Energy Policy 106 (2017) 41–47

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Natural gas and spillover from the US Clean Power Plan into the Paris Agreement

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ARTICLE INFO

Keywords:
Natural gas
Clean Power Plan
Bridge fuel
Fugitive emissions
Paris Agreement
Electric power

ABSTRACT

Climate change has been identified as one of the today's great challenges, and mitigation likely requires policy intervention. As such, in 2015 the United States introduced the Clean Power Plan (CPP) which aims to reduce CO_2 emissions from electricity production 32% from 2005 levels by 2030 and the Paris Agreement, which seeks to reduce national greenhouse gas (GHG) emissions, measured by global warming potential (GWP), 28% from 2005 levels by 2025. However, it remains unknown how the more narrowly-scoped CPP might affect the ability to achieve wider-scoped national GHG targets like the Paris Agreement. In our current state-of-world, characterized by inexpensive natural gas, the CPP will be met through large shifts from high-emitting coal power to less-emitting natural gas power, which translates to a 9.6% reduction in total US 100-year GWP without accounting for the fugitive methane. Spillover from fugitive methane could cut this reduction modestly by 0.2–1.4% or as much as 4.4% if evaluated using 20-year GWP – elucidating how different assumptions leads to different perspectives of natural gas as a "bridge fuel". The results here demonstrate the need to coordinate policies – either through additional policy (e.g. regulation of fugitive methane) or a larger-scoped CPP that includes upstream activities.

1. Introduction

In 2015, the United States Environmental Protection Agency (EPA) announced the Clean Power Plan (CPP) with a projection to reduce CO_2 emissions from the electric power generation 32% from 2005 levels by 2030. The EPA identified: i) improving the heat rate of existing coal plants, ii) substituting gas power in place of coal power at existing plants, and iii) substituting zero-emitting renewable power in place of coal power as the three best system building blocks for achieving the 32% reduction target (Clean Power Plan, 2015).[1]

The second building block is a key mechanism, because gas combustion emits approximately half the CO_2 emissions of coal combustion in electricity generation. Following the sharp decline in gas prices as a result of the US shale boom, several studies indicate that the most economic way of meeting the nationwide emission target is, at least in part, via fuel-switching from high-emitting coal power to lower-emitting natural gas as well as further capacity expansion in gas power. In fact, this transition can be observed prior to the CPP in data following the fall in gas prices in 2008–2009 (see Fig. 1).

The fall in natural gas price raised the idea of gas as a "bridge fuel" to a low-carbon electricity future, with much debate (Kerr, 2010; Howarth et al., 2011; Levi, 2013; Shearer et al., 2014; Howarth, 2014; Davis and Shearer, 2014). While this debate continues, Fig. 1 demonstrates that relatively inexpensive natural gas has already led to fuel-switching from coal power to gas power as well as a decline in total electricity sector CO_2 emissions. When measured by CO_2 emissions in the electricity sector, it is reasonable to state the natural gas is, at least, a short-term bridge fuel.

Because natural gas (i.e. methane) is 86 times more potent than CO_2 in terms of GWP over a 20-year period and 34 times more potent over a 100-year horizon (Myhre et al., 2013), one of the more recent concerns about increased gas power production is the accompanying methane emissions from extraction and transmission that occur prior to combustion in the power plant.[2] While it is difficult to generalize pipeline specifications serving gas power plants across the entire United States, it stands to reason that increased demand for gas power

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[1] Demand-side management is another key mechanism for reducing electricity sector emissions. This study uses EIA Annual Energy Outlook projections of future electricity demand (EIA, 2016b), which treats energy efficiency implicitly.

[2] Aerial observations have shown that atmospheric methane has increased over the past decade; however, isotope signatures indicate that the increase may not be attributable to oil and gas extraction (Schwietzke et al., 2016; Schaefer et al., 2016; and Nisbet et al., 2016). These studies assume that methane isotopes from shale and conventional sources are identical; however, Golding et al. (2013) suggest that isotopes from shale sources may be slightly different.

http://dx.doi.org/10.1016/j.enpol.2017.03.039
Received 19 August 2016; Received in revised form 17 March 2017; Accepted 18 March 2017
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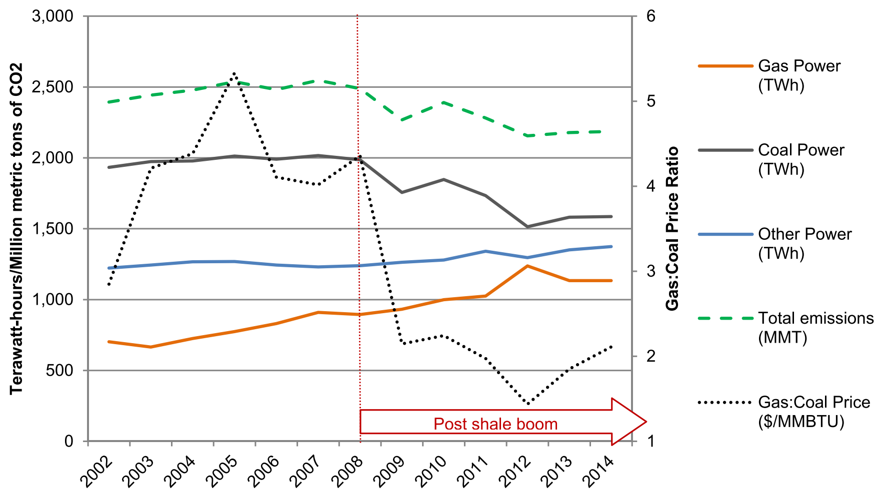

Fig. 1. US electricity sector CO_2 emissions drop because of fuel-switching from coal to gas power as a result of falling gas prices following the shale gas boom in 2008. Source: EIA, 2016a.

will not contribute significant additional methane leakage across the distribution network (i.e. the part of the network that serves municipalities and households), which accounts for approximately 20% of methane leakage (EPA, 2014).[3] Estimates of fugitive emissions from production, gathering, boosting, processing, transmission, and storage range from 1.1% (EPA, 2016) to 5.6% (the mean of the high-end of conventional and shale gas development minus distribution from Howarth et al., 2011) of total production, with a majority of studies settling slightly above the low-end EPA value (Brandt et al., 2014; Lyon, 2016).[4] In an effort to address fugitive emissions, the EPA established a federal rule seeking to reduce fugitive emissions by 40–45% (New Sources Performance Standards, 2016). Whether this target will be met through the regulation remains to be seen.

Regardless of what the actual rate may be in 2030, these fugitive emissions would not fall within the current scope of the CPP, but are still relevant in climate change mitigation. Despite its limited scope, the CPP is cited as a major component of the US contribution to the United Nations' Paris Agreement, a more broadly-scoped target that seeks to reduce net US greenhouse gas (GHG) emissions, measured by 100-year global warming potential (GWP), by 28% from 2005 levels by 2025 (US Department of State, 2016).

It remains unknown how the more narrowly-scoped CPP (i.e. CO_2 emissions in the US electricity sector) might spillover into wider-scoped national GHG targets like the Paris Agreement. A spillover effect is a situation where an activity has an unintended consequence on another seemingly unrelated activity. In terms of the CPP, the spillover is cross-sectoral in that emissions may increase in sectors outside the scope of the mitigation policy (i.e. outside the CO_2 emissions in the electricity sector). This idea echoes arguments for life-cycle instead of production-based emission policies as well as for life-cycle accounting in the study of energy and economic systems (e.g. Burnham et al., 2011; Weber and Calvin, 2012).

The question here is: how will the CPP mechanisms, designed to reduce CO_2 emissions in the electricity sector, affect broader climate change mitigation goals like the Paris Agreement considering the spillover from fugitive methane emissions* In the process of answering this question this article provides: i) life-cycle emission analysis combined with energy-economic modeling of the electricity sector, ii) clarity in the debate about whether natural gas is or is not a bridge fuel, and iii) a consensual path forward that would help reduce policy spillover through measurement and policy adjustment to mitigate fugitive methane emissions.

Section 2 introduces the scenario planning framework and energy-economic model used to explore the interaction between the CPP and the Paris Agreement targets. The four scenarios explore technological contributions to total US electricity generation in 2030 under low and high natural gas prices, with or without CPP implementation. Section 3 describes the specific data and assumptions used to project technological contributions to 2030 US electricity production and the accompanying emissions from both combustion and fugitive emissions. Section 4 discusses the scenario results and the fugitive emissions for the four scenarios. Section 5 draws conclusions from the analysis and suggests a path forward through measurement and policy that could be met with broad consensus to reduce spillover from the CPP into broader climate change mitigation objectives like the Paris Agreement.

2. Methodology

There is, of course, great uncertainty in answering the question of spillover. First, models that predict large shifts to gas power assume that current natural gas prices represent a new normal. This may not be the case due to price rebound effects, especially in the face of possible liquefied natural gas exports, or even moratoriums on horizontal drilling and hydraulic fracturing (i.e. fracking). Second, the CPP itself faces legal challenges in the Trump Administration, US Congress, as well as the US Supreme Court where it is, at the time of publication, put on hold. Third, the GWP of fugitive emissions depends on assumption regarding the emission rate, effectiveness of EPA regulation, and the time horizon of the analysis. The following sections describe the scenario-based analysis using an energy-economic model to project technological contributions to US electricity generation and the corresponding CO_2 emissions from combustion as well as fugitive methane emissions from expanding gas infrastructure.

2.1. Scenario analysis

The uncertainty in the spillover question is well-suited for scenario planning where different “states-of-the-world” are simulated in the same modeling regime in order to tease out the important mechanisms and assumptions leading to different projections of the future. The four scenarios here assume pre- or post-shale boom gas prices (2007 and

[3] Continued low gas prices could lead to increased gas demand in households, businesses, and industries where total fugitive emission rates could be higher because these sectors us the distribution network. This impact is not explored in this particular work.

[4] Schneising et al. (2014) suggests fugitive emissions from shale plays could be much higher than the high-end used in this article; however, this estimate seems to be an outlier from the wide body of literature that fits into the range used here. The implications of using the Schneising et al. (2014) estimate is straightforward in the results (that is, more fugitive emissions than the high-end presented here).