Energy Policy 50 (2012) 207–216

Contents lists available at SciVerse ScienceDirect

Energy Policy

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

Demand response in Indian electricity market

Md Zakaria Siddiqui [a,*], Gauthier de Maere d'Aertrycke [b], Yves Smeers [c]

[a] Centre for Regulation and Market Analysis, School of Commerce, University of South Australia, Adelaide, Australia
[b] Fondazione Eni Enrico Mattei (FEEM) and Euro-Mediterranean Center on Climate Change (CMCC), Corso Magenta 63, 20123 Milano, Italy
[c] Center for Operations Research and Econometrics (CORE) and Department of Mathematical Engineering (INMA), Université catholique de Louvain, 1348 Louvain-la-Neuve, Belgium

HIGHLIGHTS

- ► Modelling the impact of retail tariff in different states on spot prices of electricity in India.
- ► Retail tariffs are usually fixed below appropriate levels by states due to political reasons.
- ► Due to revenue constraint distribution utility withdraws demand from spot market in peak hours.
- ► This adversely affects the scarcity rent of generators and subsequently future investment.
- ► We show possibility of strategic behaviour among state level regulators in setting retail tariff.

ARTICLE INFO

Article history:
Received 28 June 2011
Accepted 15 June 2012
Available online 11 August 2012

Keywords:
Electricity
Regulation
Demand response

ABSTRACT

This paper outlines a methodology for implementing cost of service regulation in retail market for electricity in India when wholesale market is liberalised and operates through an hourly spot market. As in a developing country context political considerations make tariff levels more important than supply security, satisfying the earmarked level of demand takes a back seat. Retail market regulators are often forced by politicians to keep the retail tariff at suboptimal level. This imposes budget constraint on distribution companies to procure electricity that it requires to meet the earmarked level of demand. This is the way demand response is introduced in the system and has its impact on spot market prices. We model such a situation of not being able to serve the earmarked demand as disutility to the regulator which has to be minimised and we compute associated equilibrium. This results in systematic mechanism for cutting loads. We find that even a small cut in ability of the distribution companies to procure electricity from the spot market has profound impact on the prices in the spot market.

1. Introduction

India's central electricity (federal) regulator[1] circulated a staff paper in 2006 to initiate a discussion on establishing of an hourly spot market for electricity as mandated by the Electricity Act 2003 (CERC, 2006). As a result of this there are two power exchanges that are operating in India (Singh, 2010).[2] However, there has been little concern about how the regulated retail sector (downstream) will affect the spot market (upstream) outcomes.

Some argue that one of the distinguishing features of the spot market regime in India or any other developing country, would be the demand response which is so far absent in electricity markets of Europe and the USA (Phadke, 2006). In fact, regulators and academia are spending considerable amount of efforts to design policies so that retail consumers could respond to prices on real time (Spees and Lave, 2007). Motivation for such effort comes from the fact that demand response on real time can significantly restrict the ability of the electricity sellers in the spot market to abuse their market power. Much of the literature on electricity markets use Cournot models where constant elasticity of demand function is assumed. It is hard to establish the empirical validity of such a demand function. On the other hand, it is simply impossible to analyse the functioning of the spot market unless we know the demand function.

Studies relating to elasticity of demand for electricity in India are quite inconclusive. Chattopadhyay (2004) shows through a very careful micro-econometric analysis that price elasticity of demand for electricity in the case of industrial consumers is well

* Corresponding author. Tel.: +61 8830 20601 .
E-mail addresses: Zakaria.Siddiqui@unisa.edu.au (M.Z. Siddiqui), gauthier.demaere@feem.it (G. de Maere d'Aertrycke), yves.smeers@uclouvain.be (Y. Smeers).

[1] Central Electricity Regulatory Commission (CERC). At state level, regulatory bodies are usually named as respective state Electricity Regulatory Commission (SERC). SERCs regulate the retail electricity market.

[2] This paper provides a good overview of current status of reforms in the electricity sector of India. Also, see Shukla and Thampy (2011) for details on short term trading in Indian electricity market.

0301-4215/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.enpol.2012.06.030

above 2. This is because of the ability of the industrial consumers to switch to alternative sources of power when the price is high. Non-utility generators or self-generation can serve as alternative sources of power for industrial users. Bose and Shukla (2001) use macroeconometric methods to show that demand for electricity was price inelastic for industrial consumers whereas agriculture sector's elasticity of demand was 1.35.

Other major consumers of electricity are households. Santhakumar (2008) found that households and farmers in some regions were not willing to pay for any increase in the tariff even if they were assured of continuous supply of power without voltage fluctuation (i.e., a large section of Indian households have elastic demand). A study by Filippini and Pachauri (2004), using household data of the National Sample Survey Office (NSSO) of India concludes that demand for electricity is income and price inelastic for every season, particularly during the summer. Their result is limited to urban households. According to this study, the income elasticity of demand for electricity varies between 0.60 and 0.64. They argue that for developing countries, income elasticity is expected to be higher as there are many households without access to electricity. Therefore it is likely that as income of these households rise, their demand for electricity would also grow. Since, this study is limited to the analysis of urban household with access to electricity their income elasticity estimates do not include the effect of expansion in income of households without access to electricity. Most of the estimations are unable to take care of this problem because credible information about the preferences of such households are not available. Surge in demand for electricity by rural households is expected to be slow as high growth of India's gross domestic product (GDP) is concentrated in urban areas. It is difficult to foresee a rapid growth in income of poor sections, from where the incremental demand for power is expected, as growth in employment for this section has been very slow (Bhaskar and Gupta, 2007; Unni and Raveendran, 2007). Hence, their demand for electricity too is expected to grow slowly. In fact, the number of undernourished people in India increased from 200 million during 1995–1997 to 230 million during 2003–2005 according to the latest global food security report of the United Nations Food and Agriculture Organisation (FAO). Tiwari (2000) concludes that the price and income elasticities of residential electricity demand are 0.70 and 0.34, respectively for households in Mumbai metropolitan. Tiwari's results are opposed to Filippini and Pachauri (2004) in terms of values of the elasticities (Table 1).

Such differences, arising due to data and methodology, cannot be reconciled easily and therefore have little use in policy. In addition to this, elasticity is a point concept therefore, it is difficult to extrapolate this information to get a demand function for the whole nation.

In the short run, demand for electricity is usually price inelastic. In the long run, however, demand for electricity may experience some elasticity as shown in Athukorala and wilson (2010). As per capita income of the country is growing at very high rate, demand for electricity will grow faster (i.e., income elastic). Growth in demand for electricity may get a further impetus as soon as the income of the rural households without access to electricity starts growing.

Given the inconclusive nature of literature on the elasticity of demand for electricity, modelling of spot market based on such estimates may yield misleading results. The inherent assumption of unlimited access to electricity, as in the studies mentioned above, is unrealistic for developing countries. It is well known that India faces rampant power cuts (NCAER, 2007).[3] Due to power cuts, the actual quantities consumed would be lower than the potential consumption, and therefore, it is not possible to estimate the real effect of price on quantities consumed. This fact was rightly identified by Pillai (2001): "In an underdeveloped power system like ours, plagued with long-run constraints of inadequate and unreliable supply, electricity consumption remains an input too insignificant to our economic life to be analysed in the framework of some macroeconometric 'causality' models, as is usually done in the context of advanced systems". Phadke (2006) introduces demand response in a simulation study of the spot market for a particular state of India by representing curtailment of demand by load serving entities (distribution companies henceforth DISTCOs) in the retail market at a certain price that reflects the value of loss of load. This study falls short of providing a methodology for deciding the quantum of load that has to be curtailed. In other words, the quantum of load curtailed appears to be arbitrary in his model. His model assumes an exponential demand function i.e., constant price elasticity of demand for electricity.

Table 1
Elasticities of income and price for electricity demand by different studies.

Authors	Income elasticity	Price elasticity
Tiwari (2000)	0.34	0.7
Filippini and Pachauri (2004)	0.60–0.64	0.50–0.30

This paper is aimed at understanding the mechanism of the demand response. Observing procedures through which tariffs are determined in retail markets is quite helpful in modelling the demand response.[4] The annual retail tariff for different states, decided by their respective regulators, is expected to recover the entire cost of DISTCOs under cost of service regulatory regime. But, due to political influence, often exercised through informal means, the retail tariff may not be enough to recover the entire costs of meeting given levels of load in different hours of the year. Such concerns are often raised in the Government of India documents (GoI, 2011, pp. 32, 35). The government directly appoints and funds regulators and can therefore influence them (Prayas, 2003). The regulator decides the given levels of demand on the basis of the proposal given by the DISTCO. For our convenience we call it regulator's subjective demand (RSD henceforth). The regulator's objective is to enable the DISTCO to serve the RSD through the retail tariff that they fix. The regulator, foreseeing non-recovery of the cost, allows the DISTCO to curtail load in hours of high prices in the spot market. Alternatively, the government may decide to meet the RSD in each hour of the year by subsidising the loss incurred by the DISTCO. Previous experiences show that governments prefer load shedding to subsidising losses incurred by DISTCOs (Kannan and Pillai, 2001). This is the mechanism of demand response in the system. In certain states where GDP per capita is high, regulators may be in a position to fix an optimal tariff to meet load in every hour of the year. But in states with very low per capita GDP like Orissa and Bihar, tariff levels certainly have significant political implications for the government. Governments of such states are not in a position to subsidise losses because of fiscal difficulties.

Given the above picture, the use of downward sloping demand curves to model demand response is an indirect and inappropriate tool as retail consumers never see or pay the high prices of the spot market. On the other hand such a demand curve fails to

[3] National Council for Applied Economic Research, New Delhi.

[4] For a detailed description of regulatory process in India, please see Siddiqui (2007).