ELECTRICITY SECTOR REFORM AND THE IMPACT OF DEMAND SIDE MANAGEMENT IN SRI LANKA

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Overview

Implementing Demand Side Management (DSM) mechanisms into liberalised electricity markets has the capacity to reduce peak demand, defer investment and reduce wholesale markets prices [1, 2]. These benefits have been seen in a variety of electricity markets in advanced economies such as the PJM and the NYISO [3]. However, the challenges faced by electricity system operators and policymakers, which have yet to be liberalised in many developing nations, will pose a number of additional difficulties. Demand Response mechanisms have yet to be successfully deployed in South Asian economies [4], where growing populations together with rapidly advancing economies will require more electricity generation options to develop [5]. Sri Lanka which has only emerged from an internal armed conflict in the last 6 years is still on the long journey towards establishing its institutional frameworks which govern the electricity sector.

A significant amount of planning and infrastructure development will need occur before liberalisation of the electricity sector can occur. The state owned utility, the Ceylon Electricity Board (CEB) of Sri Lanka has found it extremely difficult to maintain reliability standards during a number of power crises in 1995/1996 and 2000/2001. This paper explores how Sri Lanka will need to adapt its regulatory and policy frameworks to facilitate the inclusion of DSM and Energy Efficiency programs into its electricity sector.

The results of this presentation will show how the uses of DSM and efficiency programs are an effective risk mitigation option [6, 7], for the future development of electricity markets in developing countries. The data compiled for this study is unique, as it is the first analysis to be undertaken with the objective of demonstrating the impact of DSM on bulk supply customers. This is achieved by simulating a wholesale market with a merit order dispatch system which incorporates the currently operating power plants in the electricity market of Sri Lanka. Furthermore, this paper is also unique in its analysis of an electricity grid in a developing nation.

Methods

Using half hourly dispatch data, plant capacity factors and generator marginal costs, marginal dispatch is estimated using a partial equilibrium model which we have implemented in Matlab. From the derived merit order dispatch, the percentage of DSM required at given half hour to disperse high costly oil/diesel generation is determined, including the effects of DSM deployment on the industrial and other bulk supply customers within a simulated wholesale electricity market scenario. Methodology also allows the provision to calculate the emissions abatement, on a half hourly segment, as per the emissions intensity factor (EIF) of each of the marginal plants displaced as consequence of DSM policies implemented.

In addition, the contribution toward DSM is determined based on the bulk consumption results received from respective bulk supply customers, i.e. Industrial (I), General Purpose (GP) and Hotel (H). The consumption results are represented within three time blocks of the day, i.e. On-peak, Off-peak and Day-time. Therefore the time-segment consumption is fit within the daily Load Duration Curve (LDC) to determine the fit of each block with respect to each of the bulk supply customer consumption contribution. While the most vital DSM emphasis would be with respect to the on-peak time segment, day-time DSM programs are also essential in terms of improving energy efficiency in electricity usage and types of appliances in commercial building.

Results

The results derived from the merit order dispatch of power plants, based on their marginal cost (long-run and short-run), provides visibility as to specific DSM percentage required for given half hour to curtail high costly oil generators from being dispatched, particularly during the evening on-peak hours. On an average the DSM percentage required is assessed to be approximately between 7% and 8% per half hour for the duration of the on-peak time segment, from

18:30 hours to 22:30 hours. Such a reduction of generation, also decreases greenhouse gas emissions, contributing toward emissions reduction goals set for the country.

The reduction in high-end industrial and commercial sector load (bulk supply customers), during critical periods of the day will decrease Sri Lanka's reliance on expensive oil and naphtha based thermal generation. Of the three bulk supply customers, the results indicate that Industrial sector is the highest contributor toward on-peak demand, which justifies higher penalty in terms of revised provincial Time of Use (TOU) tariff or a Critical Peak Price (CPP) tariff. Mandatory installation of smart metering for bulk supply customers is also warranted. This would provide the distribution licensee and Central System Control (CSC), which performs a similar role to that of the wholesale market, the flexibility to coordinate between the half hourly demand and DSM facilities available to curtail high costly oil generators.

Based on the half hourly DSM contribution toward the on-peak time segment to curtail high cost oil generation, we determine the half hour generation costs, as per the two scenarios of 'with DSM' and 'without DSM'. As the implementation of DSM would also incur a cost, it would be lower than the highest cost generator avoided, but higher than the next most expensive generator dispatched during that particular half hour.

Furthermore, the implementation of such DSM programs would also allow for the deferral in investment in electricity generation, and transmission infrastructure. This would not only save variable costs in terms of fuel imports, but also high capital cost with respect to new infrastructure.

Conclusions

Results of the study indicate that deployment of DSM and efficiency programs in the Sri Lankan electricity market will provide significant incentives for commercial and industrial users to reduce their electricity demand. The industrial and commercial sectors would not only save electricity consumption costs, but would intensify their efficient usage of electricity and improve return on investment. Furthermore, the study reveals other significant potential benefits from the deployment of DSM in terms of a reduction in carbon emissions from non-renewable sources and lower wholesale spot market price volatility.

The study reveals that DSM would be the fundamental building block toward improving energy efficiency to achieve low-energy intensity status as a country, but also to provide cost efficient electricity to meet the projected electricity demand for the next 30 years. To this end it is important to note that DSM also provides essential role in generation diversification, where it allows a higher percentage of non-conventional renewable energy (NCRE), i.e. solar roof-top, solar farms, wind farms, biomass, incineration, to contribute toward annual generation.

References

1. Albadi, M.H. and E. El-Saadany, *A summary of demand response in electricity markets.* Electric Power Systems Research, 2008. **78**(11): p. 1989-1996.
2. Strbac, G., *Demand side management: Benefits and challenges.* Energy policy, 2008. **36**(12): p. 4419-4426.
3. Walawalkar, R., et al., *Evolution and current status of demand response (DR) in electricity markets: Insights from PJM and NYISO.* Energy, 2010. **35**(4): p. 1553-1560.
4. Harish, V. and A. Kumar, *Demand side management in India: action plan, policies and regulations.* Renewable and Sustainable Energy Reviews, 2014. **33**: p. 613-624.
5. Wagner, L., et al., *Trading Off Global Fuel Supply, CO 2 Emissions and Sustainable Development.* PloS one, 2016. **11**(3): p. e0149406.
6. Li, Y. and P. Flynn, *Electricity deregulation, spot price patterns and demand-side management.* Energy, 2006. **31**(6): p. 908-922.
7. Li, Y. and P.C. Flynn, *Deregulated power prices: comparison of volatility.* Energy Policy, 2004. **32**(14): p. 1591-1601.