Fuel Competition in Power Generation in India and its Implications for Fuel Price Reforms and Decarbonization

Anupama Sen, Senior Research Fellow, Oxford Institute for Energy Studies,
Phone: +441865889131, Email: anupama.sen@oxfordenergy.org

Overview

This paper looks at the competition between various fuels used for electricity generation in India by estimating the elasticities of substitution among them. Studies on the elasticities of interfuel substitution are typically used to investigate a range of policy issues, including the impact of liberalisation and regulatory reform, the impact of environmental regulation on energy use, and the design of electricity markets (Dahl and Ko, 1998; Yeboah et al, 2014). Most studies have found that interfuel elasticities of substitution are generally below unity, and developed countries demonstrate higher potential for interfuel substitution than developing countries (Serletis et al, 2010).

Electricity reforms in India over the last decade have been aimed at restructuring the previously monopolistic State Electricity Boards into unbundled corporations, and have recently included the delicensing of generation, non-discriminatory open access in transmission, and the designation of power trading as a separate activity (Singh, 2010). There has been a simultaneous programme of fossil fuel (oil, natural gas, and potentially coal) subsidy reform, aimed at correcting India's highly distorted system of domestic pricing to resemble something that is rational and efficient. This merits an investigation of whether there has been any effect on interfuel substitution, particularly given India's economic growth goals and potential contribution to emissions. The analysis in this paper can be viewed in two parts. The first part considers estimates on the relative elasticities of fuel substitution for India's electricity sector and compares them with estimates for developed nations such as the USA, using existing literature. The second part considers the results in the wider context of electricity and fuel subsidy reforms, and the implications of the results for any sort of voluntary decarbonisation target or carbon pricing regime (India currently imposes a 'clean energy tax' per tonne of coal).

Methods

There is a substantial amount of empirical literature on the competition between various fuels in electricity generation, but most of this has been on determining the effects of deregulation of the electricity industry in OECD countries, based on price-driven displacement among energy sources using the economic theory of production input substitution (Bopp and Costello, 1990; Jones, 1995; Dahl and Ko, 1998; Ko and Dahl, 2001; Urga and Walters, 2003; EIA, 2012). This paper draws on the method in EIA (2012) which builds on earlier input substitution research, specifically with regards to analysing how power producers adjust their choice of fuel mix in response to changing fossil fuel prices.

The model estimates values for the elasticity of substitution, which is a measure of the responsiveness of producers in swapping inputs when the relative prices of these inputs change. Producers will tend to favour the input that has the lowest overall cost. However, various economic, technological and regulatory restrictions can limit this responsiveness (EIA, 2012). The elasticity of substitution (ε) between two fuels can be defined as:

$$\varepsilon = \frac{\%\ change\ in\ (\frac{F_1}{F_2})}{\%\ change\ in\ (\frac{P_1}{P_2})}$$

Where:

F_x is the quantity of the input (fuel) x used in production, and P_x is the per-unit price of the associated input (fuel). As the price of one input increases, producers will attempt to substitute more of other inputs. An elasticity $\varepsilon = 1$ indicates that for a given percentage decrease (increase) in the price of fuel 2 relative to the price of fuel 1, the relative use of fuel 1 in production compared with fuel 2 will exhibit a similar percentage increase (decrease). $\varepsilon < 1$ indicates that the use of one fuel in production will change less that proportionately to a given change in the relative

prices – or that producers do not have the flexibility to swap one input for another in the production process. $\varepsilon > 1$ indicates that producers are more open to substituting different fuels in the production process when relative prices change.

The variables required for calculating the elasticity of fuel consumption are price per unit and quantity of the different fuels used in generation/production (EIA, 2012). A static analysis of fuel substitution is subject to factors that can skew the elasticity value – as all of the changes in fuel consumption are attributed to movements in fuel prices. A more generalised economic model can measure price-driven substitution whilst accounting for other factors influencing fuel consumption (EIA, 2012). We attempt to apply a linear logit model which accounts for these factors in the estimation of elasticity coefficients (EIA, 2012; Considine and Mount, 1984). This model can also be adapted to study dynamic fuel displacement behaviours. Contingent on data availability, we try to focus on substitution between three broad classes of fossil fuels (coal, natural gas and petroleum) and assume that the prices of other inputs such as labour and capital have a minimal impact on generators' choice of fossil fuel. This assumption holds for the case of India, where 80% of electricity is generated from fossil fuels and 70% of the cost of generation can be attributed to fuel costs (GOI, 2013).

Results

The expected result is a low interfuel elasticity of substitution.

Conclusion

The implications of the results are important as they reveal whether (and to what extent) electricity restructuring and fuel subsidy reform has had an impact on fuel consumption patterns in the electricity sector. The results can also be related to future implications for voluntary measures on decarbonisation in the context of the pricing system. For instance, low elasticities of fuel substitution could indicate that existing policy measures are unlikely to have any significant impact on the decarbonisation of electricity generation. These conclusions could also be related to broader issues on the debate over liberalisation versus planning in the electricity sector, and the relevance of electricity sector liberalisation in developing countries.

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