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Role of targeted policies in mainstreaming renewable energy in a resource constrained electricity system: A case study of Karnataka electricity system in India

A.A. Amrutha, P. Balachandra*, M. Mathirajan

Department of Management Studies, Indian Institute of Science, Bangalore, India

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ABSTRACT

India is aggressively pursuing its renewable energy capacity expansion goals. Targeted policies such as Feed-in Tariff (FIT), Renewable Purchase Obligation (RPO) and Renewable Energy Certificate (REC) are introduced to stimulate renewable energy capacity expansion as well as generation. Currently, Indian power utilities treat RPO targets as a cost-burden, and therefore there is prevalence of non-compliance. Even other policies, such as FIT and RECs, in their present form, have failed to influence increase in renewable electricity supply. This has lead us to raise an important question whether these policies are adequate for building a cost-effective renewable energy-based low carbon electricity system for India. In this paper, we discuss the impact of above targeted policies in increasing the share of renewable electricity generation in the case of Karnataka State Electricity System. Various scenarios are developed and analysed using mixed-integer programming model to study the impacts. The results suggest that optimally managed FIT and REC schemes can provide opportunities for utilities to benefit from reduced costs. Overall, the above policies are inadequate, and introduction of market-based incentives, which expand the scope of trading in renewable energy certificates, are essential to achieve the desired objectives.

1. Introduction

The Kyoto Protocol in 1997 marks the beginning of setting binding emission reduction targets on all the developed nations to combat climate change. For developing nations like India, the Copenhagen Accord in 2009, Durban Meet in 2011 and the most recent Paris Meet in 2015 have suggested emission mitigation strategies for many sectors including the electricity sector (UNFCCC, 2015). Though the proposed emission mitigation strategies suggest the electricity sector to utilize super critical coal, hydro, nuclear, renewable energy sources such as wind, solar and biomass, the cost parity between the new low carbon sources and conventional carbon intensive sources of electricity is not yet equal (IPCC, 2014; Lund, 2011). Consequently, such unequal cost parity ultimately creates huge cost burden on electricity Utilities. Thus, it is a pertinent research question to respond to whether adoption of such low carbon power generation technologies result in least-cost electricity systems and the answer to the question is crucial for developing countries like India.

India's power system is dominated by thermal and hydro sources for electricity generation. Even though per capita emissions are low, after China and United States, India is the third largest emitter in the world with 1831 million tonne of GHG emitted in 2012, which is about three times its emission in 1990 (EIA, 2015). This increase in emission is attributed to increased coal consumption, which represented 67% of the emissions increase from 1990 to 2009 (IEA, 2012). With declining plant load factors (65% in 2014-15, MoP, 2015), lack of proper maintenance, lack of good quality coal and insufficient supply, the dominance of coal thermal power plants is already at stake. Even though large hydro is considered as best option among conventional supply options to mitigate emissions, there are challenges associated with environmental and social impacts on constructing dams for hydro plants, siltation and more importantly, the lack of water supply due to inadequate, unreliable monsoon rainfall especially in South India with non-perennial rivers. In such a situation, a high dependency and expansion of coal/hydro plants in the long-run becomes questionable, and it is very important to include other alternatives such as renewable energy sources while making capacity expansion plans.

To adopt a low carbon and secure energy pathway, ever since the Indian Electricity Act 2003 and National Tariff Policy 2006 were enacted, renewable energy exploitation is foreseen to be the most

* Corresponding author.
E-mail addresses: amrutha.appiyah@gmail.com (A.A. Amrutha), patilb@mgmt.iisc.ernet.in (P. Balachandra), msdmathi@mgmt.iisc.ernet.in (M. Mathirajan).

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potent option to meet international agreements on climate change, expand energy access, resource for capacity expansion and ensure energy security. Several policy support mechanisms such as Feed-in Tariff (FIT), Renewable Purchase Obligation (RPO) and Renewable Energy Certificate (REC) are introduced to expand the renewable energy capacity as well as generation. Though there are power purchase agreements made by the power utilities to buy renewable energy at FIT, the quantum of electricity supplied from renewable sources is not yet on par with renewable energy capacity or potential available (MNRE, 2009). Additionally, there are resource (energy or financial) constraints involved in integrating renewable energy in a conventional energy system, thus making RPO targets a cost-burden to the electric utilities. The energy resource constraints are due to insufficient renewable installed capacity as well as electricity generation to meet the RPO targets. For instance, Karnataka State (the case study system) has insufficient solar capacity to comply with solar RPO. The renewable electricity generation is dependent on variable and unpredictable solar and wind resources, which further exacerbates the situation. The financial (investment as well as operational) constraints faced by the utilities have led to making inadequate capital investments in new renewable capacity additions, and to exhibiting reluctance to procure higher priced renewable electricity. All these have caused non-compliance of RPO targets.

Similar to the presence of supply-demand gaps due to power and energy shortages, there is a gap between demand and supply even in the case of renewable electricity because of above constraints. This gap is the difference between the utility's demand for renewable electricity (as fixed by the RPO targets) and the actual supply of renewable electricity. It has resulted in non-compliance of RPO by many Indian states. As on April 2013, out of the 29 states in India, the Distribution Companies (DISCOMs) in 22 states have failed to meet the RPO (Economic Times, 2013). Overall, there is a need to understand whether these renewable energy support policies are a boon or a bane in building a cost-effective low carbon electricity system for India.

The motivation for this study comes from our earlier research on resource constrained electricity systems, and low carbon interventions such as renewable energy technologies and policies (Amrutha et al., 2016, 2014; Amrutha, 2015). The focus was on the development and application of a mathematical modelling framework to optimally plan the dynamic matching of electricity supply and demand with generations from existing and new capacities of both conventional and renewable energy sources. This was done in the presence of RPO targets, unmet demand for conventional and renewable electricity, and power and energy shortages. This model is contemporary in the context of resource constrained electricity systems to understand the impacts of RPO and REC polices under various real-life scenarios.

Till 2003, the importance of renewable policy interventions was not very prevalent in the literature on optimization in electricity planning. Subsequently, one could find studies that have considered renewable policy interventions like RPO, REC and FIT while planning for electricity supply using existing and/or future electric supply options. Wijayatunga and Prasad (2009), Daim et al. (2010), Zhou et al. (2011), Voumvoulakis et al. (2012), and Rahdar et al. (2014) have all incorporated RPO policy in an optimization framework, and these studies show that RPO policy interventions have positively influenced the objective of increasing the share of low carbon supply. Similarly, quantitative assessments of REC policy have focused on aspects like comparing REC with FIT (Gupta and Purohit, 2013; Narula, 2013), understanding the sensitivity of REC prices on renewable supply portfolio (Nishio and Asano, 2006; Unger and Ahlgren, 2005) and sustainability of RECs (Contaldi et al., 2007; Linares et al., 2008). However, an assessment of the economics of future renewable supply options that enable reduced dependence on renewable support policies is important in a resource constrained electricity system facing conventional and renewable electricity shortages. In addition, it is important to make rational choices among firm conventional sources and intermittent renewable sources in the short as well as long-term. The above aspects have not been addressed sufficiently in the literature. This paper is an attempt to bridge these research gaps. The specific objectives are to study – (i) The impact of RPO and REC policies on costs of electricity supply, total electricity supply portfolio and REC purchase portfolio; (ii) To find optimal RPO target given the renewable energy potential and demand for electricity; and (iii) The impact of changes in cost of supply due to RPO/REC policy interventions on the quantum of total electricity supply, renewable electricity supply, shortages in total electricity supply, and shortages in renewable electricity supply.

2. Accelerating renewable power integration: policy interventions in India

In the National Action Plan on Climate Change report in 2008, it was specified that a national RPO must be set at 5% at the beginning of 2009-10, and increased by 1% every year for the next ten years (GoI, 2008). Following which, the respective State Electricity Regulatory Commissions also specified their respective state level RPOs based on the renewable potential available. Later, REC mechanism was introduced in 2010 to make the renewable electricity market stable and predictable by maximizing the benefits of renewable energy generators while reducing long-term costs of renewable electricity. Non-solar REC trading started in March 2011 and solar REC trading started in May 2012 (REC Registry, 2017). Under RPO, an annual target to purchase a fixed quantity of electricity from renewable sources has to be met by the electric Utility. If it is unable to meet the RPO target due to insufficient renewable electricity supply, it can buy RECs from the market (MNRE, 2009).

The RPO policy alone cannot help in procurement of renewable electricity by DISCOMs because renewable energy potential is not equitably distributed across India. Hence, adequate knowledge about how to procure renewable electricity judiciously and economically with the help of REC driven market is important for RPO compliance. According to the MNRE report on REC policy framework for India, there are typically two options to buy renewable electricity to meet the RPO (MNRE, 2009): (i) buying renewable electricity from renewable energy generator directly through a Power Purchase Agreement (PPA) at a preferential tariff or feed-in tariff (FIT), or (ii) buying renewable electricity at average power purchase cost (APPC) and then buying renewable energy certificates (REC) from the REC market. Obligated entity (buyer of REC) is a DISCOM, open access consumers or a captive power producer. If an existing power project of a renewable energy generator is already in a PPA with an obligated entity to buy at preferential tariff, the DISCOM is not eligible to buy renewable electricity at APPC and then buy REC. The APPC is normally lower than the tariff of any one renewable source and it is a pooled price of electricity purchased from all sources. (MNRE, 2009). The difference between APPC and preferential tariff gives an idea on how far is the present cost of renewable electricity from grid parity. Since APPC is lower than FIT, the DISCOM helps the renewable energy generator to recoup the remaining cost of renewable electricity by purchasing REC at a market discovered price in REC trading market.

The market discovered price of REC falls in the range of a minimum floor price and a maximum forbearance price whose values are pre-determined by the Central Electricity Regulatory Commission (CERC, 2011). Within these pre-determined values, the RE generator will be able to earn returns based on the supply and demand of RECs. The value of one REC is one MWh equivalent of renewable electricity fed into the grid at APPC. If the supply of REC is high and demand is low, normally, it will end up being sold at lowest cost (i.e., floor price) and vice versa. If supply and demand for REC are approximately equal, a market price for REC gets discovered based on the bidding volumes and market clearing prices.

One of the important reasons for non-compliance of RPO target is