned policies; it is an assessment of the current state of policies projected forward. Finally, the DECC *Baseline Policies* projection contains only policies that existed before the Low Carbon Transition Plan of 2009 (Great Britain and HM Government, 2009), and is therefore excluded from this analysis.

1.2. Gas demand & production

In 2016, UK gas demand was 67.0–72.0 billion cubic meters (bcm) (BEIS, 2017b; OGA, 2017), which was supplied by domestic and imported sources. Total domestic production, before exports, was 37.0 bcm. Imported gas (30.9 bcm) came from Norway, Belgium, and The Netherlands via interconnections. An additional (13.9 bcm) of liquefied natural gas (LNG) was supplied from Qatar (12.9 bcm), Algeria (0.5 bcm), Trinidad & Tobago (0.5 bcm), with negligible amounts from Nigeria (44 mcm), and Norway (55 mcm). Exports through interconnection were 14.2 bcm with an additional 276 mcm exported as LNG. After subtracting exported gas, UK used around 27% of gas in electricity generation or 19.2 bcm. Of this, 16.9 bcm were used by MPPs, the remaining gas being used in autogenerators (BEIS, 2016a, 2016b; OGA, 2017).

The Oil and Gas Authority (OGA) forecasts that domestic oil and gas production will decline by 5% yr^{-1} from 2022 until 2035, with gas production dropping from 34.7 bcm in 2018 to 14.5 bcm in 2035. Demand across all UK sectors is projected to decline more slowly - from 74.1 bcm in 2018 to 61.5 bcm in 2035 - despite impetus from carbon budgets and further growth in renewable energy supply. Without a shale gas industry, falling domestic production could increase the UK's domestic supply gap to more than 796 bcm (OGA, 2017) (see Fig. 1). This would require imports to increase from 53% of demand in 2018 to an estimated 76% of demand in 2035.

1.2.1. UK shale gas resource estimates

The potential of the UK shale gas resource to fill the projected domestic gas supply gap is an area of substantial policy and commercial interest (Bradshaw et al., 2014). Advanced Resources International (ARI) estimate that the UK holds 3783 bcm (133.4 trillion cubic feet, tcf) of 'risked gas-in-place' – gas which may be accessed given geological knowledge and production history - from a larger 17,641 bcm (623 tcf) of total shale gas. Of the risked gas-in-place, 728 bcm (25.7 tcf) is estimated to be technically recoverable (Kuuskraa et al., 2013). This corresponds to a 19.2% recovery rate of technically recoverable resources, similar to the mean estimates of around 20% used by Kuuskraa et al. (2011, 2013).

The British Geological Survey (BGS) estimate that the UK has a total of 39,900 bcm of shale gas, with a range of 24,700–68,400 bcm

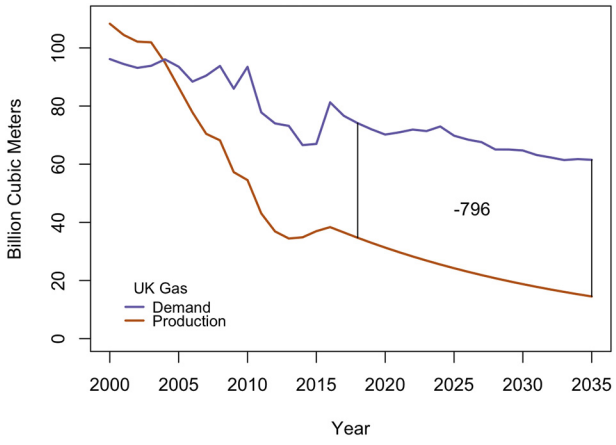

Fig. 1. UK natural gas production and demand for all sectors projected to 2035. Declining domestic production will create an import demand of 796 billion cubic meters from 2018 to 2035. Figure generated from OGA projections (OGA, 2017).