Renewable and Sustainable Energy Reviews 66 (2016) 487–498

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

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

Economic and environmental effectiveness of renewable energy policy instruments: Best practices from India

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ARTICLE INFO

Article history:
Received 16 September 2015
Received in revised form
27 May 2016
Accepted 12 August 2016
Available online 24 August 2016

Keywords:
India
Renewable Energy
Economic effectiveness
Innovative features
Policy instruments

ABSTRACT

Renewable Energy (RE) has been identified as a key tool to counter climate change and enhance energy security. Countries across the globe have been promoting this sector by several policy measures. However, limited research has been undertaken on the economic and environmental efficacy of RE policy instruments, especially in context of emerging economies like India, which have witnessed substantial capacity addition and have set ambitious targets to de-carbonize their economy. This paper identifies 25 innovative practices followed in India which have enabled accelerated RE capacity addition with minimal financial obligations. These include energy entrepreneurship, energy democratization, private sector participation, hedging and apportioning RE procurement, use of auctions with stringent participatory norms, creditworthy counter-party, leverage of risk capital by developmental institutions, regular revision of tariffs, environmental cess on polluting industries, long-term RE purchase trajectory and incentivizing green power output. Results indicate high financial impact of instruments (support of US$ 3–5/MW h over applicable tariff) which gets neutralized when tax inflow is considered. Lower carbon abatement cost (US$ 3–6/tCO2eq) depicts high environmental efficacy. The paper shares best practices from India in terms of efficient use of RE policy enablers, which may be contextualized in other emerging economies as per the local requirements.

Contents

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http://dx.doi.org/10.1016/j.rser.2016.08.025
1364-0321/

1. Introduction

With energy production and usage accounting for two third of the world's greenhouse-gas emissions GHG [1], there has been global efforts towards shifting the existing fossil fuel based energy systems to low-carbon technologies, including renewable energy technologies (RET) like solar, wind, hydro and biomass. International Energy Agency (IEA) has estimated that towards limiting the temperature rise to two degree centigrade (450 ppm, or, ppm scenario by 2050) [2], the total installed capacity of renewable energy sources for electricity production needs to be augmented to 3770 GW by 2035. This shall require annual investments of over US $550 billion in climate change mitigation and adaptation technologies [3].

During the year 2014, the global installed renewable energy capacity crossed 650 GW [4], associated with investment of US $270 billion, primarily from wind (cumulative capacity of 370 GW) and solar photovoltaic systems (cumulative capacity of 177 GW). Renewables accounted for nearly half of all new power generation capacity in the year 2014 [1]. The top five countries in terms of deployment of renewable energy capacity are China, United States, Germany, Spain and India, with the emerging economies accounting for more than half the capacity addition during this period [4].

The reasons for adopting renewable energy may vary in case of developed and developing economies. Developed nations are promoting clean energy technologies due to their heightened sensitivity towards the environment and being mandated under the various international climate conventions like the United Nations Framework on Climate Change, or, UNFCCC [6]. On the other hand, the reasons for developing economies to advocate renewable energy technologies include enhancement of their energy security (reduction in energy imports), besides bridging the energy deficit and enabling energy access to the masses through decentralized systems in form of lifeline energy services like cleaner forms of basic lighting devices (solar lanterns) and cooking systems (biogas plants).

India has its own sets of reasons for pursuing a low-carbon growth trajectory. This includes large share of fossils in its energy supply chain (over 80% share of coal based power in the grid) [7], leading to high levels of greenhouse gas (GHG) emissions, making it the fourth largest emitter globally [8]. It is also promoting renewable energy in decentralized formats to enable energy access to the un-electrified/under-electrified rural masses.

It has envisioned 15% of electricity contribution from renewable energy sources by 2020 as against the present share of 6% [15], advocated under the National Acton Plan on Climate Change (NAPCC). The electricity requirement is projected to increase to 1900 Billion units (BU) by the year 2022 [16] from the present levels of about 1100 BU [17]. Hence, over 300 BU of green power would be required as against the present levels of 60 BU [18] (fivefold increase). This shall necessitate significant scaling up of RE capacity in similar terms.

Renewable Energy projects are associated with high upfront (capital) cost and lower levels of energy generation (due to limited availability of natural resources like solar radiation and wind velocity), leading to higher cost of energy generation. Besides, they lack the ability to reach economies of scale (due to limited availability of contiguous land area in resource rich regions); most wind and solar projects are limited to not more than few hundred megawatts of capacity.

As such, to make renewable power competitive with conventional power sources and enhance their techno-commercial viability, countries across the globe have been supporting the sector by way of several regulatory enablers and market-based instruments [9]. The three main support mechanisms employed by governments to finance renewable energy development programs are feed-in-tariffs (FIT), tax incentives, and tradable green certificates, or TGC [10].

It has been found that the impact of institutional investments can be scaled up by use of these policy instruments. FIT is more effective in case of upcoming energy technologies, whereas, TGC is an appropriate market policy used for mature technologies, whose projects are self-sustainable without any grant/ subsidy [11]. Other mechanisms include RE legislations, renewable purchase obligations, subsidy and grants, low cost preferential funding, carbon taxes and cap and trade programs.

Within these set of measures, it has been opined that the financial instruments have the maximum impact as they directly reduce the cost of installing RE projects which enhances the financial viability, or, reduce the cost of energy generation, or provide part of both these benefits. Research suggests that support through capital allowances is more efficient than energy market in promoting renewable energy [12].

However, in the case of developing economies, there are constraints in terms of availability of monetary resources at competitive terms due to competing demands from other sectors like education, healthcare, agriculture and infrastructure. As such, it is of paramount importance that utilization of scare resources is done in the most prudential manner.

Interestingly, the growth of renewable energy sector in India (especially grid-connected wind and solar photovoltaic technologies) can be attributed to a more pronounced role of non-financial instruments (over financial dependency). These non-financial instruments includes wheeling and banking of power with grid, solar capacity auctions and bundling (with coal), citizens participation through green bonds and captive projects, renewable purchase obligations and tradable green certificates. Some other measures include encouraging local manufacturing and provision of low cost funds. Further, the country is endowed with good level of natural resources (like solar radiation and wind regime) and has a large skilled work force, making projects viable at affordable tariff levels; solar and wind tariffs are in the range of US $80–90 per MW h [19,20]. IRENA, in one of its report, has mentioned that the levelized cost of electricity generated from renewable technologies in China and India typically falls in a lower range when compared with other countries [103].

As a result of these innovative and enabling policies, India today is the only developing country among the top five nations in terms of total installed RE capacity (43 GW as on March 2016 [14]);

the sector witnessed an incredible rate of 20% during last five years. China (top performer) can be counted as a developed nation based on its per capita income which was US $7600 in 2014 [13].

Though similarities can be drawn with immediate neighbor China, the Chinese renewable energy industry is facing contradictory predicament of funding deficiencies and blind investment derived from the government-centered RE investment and financing. This mode has promoted the development of early stage RE industry, but it is doubtful if it can sustain a long term growth [22].

To achieve the ambitious capacity addition targets under budget constraints, the economic effectiveness of instruments needs to be high. Limited research has been undertaken to evaluate the effectiveness of support policies in order to promote the deployment of renewable energy technologies [24], especially in context of developing economies like India. There has been no detailed research on the efficacy and cost effectiveness of policy enablers like feed-in-tariff, accelerated depreciation, tax exemptions, auctions and green certificates. As per the International Renewable Energy Agency (IRENA), the criteria for evaluating the impact of policy instruments towards accelerated deployment of RE sector include effectiveness, efficiency, equity, institutional feasibility and replicability [23]. Further, the environmental efficiency of investments in renewable energy also needs to be high [21].

Hence, the aim of this study is to assess the economic and environmental effectiveness of RE policy measures being practiced in India, highlighting the innovative instruments in terms of their high ground impact (green power generation) and low dependency upon financial support. These instruments include energy entrepreneurship, energy democratization through citizen participation, private sector participation, apportioning RE costs, hedging power procurement, use of auctions with stringent participatory norms, leveraging of risk capital by developmental financial institutions, regular revision of tariffs, taxing the polluter and incentivizing green power output. This kind of research has not been attempted so far and therefore, enriches the literature in terms of identifying effective and low-cost RE policy enablers.

Accordingly, the paper is structured as follows. Section 2 gives an overview of the Indian power sector with Section 3 capturing the developments in the Indian RE sector, mapping year wise and technology wise growth. Section 4 gives a synopsis of RE policy instruments used globally to promote the RE sector. In Section 5, an in-depth analysis has been undertaken to evaluate the effectiveness of key policy instruments used in the Indian RE sector. This includes tax benefits, tariff determination and revision, hedging procurement cost, generation based incentives, solar auctions and bundling, viability gap funding, polluter pays principle, privately owned captive projects, RE cost apportioning and a dedicated financing agency. Section 6 concludes the paper and suggests research areas for the future.

2. Indian power sector scenario

Energy is a concurrent subject under the Indian constitution, bestowing rights upon both the federal (central) government as well as the provincial (state) governments to frame laws and legislations. The Electricity Act (promulgated in 2003) de-licensed the generation and distribution sectors, facilitating open access of power through power markets and energy exchanges. The National Tariff Policy 2006 advocated determination of tariff through a transparent regulatory process. The Regulatory Commission Act 1998 [25] enabled creation of statutory agencies to regulate the power sector.

As on July 2015, the total installed power capacity in India was 276 GW [26], with coal based plants having the maximum share (over 60%). Other major contributors are hydro power (15%) and renewable energy sources (13%). Since the opening of the sector, private sector has participated in a big way, with 38% share in the total capacity [27]. Refer Table 1.

Table 1
Power generation mix of India as on July 2015 [26].

Sources	Capacity (in MW)	% Share (Capacity wise)
Coal	167,708	61
Gas	22,962	8
Diesel	993	0.4
Hydro (Large)	41,997	15
Nuclear	5780	2
Renewables	36,470	13
Total	275,910	100

Over 20,000 MW of coal power plants were added during financial year FY 2014–15 [28]. The contribution from thermal energy sources (coal, gas & diesel) in the national grid was more than 80%, from July 2014 to June 2015 [52].

During the period April 2014 to March 2015, the country experienced 3.6% power deficit (in million units, or, MU) and 4.7% [29] peak deficit (in MW). The aggregate technical and commercial (AT&C) losses have been estimated to be around 25% [26] and the per capita consumption is 957 kW h units.

3. Indian renewable energy sector

India is the fourth largest emitter of GHG, though the per capita emission level is amongst the lowest in the world. Energy (attributed to electricity generation, residential and transport sectors) has been identified as a major contributor in these emissions, with a high share of 58% [30]. India's energy use is projected to expand massively to deliver a sustained gross domestic product, or, GDP growth rate of 9% through 2031–32, requiring 5.8% growth in primary energy supply [31].

To ensure a low-carbon growth trajectory, the government is working towards increasing the share of renewables in the energy mix as well as promoting energy efficiency measures (both supply side and demand side activities). Other policy measures to decarbonize the growth include differential electricity pricing and efficiency improvement targets for industries and appliances, similar to what have been undertaken in China [5].

There is a dedicated ministry - New & Renewable Energy (MNRE), set up to promote renewable energy sector, by way of enabling policies and long-term targets.

The Electricity Act 2003 advises the state commissions (referred to as state electricity regulatory commission - SERC) to promote generation of electricity from renewable sources by providing suitable measures for connectivity with the grid. Under Section 61 of the Electricity Act, the SERCs need to determine tariffs for the promotion of RE. The National Action Plan of Climate Change (NAPCC) identified measures to address global warming through eight core national missions. It advocated a minimum renewable purchase standard, setting a target of 15% penetration from RE sources by 2020. Subsequently, the Planning Commission came out with a report 'Low Carbon Strategies for Inclusive Growth' in line with the NAPCC to embark upon sustainable development of the Indian economy [32].

The government has targeted to reduce the emission intensity of GDP by 20–25%, over 2005 levels (by 2020) [33] and set a target of 175 GW of RE capacity by 2022 [34], with 100 GW solar energy and 60 GW wind energy. It has been found that in the context of ASEAN nations (with a similar economic profile as of India), the share of RE power at 30% of total electricity (by 2030) is considered politically a "low-hanging fruit" [35]. Association of South

East Asian Nations (ASEAN) group comprises of the following countries - Brunei Darussalam, Myanmar, Cambodia, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand and Vietnam.

The initial impetus in India towards development of RE was not on grid based power plants, but to meet the lifeline energy needs of rural population by substituting fossil based energy sources with cleaner forms of decentralized based energy systems (solar lanterns and biogas plants). This was exacerbated by the fact that India has been importing a substantial quantity (around 80%, even today) of its crude oil requirements [36].

Over 52% of rural households used firewood for cooking and 43% households used kerosene for lighting purposes in 2001 (Census 2001), these figures have marginally reduced to 49% and 31% respectively in 2011 (Census 2011) [37]. Grid connected wind turbines prospered in subsequent decades due to interplay of market economics and innovative business models, mainly the availability of accelerated depreciation benefits and lately the generation based incentives.

The Indian RE sector has witnessed a compound annual growth rate (CAGR) of 17% during the last five years about 43 GW of installed capacity; the share of wind is maximum (at 63%). Solar sector has been growing rapidly since past four years due to long term policy support by way of National Solar Mission with 100 GW target. Refer Tables 2 and 3.

The Indian RE sector has been led by private entrepreneurs, with a strong presence of independent power producers (IPP) and first generation companies [38].

The success witnessed in the Indian RE sector is the result of enabling policies and innovative financial instruments, which have helped circumvent constraints and barriers in the adoption of 'renewable and green' energy technologies [39].

Results suggest that the National Tariff Policy 2006, state-level policies, quantity-based instruments and a greater participation of the private sector have played a key role in promoting the development of renewable energy sector in India [41]. This includes annual capacity targets for different RE sources, premium tariff payment (preferential tariffs as determined by central and state electricity regulatory commissions), renewable purchase obligations (RPO), tradable green certificates, incentives (subsidy and grant), taxes and duty exemptions, and availability of credit at concessional terms from dedicated financial institutions [34].

There has been over 200% growth (in CAGR terms) in the grid connected installed solar capacity during last five years (2010–15). The main reasons attributed to this growth include a long term policy support (25 year fixed tariff), steep fall in prices of solar modules (prices in 2014 were around 75% lower than their levels at the end of 2009) [19] and use of auctions as a policy tool. Refer Table 3.

Table 2
RE capacity in India as on March 2016 [14].

RE Technology	Capacity (GW)	% Share
Wind	26.7	63
Solar	6.7	16
Small Hydro (upto 25 MW)	4.3	10
Biomass	4.8	11
TOTAL	42.7	

4. RE policy instruments

IRENA has defined the following mechanisms as key policy instruments which have been adopted across the globe in varying formats [9]. Each of them has been tagged with the applicable policy/regulation as valid in the case of India [44].

4.1. Grant/subsidy

It is the monetary assistance that helps in reducing the initial investment in a project to enhance its viability and the same is not required to be paid back. The Government of India provides subsidy under various schemes to promote the use of renewable technologies till they attain commercial status.

4.2. Accelerated depreciation

Allows investments in renewable projects to be fully or partially deducted from tax obligations or income; it is a kind of production tax credit. Depreciation upto 80% can be claimed in lieu of investments made in solar and wind energy projects in India [47].

4.3. Tax concessions/exemptions

Enables reduction in tax outgo on profits earned from renewable projects. Infrastructure projects (including conventional power and renewable power sectors) are exempted from payment of Income tax for 10 consecutive years within the first 15 years of their commissioning. However, they are required to pay Minimum Alternate Tax MAT (present rate of MAT is 20.81%). For remaining years, the company has to pay corporate tax (present rate is 33.99%) [48].

4.4. Preferential tariff

Utilities are bound to purchase power generated from RE projects at a fixed price for a specified number of years. In case of India, the price is determined by the respective state electricity regulatory commission (SERC), or central electricity regulatory commission (CERC) as the case may be [20].

4.5. Renewable purchase obligations

Designated consumers (distribution utilities and large power consumers) are required to procure a certain percentage of their total power consumption from RE sources. This can be in terms of actual purchase of RE power, or by way of tradable green certificates. In India, the renewable energy certificates (REC) can be sold and purchased through the energy exchanges [78,79].

5. Innovativeness of Indian RE policy instruments

In this section, an analysis has been made with respect to the effectiveness of various policy measures highlighting their innovative proposition for better understanding and facilitating adoption/adaption across other geographies and regions.

Table 3
Growth of Indian RE sector [42].

RE sector	FY 07–08	FY 08–09	FY 09–10	FY 10–11	FY 11–12	FY 12–13	FY 13–14	FY 14–15	FY 15–16
Wind (MW)	8757	10,242	11,807	14,157	17,354	19,053	21,200	23,439	26,769
Solar (MW)	–	3	10	37	942	1696	2658	3383	6763

Table 4
Promoter investment under AD business model [51, 52 and Author's calculations].

Parameters	Values
Project capacity	1 MW
Project cost	INR 62 Million
Debt: Equity ratio	70:30
Equity (Promoter contribution)	INR 19 Million
Depreciable assets (excluding land and soft costs)	INR 55 Million
Accelerated depreciation @80%	INR 44 Million
Corporate tax offset (34%) on the above depreciation	INR 14.5 Million
Effective investment by the promoter	INR 4.5 Million (19–14.5)
Net outgo as % of total equity	24% (5 / 21)
Savings in promoter investment (Equity)	76%

5.1. Tax and depreciation incentives

The initial phase of wind sector in India started in 1980s with installation of demonstration wind farms supported by multilateral and bilateral agencies. In 1988, the Danish Development Agency (DANIDA) supported plans to develop two commercial projects of 10 MW each in the states of Gujarat and Tamil Nadu [43]. This was one of the policy measures initiated by Indian Government to develop the RE sector (as an alternative to fossils), which at that time had sown seeds in many countries.

The investor companies are allowed to claim accelerated depreciation (AD) benefits on account of their investment in a wind project (made on the balance sheet of the main business). This policy helps to offset a part of the income tax payable by the company as depreciation. In initial years, companies were eligible to claim 100% accelerated depreciation on their investment in the project equipment, which was later reduced to 80% (still in force) [48].

This kind of business model catapulted the Indian wind sector to new heights. During the period 2003–10, India added more than 10 GW of wind power capacity, with 70% under AD scheme [52]. Refer Table 3 for annual wind capacity addition. Most of the wind projects were owned by private companies, which was at variance with the domination of government owned companies in the conventional power generation sector.

Innovative practice: The income tax saved under the AD model helped offset the promoter equity (upfront contribution) in a project by over 75%. As can be referred from Table 4, the promoter needs to invest INR 4.5 million[1] in place of INR 19 million due to tax offset. As a result, many established companies in India got enticed and made foray into the wind energy business and sowed the seeds for impressive growth in the Indian wind sector in the coming years. This was facilitated by concept to commissioning (C2C) business model, wherein, turbine suppliers undertook the entire project development work (including maintenance), with minimal effort on the part of the investor (who virtually acted as a silent partner). As a result, India is listed among the top first countries in terms of installed wind capacity.

Innovative practice: During the 20 year lifetime of a wind turbine, the owner company would pay tax to the exchequer on account of income earned from the generation of power. The renewable energy projects are not fully extent from payment of tax and are required to pay minimum alternate tax (at 20.81%) for the first ten years and the normal corporate tax (at 33.99%) in subsequent years. For a one MW project set up at a capital cost of INR 62 million (approximately US $1 million), the total tax paid by the company on net present value (NPV) basis during a period of 20 years [49] shall be INR 10.84 million. During this period, the turbine shall generate 37.6 million units of electricity, making the tax paid per unit at INR 0.29 per kW h. Refer Table 5. When we compare it with the benefit made by companies claiming AD, the additional support from the government exchequer shall be only INR 0.35/kW h (AD benefit taken by CERC in its tariff order at INR 0.64/kW h [46]). If calculated in terms of GHG abatement costs, it shall be equivalent to US $6.5/tCO2e,[2] which is less than tenth of the carbon abatement cost as estimated by IEA ($67/tCO2e) [50]. As such, the scheme is highly effective in terms of economic cost as well as environmental benefits.

Table 5
Tax payable by a wind energy generating company [51 and Author's calculations as per Appendix A].

Parameters	Values
Project cost	INR 62 Million
Debt: Equity ratio	70:30
Cost of debt	13%
Cost of equity	20%
Discount rate	10.81%
O&M charges (% of project cost)	1.7%
Applicable tariff	INR 5.98/kW h
Tax rate	21% for 1st 10 years 34% for subsequent years
Cpacity utilization factor (CUF)	22%
Annual performance degradation	0.25%
Total generation in 20 years	37.6 MU
Tax collection in 20 years (NPV Basis)	INR 10.83 Million
Tax collection/Unit	INR 0.29

5.2. Tariff determination & review process

With the advent of Electricity Act 2003, there was a pronounced support for renewables in terms of preferential tariffs and capacity targets. The electricity regulatory commissions (both at the federal and the state level) are required to determine the tariffs for different RE sources based on set parameters. This was initiated by CERC in the year 2009, which first came out with the Terms and Conditions for Tariff determination from Renewable Energy Sources, Regulations, 2009 [55], setting a precedent for the state electricity regulatory commissions (SERCs) as electricity is a concurrent subject under the Indian constitution.

The tariffs for RE technologies like solar & wind are determined on a cost plus basis by the electricity regulatory commissions based upon a set of parameters. It may be noted that unlike tangible natural resources (like minerals), renewable resources (wind velocity and solar radiation) are intangibles and therefore, the economic feasibility (cash flow calculations) is computed using a traditional discounted cash flow methodology over the mean-reverting process as suggested by some researchers [40].

The input parameters used by CERC in tariff determination process include return on investor equity, capacity factor, capital cost (indexed to inflation rate of commodities) and interest rates (risk premium over and above the base rate of State Bank of India). The tariff is applicable for a long term period. Refer Tables 6 and 7.

Innovative practice: The long term tariff set for wind and solar projects (25 years) with a guaranteed off-take agreement between the project developer and the power utility assured the investors of a long term market (revenue generation). It has been found that long-term take-or-pay contracts minimize

[1] 1 US $=INR 67 (average currency exchange rate for the period October 2015 to March 2016, [104]).

[2] Grid emissivity factor (GEF) of Indian grid is 0.82 tCO2eq/MW h [51].

Table 6
CERC Tariff parameters for wind and solar PV for FY 2015–16 [46].

Parameters	Wind	Solar PV
Capital cost (INR Million)	62	59
Debt equity ratio	70:30	70:30
Cost of debt	13%	13%
PLF	20–32%	19%
Return on equity	20%	20%
Depreciation values	5.83%	5.83%
Discount factor	10.81%	10.81%
O&M cost (% of project cost)	0.17%	0.22%
Levelized cost of generation LCOE (INR/kW h)	4.11–6.58	6.86

Table 7
Wind Tariff determined by SERC as on July 2015 [34].

State	Tariff (INR/kW h)
Tamil Nadu	3.51
Gujarat	4.15
Maharashtra	3.92–5.70
Karnataka	4.2
Rajasthan	5.12–5.38
MP	5.92

regulatory uncertainty, create appropriate incentives for operation and allow for efficient system operation [45].

Innovative practice: Even though the tariffs determined for RE projects are higher than the average cost of power procurement by the distribution utilities, there is no subsidy outgo from government exchequer as the same is allowed as a pass-through in the power procurement cost incurred by the distribution utilities. The distribution licensee of Ahmedabad city of the state of Gujarat in its annual revenue requirement (ARR), filed an expenditure of INR 735 Million incurred towards purchase of RE power and INR 549 million towards purchase of RE certificates [58]. Due to lower share of RE power in the grid, the impact of RE purchase on the consumer bill is minimal. As per an analysis conducted by the 'Forum of Regulators' (FoR), the per unit impact on consumers towards meeting RPO level of 11.40% shall be less than INR 0.15/kW h [59]. Moreover, the tariffs payable by end consumers are set at differentiated slabs to minimize the impact upon the low-income earning sections of the society [53].

Innovative practice: CERC, and the state electricity regulatory commissions (SERC), have been determining tariffs for different RE technologies for each financial year after taking into account the relevant input cost parameters (prices of steel, cement and bank interest rates [46]), reflecting ground realities. This helps to curtail the possibility of excessive profiteering [56] on the part of investor companies (and improve the economic efficacy) as has been reported in the feed-in-tariff programs of Germany and the United States [57]. It can be observed from the Table 8 that the steep decline in capital cost of solar PV projects (over last five years) is appropriately reflected in the tariffs (55% reduction), thus increasing the acceptability of the technology among the utilities and the end consumers.

Table 8
Year-Wise Tariff for wind & solar energy from CERC [46].

Financial year	Wind - project cost (INR Million)	Wind - tariff (INR/kW h)	Solar - project cost (INR Million)	Solar - tariff (INR/kW h)
2012–13	57.5	5.42	100.0	10.39
2013–14	59.8	5.72	80.0	8.75
2014–15	60.4	5.76	69.1	7.72
2015–16	61.9	5.98	58.7	6.86
2016–17	61.9	6.01	55.0	5.68

Table 9
Year wise installed wind capacity- Tamil Nadu [76].

Financial year	Cumulative capacity (MW)
2014–15	7457
2013–14	7276
2012–13	7162
2011–12	6988
2010–11	5904
2009–10	4907
2008–09	4304

5.3. Hedging power procurement cost

The state of Tamil Nadu in India has the highest installed capacity of wind energy due to availability of high wind velocity. Refer Table 9. As a result, wind projects have been operational in the state since over last few decades.

During the FY 2014–15, the total cost of procuring power (37,589 MU) in Tamil Nadu from utility owned generating stations came as INR 127 billion, making the average cost of power procurement at INR 4.14/kW h. Utility owned wind power generation [at INR 2.75/kW h] was the second cheapest among all sources (after hydro power) and substantially inexpensive than power procurement from coal fired power plants (range of INR 3.81–7.46/kW h) [54]. Refer Table 10.

With respect to the power plants not owned by the utility, the average procurement price paid by the Tamil Nadu utility was INR 3.82/kW h, which included 2291 MU of green power, purchased at an average price of INR 3.48/kW h (wind at INR 3.41/kW h and solar at INR 5.37/kW h). This was substantially cheaper than cost of power procured from newly established thermal power plants (INR 4.25/kW h) as well as privately owned thermal power plants (INR 7.16/kW h). Further, with regard to RE plants (being located within the state), there shall be no levy of inter-state transmission losses [4.34%], making them even more competitive [54].

Innovative practice: RE capacity addition in the state happened over last few decades. The sourcing of green power by the utility includes cumulative generation from vintage wind projects with tariff fixed under long-term PPA (no escalation). As such, compared to power procurement costs from conventional power sources (associated with fuel cost volatility), RE presents an excellent opportunity for the distribution utilities to hedge their procurement cost by entering into a long-term PPA with wind and solar power generators.

5.4. Generation based incentives (Wind)

To promote independent power producers (IPP) (not eligible to take advantage of accelerated depreciation benefits), the Government of India launched the GBI scheme in 2009 [60]. Under the scheme, an incentive of INR 0.50 is available on every unit of wind

Table 10
Power procurement cost - Tamil Nadu [54].

Source	INR/kW h
Utility owned RE	2.75
Externally owned RE	3.48
Utility owned coal	3.81
Externally owned coal	4.25
Private owned coal	7.16

power generated over and above the applicable tariff set by the respective SERCs. The total benefits have been capped at INR 10 Million per MW. Taking an average wind tariff of INR 5 per kW h, the incentives (INR 0.50 per kW h) provided a ten percent premium over and above the revenue under business as usual.

Innovative practice: The GBI scheme heralded the coming up of professional actors (IPPs) into the Indian RE sector, many of whom had set-up projects using money sourced from foreign direct investment (FDI). It enticed many established companies to venture into the RE sector as a business diversification strategy by creating subsidiary companies in form of special purpose vehicles, or SPV. As per industry estimates, over a third of wind capacity in India has been set up under the IPP business model [52]. Further, the GBI motivates the project developers to maximize their generation as the incentives are disbursed only upon actual generation.

Innovative practice: For every MW of wind turbine installed, the financial support provided by the government is equivalent to INR 5.2 million (on NPV basis). With the tax payable by a wind generation company in the range of INR 11 million per MW (as estimated in Table 5), the GBI support would be effectively net positive for the government.

Innovative practice: Per unit subsidy comes out to be less than INR 0.14 (generation of 37 million units by a one MW wind turbine during its 20 year lifetime), indicating the cost effectiveness of the scheme. Similarly, the cost of displacing 1 t of GHG comes out to be less than US$ 3 (taking GEF of Indian grid as 0.82 tCO2e/MW h and support of INR 0.14 for generating one unit of power) highlighting the environmental efficiency of the scheme.

5.5. Solar auctions & bundling

Government of India launched the National Solar Mission in the year 2009 for setting up 20 GW of grid based solar based power capacity by 2022 (which has been recently revised to 100 GW capacity) [61]. Under the Phase-I of the 'Mission', bids were invited from project developers for 1000 MW of solar power, equally divided between photovoltaic (500 MW) and thermal technologies (500 MW). With regard to PV technologies, the first phase was further split into two batches of 150 MW and 350 MW for the two financial years FY 2010–11 and FY 2011–12 respectively. The projects were to be selected on the basis of global tenders under reverse auctions - discount offered on the CERC approved base tariff. As a result of the bidding, a marked decrease was observed in the solar tariff – 32% reduction in Batch-I tariffs (from INR 17.91/kW h to INR 12.16/kW h) and 43% reduction in Batch-II tariffs (from INR 15.31/kW h to INR 8.77/kW h).

To make solar power less expensive for distribution utilities, an equal capacity of coal based power was allocated to them from the unallocated central pool (central coal based generating stations), making the effective power purchase cost to INR 5.5 per kW h. Considering CUF of solar PV plant as 19% and plant load factor (PLF) of a coal plant as 95%, a total of 5 units of coal power (tariff of INR 3/kW h) would get bundled with one unit of solar power (tariff of INR 17.91/kW h). This price of bundled power gets reduced further (to INR 4.53 per kW h) when the discounts offered on CERC base tariff under bidding is considered. Refer Table 12.

Innovative practice: The intense competition anticipated in the auctions made the companies explore cheaper markets for sourcing of equipment (solar modules) as well as funds to enhance their winning chances. As per a report, during the phase-I of the National Solar Mission, project developers sourced US $250 million from the US Exim Bank and OPIC at competitive terms (lower rates of interest with a long term repayment schedule), thus, enhancing project viability [67]. The success of bidding witnessed during Phase-I of the Mission paved the way for using auctions as a viable instrument in exploring true market costs of solar projects and encouraged many Indian states to promote solar sector under this mechanism (refer Table 11), resulting in steep reduction in the discovered prices (as low as US $70 per MW h). It is observed that auctions as a RE support instrument [63] can lead to significant savings of public spending (in the range of 20% and 41%) [64].

Innovative practice: The bundling mechanism helped made the expensive solar power more acceptable for the distribution utilities as the effective cost reduced by almost 70% (refer Table 12). It may be noted that the 'Solar Mission' was initiated in the year 2010 when the solar modules were costing over US $1.21/W [94], leading to high cost of energy generation from solar PV projects, acting as a deterrent for the utilities to procure it. As such, the tool can be used to commercialize an expensive technology. There was no financial outgo from the Government coffers as the utilities were allowed to pass through the power procurement cost to the end consumers in the ARR [58]. Further, even the unallocated coal power was procured by the utilities as per the actual purchase price without any discounts.

Innovative practice: There was no provision of capital subsidy in the auctions. As such, the scheme was a net gain for the government as a MW of solar project would end up paying INR 10 million as tax (in NPV terms) during its lifetime of 25 years (CERC Tariff guidelines estimates the life of a solar PV project as 25 years). Refer Table 13. Detailed calculation is provided in Appendix B as attached file.

Innovative practice: To discourage non-serious players and translate commitments into capacity addition on the ground, the scheme had a provision of sourcing bank guarantee from the investors, who were also required to provide documentary support with respect to their assets (minimum net worth of INR 30 million/MW, sufficient to cover equity investments). This led to filtering out of market speculators and encouraged only serious players to participate in the scheme. As a result, most of the

Table 11
Tariffs discovered under State Auctions [92, 93, 97, 98, 102,107 and Author's calculation].

State	Capacity (MW)	Year	Preferential tariff (INR/kW h)	Tariff (Min) (INR/kW h)	Tariff (Max) (INR/kW h)	Tariff (Average) (INR/kW h)	Discounting (percentage)
Andhra Pradesh	500	2015	6.86	4.63	–	5.334	32
Haryana	150	2015	6.44	5.00	5.00	5.00	22
Madhya Pradesh	300	2015	6.86	5.05	5.64	5.36	26
Punjab	500	2015	6.35	5.09	5.98	5.65	20
Rajasthan	420	2015	6.86	4.34	5.60	–	37
Telangana-I	500	2015	6.45	5.50	5.87	5.73	15
Telangana-II	1500	2015	6.45	5.18	5.89	5.62	20
Karnataka	500	2014	7.72	6.71	7.12	6.94	13

Table 12
Cost of bundled power [65, 70 and 71 and Author's calculations].

	Solar (Rs/kW h)	Coal (Rs/kW h)
Cost (INR/kW h) – Base tariff	17.91	3
Number of kW h	1	5
Total cost	17.91	15
Weighted cost (INR/kW h)	=(17.91+15)/ 6=5.50	
Cost (INR/kW h) – discounted tariff	12.16	3
Number of kW h	1	5
Total cost	12.16	15
Weighted cost (INR/kW h)	=(12.16+15)/6=4.53	

Table 13
Tax payable by a solar PV generating company [51 and Author's calculations as per Appendix B].

Parameters	**Values**
Project cost	INR 58 Million
Debt: Equity ratio	70:30
Cost of debt	13%
Cost of equity	20%
Discount rate	10.81%
O&M charges (% of project cost)	2.2%
Applicable tariff	INR 6.86/kW h
Tax rate	21% for 1st 10 years 34% for subsequent years
Capacity utilization factor (CUF)	19%
Annual performance degradation	0.5%
Total generation in 25 years	39 MU
Tax collection in 20 years (NPV Basis)	INR 10.2 Million
Tax collection/unit	INR 0.26

solar PV projects awarded under the bidding scheme have been commissioned [101]. It may be noted that some of the wind auction schemes in Brazil failed on account of aggressive bidding by non-serious actors/speculators as there was a lack of enforcement mechanism [95].

5.6. Viability gap funding

Under the Batch-II, Phase-I of the Solar Mission, bids were invited for 750 MW of solar projects split in two categories: 375 MW capacity under domestic content requirement (DCR) and 375 MW capacity under open category. In this scheme, the projects were required to sell power at a fixed tariff of INR 5.45/kW h to the Solar Energy Corporation of India (SECI), to be further sold to the state distribution utilities at INR 5.50 per unit (fixed for 25 years) to meet their solar purchase obligations [68]. Capital Subsidy in form of viability gap funding (VGF), limited to INR 25 Million per MW, was offered by the government on which the project proponents were asked to bid under a reverse auction. A total of 122 applications worth 2170 MW of solar capacity were received.

The outcome of the bidding process indicated a 20% reduction in case of DCR projects (INR 20.19 million/MW) and 60% reduction in case of open category projects (INR 10.67 million/MW) [62], leading to a total VGF support of INR 11.65 billion against the initially estimated INR 18.75 bn; On a MW basis, the VGF support came at INR 15.43 million per MW for DCR and INR 12.13 for open category projects. Till June 2015, solar PV capacity of 555 MW has been commissioned under the scheme. In the month of June 2015, the government launched Batch-III of NSM, offering 2000 MW capacity to solar project developers with a VGF support capped at INR 10 million for open category (1750 MW) and INR 13 million for domestic category (250 MW) [71].

Innovative practice: The VGF support reduced the upfront capital (equity) investment by the developer (to almost half); VGF at INR 12 Mn per MW constituted about 15% of the total project cost (INR 75 Mn per MW), thus, reducing the equity investment from 30% to 15%. This enabled reduction in the weighted average cost of capital by over 17% (from 13.90% to 11.50%). Refer Table 14. Many of the project promoters used the spared equity to put up more RE capacity [96]. The off-take of energy by a creditworthy counterparty (Solar Energy Corporation of India, which is a government agency) further assured the investors of a regular stream of income.

Table 14
Weighted average cost of capital (87).

Source of funds	Debt	Equity
Without VGF		
Share in project cost	70%	30%
Cost of capital	13%	16%
Weighted average cost	13.90%	
With VGF		
Share in project cost	70	15% (30–15%)
Cost of capital	13%	16%
Weighted average cost	11.50%	

Innovative practice: The estimated tax inflow to the government exchequer from a one MW solar project would be INR 10 Million, against a VGF payout of INR 12 Million (comparison on NPV basis), making it almost revenue neutral for the government. Refer Table 13. With regard to environmental efficiency, the cost of offsetting 1 t of GHG comes at less than US $6, which is less than a tenth of the carbon abatement cost as estimated by IEA at $67/tCO2e [50].

Innovative practice: The projects were required to maintain a minimum level of generation (capacity utilization factor, CUF), forced by staggered VGF payments spread over a period of 5 years. This motivated the project developers to undertake prudential maintenance practices. It may be noted that the average CUF of projects supported under VGF scheme is 20.92% [69].

5.7. Polluter pays principle

The funds required to support most of the programs/schemes for promotion of RE sector in India is being sourced from the national clean energy fund (NCEF) [70,77], which is being generated by levying a cess on production (including imports) of coal in India. As such, the effective outgo from the government exchequer is not there and it encourages coal based power plants to reduce their coal consumption by improving the system efficiency.

5.8. Citizen participation

Under the Electricity Act, the electricity generation has been de-licensed. As such, institutions (industries and commercial establishments) as well individuals are allowed to set up captive power projects (even at some distant location from the facility). This has helped the consumers to become producers of power. In case of RE sector, utilities have allowed wheeling of power generated from a distantly located wind project and banking it with the grid at a nominal charge basis [99].

With regard to putting up a solar rooftop project at the site of the host institution, the government has issued net metering guidelines to offset part of their consumption and sale the excess energy generated to the grid. It may be noted that the national target for solar rooftop has been set at 40,000 MW to be achieved by the year 2022. Till the end of FY 2015–16, over 700 MW capacity of rooftop projects have been commissioned [100].

Table 15
Comparison of HT Industrial Tariff with Wind Tariffs [72].

State	HT Tariff (INR/kW h)	Wind Tariff (INR/kW h)
Andhra Pradesh	5.73	4.70
Gujarat	4.5	4.15
Karnataka	6.80	4.15
Madhya Pradesh	4.6	5.92
Maharashtra (22% CUF)	7.01	5.05
Rajasthan	6.25	5.46
Tamil Nadu	5.5	3.51

Innovative practice: The banking of wind power with the grid was a kind of pre-cursor to the current net-metering mechanism. This encouraged large scale wind power capacity addition by private sector in Tamil Nadu in decade of 1990. The participating industry was able to partly offset its electricity consumption against the banked wind power. It may be noted that in most of the Indian states, the wind tariff is cheaper than the grid power (for industrial category consumers, refer Table 15), making it viable for the industry to set up captive wind projects facilitated by provision of energy banking.

Innovative practice: Several rooftop projects have come up under 'RE Service Company' (RESCO) business model, wherein, the RESCO installs (and maintains) the rooftop system at its own expense (without any subsidy support from the government [73]) and sells power to the host institution at (generally) a discounted price to the grid tariff. The projects are set up under OPEX model (operating expenditure) rather than CAPEX model (capital expenditure) and the end consumer only needs to pay for the power consumed (with no upfront investment). As per a recent analysis, commercial and industrial consumers in 12 states of India have reached grid parity (tariff levels similar to cost of power from rooftop projects) [74].

5.9. Cost apportioning across states

Ninety percent of the installed wind capacity in India is concentrated in the southern and western states due to availability of high wind regime. Refer Table 16. As such, the utilities (and ultimately the end-consumers) belonging to these resource-rich states have to bear the extra cost on account of absorbing intermittent renewable power in the grid. The state of Tamil Nadu, with the highest installed wind capacity in the country, is facing issues on account of integrating wind power (over 40% share in grid) during the peak wind season [75]. This is further constrained by the limited sale (flow) of wind power from one state to other due to transmission constraints and associated charges.

To enable virtual transfer of renewable power from resource rich regions to areas lacking renewable resources, the Indian Government launched the renewable energy certificate (REC) mechanism. Under this scheme, renewable projects can sell power to local distribution utilities at a tariff equivalent to average power purchase cost (APPC) and are issued tradable certificates (REC) to account for the green attributes. The buyers are obligated entities (mostly distribution utilities and large industries), which are required to procure RE power as a certain percentage of their total power in line with the renewable power obligations (RPO) set by their respective regulatory commissions. The RPO level is envisaged to reach 17% by the year 2022, with 8% share from solar sources [78,79]. A total capacity of 4809 MW RE projects have been registered under the scheme till August 2015 [80,81].

Table 16
State wise installed wind capacity [76].

State	Capacity (in MW)	% Share of total wind capacity in India
Tamil Nadu	7457	32
Maharashtra	4438	19
Gujarat	3643	15
Rajasthan	3308	14
Karnataka	2639	11

Innovative practice: The REC mechanism encouraged the states with significant RE potential (and installed capacity) to put up more capacity by minimizing the fallouts (both financial and technical) on account of absorbing a higher quantum of RE power; 970 MW wind capacity has been registered in the state of Tamil Nadu under REC mechanism [80]. It further enabled practice of uniform RE regulations across the states, even though 'Energy' is a concurrent subject under the Indian constitution, with both the central government and the state governments empowered to frame legislations on the subject.

Innovative practice: Under the scheme, the projects are not eligible to claim any kind of financial support from the government. Further, the distribution utility procures green power at a nominal cost equivalent to the weighted average price of electricity procured from all energy sources (excluding renewable energy sources) making it revenue neutral for them; APPC price lies within the range of INR 3 per unit [98].

Innovative practice: The mechanism supports democratizing the sector by encouraging industrial/commercial establishments to supplement a part of their energy requirement by setting up RE projects under captive mode and benefit by selling green RE certificates in the power exchange.

5.10. Risk capital by dedicated financing agency

Renewable projects are characterized by high upfront cost and lower CUF values, leading to a long payback period and lower level of returns. They present a range of risks (performance, policy and counter party risks) for commercial banks and private financing community. As such, project developers find it difficult to get funds at competitive terms to make them viable. It has been found that firms in large emerging markets (like Brazil, China and India) expose multinational investors (investing in the RE sector) to a great risk [88].

Against this backdrop, public financial institutions (including national, bilateral and multilateral agencies) have been playing an important by absorbing the initial investment risk so as to attract the early set of investors [83]. These institutions have traditionally leveraged private sector capital through risk-sharing facilities to insure commercial borrowings. They have reduced the cost of public budgets by providing concessional loans in countries where public and private finance would be too expensive, or extending maturities, where commercial investors are present but poorly suited for project finance [84].

In this context, the government of India incorporated a dedicated financial institution, the Indian Renewable Energy Development Agency Limited (IREDA), to finance renewable energy projects. Till the end of FY 2014–15, IREDA has funded over 2100 clean energy projects on commercial terms (with a cumulative capacity of 2500 MW), involving a capital disbursement of INR 143 bn (approximately US $2 bn) [85]. The project financing is made under innovative schemes and instruments (like non-recourse and structured finance, take-away finance, payment guarantees, line of credit etc.) to meet the specific needs of the sector [86].

Innovative practice: IREDA has been funding projects with lower levels of delinquency (its non-performing asset, NPA was 2.5% during FY 2013–14) due to its unique infrastructure and mission mode approach. This is in stark comparison to high

Table 17
Funding made by IREDA [85].

Financial year	Disbursement by IREDA (INR Million)
2009–10	8900
2010–11	12,442
2011–12	18,550
2012–13	21,255
2013–14	24,711

Table 18
Financial Contribution of IREDA[85].

Year	Equity contribution A	Tax payment B	Dividend payment C	Net Receipt by Government B+C-A and D
2009–10	19.60	68.36	14.54	63.3
2010–11	50.00	46.24	20.00	16.24
2011–12	50.00	34.99	25.00	9.99
2012–13	60.00	47.93	27.50	15.43
2013–14	45.00	99.8	35.00	89.8

levels of NPA observed in funding of power projects by leading commercial banks [89]. As such, the success stories sculpted by IREDA made the banks in India to look at the RE sector as an important credit portfolio associated with low levels of default. It can be observed that despite 20% growth in its business (over last 5 years), the market share of IREDA has been reducing [90], indicating a rapidly growing RE market. The leverage factor of IREDA at 20 is substantially higher than the usual figure of 8-10 (World Bank study) [91]. Refer Table 17.

Innovative practice: The viability of capital intensive sector like RE project depends upon the cost and tenor of debt, as also in case of mineral extraction industry [97]. As per a research report, high cost and short tenor of debt raises the cost of RE in India by 24–32% [87]. In this regard, IREDA has been raising low-cost long term funds from international financial agencies and domestic sources; this includes green bonds worth INR 7.57 bn raised during FY 2014–15. The raising of green bonds to support RE projects led to greater participation (and sensitization) of citizens, thus enhancing the overall acceptance and subtly influencing the policy makers for a long term consistent policy regime.

Innovative practice: In order to enhance the ability of IREDA to finance larger capacity RE projects, the government has been infusing equity so as to increase its net worth. The lending norms for a financing company restrict funding upto a specific percentage of its net worth. Being a company, IREDA has been giving dividends to its shareholder (Government of India) in line with its profits revenue and paying corporate tax. The total inflow to the government in terms of dividend and corporate tax from the agency is much higher than the equity support provided by the government, making it revenue positive for the government. Refer Table 18.

6. Conclusions and future work

Developing and emerging economies have set ambitious RE capacity addition targets to reduce energy emissions on account of their growing economy. The probability of achieving these targets gets enhanced if the policy instruments recognized globally to promote RE sector are used effectively and efficiently. As has been described above, India has used many of these tools innovatively to achieve an impressive growth in its RE sector with a high impact on the ground (green power generation) and a low dependency upon financial support. Sharing a similar demography and economic profile, the emerging economies can emulate/contextualize many of these measures, with an aim to de-carbonize their growth trajectory. Further research is required to study the type of RE policy enablers deployed across these countries along with their impact assessment so as to share the lessons learnt and the best practices among stakeholders. The countries to be studied can include those located in South-East Asia, Latin America and Asia Pacific regions. The author is currently engaged in designing community energy business models which can facilitate wider citizen participation in the global cleantech revolution so as to optimize the sharing of benefits in an equitable manner.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.rser.2016.08.025.

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