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Cost-effective policies for reaching India's 2022 renewable targets

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ABSTRACT

India has ambitious renewable energy targets by 2022: 100 GW of solar and 60 GW of wind. Both of these technologies are perceived to be more costly than conventional, fossil-fuel, power; and, therefore, require policy support. Using representative, project-level cash flow models, we examine two related questions: First, what would be the cost of policy support under existing federal policies; and, second, what would be the most cost-effective federal policy? We answer these questions by first forecasting the unsubsidized levelized cost of electricity for wind, solar, and the marginal fossil fuel; and then examining the cost of support under existing as well as proposed debt-related policies. We find that wind energy is already competitive with the marginal fossil fuel and, therefore, does not require any policy support. We also find that solar energy will become competitive by 2019; and prior to that the most cost-effective federal policy is provision of reduced-cost long-term debt, which can significantly reduce (by more than 90%) the total cost of support compared to accelerated depreciation, the most cost-effective existing federal policy.

1. Introduction

For India, high import dependence (oil and increasingly coal), large peak power and energy deficits, and high energy intensity indicate serious challenges related to climate change, energy scarcity, and energy security [20]. On one hand, India's energy portfolio is dominated by fossil fuels, with 68% of the total power generated from coal and oil (IBEF, 2014). On the other hand, though the domestic production of energy sources is expected to increase, the dependence on the imports will also continue to rise. For instance, between 2005–06 and 2012–13, import of coal and crude oil increased approximately four-fold and two-fold, respectively [31].

To overcome these challenges, India has set highly ambitious renewable energy targets. As stated in the National Action Plan for Climate Change [43], deploying renewable energy is a strategic priority for India. Under India's most recent budget, Union Budget 2015–2016, India aims to install 100 GW of solar energy capacity and 60 GW of wind energy capacity by 2022 [14], which is more than six times the current installed capacities of approximately 22 GW of wind and 3 GW of solar [29]. The previously articulated targets under the 12th Five Year Plan (2012–2017) aimed to install an additional 20 GW of solar and 30 GW of wind capacity by 2022.

Due to current accounting practices, which do not account for the social and environmental costs of fossil fuels, renewable energy is currently perceived to be more expensive than fossil fuels [44]. Therefore, in order to compete with energy generated from fossil fuels, renewable energy requires policy support from the government.

In India, policy support is provided for renewable energy at both the state and federal (i.e., central) levels. The existing federal government policies are (see Appendix for more details): (1) a generation based incentive of INR 0.5 per unit (USD 0.008 per unit) of electricity, (2) viability gap funding (i.e., capital grant) up to 30% of project cost, and (3) accelerated depreciation of 80%. The federal government's policies typically cover only some of the difference between the cost of unsubsidized renewable energy and the average pooled purchase cost (APPC), the average price paid by state-level public-sector utilities to procure power. The remaining difference is met by state governments through Power Purchase Agreements with renewable energy developers, agreeing to pay feed-in tariffs for 20–25 years.

In spite of these policy support mechanisms, which have deployed renewable capacity and brought down costs of renewable energy via learning [35], our analysis shows that renewable energy continues to be more expensive than conventional power [47]. Therefore, there is a need to continue policy support for renewables in India. However, this task is made difficult by the Indian

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government's large fiscal deficit and multiple development priorities [13]. Given that subsidies require allocation of scarce public resources, it is imperative that RE deployment is cost-effective [12,19].

Based on discussions with policymakers in India, this paper investigates the following questions:

Q1) *How much it would cost the Indian government to achieve its renewable energy targets?*

We answer this question by forecasting levelized (or delivered) cost of electricity (LCOE)[1] from renewable energy and that from the fossil fuels in the absence of any policy support – whether explicit or implicit.[2] In this process, we also answer the following question:

Q2) *What would be the most cost-effective policy mechanism to achieve India's renewable targets?*

To the best of our knowledge, such analysis has not been attempted. Prior work on the cost effectiveness of renewable policies [49,55] is based on developed economies. Further, their focus is on financial incentive policies without much “direct” focus on cost of capital, which happens to be a significant issue in developing countries [34].

Shrimali et al. [46] was the first study to examine impact of policy pathways on renewable financing in India [47]. extended this result to compare debt-related federal policies (i.e., low-cost, long-term debt) to existing policies. This paper further extends [47] to not only forecast cost of renewable energy until 2022 but also compare policy options in a dynamic fashion.

This paper is organized in four sections. Section 2 details the methodology used for the analysis; Section 3 presents the results; and Section 4 concludes. The Appendix provides further information on policies as well as a comprehensive literature.

2. Methodology

The primary objective of this paper is to calculate the cost of policy support and identify the most cost-effective policy mechanism to achieve the government's renewable deployment targets.[3] Policy support reduces the effective (i.e., subsidized) levelized cost of electricity from renewable energy so that it is competitive with fossil-fuel based energy. The levelized cost of electricity represents the average life cycle energy cost for a project. It enables comparison of the cost of energy across different technologies, particularly when capital cost, scale and project life differ [5].

At a conceptual level, the levelized cost of electricity is calculated as the net present value of total project life cycle costs divided by the total amount of energy produced over system life. It is not easy to derive formulas for levelized cost of electricity, given the intricacies of project cash flows; however, a representative formula that provides intuition is as follows [46]:

$$lc = \frac{C - \alpha\sum_{t=1}^{T}\frac{D_t}{(1+r)^t} + (1-\alpha)\sum_{t=1}^{T}\frac{W_t}{(1+r)^t} - (1-\alpha)\frac{C_T}{(1+r)^T}}{(1-\alpha)*8760*\sum_{t=1}^{T}\frac{CF_t*x_t}{(1+r)^t}}$$

where lc: levelized cost of electricity; T: the life of project, C: capital expenditure (or CAPEX); D: depreciation; W: operating expenditure (or OPEX); C_T: terminal value; α: tax rate; CF: capacity factor (i.e., plant load factor); x: degradation factor; and r: cost of capital.

To calculate the cost of policy support, we began by forecasting the unsubsidized (i.e., in absence of any government support) levelized cost of electricity for three technologies up to 2022: utility-scale wind and solar, the dominant renewable energy technologies; and the marginal fossil-fuel based power plant. The unsubsidized levelized cost of fossil-fuel based power serves as the baseline cost of electricity. We then calculated the amount of policy support required to equate the subsidized (i.e., in presence of policy support) levelized cost of renewable energy equal to the baseline cost of electricity.

2.1. Baseline cost of electricity

Using the appropriate baseline cost of electricity is critical as it can provide a fair basis for government planning and budget allocation for renewable energy deployment. We use the levelized cost of electricity from a marginal fossil-fuel based power plant to indicate the baseline. Marginal fossil fuel is the most expensive form of fossil fuel based energy that is being added to the existing energy mix. In other words, a marginal plant is a new build power plant that uses the marginal fossil fuel which is expected to be commissioned after 2014. It represents the set of power plants most likely to be replaced by new renewable energy deployment.

We considered four possible options for estimating the levelized cost of electricity from the marginal fossil fuel based plant (Fig. 1), to arrive at the imported coal based power plant as the marginal fossil power plant.

First, the *average pooled purchase cost,* which is the cost of purchase for distribution utilities from all sources except renewable energy. This cost has to be approved by the state regulator and varies across states. It also includes the cost of purchase for old and depreciated plants, which may not be comparable with the cost of plants being set up today. Therefore, it is not an accurate baseline for comparing forecasts of levelized cost of electricity from renewable energy, and would overestimate the policy support

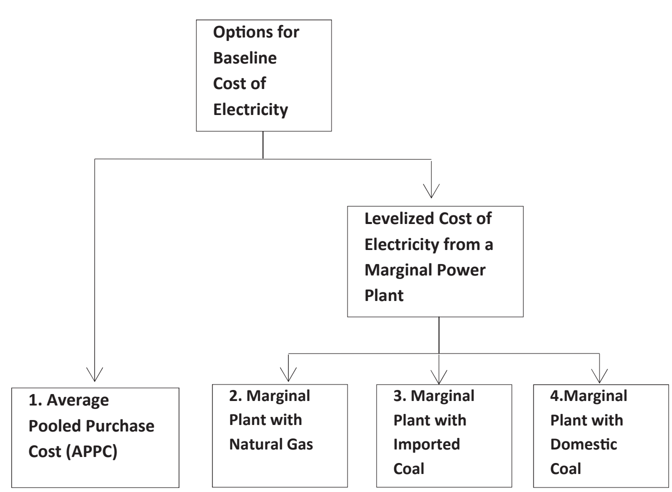

Fig. 1. Baseline cost of electricity.

[1] The levelized (or delivered) cost of electricity or LCOE is the average cost of electricity that helps to break even in terms of the return expected by the developer. It represents the minimum unit revenue required to meet the return on equity, given the project's financial parameters.

[2] This is key to ensure that implicit subsidies, such as ones provided to domestic coal, do not distort the comparison.

[3] Similar work exists is other contexts, such as agriculture, irrigation, and drainage – e.g. Refs. [50,51] [52,53]; and [54].