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Policy Perspective

The unstudied barriers to widespread renewable energy deployment: Fossil fuel price responses

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ABSTRACT

Renewable energy policy focuses on supporting the deployment of renewable power generators so as to reduce their costs through scale economies and technological learning. It is expected that, once cost parity with fossil fuel generation is achieved, a transition towards renewable power should continue without the need for further renewable energy subsidies. However, this reasoning implicitly assumes that the cost of fossil fuel power generation does not respond to the large scale penetration of renewable power. In this paper we build a standard economic framework to test the validity of this assumption, particularly in the case of coal and gas fired power generation. We find that it is likely that the cost of fossil fuel power generation will respond to the large scale penetration of renewables, thus making the renewable energy transition slower or more costly than anticipated. More analysis is needed in order to be able to quantify this effect, the occurrence of which should be considered in the renewable energy discourse.

1. The energy transition and the flaw in policy architecture

In the 21st Century we are faced by two challenges that are highly dependent on the energy sector: sustainable economic development and global climate change. Addressing them is often being linked to the decarbonisation of today's energy system. Primary energy consumption is growing by approximately 2% per year, however this growing demand is heavily dependent on fossil fuels (GEA, 2012). Therefore, low carbon and renewable energy technologies are needed to mitigate the negative externalities associated with the fossil fuel sector. In particular, anthropogenic greenhouse gas emissions are increasing at a rapid rate and are very likely to be already causing changes to the global climate system (IPCC, 2014). According to BP (BP, 2014), without strong mitigation policies, emissions are set to increase by approximately 30% over the next 20 years. For this reason, future energy scenarios that are compatible with averting extreme impacts of climate change are characterised by strong penetration of low carbon technologies, including renewable energy (IPCC, 2014).

The pressing need for low carbon and renewable energy generation capacity has resulted in policy measures to support research, development and the rapid deployment of alternative technologies – thereby initiating the early stages of a low carbon energy transition. The power generation sector is arguably at the forefront of this transition and renewables in particular are increasingly competing with conventional fossil fuel plants that run predominantly on coal, natural gas, and to a lesser extent, oil. According to BP (BP, 2014), renewable generation capacity has grown at an average annual rate of 10.6% since 1990. BP expects renewable generation capacity to continue to grow at an average annual rate of 6.6% over the next two decades (BP, 2016). The penetration of renewables in the power generation sector is therefore the focus of this paper.

It is inevitable that the rapid emergence of new technologies is set to interact with the incumbent energy value chain in the power generation sector. The degree to which renewable energy can displace fossil fuels will conceivably be influenced by the following three issues.

The first is the extent to which fossil fuel backup generators are needed in order to balance electricity grids with medium to high levels of penetration of intermittent renewables, also considering the future role of storage and demand-side management; results of analysis differ depending on the geographical area and technology mix considered, see for example (EnerNex Corp., 2011; Pöyry, 2011; Strbac et al., 2012), hence no generally valid conclusions can be drawn.

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The second factor is the effect that the deployment of renewable technologies is already having on the profitability of fossil fuel generators and hence the decision to invest in new capacity. This is due to the fact that the deployment of renewables at a significant scale tends to decrease wholesale electricity prices[1] and, at the same time, increase their volatility,[2] as further discussed in Section 2. Moreover, renewables such as solar are displacing fossil fuel generation at daily peak times when wholesale electricity prices are higher (Channell et al., 2013). This is worsening the economic perspective of current investments, in particular for fossil fuel generators that do not benefit from the same level of public support of renewable generators. The relationship among renewable technologies, wholesale electricity prices and investment in new generation capacity is potentially another line of research.

The third factor, which we address in this paper, is the cost competitiveness of renewables relative to fossil fuel generators. Exactly how this should be measured is also somewhat controversial, particularly with regard to whether or not grid integration costs of renewables should be accounted for (Ueckerdt et al., 2013) and how they should be estimated (Hirth, 2013). However, taking levelised cost of electricity (LCOE) as a metric, cost estimate studies suggest that the competitiveness of renewable power generators is strongly dependent on endogenous technological learning (Gross et al., 2013), while that of fossil fuel generators is mainly determined by the price of the fuel itself, i.e. coal and gas (Gross et al., 2013; IEA, 2007; Tidball et al., 2010; US EIA, 2016). In particular, according to (US EIA, 2016), operating and maintenance costs (of which fuel is a very significant part) of a conventional combined cycle gas turbine represent 74% of the total LCOE, while these cost only represent 26% in the case of onshore wind. This example suggests that fuel prices are critical to assessing the economic competitiveness of fossil fuel generators. Here it is argued that the penetration of renewable energy into the power market, by reducing the demand for fossil fuel generation, can directly result in a price response of fossil fuels which in turn affects the relative competitiveness of renewable power, potentially hindering their further penetration. As will be discussed in Section 2, this has not been directly addressed by the literature investigating the interaction between renewables and fossil fuels.

Since the existence of a fossil fuel price response to the introduction of renewables has not been tested yet, it has not been taken into consideration by policymakers. Renewable energy policy addresses the cost of renewable energy technologies in order to enhance their competitiveness and support their uptake. However, it largely ignores the value chain of fossil fuel generation and its possible reaction to the uptake of renewables. In this paper we seek to advance the understanding of the response of fossil fuel value chains to renewable technology market penetration. The question we pose is whether and to what extent overlooking this response leads to a slower than anticipated rate of the renewable energy adoption or a higher cost of the policy support measures required to achieve it.

The current literature on potential interactions between renewable technology penetration and fossil fuel value chains is critically reviewed in Section 2. Section 3 presents an initial analysis of the hypothesised price response mechanism, where we develop a framework based on standard economic theory of supply and demand and we apply it to the fossil fuel markets considered. In Section 4 we summarise our initial findings on the price response mechanism and formulate recommendations for further research.

2. The interaction between renewables and fossil fuels in the literature

We have reviewed the limited literature on the response of fossil fuel value chains to renewable energy penetration, and identified two main theories: the Green Paradox and Carbon Leakage. The Green Paradox theory (Sinn, 2008) is based on the idea that, by decreasing future demand for fossil fuels, climate change policy may accelerate their current rate of extraction and may therefore result in higher overall carbon emissions. The Carbon Leakage theory (Tirole, 2012), on the other hand, postulates that in the absence of globally coordinated climate change policy, production of goods and services based on fossil fuels will move to countries with less stringent environmental regulation therefore offsetting the carbon emission savings realised in countries where climate change policy is in place. One key difference between the two is that the Green Paradox describes an upstream, supply-side response of fossil fuels while the Carbon Leakage essentially describes a downstream, demand-side response. Both theories imply market changes (van der Ploeg and Withagen, 2015), either on the supply or demand side, which ultimately impact fossil fuel prices. However, the theories focus on better understanding the possible future effects of climate change policy, particularly carbon pricing, on global carbon emissions and therefore neither of them specifically addresses the possible effect of the deployment of renewables on the price of fossil fuels. The two theories are summarised in Table 1, together with their strengths and current limitations as discussed in the most recent literature (Jensen et al., 2015; Long, 2015; Sinn, 2015; van der Ploeg and Withagen, 2015).

Aside from the above-mentioned theories, renewables also interact with fossil fuel value chains through the effect that their penetration has on electricity markets. A review of the literature (Browne et al., 2015; Clò et al., 2015; De Vos, 2015; Dillig et al., 2016; Paraschiv et al., 2014; Pöyry, 2010; Würzburg et al., 2013) shows that, thanks to its low marginal cost, the deployment of this type of renewable generators tends to reduce electricity wholesale spot prices and to displace either coal or gas fired power generation due to its effect on the merit order curve. Finally, other studies address the interaction between fossil fuel and renewable generation technology from the perspective of technological improvements of the former as a result of competition with the latter; this is known as the 'Sailing Ship' effect (Pearson and Foxon, 2012). However, neither of these literature strands addresses the direct effect that the large scale introduction of renewable power generation can have on the price of fossil fuels and its potential hindrance to the further penetration of renewables.

3. A perspective on the price response of fossil fuels to the deployment of renewables

Given the lack of analysis of a possible price response of fossil fuels to the deployment of renewables, we set out to build a hypothetical price response mechanism based on standard economic theory and to test it based on the available evidence. Our approach is based on supply-demand analysis, the use of which can also be found in past studies explaining determinants of oil prices (Hamilton, 2008; Horn, 2004; Stevens, 1995). Since according to standard economic theory, prices and quantities in a particular market are the result of the balance between supply and demand, in the next paragraphs we will analyse possible shifts in the demand and supply curves of fossil fuels as a result of the introduction of renewables.[3] This will allow us to draw conclusions on the plausibility of the hypothesised price response mechanism, also taking into consideration factors that are specific to the fuel markets considered. Although demand and supply curve shifts in reality may occur simultaneously, here we will discuss them in turn for the sake of illustration.

[1] Liberalized spot electricity markets have a marginal approach, implying that the price of electricity equals its marginal cost of production. The reason for this evolution of prices is that renewable technology has very low marginal costs.

[2] This is linked to the intermittent nature of renewable power generation.

[3] It is worth noting that a partial equilibrium analysis of the kind we conduct does not capture the interactions with all other markets in the economy.