European Journal of Operational Research 245 (2015) 273–285

Contents lists available at ScienceDirect

European Journal of Operational Research

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

Innovative Applications of O.R.

Simulating the new British Electricity-Market Reform

Carlos J. Franco [a], Monica Castaneda [b], Isaac Dyner [a,c,*]

[a] CeiBA, CIIEN, Universidad Nacional de Colombia, Colombia
[b] CeiBA, ITM, Universidad Nacional de Colombia, Colombia
[c] Universidad Jorge Tadeo Lozano, Colombia

ARTICLE INFO

Article history:
Received 31 March 2014
Accepted 19 February 2015
Available online 26 February 2015

Keywords:
Simulation
Electricity markets
Environmental issues
Security of supply
Sustainability

ABSTRACT

The British government is implementing fully its novel Electricity Market Reform (GB EMR). Its objective, in line with European directives, aims at replacing existing nuclear and coal plant with low-carbon systems, to deliver reliable and affordable power. Though the GB EMR has proposed several policy instruments for meeting its objectives, and the academic literature has discussed the main issues, no known report includes a comprehensive and dynamic simulation exercise that assesses the extent of this profound and important initiative. This paper presents a system dynamics model that supports analysis of long-term effects of the various policy instruments that have been proposed in the GB EMR, focusing on environmental quality, security of supply and economic sustainability. Using lessons learned from simulation, the paper concludes that effectively achieving the GB EMR objectives requires this comprehensive intervention or a similar one that includes the promotion of low carbon electricity generation through the simultaneous implementation of various direct and indirect incentives, such as a carbon price floor, a Feed in Tariff (FIT) and a capacity mechanism.

© 2015 Elsevier B.V. All rights reserved.

1. Introduction – Background of the British electricity market

In the late 1980s, the British electricity industry pioneered the liberalisation of electricity markets in the industrialised world. The most important changes included the creation of a wholesale electricity market – based on long-term contracts and an electricity pool – and the separation of activities along the supply chain. The purpose of the government was to promote a competitive generation industry (Anderson & Cau, 2011; Bunn & Oliveira, 2007; Green, 2006; Newbery, 2006). In the late 1990s, a new set of reforms took place – New Electricity Trading Arrangements (NETA) – which, notably, removed centrally dispatched generation, seeking efficiency and transparency. In 2005, NETA was replaced by British Electricity Trading and Transmission Arrangements (BETTA), which incorporated Scotland within the England and Wales market (Green, 2010).

During the past few years, the political trend in the British and European electricity markets has not only been directed at inducing a competitive electricity industry; but also seeking to achieve environmental targets and delivering secure, sustainable and affordable electricity (Newbery, 2011a). According to the EU goals, the UK commitment is to achieve 15 percent of its energy consumption from renewable sources by 2020; this target could be met with the support of renewable-based electricity generation (seeking up to a 30 percent contribution from renewables in the electricity generation sector) (National Grid, 2011). In addition, the Climate Change Act (2008) establishes that the UK 2050 target is to reduce 80 percent of Green House Gases (GHGs) with respect to the 1990 levels, where the power generation sector is the largest contributor to GHGs of all sectors (DECC, 2012a).

Against this background, the withdrawal of 11.5 gigawatts of coal and oil plant is scheduled to occur by 2016, in order to follow the Large Combustion Plant Directive (LCPD), a European Directive. Further, plans are in train to close about 6.5 gigawatts of nuclear power by 2020, as these facilities are reaching the end of their operational life. In summary, before 2020 around 18 gigawatts of power will be shut down, about 22 percent of current capacity. To meet the decarbonisation and security-of-supply targets this power-generation gap should be filled by low-carbon capacity (Redpoint Energy, 2010).

2. The British electricity-market concern

The Great Britain Electricity Market Reform (GB EMR) seeks three main objectives: (i) to achieve an efficient market, based on low-carbon sources in the power industry, (ii) to ensure security of supply, and (iii) to provide affordable prices to customers (DECC, 2011). These are conflicting objectives: although most renewable energies supply low-carbon electricity they do not contribute adequately to security

* Corresponding author at: CeiBA, CIIEN, Universidad Nacional de Colombia, Colombia. Tel.: +57 1 6166279.
E-mail addresses: cjfranco@unal.edu.co (C.J. Franco), mcastanr@unal.edu.co (M. Castaneda), idyner@unal.edu.co, idyner@yahoo.com (I. Dyner).

http://dx.doi.org/10.1016/j.ejor.2015.02.040
0377-2217/© 2015 Elsevier B.V. All rights reserved.

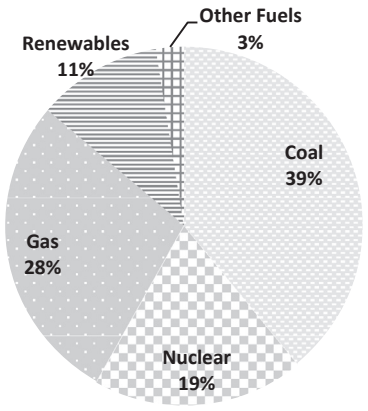

Fig. 1. Electricity mix UK 2013 (DECC, 2013a).

of supply. In addition, as they are not yet competitive enough, their deployment must initially be supported with subsidies, which will be passed through to consumers (Moreno & Martínez, 2011).

The Great Britain Electricity Market Reform (GB EMR) aims at achieving the aforementioned goals. Given the evolution of the British electricity industry, the EMR is grounded on *market failures* of the power sector. The first market failure is that carbon price does not sufficiently incentivise low-carbon generation, and the second one is that carbon price does not adequately promote security of supply (Helm, 2012). Therefore, under the present market conditions, investment in low-carbon technologies will not be resilient unless some subsidies are in place; this, because carbon prices will not deliver clear signals for the use of low-carbon technologies, given their relatively high capital cost and the dominance of gas and coal fired plant in the electricity mix (see Fig. 1). Accordingly, a reform such as the one proposed by the GB EMR seems necessary for achieving the right amount of investment.

The British electricity industry confronts a number of challenges: (a) the retirement of about 18 gigawatts capacity before 2020 (EC, 2001), (b) electricity demand for transport and heating may increase, (c) the decarbonisation of the electricity sector entails the deployment of intermittent capacity (such as wind) and inflexible capacity (such as nuclear), and (d) the assessment of the demand response policies in the sector (Redpoint Energy, 2010).

The main instruments being implemented by the GB EMR, to face such challenges, include:

Carbon Market and Carbon Price Floor: The EU ETS market (European Union Emission Trading System) or carbon market has been mandatory for trading emission certificates in the UK. The demand side in this market includes all the polluting generators that buy emission allowances (Kirat & Ahamada, 2011) as they must offset each ton of CO_2 emitted into the atmosphere by acquiring emission allowances in the EU ETS market or, alternatively, pay a penalty. As carbon prices in this market are dropping to very low levels, this may not offer a clear signal for promoting investment in low-carbon generation, and thus further legislation has introduced a Carbon-Price Floor in Britain. This should reduce volatility and induce the dismantling of carbon-intensive technologies more speedily, as well as potentially increasing electricity imports (DECC, 2011).

Feed in Tariff with Contract for Difference (FIT CfD): Through the FIT CfD, the low-carbon generators will secure their revenues to a strike price, which is defined in long-term contracts. The low-carbon generators receive the electricity market price for their output, but they must pay or receive the difference between the strike price and a reference electricity market price (DECC, 2011). This scheme will be introduced for some technologies in 2017; the CfDs will be allocated through auctions (DECC, 2012b).

Capacity Market: The required capacity is contracted through auctions that run alongside the energy market and CfDs. In this way the delivery body guarantees the necessary capacity margin to maintain the reliability standard defined by the government. The system operator will maintain a security margin to guarantee reliable supply (DECC, 2011).

The preceding policies are supported by:

Emission Performance Standard (EPS): The EPS establishes an emission threshold for new generators that use fossil fuels; the standard is 450 grams CO_2 (carbon dioxide)/kilowatt hour. The EPS requires that new coal plants will be built with at least 300 megawatts of installed capacity with carbon capture and storage (CCS) (DECC, 2011).

Renewable Obligation (RO): This instrument was introduced to increase the share of renewable generation; the government placed an obligation on licensed electricity suppliers to source a percentage of electricity from renewable sources. The RO will remain open to new generation until 2017, and between 2014 and 2017 the generators will be able to choose between CfD and RO (DECC, 2012b).

On November 2012, the key aspects of the EMR were presented to Parliament in the proposed Draft Energy Bill (HM Government, 2012). The first FIT CfD contracts are expected by 2014; for the capacity market, the first auction is expected by 2014, for delivery in 2018/2019. The carbon price floor introduced from 1 April 2013 at around £15.70/tCO_2, following straight line increases that will reach £30/tCO_2 in 2020, rising to £70/tCO_2 in 2030.

In this context, the future of the British electricity sector is uncertain and poses questions, including: What are the long-term effects of the reform? What will the economic impact of the GB EMR policy be? Will the new policies guarantee investments in low-carbon electricity? How can security of supply be guaranteed under these complex conditions?

The objective of this paper is to show how a simulation model, built specifically for this purpose, helps in responding to the preceding questions and thus in the assessment of: (i) the long-term effects of policy that promotes low-carbon power in the electricity sector in Britain, (ii) the economic impact of EMR policies and whether these deliver both affordable prices and security of supply, and also meet environmental goals, and (iii) the undesirable effects of the EMR in Britain.

3. Methodology and model description

Much has been published in recent years regarding the GB EMR. Newbery (2011b) provides a clear explanation of why the EMR is necessary for reducing political failures while addressing market failures. It emphasises the necessity for the development of the EMR at least cost and proposes regulation for a proper long-term contract design for each low-carbon technology. The paper appraises the proposed FIT Contract for Differences (FIT CfD) as this increases costs to consumers and risks to investors, as well as likely windfall profits to investors. After the publication of the Draft Energy Bill more criticisms of the EMR have come about (Newbery, 2012), including: the weak long-term contract design, which does not seem promising; the carbon price floor efficiency; and the requirement for adequate R&D legislation on low-carbon technologies. Also, Helm (2012) presents complications embedded in the EMR and proposes a single auction (two-stage process) for both the FIT and the capacity mechanism; it also proposes the creation of a secondary market for the capacity mechanism.

Foxon (2013) studies the long-term behaviour of the British electricity market to the year 2050, through scenario analysis. The proposed scenarios consider interactions between the actors in the market, government and civil society. Each of the posed scenarios takes into account the key institutional changes, roles of actors, and risks. The largest deployment of low-carbon generation is achieved in the scenario where market actors take a significant role. Low-carbon

Download English Version:

https://daneshyari.com/en/article/479559

Download Persian Version:

https://daneshyari.com/article/479559

Daneshyari.com