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Renewable energy certificate markets in India—A review

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ABSTRACT

In India, the National Action Policy on Climate Change (NAPCC)[1] has set a target of 15% of electricity via renewable energy sources by 2020. To reach these ambitious targets, in March 2011, the Government of India launched the renewable energy certificates (REC) – a market based mechanism – to drive renewable energy development and spur further investments. However, a look into the actual performance of REC market trading during the first year of operation shows that, though volume of trading steadily increased, the number of accredited certificates issued was less than 2.5% of the technical REC demand potential, indicating that the full potential of the REC markets was far from being realized.

We critically examine the design and implementation of the REC market in India as well as its effectiveness in meeting the desired objectives in the context of international best practices. Our analysis of REC market best practices reveals that, though forward markets, banking and price bounds are recommended for stable markets, best-of-class methods for determining the optimal length of banking, the level of floor and forbearance prices, and the values of credit/vintage multipliers are not fully established. We then establish that the main issues with the Indian REC markets appear to be demand uncertainty resulting from lack of long term targets, absence of clarity on compliance, and near-absence of long-term price signals to investors. Finally, we present an analysis of other important features of the Indian REC market in the context of well-functioning REC markets, such as credit-multipliers/set-asides, vintage multipliers, and voluntary markets.

Contents

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[1] List of abbreviations: Australia Securities Exchange (ASX); Average Purchase Pooled Cost (APPC); Central Electrical Authority (CEA); Central Electricity Regulatory Commissions (CERC); Chicago Climate Futures Exchange® (CCFE); Feed-in-Tariffs (FIT); Forum of Regulators (FOR); Generation Based Incentives (GBI); Indian Energy Exchange (IEX); Jawaharlal Nehru National Solar Mission (JNNSM); National Action Policy on Climate Change (NAPCC); National Load Dispatch Center (NLDC); Power Exchange of India Limited (PXIL); Renewable Energy Certificates (REC); Renewable Portfolio Obligation (RPO); Renewable Portfolio Standard (RPS); State Electricity Regulatory Commissions (SERC); State Load Dispatch Center (SLDC).

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1. Introduction

1.1. Motivation

In India, the renewable energy sector is undergoing changes rapidly – renewable energy has begun to play a significant role in the energy security of the nation as conventional energy sources (e.g., coal) have become scarcer and more expensive to import. Further, India has set ambitious renewable energy targets. The NAPCC, which in addition to India's response to climate change also tackles diverse issues such as energy security and industrial competitiveness, has set a target of 15% of electricity via renewable energy sources by 2020, with a starting target of 5% in 2010, increasing by 1% every year [45]. Under the Jawaharlal Nehru National Solar Mission (JNNSM), the government aims to develop 20,000 MW of solar energy by 2022 [43].

India is the only country with a separate ministry for renewable energy—called the Ministry of New and Renewable Energy (MNRE). Regulations supporting the development of renewable energy in India are the Electricity Act of 2003 and the National Electricity Policy of 2005. The Electricity Act of 2003 stipulates purchase of a certain percentage of the power procurement by distribution utilities from renewable energy sources. Under this act, implementation of the renewable portfolio obligation (RPO) is to be guided by the regulatory provisions issued by the respective State Electricity Regulatory Commissions (SERCs).The National Electricity Policy of 2005 also mandates that the share of electricity from non-conventional sources has to be increased progressively. Several other incentives in the form of generation based incentives (GBI), feed-in-tariffs (FIT), depreciation benefits and tax incentives have also been introduced.

Due to a supportive policy environment coupled with abundant resources, India has seen tremendous growth in renewable energy deployment, with wind energy surpassing 16 GW of installed capacity by 2011 (CPI 2012). However, the actual generation of electricity from renewable sources has been only 5.5% of the total electricity generation as of August, 2012 [11], as opposed to the annual target of 7% [45]. Though this is a marked improvement than the share of less than 4% just four years ago [12], renewable energy in India is lagging behind the targets, and it needs a comprehensive and focused effort to catch up.

Though India has a huge renewable energy potential,[2] availability of renewable energy sources is widely dispersed. In some states the potential for renewable energy is insignificant (e.g., Delhi), whereas some states have abundant renewable sources [35,56]: wind energy is abundant in Gujarat, Karnataka, Maharashtra, Tamil Nadu, and Jammu and Kashmir; solar energy is concentrated in the northwest region of the country—in Gujarat, Rajasthan, Ladakh, Maharashtra, and Madhya Pradesh; and the small hydro potential in the country is concentrated in hilly states of Himachal Pradesh, Uttaranchal, Jammu and Kashmir, Arunachal Pradesh, and Chattisgarh.

However, since renewable energy is typically more expensive than fossil-fuel based energy at a levelized cost basis [38], and since the intermittent nature of renewable sources results in higher integration costs [29], inclusion of renewable energy results in increased financial burden on local distribution companies, many of which are in poor financial health to begin with [60]. Thus, even though there are opportunities for harnessing renewable energy in states with abundant renewable resources, financial burden discourages corresponding distribution companies from purchasing renewable power beyond the RPO level mandated by the state-level regulatory authorities.

To address this mismatch and to achieve the targets set, MNRE launched the renewable energy certificates (RECs) trading mechanism in March, 2011. States with low renewable potential can now support renewable energy and meet their RPO by purchasing RECs. For states with high renewable potential, this would reduce the burden on state utilities to purchase renewable energy beyond the RPO fixed by the SERCs. This would help to minimize cost of power procurement, and lead to efficient resource utilization across the country. The REC market mechanism was widely touted as the solution to drive investment into renewable generation [7,61].

However, a look into the actual performance of REC market trading till March, 2012 – i.e., over the first year of operation – shows that, though volume of trading increased in the last few

[2] As of March 2011, the renewable Energy Potential of India is estimated at 89,760 MW, including wind (49,132 MW), small hydro (15,385 MW), biomass power (17,538 MW), and cogeneration (5000 MW) [44].

trading sessions, the number of accredited certificates issued was less than 2.5% of the technical REC demand potential. Further, most of the existing demand for certificates was from existing renewable energy producers and the REC mechanism did not mobilize much new investment.[3]

Thus RECs did not meet the intended objectives in the first year and the full potential of the markets was far from being realized. With this motivation, we look into the REC policy framework and understand the reasons as to why RECs did not have the projected effects.

1.2. Prior work

We first discuss relevant work before looking deeper into the actual functioning of the REC markets. REC markets are in practice worldwide and there are several studies that looked in the functioning of REC markets. We discuss these in latter sections when we look into each design aspect of RECs. In this section we focus on the literature that discusses REC markets in India—in particular, (a) studies that made the case for introducing REC markets in India to promote renewable generation in an economically efficient way [34,57,58]; and (b) studies that examine in performance of REC markets so far [35,41].

Sonee et al. [57] provide details on the various regulatory developments for renewable power generation in India including Indian Electricity Grid Code-2010 (IEGC), Electricity Act of 2003, and National Electricity Policy of 2005. They highlight salient features of REC markets and provide an overview of the implementation framework of REC mechanism in India. They acknowledge many advantages of REC markets including: attracting investment, allowing renewable generators to run as stand-alone systems, and providing a flexible mechanism for obligated entities to fulfill RPO despite natural diversity.

Singh [58] discusses the advantages of a market based system and also draws attention to the regulatory and implementation issues involved in enacting such systems. Regulatory issues identified include quantifying floor or forbearance prices, fixing tariff for procured electricity, provision for rollover of credits etc. On the implementation side, effective coordination and harmonization between various SERC and the need for an efficient monitoring and accrediting national level institution are recognized as the main challenges. This paper also provides a detailed discussion of the various advantages REC markets have to offer and suggests use of credit multipliers and implementation of sunset clause in the REC market design.

Goyal and Jha [34] present an overall framework for introducing REC markets which includes setting of RPO targets and a mechanism to meet RPO through trading of certificates. Instead of determining the price for renewable energy certificates in the market, they propose that obligated entities either buy certificates directly from the generator or pay penalties. Using a case study for Madhya Pradesh, they estimate that RECs would have minimal impact on the cost of supply—approximately ~\$0.0028[4] in 2012.

Kumar and Agarwala [41] present an innovative energy model for exploring the techno-economic feasibility of renewable generation, taking into account resource variability and policies, including regional incentives and certificate schemes, such as RECs. Though the focus of the paper is mostly on developing this model, it provides a brief overview of the Indian RPO and REC market and tracks the performance of the REC market until 2012. However, despite presenting aggregate demand-supply data that confirms our analysis that the REC markets have failed to incentivize investments it claims that the REC markets have been successful, purely on the basis of administrative details.

Gupta and Purohit [35], to the best of our knowledge, is the only paper that performs an ex-post analysis of the REC markets. Similar to our paper, this paper notes that REC markets have low participation and have failed to attract investors. It also focuses on cost-competitiveness, distributed generation deployment, and resource diversity. It finds that REC price bounds are not cost competitive and that the state-wise REC distribution is skewed towards a few states. However, a major difference from our work is that this paper does not provide a comparative analysis of worldwide best practices and how they can be used to inform RPO-REC related policymaking in India, especially in the current context.

From our review of literature it appears that, though the case for REC markets is clear and issues in implementation in India have been identified, few studies have probed into designing various aspects of the REC policy framework in the context of international best practices as well as looked into the actual performance of REC markets. We address this gap in literature through this paper. Our novel contributions are to situate Indian REC market design into a best practice – theory as well as implementation – as well as look at the REC market design in the context of actual market performance.

1.3. Paper organization

In Section 2, we study the background for the REC markets in India. We look into the current REC policy framework—including the institutional structure, state RPO regulations and also the functioning of the markets till date. In Sections 3 and 4 we analyze design aspects of REC policy in the context of theory and existing practices worldwide and identify the best practices for REC policy design. We examine the current REC policy framework—not only features that are relevant to the current shortfall but also the design of REC markets in a comprehensive fashion. Finally, Section 5 provides a short summary of this work and directions for future work.

2. REC markets: Institutional framework and current performance

In this section, we first examine the institutional structure of REC markets as well as the main driver—the RPO targets, followed by an estimation of the size of the REC markets, and finally present an analysis of the performance of the REC markets in the first year of operation.

2.1. The institutional structure for REC markets

India has a federal structure, where concurrent subjects such as electricity (and hence RECs) are under the jurisdiction of state governments. Thus, though the center can influence policy design and implementation, the final implementation is in the hands of state governments. The REC mechanism involves existing and new institutions from state as well as from the central level. Renewable energy generators undergo an "accreditation" process by the state agencies and a "registration" process with central agencies. The central agencies then "issues" certificates and also oversee the trading activity in power exchanges.

2.1.1. Central agencies

2.1.1.1. Central electricity regulatory commission (CERC). CERC is the central regulatory authority driving the REC market mechanism in India. It has developed the institutional and regulatory framework

[3] This is based on our conversations with (and hence research of) REConnect, an REC trading firm which specializes in analyzing the Indian REC markets.

[4] An indicative exchange rate of 1 USD = 50 INR has been used here throughout this paper.

for the REC mechanism, including the rules for recognition and issuance of RECs, the floor and forbearance prices,[5] and other registration and application fees. Appointment of compliance auditors for monitoring REC transactions is also the responsibility of CERC.[6]

2.1.1.2. National load dispatch centre (NLDC). CERC has recognized NLDC as the central agency responsible for registration, issuance, redemption, and settlement of REC certificates. NLDC issues RECs to registered renewable generators, which have been accredited by state agencies, based on reports prepared by state load dispatch centers and state nodal agencies. One REC is issued for every MW h of electricity produced from renewable energy and fed into the grid. Obligated entities register with the NLDC to purchase the necessary certificates. NLDC also maintains an online REC registry (www.recregistry.in) and that tracks every REC that has been issued. It also oversees the trades in the markets.

2.1.1.3. Power exchanges. RECs issued by NLDC can be traded only in power exchanges recognized by CERC. Currently two such power exchanges are in operation—Power Exchange of India Limited (PXIL) and Indian Energy Exchange (IEX). These exchanges facilitate trading of RECs amongst interested parties in accordance with CERC regulations and report periodically to the CERC.

2.1.1.4. Forum of regulators. The forum of regulators (FOR) is a statutory body constituted by the Government of India under Section 166 (2) of the Electricity Act, 2003. The forum is responsible for harmonization, coordination and ensuring uniformity of approach amongst the various SERCs across the country. It has been instrumental in designing the REC mechanism, developing guidelines for implementing REC framework in states, and bringing about consensus among the different SERCs on various issues.

2.1.2. State agencies

The Electricity Act of 2003 mandates SERCs to establish policies and rules for development of renewable energy in their respective states. Accordingly, SERCs determine the obligated entities in their states and the corresponding RPO targets. The guidelines provided by CERC suggest that RPOs be set based on the availability of renewable resources in the state and the burden on the consumers, however there is no minimum RPO requirement. The obligated entities list usually includes licensee distribution companies, open access and captive consumers.

SERCs also appoint state agencies for accreditation of renewable energy producers and enforcement of RPO targets. These agencies are responsible for scrutinizing and verifying of applications from renewable energy generation companies. Applications are assessed by the state agencies based on guidelines laid down by CERC and MNRE. Details on state agencies appointed for accreditation can be found at http://mnre.gov.in/list/sna_list.pdf.

The State Load Dispatch Center (SLDC) monitors renewable power injected into the grid and maintains the records of meter readings for each accredited project on a monthly basis. It informs the state and central agencies about the amount of electricity fed into the grid by the project. These agencies then determine the number of certificates to be issued.

[5] These represent the price-band on the REC markets. Floor price sets the minimum whereas forbearance price sets the maximum

[6] Compliance auditors are a key component of the enforcement/compliance team. They investigate compliance of eligible generators in accordance with CERC/SERC regulations.

2.2. Renewable portfolio obligation: The driver of REC markets

The level of RPO target, which specifies a target share of renewables in the electricity mix, is typically driven by the broad policy goals of the nation (emission reduction, energy security, job creation, etc.) as well as the potential for development in the country/state. The use of RPO targets has been widespread around the world. Australia was the first country to introduce mandatory renewable energy targets. The European Commission has adopted a target of deriving 20% of the final energy consumption from renewable source by 2020 and has established targets for each member state. Sweden has been a forerunner – their quota obligation system aims to reach 49% of by 2020. The US is not far behind – 29 states have RPO targets in place and seven major tracking systems are in operation in seven regions for managing and retiring RECs [26].

As mentioned earlier, under the 2003 Electricity Act, the implementation of RPO in India is guided by the regulatory provisions, terms and conditions issued by respective SERCs. Pursuant to provisions of section 86(1)(e) of the Electricity Act, each SERC has to fix a minimum percentage for purchase of energy from renewable sources taking into account availability of such resources in the region and its impact on retail tariffs [14,16]. Several states had earlier specified RPO targets – the RPO limits ranged from as low as 0.8% for Madhya Pradesh to as high as 10% for Tamil Nadu – but enforcement was not stringent. Also, only instate generation was allowed for compliance purposes.

With the launch of the REC market scheme in 2011, many states made meeting RPO targets mandatory and scaled down their ambitions to more realistic renewable energy addition goals. 8 states – Bihar, Chhattisgarh, Himachal Pradesh, Haryana, Karnataka, Madhya Pradesh Uttar Pradesh and Tamil Nadu – issued notifications that reduced RPO targets from 2011. For example, Madhya Pradesh reduced its target to less than 1% from the previous 10% limit owing to low target achievement in previous years. Table 1 shows the pre- and post- REC market RPO standards in different states as of January, 2012.

Some key points to note are (see the description of obligated entities in the sub-section below):

- All states except Sikkim and Arunachal Pradesh had declared their RPO targets.
- While some SERCs have specified separate RPOs for different sources, others had chosen to specify a common RPO target (see Appendix A).
- 16 of the 27 states had RPO targets declared only up to 3 years. As we discuss later, long term targets are essential for effective functioning of REC markets.
- Andhra Pradesh had declared an RPO of 5% for all distribution companies and captive consumers, but the obligation wouldn't start till 2014–15.
- Only Karnataka has separate targets for distribution companies, captive consumers, and open access consumers.

2.2.1. Obligated entities

In India, generally distribution licensees (e.g., public and private distribution companies), captive consumers and any open access users are obligated by RPO in all the states. These entities can purchase RECs in the power exchanges to meet the RPO in their respective states or purchase renewable energy directly from renewable generators. In India, many electricity intensive industries such as Cement, Steel, Ferro Alloys, Paper and Pulp etc., are operating their own power plants run by either thermal generation or generation from other resources including renewable

Table 1
RPO targets across states.
Source: www.recregistry.in, Singh [59].

State	Year of first regulation	Pre-REC target			Post-REC Targets					
		2007–2008 (%)	2008–2009 (%)	2009–2010 (%)	2010–2011 (%)	2011–2012 (%)	2012–2013 (%)	2013–2014 (%)	2014–2015 (%)	2015–2016 (%)
Andhra Pradesh (Draft)*	2005	5.0	5.0	5.0					5.0	5.0
Assam	2010				1.4	2.80	4.20	5.6	7.0	
Bihar				4.0	1.5	2.50	4.00	4.5	5.0	
Chhattisgarh	2008	10.0	10.0	10.0	5.0	5.25	5.75			
Delhi (Draft)*		1.0	1.00		2.0	3.40	4.80	6.2	7.6	9.0
Gujarat	2005	1.0	2.0		5.0	6.0	7.0			
Haryana	2007	2.0	5.0	10.0	1.5	2.0	3.00			
Himachal Pradesh		20.0	20.0	20.0	10.01	10.01	10.25	10.25	10.25	10.25
Jammu and Kashmir					1.0	3.0	5.00			
Goa and UT					1.0	2.0	3.00			
Jharkhand					2.0	2.50	3.10			
Karnataka	2008	1.0	1.00	1.0	0.25	0.25	7.25	7.25	7.25	7.25
Kerala	2006	5.0	5.0	5.0	5.25	5.25	5.25	5.25	5.25	5.25
Madhya Pradesh	2008		10.0	11.0	0.80	2.50	4.0	5.50	7.0	
Maharashtra	2006	4.0	5.0	6.0	6.0	7.0	8.0	9.0	9.0	9.0
Manipur	2010				2.0	3.0	5.0			
Mizoram	2010				5.0	6.0	7.0			
Meghalaya	2010				0.50	0.75	1.0			
Nagaland					6.0	7.0	8.0			
Orissa		3.0	3.0	4.0	5.0	5.0	5.50	6.0	6.50	7.0
Punjab	2007	1.0	1.0	2.0	2.4	2.86	3.44	3.94	4.0	
Rajasthan	2006[a]	4.28	6.25	7.5	8.5	9.50				
Tamil Nadu	2006	10.0	10.0	13.0	10.15	9.05				
Tripura	2010				1.0	1.0	2.0			
Uttarakhand		5.0	5.0	8.0	10.0	11.0				
Uttar Pradesh		7.5	7.5	7.5	4.0	5.0	6.0			
West Bengal	2005				2.0	3.0	4.0			

* Final regulations are not yet published in the official gazette of the state.
[a] Rajasthan started obligation on captives and open access users from 2007.

energy. In March 2013, nearly 15% of the installed capacity in the country was in captive power plants [10]. Open access consumer segment largely comprises of consumers purchasing electricity directly from Power Exchanges. This consumer segment has been developed recently and represents a very small capacity of less than 1%.

Examining international practices, with a few exceptions, obligated entities have usually been retail suppliers in most nations. The exceptions are: Sweden, where the obligated entities were the final consumers; and Italy, where the producers and importers of electricity are obligated rather than the suppliers. Thus, for most part, the Indian design follows the conventional wisdom of focusing on the suppliers. The trading of certificates on recognized exchanges is done so that it is easier to keep track of the RECs that are issued and redeemed.

2.3. *Estimated REC demand based on RPO targets*

Given the early stage of the REC markets and the uncertainty on compliance enforcement it is hard to predict the size of the REC markets. To understand the significance of RECs in meeting RPOs, we first need to estimate the total REC demand. According to the latest available statistics from the Central Electrical Authority (CEA), total power distributed in 2010–2011 is estimated at 869,924 GW h. Using the RPO obligation percentages from Table 1; this would imply a maximum demand of over 36 million RECs to the REC market (Table 2). We note that this (maximum) potential of the market is estimated assuming all the distribution companies and captive consumers fulfill their obligations by purchasing certificates from the REC markets.

2.4. *Status of REC markets after one year of operation*

In India, renewable energy generators have the option to opt for generating electricity at the existing feed-in-tariff rates[7] or participate in the REC markets. In the later case, renewable energy producers feed their electricity into the grid at the average purchase pooled cost (APPC) and apply for RECs to NLDC.

As on June 2011, total installed renewable capacity in India was 20,162 MW [33]. By February 2012, 418 projects or only 12.3% (2478 MW) of the estimated installed capacity was accredited by the NLDC. Thus, majority of the renewable generators still seemed to prefer feed-in tariffs. Nearly 850,000 RECs were issued to these generators (Table 3), with over 45% of the certificates coming from wind energy projects. 90% of these projects were based in 4 states–Maharashtra, Tamil Nadu, Gujarat and Chhattisgarh. This means less than 2.5% of the total estimated RPO obligation (~36,357 GW h–Table 2) could be met using the certificates from the REC market. Further, REConnect research reveals that almost all the supply for RECs was coming through existing generators that were viable to begin with, and all RECs were doing was to provide extra (i.e., windfall) profits.

2.4.1. *Trading*

RECs can only be traded in exchanges recognized by CERC. Since March 2011, REC certificates are being traded in PXIL and IEX and 12 trading sessions had taken place until March 2012. Trading takes place on the last Wednesday of every month at these

[7] Feed-in tariffs (FiTs) are guaranteed tariffs for renewable energy. Examples of FiTs are the solar tariff under JNNSM and the solar as well as non-solar preferential tariffs announced by states (MNRE [43]).

Table 2
Power generation and estimated renewable obligation.

State/U.Ts	Total—electricity distribution (GW h)	Captive generation 2007–2008 (GW h)	2010–2011 RPO obligation (%)	RPO obligation (GW h)
Andhra Pradesh	73,544.0	6,707.3		–
Arunachal Pradesh	255.1	–		–
Assam	3,829.9	1,647.6	1.40	76.7
Bihar	6,613.4	252.7	1.50	103.0
Chhattisgarh	15,974.6	5,618.9	5.00	1,079.7
Delhi	24,575.6	0.8	2.00	491.5
Goa	3,835.3	61.4	1.00	39.0
Gujarat	66,582.9	27,885.6	5.00	4,723.4
Haryana	27,485.0	1,716.9	1.50	438.0
Himachal Pradesh	7,555.1	99.2	10.01	766.2
Jammu and Kashmir	6,067.1	5.5	1.00	60.7
Jharkhand	17,140.0	5,421.9	2.00	451.2
Karnataka	51,529.9	5,369.1	0.25	142.2
Kerala	17,746.7	505.1	5.25	958.2
Madhya Pradesh	35,508.2	5,033.0	0.80	324.3
Maharashtra	102,247.2	7,386.1	6.00	6,578.0
Manipur	297.1	–	2.00	5.9
Meghalaya	1,344.5	127.5	0.50	7.4
Mizoram	270.1	–	5.00	13.5
Nagaland	275.0	–	6.00	16.5
Orissa	17,007.0	13,898.2	5.00	1,545.3
Punjab	44,984.6	1,198.3	2.40	1,108.4
Rajasthan	35,608.9	7,116.4	8.50	3,631.7
Sikkim	391.7	–		–
Tamil Nadu	79,702.4	9,170.7	10.15	9,020.6
Tripura	598.8	–	1.00	6.0
Uttar Pradesh	56,491.6	11,863.1	4.00	2,734.2
Uttarakhand	7,128.6	664.7	10.00	779.3
West Bengal	39,507.5	2,368.5	3.00	1,256.3
A.and N. Islands	225.5	–	1.00	2.3
Chandigarh	1,741.7	5.9	1.00	17.5
D. and N. Haveli	4,403.8	11.3	1.00	44.2
Daman and Diu	1,933.9	1.3	1.00	19.4
Lakshadweep	36.3	–	1.00	0.4
Puducherry	3,118.7	229.7	1.00	33.5
Total all India	**869,924.5**			**36,357.4**

Includes generation by State Electricity Boards, Municipalities and Private Sector.

exchanges. Table 4 shows the details of trades that have occurred in these 12 sessions.

Trading volumes and price of certificates were initially low, with less than 100 certificates sold in the first three sessions. However, in later sessions trading volumes increased significantly and close to 816,000 non-solar certificates worth nearly $47 million were traded in the first year. This spur could have been due to the approaching end of compliance period in March 2012. Price of certificates increased steadily as well, from $30 in the first session to over $60 in January 2012. In all these 12 sessions, only non-solar certificates were traded in the markets, and there were no solar REC 'sell' bids even though all sessions had few 'buy' bids for the solar certificates. Thus the solar RECs were yet to see any trading happen.

Given this background, we take a deeper look into the actual design aspects of REC. Three main design aspects stand out for the clear under performance of REC markets in the first year of operation – lack of enforcement, absence of long term targets, which lead to the third issue of inadequate support for long term price signals to investors. We look into each of these issues in detail in the next section.

3. REC market design: Addressing long-term stability

In this section we analyze all these issues in the context of international best practice and theory. The design and functioning of REC markets in India is similar to other REC markets worldwide. Appendix B provides a comparison between REC design features in REC markets worldwide.

A key risk in any REC market, which is a major concern in the Indian REC market, is the expected size of the demand for RECs, given the high-level of uncertainty about states enforcing their RPO targets. In the absence of certainty about the size of the market financiers are unlikely to feel comfortable with the underlying cash-stream, and the REC dependent renewable energy projects will remain un-bankable.[8] Though CERC had taken some measures to address these issues, as we see in the discussion later, these measures seemed to be either inadequate or questionable on many accounts.

3.1. Enforcement of RPO is key to establishing a robust REC market

Penalties and, more importantly, enforcement of penalties is essential to ensure that the obligated fulfill their RPO requirements. It is well known that, in the absence of an effective penalty to failure in meeting the RPO targets, there may not be enough motivation for the obligators to comply with the state RPOs. The level of the penalty could be looked upon as a degree of political willingness to keep actors to the target. Therefore, the size of penalties, together with the level of ambition of an obligation, will influence market expectations of potential investors in renewable energy [54].

[8] This was verified through many conversations with financiers, including IDFC project finance.

Table 3
RECs issued and redeemed.
Source www.recregistry.com.

Month year	Opening balance	REC issued	REC redeemed	Closing balance
Mar-11	–	532	424	108
Apr-11	108	4,503	260	4,351
May-11	4,351	28,270	18,502	14,119
Jun-11	14,119	27,090	16,385	24,824
Jul-11	24,824	30,224	18,568	36,480
Aug-11	36,480	31,813	25,096	43,197
Sep-11	43,197	74,612	46,362	71,447
Oct-11	71,447	126,544	95,504	102,487
Nov-11	102,487	135,697	105,527	132,657
Dec-11	132,657	88,055	111,621	109,091
Jan-12	109,091	102,348	171,524	39,915
Feb-12	39,915	200,736	206,188	34,463
Total		**858,069**	**815,961**	

3.1.1. Penalties outside India

Many countries—e.g., Belgium, Italy, and US etc. have penalties and strict enforcement mechanism in place. US state laws typically set an Alternative Compliance Payment (ACP), or a fine that must be paid for each MW h that the obligated entity falls short of its obligation. Sweden and the UK are notable examples of countries that have enforced penalties in case of non-compliance, and are worth examining in detail:

- The Swedish case: A penalty can either be a fixed price per certificate or a multiple of the average or maximum market price in the (previous) compliance period. For example, a penalty as a factor of the maximum market price would ensure that the penalty does not automatically act as a maximum price for the certificates and thus encourages obligated entities to purchase certificates in the market. This type of penalty enforcement is in practice in Sweden, where the penalty currently amounts to 150% of the average certificate price in the previous accounting period.
- In case of UK, the penalty exists in the form of a buyout price. This was set at 30 pounds per MW h in 2002, and is tied to the retail price index. At the end of each compliance period, defaulters pay the authority an amount equal to the product of unmet requirement at the buyout price. This then goes into a buyout fund, and redistributed to complying agencies in proportion of their contribution to meeting the compliance target [49]. Thus under this system, if there is an under-supply of certificates, their market value increases, (theoretically) encouraging more expensive generation to be developed to meet the gap in the renewable electricity market.

3.1.2. Penalties and compliance in India

As mentioned earlier, in India, enforcement of RPOs on obligated entities is entrusted to SERCs. In case of non-compliance state regulations have provisions to not only collect penalties at the forbearance price and deposit into a separate fund but also impose additional penalties. The amount thus collected may be used to purchase RECs in the power exchange or used for any SERC related expenses—e.g., distribution and transmission infrastructure; development of renewable energy; etc.

Though RPO seems to have driven renewable deployment in India to some extent [55], there is considerable uncertainty about the extent of this deployment due to uncertainty in eventual compliance of RPO, due to the following reasons.

First, in the Indian market design, though state notifications and regulations issued have called for penalties at the forbearance price (the maximum price set for the REC certificates) and additional penalties as well on defaulters, specific guidelines and laws for enforcement are still not in place.

Second, a potential loophole exists—in case of genuine difficulty arising out of non availability of RECs or any other reason, SERCs have been empowered to allow obligated entities to carry forward compliance requirements to the next year or to relax the targets [18,31,32]. This is a loophole for the obligated entities to exploit and adds to the uncertainty of the demand in the market.

Third, though rules have existed in most states for non-compliance in the pre-REC market period, enforcement of these is yet to see the light of the day in many cases. States have relaxed the RPO obligation due to various reasons, including lack of available renewable energy in the state. The case of Maharashtra is a notable example, given that Maharashtra did try to enforce the RPO targets before the REC regime. Chasing an RPO target on 4%, in 2004–2005 and 2005–2006, share of renewable energy was 0.78% and 1.09%, respectively, of the total electricity consumption in the state. From the latest data available, only one of the 4 distribution companies – Tata Power Co. – in the state has been able to meet its RPO target in 2007–2008 [46]. The other private distribution companies in the state – Reliance and BEST – have not been able to procure renewable energy because of lack of suppliers in their distribution area and high cost for sourcing them from outside. Further, RPO compliance targets led to high land prices which made new renewable energy projects financially unviable, leading to stalled growth and high demand for existing renewable generators, with price of renewable energy shooting up due to lack of supply [46].

Last, the financial condition of the state electricity boards and government distribution companies, which own nearly 95% of the distribution network [40], raises questions on their participation in REC markets and renewable development. Aggregate SEB losses in 2009–2010 were USD 12.7 million, without accounting for subsidy [60]. Further, losses of state electricity boards are projected to reach USD 23.2 billion by 2014–2015 [62].

These issues put a big question mark on the eventual compliance of the RPO targets as well as the eventual size of the REC market. The market anticipation, after the introduction of REC markets, on enforcement by states was variable. The only market sizing available was performed by REConnect. Based on current actions, REConnect estimated that very few states – Chattisgarh, Madhya Pradesh, Jharkhand and Orissa, representing ~9% of renewable generation – were expected to enforce RPO obligations in 2011–2012[9]. However, based on other actions such as past enforcement initiatives many more states were expected to enforce RPO obligation, raising the expected compliance to ~54%.

3.2. Long term targets

A key feature of international best performing markets has been the declaration of long term targets and obligation requirements. Long term declaration of obligation targets guarantees existence of markets to investors. It creates sufficiently long planning horizons to take up long-term projects. This also enables suppliers with quota obligations to predict developments and act in accordance with the conditions of the system [1].

Australia is one example where long term declaration of targets has helped in the countries eventually reaching targets. Australia has set typically set targets and obligations for 10 years at a time. In 2000, it set a 2010 target of 9500 GW h: this was reached by

[9] Based on our discussions with REConnect, REConnect research reveals that the current actions are as follows—Chhattisgarh, Karnataka and Orissa have sent notices to obligated entities asking for compliance status. Madhya Pradesh and Orissa have issued a newspaper advertisement asking obligated entities to fulfill their RPOs.

Table 4
Trade details in Indian REC markets (non-solar certificates).
Source—http://www.powerexindia.com and http://www.iexindia.com/.

Auction date	PXI				IEX			
	Buy bid (Number of RECs)	Sell bid (Number of RECs)	Total volume traded	Price of RECs (USD)	Buy bid (Number of RECs)	Sell bid (Number of RECs)	Total volume Traded	Price of RECs (USD)
February '11					120	–	–	–
March '11	325	274	274	44.5	70,377	150	150	78.0
April '11	–	565	–		260	4,046	260	30.0
May '11	4,500	5,322	4,500	30.0	14,002	15,143	14,002	30.0
June '11	10,000	3,183	483	30.0	72,002	21,331	15,902	30.1
July '11	14,766	3,800	3,900	31.0	81,493	34,976	14,668	31.1
August '11	38,101	8,155	3,000	34.2	145,204	49,897	22,096	36.0
September '11	30,853	9,562	4,977	46.0	196,159	76,026	41,385	46.0
October '11	33,869	3,201	3,201	60.0	201,532	135,424	92,303	54.0
November '11	20,882	30,317	9,373	56.0	257,578	155,917	96,154	58.0
December '11	21,179	14,336	5,679	59.0	264,093	166,000	105,942	59.0
January '12	18113	6072	6064	61.0	414,387	186,610	165,460	61.0
February '12	28,933	19,045	15,706	61.0	360,330	215,157	190,482	61.3

2006, a good four years ahead of schedule. Based on the success of the first target, in 2009, Australia set a new renewable energy target of 45000 GW h by 2020. In Sweden, annual obligation quotas up until year 2035 are already decided and implemented in Swedish law. Experience in the US as well shows that if certificates are delivered under long-term agreements, the effectiveness of an obligation can be high and compliance levels can be reached [22]. Markets where long term contracting exists – Texas, Minnesota, California, Iowa, and Wisconsin – have contributed over 84% of the 2335 MW of new renewable energy capacity added through 2003. On the other hand, in the case of UK, the absence of not only long-term targets but also a strong commitment from government has resulted in reduced certainty for the industry, and has halted investment in additional capacity [22].

Despite the importance of long-term targets, most Indian states have declared RPOs for a maximum of 3 years. Out of the 26 states that have RPO targets in place, less than 10 have specified quota obligations for more than 3 years (Table 1). The absence of long-term targets in India is unlikely to provide long-term estimates of REC demands and, hence, credible price signals to investors. Drawing from international experience, the RPO targets in India need to be set for at least 10 years, with intermediate annual targets.

3.3. Long term price-signals

The third key reason for the low performance of REC markets is the lack of enough support for providing long term price signals to investors. To be able to leverage RECs as a financial instrument and drive investment, it is necessary that capital providers recognize RECs as a viable income source. CERC has attempted to address this issue through the creation of price bands. However, as we see later in this sub-section, several caveats exist in their design. In addition, banking and secondary markets are two features that can help provide long-term certainty to investors. Unlimited banking is an essential feature and has been observed in REC markets as well as other trading markets. Depending on market expectations and price bounds, secondary markets can be very valuable to drive investment as well. We now provide a comprehensive overview of these three features which, taken together, could play a significant role in providing long term REC stable markets.

3.3.1. The role of secondary markets in providing long-term price signals

Given that the price of RECs is determined in a market, they can pose considerable financial risk to the obligated entities as well as renewable generators. There is real concern about the bankability of renewable energy projects because of high perceived risks by financiers. These risks arise not only due to resource variability, and hence eventual production, of renewable sources but also due to uncertainty in REC markets. Secondary markets – trading agreements for RECs outside of the normal trading activities – are considered a solution for fixing this problem.

Forward contracts – contracts that guarantee a fixed price for a product at some date in the future – are commonly used in commodity markets. Forwards and futures – standardized forward contracts that are traded in an exchange – would enhance liquidity in the market and reduce risk for generators and obligated in a number of ways [19,37]. First, in case of shortage of certificates, market participants can purchase forward contracts – contracts where the seller promises to deliver a fixed number of RECs every year for a fixed price – to meet their obligations at less than penalty price. This extra demand for forward contracts helps renewable energy developers secure investment from financial institutes. Second, forward contracts can help correct the uncertainty in supply of certificates resulting from the annual variations in wind or solar energy. In this context, a recent 20-year REC forward contract between Idaho Wind Project and Seattle City Light and 3Degrees is instructive, bringing in the following comment from Morgan McGovert, CEO, Idaho Wind Project: “Commitments like those from Seattle City Light and 3Degrees enable us to improve our return on investments and build more projects.”[10]

Secondary markets for electricity have existed for a long time in many countries. Secondary markets for RECs have successfully existed in the US and Australia. In US, the Chicago Climate Futures Exchange® (CCFE) has futures contracts on RECs for the states of New Jersey, Connecticut and Massachusetts as well as for voluntary participants. Australia Securities Exchange (ASX) also issues REC futures contracts – a minimum of 1000 certificates with a contract term of 5 years. In a similar market, the European Carbon Trading Scheme, secondary markets are well established – for example, futures accounted for 85% of transaction volume in 2009 [67].

In its current form, the Indian REC market does not allow for secondary market activities, thus exposing the financiers to the

[10] See http://www.3degreesinc.com/news/tradition-brokers-20-year-rec-take-idaho-wind-project-seattle-city-light-and-3degrees. Note that forward contracts do not eliminate the REC market risks related to demand – i.e., RPO compliance – as well as supply – i.e., renewable output – risks. However, it is well known that they reduce these risks considerably.

underlying risks of the REC spot markets. Addition of this feature would be a key requirement to making RECs bankable, and rendering them a practical financial instrument. However, the policy makers need to be aware that, though secondary market instruments can offer advantages, risks also exist. One of the key risks relates to ineligible projects selling RECs in the REC market given that secondary trades are hard to verify independently. Though this issue might be of less concern in some of the developed countries it a key concern in India where the legal system is not robust and the limited experience with open markets.

3.3.2. *The role of banking in providing long-term price signals*

Banking of certificates has also been suggested as an economic solution to reduce volatility in the price of RECs [53,63]. With banking provisions, renewable generators can preserve their certificates and sell them at a later stage. Similarly, if resale were to be allowed, renewable energy buyers can buy the certificates, hold them for some time, and re-sell at a later stage. Theoretically, banking can be implemented in different ways [53]—banking for a limited time, banking for unlimited time, banking with interest rates, banking with a levy which discourages hoarding of certificates, etc.

Banking in renewable energy certificate markets is similar to storage and inventories in commodities. Markets for commodities such as wheat, sugar and coffee have some similarities to REC markets—short-term demand and supply elasticities are low but output is subject to large random shocks. Studies from commodity markets show that price volatilities – both spot and future – tend to be low when storage and speculation exist [20] and when inventories are high [47,66]. In an analysis of wheat price variations, Miao et al. [42] show that storage can explain some of the price correlations observed.

Though theory and practice suggest banking for existence of stable markets in long-term, and there can be a potential argument for the “more the better”, there are also some potential risks in allowing banking of certificates—REC holders may reduce liquidity in a market by holding up their certificates in anticipation of higher prices, and creating a shortage in the spot market. This may be a major concern in nascent markets where the policy makers may be concerned about creating liquidity in the market. This is especially the case in India where the markets have been controlled until two decades ago and hence it is essential that free market instruments are introduced gradually. Then, one major question is: what is the optimal time period should be for banking – in a new as well as a stable market? It is then appropriate to examine the performance of banking in existing REC (and similar) markets.

3.3.2.1. Banking studies in REC markets. Schaeffer et al. [53] argue that allowing banking – by extending validity of certificates to more than one year – will stimulate increased stability. They contend that short term price determination in the spot markets will follow the long term green certificate market expectations across compliance periods, and hence is based on real cost – long term marginal cost – of renewable energy production. Further, the Center for Resource Solutions [17], based on recommendations from stakeholders, argues that the highest economic value for RECs will be derived if owners have the option to hold and resell RECs anytime during a three-year period following its creation.

Most of the countries have provisions for some form of banking in their REC markets (Appendix B). Allowing for longer – in fact, indefinite – banking periods is a more common practice. In the case of UK, Poland, Denmark, and the Netherlands, certificates don’t expire – i.e., indefinite banking is allowed. On the other hand, some countries limit the length of banking – the validity of tradable RECs extends up to two years and five years in Italy and Belgium, respectively. However, it is hard to find any arguments for why banking, once allowed, needs to be limited.

There is little empirical work on the effects of banking on the functioning of REC markets. Most of the work has been experimental–either in laboratories or by using simulation techniques. Applying a rational expectations simulation model of competitive storage and speculation of green certificates, Amundsen et al. [2] compare price volatility with and without (indefinite) banking and show that introduction of banking for green certificates reduces not only prices volatility by 60% but also the average certificate prices by 60%.[11] In a related work, Ford et al. [27] simulate price dynamics and trading for wind generation and related certificates. Their results show that obligated entities would find it difficult to reach their goals without banking. Banking provides price stability against variations in wind generation; but it was observed that extensive banking forces prices to remain at the cap for a longer interval–for an additional 2 years compared to the base case.

Given limited experience with banking-related studies in REC markets, we next look at the performance of banking in a similar–emissions trading market.

3.3.2.2. Banking studies in emission trading markets. Banking has been in practice in most of the other emission trading markets. In a survey of 27 banking and related provisions in various emission trading markets around the world, Haites [36] reports an approximate 50–50% split: 12 schemes have banking with no restrictions while 11 had banking with some restriction, either with a limit on the period of banking or with discounts on the banked credits.

There have been experimental studies as to examine the effect of banking on compliance and price stability in emission trading markets. Experimental work conducted by Ishikida et al. [39] for pollution trading markets in the California region has clearly shown that price volatility can result in environmental markets with fixed, inflexible annual targets. Cason and Gangadharan [8] find that banking improves price stability – price variations without banking are 3 times the case when banking is present – of trading market

In addition to creating stable markets, banking may have some unintended consequences, however. Cason and Gangadharan [8], in an experimental study, find that banking not only improves price stability of trading market but also increases short term non-compliance. This is due to the fact that perceived benefits to underreporting emissions are greater when unused permits can be banked for future use or sale. Results from a model of banking in the Acid Rain program studied by Burtraw and Mansur [5] show that allowance trading and banking leads to early emission reductions – by as much as 20% – and later emission increases. However, in summary, literature suggests banking has been in practice in several markets and experimental studies have proved the case of banking for stable markets.

In practice, the need for banking has been observed during the trial phase of the EU-ETS (2005–2007). There was a sharp decline in allowance price towards the end as there were no provisions for banking reductions for use in the second phase (2007–2012) of the program. Consequently unrestricted banking was introduced for the next compliance period [21]. Similarly, banking provisions enabled agents to smooth their emissions stream through time and has played a key role in the success of the US Acid Rain Program [6,13].

Though an argument for the presence of banking to reduce price volatility of RECs exists, and it is hard to find a good argument for limiting the banking period in the long-term, definitive studies to understand the relation between the banking period and the effectiveness of trading mechanisms have not been encountered and, despite the movement towards allowing unlimited banking in

[11] The standard deviation is reduced from 1.57 to 0.61 and the average price is reduced from 1.23 to 0.50.

most (e.g., REC and emissions trading) markets, the question on the optimal banking period remains open to some extent.

3.3.2.3. Banking of RECs in India. During the first year of operations, the REC regulations in India specified the validity of a REC to be 365 days from the day of crediting. Thus, though banking was allowed for up to a year, banking of certificates beyond this year was not allowed. Given that the market was in a nascent stage, absence of banking may be justified on the basis of creating sufficient liquidity in the Indian market. As the REC market matures, based on the experience in other REC as well as emissions-trading markets, the banking period needs to be extended – preferably to unlimited banking – to ensure stable market prices.

3.3.3. Price bounds: Ceiling and floor prices

Due to the uncertainty that exists in the price of RECs, especially in newer markets where large price swings are possible – upper and lower price bounds are proposed to protect the consumers and renewable energy generators, respectively. Floor prices or lower bounds guarantee a minimum return to renewable energy generators and forbearance prices or upper bounds are set to prevent REC prices from going high and consequently burden consumers. Floor prices can also be useful for renewable energy developers to obtain financing as they act as a guaranteed revenue stream. Along with secondary markets and banking, price bounds can limit volatility and encourage further investment [2].

Determination of the correct minimum and maximum price, as well as a correct prediction of the supply curve, is of crucial importance if the certificate market is to provide the desired effect. A high forbearance price is desired when it acts as a penalty, so that entities are encouraged to buy certificates, and thus promote renewable technologies, rather than choose to pay penalties. On the other hand, it should be reasonably low so that the ultimate burden on the obligated entities, and thus the consumers, is not very high. While it is essential that floor price be set so as to guarantee the renewable energy generators a minimum rate of return on their investment, it should also not be very high to give generators very high profits and discourage any technological advances that may reduce cost of production.

3.3.3.1. Floor/forbearance prices in practice. While the rationale behind the need for floor and forbearance prices is clear, studies to study effect of these on actual system performance are few. Simulation experiments by Amundsen et al. [2], using a rational expectations model, show that introducing price bounds on top of banking further reduces price volatility by 1/3rd. Similarly, in climate policy context, in the absence of banking, price caps on emission prices are shown to decrease cost of abatement [28].

Some countries have implemented explicit floor and forbearance prices for RECs. Belgium has minimum and maximum prices set for RECs, which vary by technology and geographical region. Romania also has technology-agnostic floor and ceiling prices, which are revised every year. In the US, long-term price floors have been implemented in Massachusetts and New Jersey for solar RECs [4]. Several US states have put upper bounds on the burden, though it is not clear how this is enforced in practice. Most REC markets around the world (e.g., UK, Sweden, Italy, and Norway) do not have any explicitly-fixed floor and ceiling prices—these markets do set penalty prices in case of non-compliance, which act as (a proxy for) the ceiling prices as obligated entities would prefer paying penalties for meeting RPOs instead of buying RECs in the market.

These penalty prices and/or the forbearance prices can be derived from cost caps on Renewable Portfolio Standard (RPS) compliance [51,64]. The cost cap is further derived from the maximum allowed rate-increase and the size of the electricity market – as the product of the two; and the penalty price is derived from the cost cap and the size of the REC market – by dividing the former by the latter. On the other hand, the method behind choosing the level of floor prices is not clear, and we were unable to find any supporting evidence in literature.

Table 5
Floor and forbearance prices for 2012–2015.

	Non solar REC ($/MW h)	Solar REC ($/MW h)
Forbearance price	66	268
Floor price	30	186

3.3.3.2. Floor/forbearance prices in India. In India, the CERC revised the forbearance and floor price for solar and non-solar RECs for the period 2012–2015 (Table 5). To do so it looked at the following parameters across the states: (a) the feed-in tariffs (or preferential tariffs); (b) the APPC; and (c) the basic minimum requirements for ensuring the viability, including expenses to cover loan repayment and interest charges, operations and maintenance (O&M) expenses and fuel expenses.

The CERC has set the forbearance price at the maximum difference between feed-in-tariff and APPC across the states.[12] The floor price has been determined keeping in view the basic minimum requirements of renewable energy projects set up to meet the renewable targets [9]. For the non-solar RECs, the floor price has been taken as the price difference between the minimum required for viability and APPC at which the target renewable energy generation of 70,000 million units – the average of renewable energy target as per NAPCC [45] and MNRE [43] – will be realized. For solar, the highest difference between the minimum requirement for project viability of Solar PV/Thermal and respective state APPC of previous year (2011–12) has been considered as floor price. The basic idea behind using these parameters seems to be straightforward: these parameters represent the variation on tariffs and costs across the REC market and their range, as used by CERC to determine the price bands, seems to be a reasonable choice.

However, the parameters as well as the method used in CERC's calculation of the price band are questionable on many accounts, as follows:

- First, though the calculations seem to assume that these parameters are exogenous to the system, and reflect the heterogeneity of project economics across states, there is an issue with endogeneity. The state-level preferential (or feed-in) tariffs have been determined by the SERCs based on guidelines from the CERC. These tariffs are, in turn, used by the CERC to determine the floor and forbearance prices. Further, it is not clear what causes the variation in preferential tariffs, and whether that variation is exogenous to the system.[13]
- Second, for the forbearance price, it is hard to see the rationale for moving away from a cost-cap based methodology [59], which limits the total cost of the RECs and their eventual impact on ratepayers, and seems to be the dominant rationale for setting ceiling prices [64].
- Third, the use of the minimum requirement for project viability for the determination of the floor price raises the question of not only what needs to be included in the calculations (i.e., should CAPEX be included?) but also how different this

[12] Though there is considerable variation in the non-solar feed-in tariffs across the states, the solar feed-in tariffs are essentially the same. Thus, the variation in non-solar forbearance prices comes from both feed-in tariffs and APPC, and the variation in solar forbearance prices comes only from APPC.

[13] Details on determination of floor price and forbearance prices are provided in [9].

exercise is from determining a feed-in tariff in the first place, which is something the REC markets should try to avoid, given the focus on a market based mechanism.

- Finally, the choice of the floor price promotes inefficiency in choice of resource and technology and also provides potential windfall gain to technologies which have significant cost advantage [35]. Singh [59] provides a comparison of feed in tariff rates and proposed band prices across states and technologies and shows that some generators can make profits as high as 1.24 cents/kW h even if the certificates are sold at floor prices.

Further, it is not clear as to how long these (in particular, floor) prices have to be set in terms of providing long-term investor guidance—since setting long-term floor prices essentially amount to setting long-term feed-in tariffs, a very-hard if not impossible exercise for policy makers to perform, given lack of long-term credible information on the cost of technologies. It also raises the issue of over-constraining the market. Furthermore, it can be argued that the presence of a liquid REC market, along with the presence of forward contracts with (or without) banking can mitigate the major issue of bankability that the floor price is attempting to address and, under appropriate market conditions, the floor price would automatically emerge from the system. This suggests that CERC should focus on using market-suitable interventions such as secondary markets and/or banking instead of attempting a very hard task of setting long-term floor prices.

From our review, it appears that a clear methodology for setting floor and forbearance prices (in particular, for floor price) is yet to emerge. Further, floor and ceiling prices have to be set consistent with other design features (e.g., banking) of the market and taking the trade-off mentioned above into consideration. This is certainly an area open for future research.

4. REC markets design: Additional features for a well-functioning market

Having examined the features of REC markets directly relevant to the seemingly poor performance of the REC markets, we now examine some other relevant features of the REC markets that are important for well-functioning REC markets—(a) set asides and multipliers, (b) vintage multipliers, and (c) voluntary markets.

4.1. Set asides and credit-multipliers

Renewable energy generation includes several sources—wind, solar, biomass, wave, tidal, geothermal etc. While the markets for some of these technologies (e.g., wind) are fairly developed, some are still in nascent stages (e.g., solar). That is, the capital and operating costs are different across these technologies. This is especially the case with solar technologies where high upfront costs are involved. If all sources are treated alike, in REC markets, the lowest cost technology would be developed first. Tiers and multiplier based mechanisms are often used to ensure that an RPO supports certain “preferred” resources, not just the least-cost renewable energy options. This section provides details on these two types of market-segmentation mechanisms.

4.1.1. Tiers and credit-multipliers

Tiers or set-asides consist of different targets for different renewable technologies, often with varying penalty levels to further encourage compliance. This creates separate markets for each technology. On the other hand, credit multipliers give additional credit for preferred technologies, by crediting more than one certificate for each MW h generated.

While set asides guarantee creation of energy from a preferred technology, multipliers may be useful to instill liquidity in the market. Since they can dilute the liquidity in the market and influence the ability of the market to determine efficient prices for the RECs, the multiplier number and the set-aside quota target should be chosen carefully. The advantages and disadvantages of both these systems, specifically to solar energy have been discussed in greater detail by Wiser et al. [65].

The most important advantage of set-asides is that they provide a degree of certainty that the RPO will result in the development of a specific amount of a particular technology, such as solar—this may be an important element to obtain financing for large-scale solar projects. A prime disadvantage of set-asides, on the other hand, is the risk that they will put upward pressure on RPS compliance costs for e.g., if solar is more expensive than other sources of renewable generation [38]. However, this risk can be controlled through the use of forbearance prices.

Credit multipliers have the advantage of providing a means by which states can directly indicate the degree to which they value particular types of renewable resources over others [65]. To allow technology differentiation in an economically efficient way through the multiplier co-efficient requires the public authority to know the supply curves of each renewable energy sources with certainty, which is a tough task however. Further, given that credit multipliers attempt to match a dynamic cost relationship between technologies using a static number, they have the potential to be prone to bang-bang outcomes where only one or the other technology is eventually supported. For example, assume that the credit multiplier is set to reflect the relative costs of solar vs. wind. If the realized cost-ratio turns out to be lower (higher) than the multiplier, the market would result in deployment of only wind (solar). This is what we actually observe in actual implementation. Thus, since they don't guarantee the desired development outcome of balancing the deployment of various technologies, the effectiveness of credit multipliers can be questioned.

4.1.2. International experience with Tiers and multipliers

In the US, set asides has been more popular than credit multipliers for solar support [65]. 16 states in the US, including New Jersey, New York, and Washington DC have solar specific RPO targets. To support solar electricity, some states have issued separate RECs, while some states have specified credit multipliers. Many projects have been developed in states with set-asides, whereas solar credit multipliers have yet to demonstrate any comparable success. The experience in other international markets is similar, as discussed below.

A multiplier based mechanism to combine RECs for different energy sources under a single certificate scheme has been adopted in UK, Belgium and Italy. UK provides additional certificates to emerging technologies (e.g., wave, tidal, geothermal, etc.). In addition, generators in Northern Ireland are entitled to additional certificates in 2010 and 2011 [49]. In Belgium, Wallonia and Brussels issue 7 green certificates for 1 MW h of solar electricity, but the underlying rationale is not known. Sweden doesn't distinguish between the source of renewable energy and all sources get 1 REC for 1 MW h. However, in Sweden, most of the addition in renewable generation has been from wind power – the most viable source – and resource diversity has been low.

Australia has two separate markets for trading RECs – small scale technologies (e.g., solar) and large scale technologies (e.g., wind). The Australian government launched the “Solar Credits Scheme” for grid connect and off grid solar power systems. This scheme offered up to 5 times the usual number of RECs issued for solar power systems. This created a huge influx of RECs in the market in 2011, resulting in steep decline of REC prices by almost half and forced the Australian government to create two separate markets. Under the new scheme, small-scale SRECs can be sold at a fixed price of AUD40 per certificate in a clearinghouse set up by the government.

4.1.3. The Indian context

Currently, CERC has decided to go with set-asides and has specified two categories of RECs – solar and non-solar markets. The rationale provided by CERC is obvious – in particular, in light of the JNNSM, which has set a target of 20 GW by 2022 [43]. Given the huge solar potential, ambitious targets, higher up-front costs, the less mature state of technologies in the Indian market, separate treatment for solar power is essential to encourage these projects. Treating them alike with other mature technologies (like wind) will not spur any development in the solar sector and; given that credit-multipliers have not worked in practice, as evidenced by the earlier examples in the US, Sweden, and Australia; use of set-asides seems appropriate in the Indian context.

4.2. Vintage multipliers

One of the objectives of REC market design is to drive investment into renewable energy production and to increase installed renewable energy capacity. Existing installations that are already depreciated can obtain windfall profits by selling into the REC markets. In such situations, the reward for entrepreneurs developing relatively immature technologies is low. In an analysis of Swedish markets between 2003 and 2008, Bergek and Jacobsson [3] show that substantial rents were reaped investors in relatively mature technologies and most of the increase in capacity has occurred in existing plants. Thus, there is a need to block REC sales from existing, already depreciated, plants.

In contrast, as new technologies mature, their costs reduce over time, and newer deployments may be cheaper than older installations, driving the price of RECs below what is economically appropriate for the older plants. Market segmentation in terms of older versus newer deployment using vintage multipliers – so that RECs from older plants can be priced at multiples of RECs from newer plants – can be used to avoid such outcomes. There are, however, trade-offs involved in selecting the right mix of market segmentation due to changing vintage multiplier settings over the years because higher market segmentation results in higher transactions costs and lower efficiency. Further, setting the vintage multipliers also brings up the same issues as setting the credit-multipliers: it is very hard to mimic a dynamic relationship using a static number!

In our research, two questions remain partially unanswered: first, what is the need for vintage multipliers; and second, what should be their eventual design. Further, the Indian REC market designers are silent on vintage multipliers. However, the question of vintage multipliers may become moot if forward contracts are allowed, given that they absorb the vintage issue in the forward contracts.

4.3. Voluntary markets

In India, currently only obligated entities are allowed to buy RECs from the market. Public Enterprises have recently been allowed to purchase RECs to offset their carbon footprint[14]. However several energy conscious consumers, especially corporate houses may be willing to purchase RECs as part of their social responsibility commitments. This would provide additional support for development of renewable energy in the country. Voluntary demand can be treated as part of the obligation or treated as amount on top of the obligation; however no studies that estimate the size of voluntary markets exist.

In United States, in addition to the REC market created for compliance to RPOs, a voluntary REC market, driven by energy conscious consumers who are interested in supporting renewable energy for reducing their environmental footprint, also exists. Nearly 25% of U.S. utilities offer a green power program and offer consumers the option to purchase green power. These green power markets provide support for nearly 30% of new renewable energy capacity additions since 1997 [48]. Thus, there is a case for allowing voluntary markets for RECs in India.

[14] See https://www.recregistryindia.in/pdf/SD_Guidelines.pdf

5. Summary and conclusions

RECs are expected to encourage efficient investment and operation of renewable projects in India. At the outset it is expected that the design of the system should be based on sound economic principles. A look into the actual performance of REC market trading in the first year shows that though volume of trading increased in the last few trading sessions, and prices of RECs rose, less than 2.5% of the estimated REC demand could be met through the market.

While no "best practices" were discovered in many cases, we have identified that several trade-offs exist in choosing the elements of an effective REC design. While banking and price bounds are recommended for stable markets, best-of-class methods for determining the optimal length of banking, the level of floor and forbearance prices, and the values of credit/vintage multipliers are not resolved completely. In particular, empirical studies relating REC market design elements to the actual effectiveness of REC markets are scarce.

Despite the limitations in best practices/theory, our review critically examines the design and implementation of the REC markets in India. Three key issues in design raising doubts about India meeting its RPO targets via the REC market mechanism have been identified:

- The biggest issue is demand uncertainty in the absence of clarity on compliance on RPO. In absence of demand certainty, long-term stable markets are unlikely to develop. This can happen only if the states, in addition to passing regulations, ensure compliance through strict enforcement. In this context, a starting point may be establishment of realistic RPO targets that take into account resource diversity as well as the economic status of participants [50].
- The absence of long term targets raises questions about how long RECs will be available. Once it is established that REC markets are here to stay—RECs would be valued as a financial instrument and will drive investment into renewable generation.
- Investors still do not recognize RECs to be bankable and lack confidence in RECs as a viable income source. CERC has attempted address this issue by using price bands to provide some certainty on the returns to the market participants—however, this approach has issues ranging from the determination of these price bounds to the fact that the current levels of floor and forbearance price provide high profits to projects in some states. Provisions for banking and creation of secondary markets are identified as measures that are can create stable markets.

As far as other design features are concerned, given that set-asides have been more successful than credit-multiplier in promoting resource diversity, the choice of set-asides appears to be the right option to promote solar energy; though many gaps still remain. The opening of REC markets to public enterprises is a welcome step in encouraging voluntary markets, allowing other corporate and interested parties to participate would further boost the demand for RECs.

We hope that the policymakers in India will benefit from our analysis, and modify the current design of the REC markets so as to not only create a vibrant REC market but also ensure that the RECs become a viable financial instrument, leading to the eventual fulfillment of the RPO targets.

Appendix A. Source specific RPOs.

	Tiers by source	
Bihar	Solar	2010–11—0.25% 2011–12—0.5% 2012–13—0.75% 2013–14—1.00% 2014–15—1.25%
Chhattisgarh	Biomass Solar	3.75%, 2010–11—0.25% 2011–12—0.25% 2012–13—0.5%
Delhi	Solar	2011–12—0.10% 2012–13—0.15% 2013–14—0.20% 2014–15—0.25% 2015–16—0.30% 2016–17—0.35%
Gujarat	Solar	2010–11—0.25% 2011–12—0.5% 2012–13—1.00%
Jammu and Kashmir	Solar	0.02%, 0.5%,
Karnataka	Solar	0.25%
Kerala	Solar	0.25%
Maharashtra	Solar	2010–13—0.25% 2013–16—0.5%
Uttar Pradesh	Solar	2010–11—0.25% 2011–12—0.5% 2012–13—1.00%

Appendix B. Design features of REC markets in select countries.

	India	UK	USA	Belgium	Australia	Sweden	Romania
Targets	20% by 2020	15% by 2020, sunset		Wallonia : 3% 2003—increase of 1 % a year till 2012 Brussels: 2.5 % in 2006, 2007 and 2008 increase of 0.25 % after 2008 Flanders: 3.75% in 2007 4.90% in 2008 5.25% in 2009 6% in 2010	45000 GW h by 2020	49% from renewables in final energy consumption by 2020	
Market	frag-menta-tion	Solar obligation targets set separately in few states	Solar PV, wave tidal, geothermal —2 RCs per 1 MW h, wind, hydro, standard gasification get 1 RC per 1 MW h, sewage, co-firing of biomass 0.5 RC, landfill gas 0.25	Compliance market and voluntary market. Some states have separate trading for Solar RECs.	In Flanders 1 GC is issued for 1 MW h for all sources. In Wallonia and Brussels 7 GCs for 1 MW h of solar electricity, other sources get 1 GC for 1 MW h.	Separate markets for small scale and large scale production, Solar RECs can be sold in a separate clearing house	Not technology specific—1 MW h of electricity from any source gets 1 credit

Approximate price	2900 in Dec 2011, min and max prices exist for solar and non solar RECs		On August 31, 2010, for instance, all bids for solar RECs for New Jersey, Pennsylvania, Maryland, Delaware, and Ohio were at least $300/MW h, while other, non-solar bids and offers ranged from $.05 to $35.00	Min and max prices exist for GCs depending on the region and vary by energy source	19	Market is fully deregulated	Min price 24 €/certificate, max price is 42 €/certificate
Other incentives/ policies	Feed in tariffs exist		Federal tax credits for based on kW h produced for generation costs or capital costs	Biofuels—reduced excise duties, investment in renewables are subsidized -up to 40%, additional 20% for solar investments		Upton 70% investment subsidy on Solar PVs was given.	
Banking	Not allowed. Certificates valid for a period of 1 year from the data of issue.	Yes (1 year)	Provisions vary across states. In Texas banking allowed for 2 years	Not allowed	Yes (No limit on duration)	Yes (No limit on duration)	
Penalty		€30 per MW h in 2002, tied to retail index, €37.19 in 2009-10 funds collected given back to liable entities	ACPs vary across states. e.g., Maine (USA) $ 57.12 (2008) Massachusetts (USA) $ 58.58 (2008)	Wallonia and Brussels—100 €, Flanders—125 € for each missing green certificate	AUD 40/MW h		63 €/certificate in the period 2005–2007 and 84 €/certificate starting with 1st January 2008.

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