Utilities Policy 31 (2014) 29–35

Contents lists available at ScienceDirect

Utilities Policy

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

Toward a less natural gas dependent energy mix in Spain: Crowding-out effects of shifting to biomass power generation

María J. Colinet [c], José M. Cansino [a, b, *], José M. González-Limón [a], Manuel Ordóñez [a]

[a] University of Seville, Spain
[b] Universidad Autónoma de Chile, Chile
[c] Andalusian Energy Agency (Andalusian Regional Government), Spain

ARTICLE INFO

Article history:
Received 30 January 2014
Received in revised form
27 July 2014
Accepted 27 July 2014
Available online

Keywords:
Biomass for electricity generation
Natural gas generation
Combined cycle technology
Input–output framework
Fuel substitution
Renewable energy

ABSTRACT

This paper estimates the impact of a hypothetical change in Spain's energy mix on a number of productive sectors. The change would be brought about by substituting power generation from natural gas with generation from biomass. The total amount of electricity supplied has been calculated to remain constant so that a crowding-out effect would be derived from the displacement of one technology with another. An input–output (IO) framework has been used to estimate the overall economic impact on 26 productive sectors included on Spain's 2007 IO Table. Based on the available literature, the consideration of net impact improves the analysis. The results show that the overall net impact across all productive sectors of this change in the energy mix would be positive and equal to about 0.5% for the period. Higher impacts were measured for the 'Electricity power and Electricity Supply' sector (15.4%) followed by the 'Agriculture, Hunting, Forestry' sector (7.1%). Only the 'Gas generation and Gas supply' sector showed a negative impact (−2.5%), which is consistent with the reduced use of natural gas. The overall calculated total impact for Spain's productive sector was equal to € 8074.95 million at the 2007-equivalent value.

1. Introduction

To raise the targets established by the European Union (EU) Directive 2009/28/EC, the authorities of Spain approved a document titled 'Plan de Energías Renovables ("Renewable Energy Plan" in Spanish) 2011–2020' (IDAE, 2011). This legal document fixed mandatory deployment targets until 2020 for each renewable energy technology type.

Complying with these mandatory targets will affect Spain's economy; therefore, assessing the economic impact becomes a relevant question. When the impact of the deployment of a particular technology is assessed, the available literature usually assumes that there will be an increase in the total installed capacity (Caldés et al., 2009; Cardenete et al., 2010; Cansino et al., 2013).

However, an alternative assumption that implies no change in the total installed capacity could be more useful. In 2013, the total capacity installed in Spain was 108,148 MW. However, the demand peak was only 39,963 MW (REE, 2013). This means that the total capacity installed was 2.7 times greater than what was necessary to supply the peak. In fact, the experts recommend that the relationship between the available power and the demand peak (known as Demand Coverage Index) be 1.10 (CNE, 2012).

Given that Spain has excess generation capacity, a crowding-out effect implying displacement by new technologies seems more plausible than the assumed increase in total power generation. The displacement is based on substituting Combined Cycle Plants (CCP) for Biomass Plants (BP) and accepts that the total installed capacity remains constant. The choice of the two technologies used in this analysis is explained herein.

First, the literature offers evidence about the positive impact of BP on rural areas (Cardenete et al., 2010). Second, this idea is also consistent with the design of the EU Common Agriculture Policy (CAP, Council Decision 2006/144/EC). Third, the electricity supplied by BP does not depend on weather (sun or wind based technologies) and can be modulated based on the electricity demand (i.e., it is a dispatchable form of energy). BP has a low disruption risk. Section 3 provides greater detail on this point.

In the case of CCP, there are two additional reasons that support our hypothesis. First, the electricity generated by these plants in 2013 accounted for only 9.6% of all electricity generated (REE, 2013). Dismantling and substitution CCPs with BP would not jeopardize overall supply. Second, Spain has no natural gas resources; 99.4%

* Corresponding author. University of Seville, Spain.
E-mail address: jmcansino@us.es (J.M. Cansino).

http://dx.doi.org/10.1016/j.jup.2014.07.006
0957-1787/

comes from imports (CORES, 2012). Reducing the installed CCP capacity means reducing Spain's dependency on foreign suppliers for this energy source. This also is one of the pillars of the EU energy strategy (European Commission, COM/2000/0769 final).

In the case of BPs working 7000 hours per year (as occurs with CCP replacement), the reduction in natural gas consumption relates to a decrease in imports associated with 11,000,000 MWh, which can be valued at € 290.3 million when considering an import price for natural gas of 26.4 €/MWh (CNE, 2013).

Substituting CCP for BP plants is technologically feasible (as discussed below). The BP technology considered in this study is a mature technology on the market. This substitution implies no risk for the security of the electricity supply. Moreover, the hypothesis is consistent with the objectives for rural development established in the CAP. This change in Spain's electrical mix would contribute to reducing dependency upon foreign energy, as Spain lacks natural gas deposits. In sum, all of the above means that our proposed shift is realistic and feasible.

As mentioned, the authorities of Spain have established mandatory deployment targets for all renewable energy technologies up to the year 2020. Each technology, including biomass, is listed in the document titled 'Plan de Energías Renovables 2011–2020' (PER or Renewable Energy Plan) (IDAE, 2011) with corresponding targets. The target fixed by the PER for biomass power generation using biomass feedstock is an installed capacity of 1350 MW in 2020 (an increase of 817 MW over the amount installed in 2010).

Considering the priority placed on the use of green electricity in Spain's power grid, the fully installed capacity of BP-produced electricity is used in all cases. This technology can be managed in a planned manner if raw materials are available; this differs from other RES technologies that are "variable" and dependent on natural phenomena such as rain, wind or solar radiation (Sovacool, 2009). Because CCP power output can be modulated, in this present study, we consider that the electricity generation levels using CCPs would be reduced to maintain a balance with the added power derived from BP. However, no CCPs would be dismantled.[1]

This paper considers the economic impact of the change in Spain's energy mix associated with compliance with the PER (2011–2020). We estimate the impact on Spain's productive activities when deploying BP instead of CCP to generate a comparable amount of electricity. The analysis contributes to the literature by providing, to our knowledge, the first study that evaluates the net economic impact of shifting to an alternative energy technology. Moreover, our Input–Output (IO) approach constitutes an analytical improvement by considering the crowding-out effect instead of assuming a gross increase in MW installed. These results are interesting not only for researchers but also for utility companies and policy-makers. In fact, this paper speaks directly to the authorities of Spain and the policy agenda with regard to several issues, including energy security.

This paper proceeds as follows. Section 2 explains the IO methodology and Section 3 describes the data used in the analysis. The results and discussion are presented in Section 4, while Section 5 summarizes the main conclusions.

[1] In 2012, Spain had 51 CCPs with an installed capacity of 25,269 MW (this accounted for 25.22% of the total national installed capacity); 50.734 GWh (19.2% of the total) were generated, which is a utilization ratio of 25.1% of the CCPs' production capacity. By 2010, this had increased to 31.9%. The functioning electricity system has a rated capacity of 2007.75 hours per year. In 2012, the operations stood at 1579.46 hours per year (See REE, 2011 and 2012).

2. Methodology

The IO approach is largely supported by the available literature. The economic impact of Renewable Energy Sources (RES), such as solar energy, has frequently been estimated using IO models. In the US, for example, IO analysis has been used by Cook (1998) and Ciorba et al. (2004), while in Europe, Kulisic et al. (2007), Madlener and Koller (2007), and Allan et al. (2008) developed similar approaches. Caldés et al. (2009), Calzada et al. (2009), and the European Commission (MITRE, 2009) recently used an IO model to estimate the economic impact of RES in Spain.

The basis for the methodology applied herein is the Leontief (1941) model. The starting point is the concept of a technical coefficient, a_{ij}, indicating how the needs (z_{ij}) of sector j relate to the inputs from another sector I per unit of output (x_j) from sector j itself, which is expressed as follows:

$$a_{ij} = \frac{z_{ij}}{x_j} \tag{1}$$

From (1), (2) is obtained:

$$z_{ij} = a_{ij} \cdot x_j \tag{2}$$

On the other hand, the total output of sector j is the sum of intermediate consumption for the entire sector (n) of this sector's economy makers (z_{ij}) and products that are destined to final demand (f_j). Thus, the production of sector j can be expressed as:

$$x_j = z_{j1} + z_{j2} + \ldots + z_{jj} + \ldots + z_{jn} + f_j \tag{3}$$

The production of the remaining sectors follows a similar pattern. The production of each of the n sectors is defined by the following expression:

$$\begin{array}{l} x_1 = z_{11} + z_{12} + \ldots + z_{1j} + \ldots + z_{1n} + f_1 \\ x_2 = z_{21} + z_{22} + \ldots + z_{2j} + \ldots + z_{2n} + f_2 \\ \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \\ x_j = z_{j1} + z_{j2} + \ldots + z_{jj} + \ldots + z_{jn} + f_j \\ \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \\ x_j = z_{j1} + z_{j2} + \ldots + z_{jj} + \ldots + z_{jn} + f_j \end{array} \tag{4}$$

Substituting each z_{ij} by $a_{ij} \cdot x_j$ gives:

$$\begin{array}{l} x_1 = a_{11} \cdot x_1 + a_{12} \cdot x_2 + \ldots + a_{1j} \cdot x_j + \ldots + a_{1n} \cdot x_n + f_1 \\ x_2 = a_{21} \cdot x_1 + a_{22} \cdot x_2 + \ldots + a_{2j} \cdot x_j + \ldots + a_{2n} \cdot x_n + f_2 \\ \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \\ x_j = a_{j1} \cdot x_1 + a_{j2} \cdot x_2 + \ldots + a_{jj} \cdot x_j + \ldots + a_{jn} \cdot x_n + f_j \\ \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \\ x_n = a_{n1} \cdot x_1 + a_{n2} \cdot x_2 + \ldots + a_{nj} \cdot x_j + \ldots + a_{nn} \cdot x_n + f_n \end{array} \tag{5}$$

Solving f_i, one obtains:

$$\begin{array}{l} (1 - a_{11}) \cdot x_1 - a_{12} \cdot x_2 - \ldots - a_{1j} \cdot x_j - \ldots - a_{1n} \cdot x_n = f_1 \\ -a_{21} \cdot x_1 + (1 - a_{22}) \cdot x_2 - \ldots - a_{2j} \cdot x_j - \ldots - a_{2n} \cdot x_n = f_2 \\ \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \\ -a_{j1} \cdot x_1 - a_{j2} \cdot x_2 - \ldots + (1 - a_{jj}) \cdot x_j - \ldots - a_{jn} \cdot x_n = f_j \\ \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \\ -a_{n1} \cdot x_1 - a_{n2} \cdot x_2 - \ldots - a_{nj} \cdot x_j - \ldots + (1 - a_{nn}) \cdot x_n = f_n \end{array} \tag{6}$$

The expression (6) can be shown in this matrix formula:

$$(I - A) \cdot x = f \tag{7}$$

where I is the identity matrix of order *n x n*, A is a matrix of order *n x n* for the technical coefficients, x is a column vector of order *n x 1* for the production of each sector, and f is the column vector of order *n x 1* of the final demand of each sector.

If we pre-multiply the two terms in (7) by $(I-A)^{-1}$, we obtain: