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India's solar mission: A review

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ABSTRACT

The Jawaharlal Nehru National Solar Mission (JNNSM) is one of India's key policy and scientific experiments. The programme is audacious in its goal, deterministic in its approach, disjointed in its design, and challenged in its governance. Yet it holds the promise of transforming the lives of millions of Indians. This paper provides an analysis of the JNNSM in the Indian institutional context—in particular, in the context of the power sector reforms. It highlights the barriers to development and diffusion that have been dismantled though the use of appropriate policy tools, and those that still remain. It identifies the policy implementation challenges likely to be encountered in the case of grid-connected, roof-top, and off-grid applications as well as in the areas of research, development and technology transfer. Finally, it discusses a series of high-level approaches based on global best practices to address these remaining challenges.

Contents

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1. Introduction

1.1. Background

As India and other emerging economies develop, their per capita consumption and carbon emissions are expected to increase dramatically. This has raised serious concerns about their effects on global warming. Even during the global downturn in 2008–2009, the Indian economy registered a GDP growth of 6.5%. Its greenhouse gas emissions have risen correspondingly. At present India is the third largest GHG emitting country; however, in per capita terms the contribution (1.8 t) is much below the global average of 4.2 [51].

India needs a sustained growth rate of 8–9% over the next 20 years to meet its growth objectives [1]. This implies that it will need to increase its primary energy supply by a factor of three to four and to increase electricity generation by a factor of five to six. However, in 2009, approximately 400 million Indians still have no access to electricity and severely limited access to any form of renewable energy [38]. Further, given its low reserves of conventional fuels, such as oil and coal, India is increasingly reliant on imports, which raises questions about energy security. Thus, the challenge is to ensure continued sustained economic growth while treating the environment responsibly. Low carbon technologies and related policies are likely to play a key role.

The Jawaharlal Nehru National Solar Mission (JNNSM) is one of the eight missions of India's National Action Plan on Climate Change (NAPCC)[2] that elucidates the nation's vision for solar technology: installation of 22 GW of solar capacity by 2022—this, by no means is a small task, given that India had a mere 10.28 MW of installed solar capacity in 2010. The objectives and goals of JNNSM are as follows: increase supply of grid-connected solar power to 1 GW by 2013, 10 GW by 2017, and to 20 GW by 2022; promote off-grid applications equivalent to 2 GW; distribute 20 million solar home lighting systems in rural areas; expand the area occupied by solar thermal collectors to 20 million square meters by 2022; and create favorable conditions for solar manufacturing capability.

The Mission will adopt a 3-phase approach [55], spanning the remaining period of the 11th Plan (until 2012) and first year of the 12th Plan (up to 2012–2013) as Phase 1, the remaining 4 years of the 12th Plan (2013–2017) as Phase 2, and the 13th Plan (2017–2022) as Phase 3 (see Table 1).[3] At the end of each plan, and mid-term during the 12th and 13th Plans, progress of each phase will be evaluated and capacity and targets of subsequent phase reviewed so that the government can regularly adjust its subsidy burden in case expected cost reduction does not take place as the technology evolves. Ambiguity over financing this decade long programme, with an approximate cost of US $20 billion [55], has not deterred India's ambition to emerge as a global leader in solar technologies.

The JNNSM is supplemented with a series of guidelines that outline the implementation roadmap and the regulatory architecture for each technology and application type, such as solar photovoltaic (PV) and solar thermal; and grid-connected power plants, off-grid and decentralised applications, and roof-top installations.[4] An overarching policy and regulatory framework, the JNNSM touches upon the required industrial policy; highlights the need to build research and development capabilities, with emphasis on demonstration; recognises the need to build a skilled talent pool; outlines a governance structure; and identifies sources of finance.

1.2. Our work

It is clear that JNNSM cannot be viewed separately from the power sector reforms in India. The central government introduced Electricity Act (2003) [94], replacing the legal framework introduced 55 years earlier, where the government was responsible for all aspects of the electricity sector—namely generation, distribution, and transmission. The thrust of the Electricity Act was to usher the sector toward creation of markets for electricity, dominated by private players.

Reformers hoped that introducing private actors and the profit motive would unwind the system of perverse incentives in the sector. Various states, with the support of the World Bank and to a smaller extent the Asian Development Bank, have introduced initiatives aimed at unbundling components of the electricity sector, privatization, and introduction of independent regulation.

However, despite privatizing the generation and transmission sectors to a large extent, a crucial component – the distribution sector – remains under (state) government control, and the political economy that led to past subsidies, problematic infrastructure, and lack of transparency has remained in place [95]. Without addressing the need for political reform, privatization and market creation, by itself, has been insufficient to the task.

The evolution of the JNNSM is premised on the interactive model of policy [32][5] In this case, pressures to reform policy come from many sources and groups that have emerged—the solar versus the anti-solar cohort; the concentrated solar power (CSP) vis-a-vis the PV lobby; and indigenous against international cell and module manufacturers. Manifold institutional agents have designed action plans to accelerate the take-off of solar technologies. These include: Ministry of New and Renewable Energy (MNRE); the central regulator responsible for policy design – the Central Electricity Regulatory Commission (CERC); the state regulators responsible for policy implementation – the State Electricity Regulatory

[2] National Solar Mission, is the first of the 8 missions in the National Action Plan on Climate Change released by the Prime Minister and can be found at: 〈http://pmindia.nic.in/climate_change.htm〉.

[3] The economy of India is based in part on planning through its five-year plans. The 11th plan is during 2007–2012, the 12th during 2012–2017, and the 13th during 2017–2022.

[4] JNNSM and all the guidelines, such as for grid-connected, off-grid, and roof-top projects, are referred to as JNNSM hereafter in the paper.

[5] The interactive model of policy views reform as a process in which interested parties can exert pressure for change, with varying effectiveness, at various levels within the government and bureaucracy.

Table 1
Phase-wise (and total) target of JNNSM.

	Till 2009	Phase 1	Phase 2	Phase 3	Total
Grid-connected (MW)	6	1100	3000	16,000	20,000
Off-grid (MW)	2.4	200	800	1,000	2,000
Thermal collectors (million m^2)	3.1	7	8	5	20
Solar lighting systems (million)	1.3				20

Commission (SERC); the body where the CERC influences the SERCs, given India's federal structure – the Forum of Regulators (FOR); NTPC[6] Vidyut Vyapar Nigam Ltd (NVVN); and the Ministry of Communications and Information Technology.

Against this context, this paper has a two-pronged focus. First, it evaluates the efforts of the JNNSM in dismantling the institutional barriers to development and diffusion of solar technologies and applications [79]. Second, it analyses various features of the policy from the aspect of the feasibility of implementation,[7] given its dependence on the struggling power sector and the interactive policy making process described earlier. In particular, the paper focuses on the gaps in design and implementation-gaps that would make the JNNSM less effective than expected, and what approaches could the policymakers follow to make the JNNSM more effective.

Our approach is primarily based on analysis backed by secondary-research as well as interviews conducted with various stakeholders. Thus, our work may be considered closer to policy research performed in the social science domain, and we are aware of the "subjective" bias introduced due to the use of primary-research; however, we have not only minimized it but also used it mainly to corroborate evidence gathered via objective analysis.

Our analysis concludes that significant attempts to address barriers have been made. These include the introduction of measures, such as the Renewable Energy Certificates (RECs), the promise of easier access to capital, and measures to bolster basic R&D. The analysis also highlights issues encountered in policy practice, where the design and implementation of a policy may be different due to the lack of attention given to implementation in the design phase [15,32]; and demonstrates that, though the relevance of these policy measures is sound, their effectiveness and efficiency is sometimes questionable because of the gaps in implementation [43,34].[8]

Given the broad scope of this work, our attempt has been on analyzing as many key issues as possible. While we suggest high level approaches for addressing gaps in design as well as implementation, we do not attempt to provide detailed policy prescriptions. Thus, this work should be considered primarily as a high-level review of JNNSM. We expect that a lot of detailed work focused on detailed policy design will follow based on issues and gaps identified in this work.

1.3. Literature survey

Though there has not been a lot of literature on analyzing the JNNSM, three papers are worth mentioning: Harriss-White et al. [34]; Deshmukh et al. [22]; Harish and Raghavan [35]. However, none of these are as comprehensive an analysis of the JNNSM as our work.

Harriss-White et al. [34] is perhaps closest to our approach. It analyzes India's solar policy from an institutional perspective; develops a framework to explain the retarded development of solar technology in India prior to 2008-2009; and outlines the implications for policy. Is asserts that though technology is available, it is obstructed by the structure of energy subsidies, the risk aversion of banks, and the coordination failures of the system of market- and state-institutions. It further asserts that, as a result, the government is hampered from acting in long-term public interest, and policy reform may require institutional destruction as well as creation, adaptation and persistence. This work differs from our work in two different ways: first, it is focused on solar policy prior to JNNSM; and second, it is focused on finding gaps as opposed to proposing solutions as well.

Deshmukh at al. [22] focuses on the JNNSM, and examines not only the subsidy burden but also the appropriate focus of the policy. It argues that, given the subsidy burden, JNNSM is not aligned with India's development needs. It further argues that the subsidy, instead of being inefficiently focused on utility scale solar, should target the off-grid market by focusing on solar home solutions and solar lanterns. Finally, Harish and Raghavan [35] focuses on the JNNSM, and examines the institutional structure and subsidy design related to the off-grid solutions. It recognizes that, given their small system sizes, off-grid solutions do not have the scale advantage of larger systems, and suffer from higher per unit costs. This, in turn, results in allocated subsidy not being enough to cause large-scale diffusion. It finally asserts that if the dissemination of these technologies is to be inclusive and sustainable, multiple institutional models should be recognized, such as central charging stations with a local NGO absorbing the financing risks. Both of these differ from our work in two different ways: first, they are not as comprehensive in terms of covering various issues related to the JNNSM; and second, by being narrower they focus on some policy prescriptions that we stay away from.

1.4. Paper organization

The rest of this paper examines each cornerstone of the programme to examine its role in dismantling existing barriers and the feasibility of implementation. It is organised in the following sections: the Grid-connected solar policy section examines the policies for grid-connected solar power; the Off-grid solar policy section analyzes the off-grid solar policy; the Support for innovation section looks at the policy efforts in the innovation area, including research and development and related institutional arrangements; and the Conclusions section concludes.

2. Grid-connected solar policy

The section is divided into two parts. The first aspect focuses on the salient features of the policy for grid-connected plants [57,58]. They include solar renewable purchase obligation (RPO), RECs and

[6] NTPC stands for National Thermal Power Corporation, the largest state-owned energy service provider, NVVN is a wholly owned subsidiary responsible for the trading of power.

[7] India's focus on alternative energy sources began after the oil embargo in 1970s yet the country had a mere 9.13 MW of grid connected installed solar capacity at the end of 2009.

[8] Effectiveness relates to the observable outcomes to the stated objectives; efficiency compares the outcomes based on resources utilised; and relevance refers to the relationship between the objectives and the problem to be resolved.

their ability to facilitate compliance of the RPO;[9] Feed-in tariffs (FIT), and their implications along with project selection; financing solar projects including the evacuation and distribution arrangements; and project commissioning and execution. The second aspect focuses on the roof-top policy and outlines some of the key challenges presented by the current draft guidelines, i.e., the policy design pertinent to the evacuation and distribution arrangements, lack of emphasis on establishing grid standards, and the absence of mechanisms to create market infrastructure for retailing of solar applications.

2.1. Utility scale solar plants

2.1.1. RPO and REC

The NAPCC, introduced in June 2008, asserted that renewable energy should account for 5% of a state's energy mix in FY 2009–2010, and should increase by 1%-on-year for the next 10 years—a requirement known as the RPO, where the obligated entities are public and private distribution companies (discoms), captive power producers, and open access consumers [94]. A recent amendment in the tariff policy has put a solar specific requirement: the solar power purchase obligation for states may start with 0.25% in Phase I (by 2013) and go up to 3% by 2022.[10] However, as of 31st July 2009, renewable energy accounted for only 3.5% of India's generated capacity, much below the target, with solar energy contributing a minuscule amount [11].

In order to make the RPO effective and in turn develop the market for renewable energy, solar power in particular, the CERC introduced RECs, market-tradable commodities generated with renewable energy, used effectively in many jurisdictions around the world, e.g., the US [81].[11] This allows the states to meet their RPOs either through internal generation (for which they may pay a FIT) or through purchase of RECs. The theory is that a market based mechanism, such as RECs, will allow the states to meet their RPO obligation in the most cost-effective way.

2.1.1.1. Issues with the RPO. However, the biggest issue with meeting the NAPCC goals is that, the RPO is not legally enforceable at the federal level given that electricity is a concurrent subject in the Indian constitution. Though the FOR has approved a draft RPO regulation for the SERCs, it is unclear if the SERCs will enforce respective RPOs, given that public discoms, which own 95% of the distribution network [41], are state-owned as well. This is made harder by the fact that the cost of solar power is much higher than conventional power.[12] State fiscal deficit has been increasing over time, estimated at 3.2% of GDP for 2009–2010 from 1.5% in 2007–2008 [76], and this would increase the reluctance of state-owned discoms to purchase expensive solar power. One way for the central government to push the RPO is to incentivise state governments to meet their RPOs.

2.1.1.2. The renewable energy legislation. In this context, India needs Renewable Energy Laws that are: binding on all states with specific targets and timelines, supported by the necessary enabling policies and resources, and implemented by skilled administrators. For example, renewable energy legislation is in place in more than half of the 50 American states, and the recent Waxman–Markey climate change bill even contained a national RPO of 20% by 2020 [84].

Given India's federal structure, it may be hard to pass a renewable energy legislation at the center, and one solution would be through financial incentives. In this context, the 13th Finance Commission[13] recently introduced a conditional incentive of US $1 billion payable to states based on their ability to get additional grid-connected capacity of renewable energy on line.[14] This conditional grant, if effectively administered, could yield over 3 GW of renewable energy [27]. Though a progressive initiative, much of its success will depend on effective implementation and administration, and much can be learned from the somewhat ineffective implementation of similar programs, such as the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) and the Accelerated Power Development Reforms Program (APDRP).

JNNURM's aim was to fast track planned development of identified cities, with focus on efficiency in urban infrastructure [62]. However, most of the reforms are yet to be implemented and consequently many projects are incomplete (Planning Commission, 2012) [46,103].[15] Similarly, APDRP's aim was to look at the distribution sector in the holistic manner and improve the performance using Information Technology [44]. Yet it failed to deliver on all fronts [45]. In both cases, the main problem was due to implementation issues resulting from the lack of technical expertise and capacity at all levels. In this context, creating a group of skilled renewable energy experts in government, and collaborating with academic and independent research organizations to craft effective RE implementation strategies would be crucial for success.

2.1.1.3. REC pricing. Finally, even though RECs will be traded in a market, to ensure that the RECs prices do not have uncontrolled swings [47], appropriate control of REC prices is critical such that they remain within a band defined by floor and forbearance prices [29]. If supply is too plentiful, REC prices may go too low, meaning that investors may not be able to recoup their investments. The floor price, which guarantees a minimum return on investment, should be attractive enough to draw investors into the market, especially given the higher risks due to dealing with the uncertainty in the REC market [81,8].[16] On the other hand, if supply is too little, REC prices may swing very high. Given that the REC prices will ultimately be reflected in the delivered price to electricity consumers, the regulator needs to ensure that organisations purchasing RECs are protected from unreasonably high electricity prices that may result due to volatility in spot market prices.[17] The ceiling (or forbearance) price, which restricts the REC prices to a maximum, is necessary for the stability of the market.

The interactive nature of policy making is evident in the policy-making process so far: CERC has already taken the first step in this direction and determined the solar floor and forbearance prices as US $0.24/kW h and US $0.32/kW h, respectively [12]. However, this

[9] These are instruments used worldwide to promote the diffusion of renewable energies. RPO and REC are described in the RPO and REC section. RPO is provisioned as per Section 61 (h) and Section 86 (I) (e) of the Electricity Act (2003) [94]. FIT are subsidies guaranteed to power producers over a certain period of time. These are discussed in detail in the FITs section.

[10] See 〈http://www.domain-b.com/economy/Govt_Policies/20110106_power_tariff_policy.html〉.

[11] CERC has introduced two categories of saleable credit certificates—solar certificates for generation of electricity based on solar and non-solar ones for generation of electricity based on other renewable energy sources.

[12] See http://www.bloomberg.com/news/2011-05-16/solar-may-equal-cost-of-producing-coal-power-by-2017-in-india-kpmg-says.html: cost of solar is at least twice of the cost of delivery to customers

[13] The Finance Commission of India, established under *Article 280* of the Indian Constitution, was formed to define the financial relations between the centre and the state.

[14] A cap of US $0.25 million per MW for general category states and a cap of US $0.3 million per MW for special category states, to account for factors related to access and consequent cost disability.

[15] See article in Business Standard dated April 5, 2010, http://www.business-standard.com/india/news/sunil-jain-urban-disaster/390761.

[16] In the RPO market, an investor faces additional "market" risk beyond the regular "investment" risk faced under the pure FIT mechanism.

[17] The volatility in spot market prices may occur due to short-term mismatches between demand and supply, especially given that demand for RECs is artificially fixed.

methodology is primarily based on the cost-spread revealed through consultation with the industry, and may suffer from agency problems since these prices are based on information provided by potential developers – recipients of the subsidy – who may inflate costs in order to improve their returns. Thus, this remains an area where future work is required to determine effective floor and ceiling prices.

2.1.2. FITs

Given that they provide a certain revenue stream to power produces [8], FITs are considered the most effective policy measure to encourage the diffusion of renewable technologies, and have been adopted in 63 jurisdictions worldwide [16]. However, setting the right FIT over time is not an easy task, and faces the same issues that are faced in setting REC floor/forbearance prices [16].

The debate on FITs in India has been intense. Between 2008 and 2010 several policies were developed with the intent of price discovery. In the beginning of JNNSM, FITs were to be revised annually. This meant that developers needed to receive approvals, and secure financial closure within 12 months. But the institutional measures to address these issues in order to complete project development, commissioning and execution within 12 months did not inspire enough confidence in the developer community.[18] After an intense consultative process, the CERC succeeded in extending the tariff applicable for FY 2010–2011 to FY 2011–12, and fixed US $0.36/kW h and US $0.31/kW h as the biennial FITs for solar photovoltaic and solar thermal, respectively [13].

However, this process has several potential issues. First, while the extension of tariffs from annual to biennial periods supports diffusion through increased stability for investors, this may result in disproportionate rents to the developers as the prices of solar technologies slide faster than expected. For example, the installed cost of solar fell to $3.50 per watt in 2009 and was expected to touch $2.50 in 2010.[19] Given that the burden of these rents is eventually borne by the rate (or tax) payers, FITs have come under increasing fire in many countries, including Spain, Germany, and Italy; requiring frequent changes to FITs (see Fig. 1) in keeping with declining costs of technology, and increased uncertainty for investors.[20] Second, given that these FIT prices were primarily driven by industry-consultation, this process suffers from the same agency problem faced in the determination of REC floor and forbearance prices. Third, this assumes that reduction in costs is exogenous to the jurisdiction, and does not account for the endogeneity in cost reduction due to local learning and scale effects stemming from increased deployment driven by the FIT itself [86]. In what follows, we discuss some potential ways of dealing with the issues of FIT tariff determination and project selection.

2.1.2.1. Tariff determination. The method for determining FITs through (primarily) industry consultation needs to be as objective and accurate as possible. Appreciating the multi-source, multi-stakeholder tariff calculation methodology used by the German Federal Environmental Ministry (BMU) [48] could help India avoid the pitfalls associated with its current approach, especially as related to avoiding the agency problem discussed earlier.

In the three-pronged approach, BMU commissions studies that are conducted by various independent research institutes. In addition, wide-ranging surveys are conducted across the producer

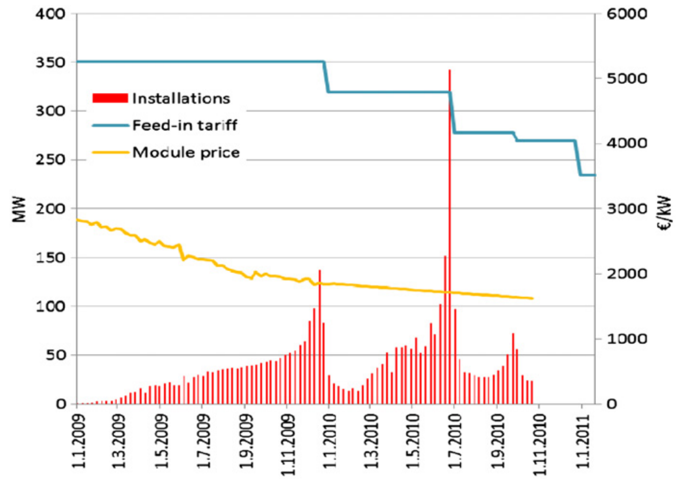

Fig. 1. The German FIT (and rapidly declining module prices).

community. Finally, the results are cross checked with published cost data and empirical values from project partners of the ministries. This approach ensures that not only all stakeholders are taken into account but also that the final tariffs are determined as objectively as possible. Taking cue from this approach, the CERC and MNRE must commission independent research to determine project economics, and conduct an independent review of investments costs, operations and maintenance costs, grid-related and administrative costs and account for endogenous factors in a clear and transparent manner.

Further, collaboration with international organizations and European countries (e.g., Germany) that have successfully implemented such policies could prove beneficial. Feed-in laws are also under discussion or in development in some developed and developing countries like the UK, Finland, New Zealand, Japan, Nigeria, Malaysia, Singapore and Taiwan [48]. It will be worthwhile for India to evaluate the success of this measure before it considers adopting it in India to override state level issues, and to placate issues related to project selection guidelines in the future.

2.1.2.2. Project selection. FIT is only one part of the solar deployment equation. Governments need also to decide which projects should be awarded the decided FIT. The common approaches include: (a) first come first serve (FCFS), (b) beauty contests,[21] and (c) auctions.[22] FCFS is the simplest mechanism possible—however, it is effective only as long as total demand for capacity is less than the total capacity to be allocated. Otherwise, the twin criteria of efficiency and fairness become important,[23] and it is well known that, in well-functioning markets, auctions work better than beauty contests [71]. The architects of JNNSM have taken this to the heart, and the draft guidelines issued by the MNRE for the selection of projects contained an explicit clause that if the scheme were to be oversubscribed, project selection would depend on a developer's ability to share a percentage of the CERC guaranteed tariff with NVVN, and the developer offering the maximum in a reverse-auction format – e.g., the one used in California to assign

[18] If developers are not equipped to design the plant the engineering, procurement and construction costs increase the overall capital expenditure by 20 per cent.

[19] Presentation by Sunil Gupta, Managing Director, Clean Tech, Morgan Stanley, January 2010.

[20] See http://www.nytimes.com/gwire/2009/08/18/18greenwire-spains-solar-market-crash-offers-a-cautionary-88308.html.

[21] Under a beauty contest the allocating authority picks projects based on some pre-defined (potentially subjective) criteria.

[22] All of these may require some pre-qualification to ensure that the risk of non-delivery is minimized.

[23] Efficiency refers to allocation of a scarce resource to the entity that values it the most—because it can be shown to maximize social welfare; fairness refers to the allocation without any subjective preference, provided some technical requirements are met.

projects to bidders in order to fulfil the renewable portfolio standard (RPS) requirements [18] – would be selected [58].

However, the overall approach (FITs followed by reverse-auctions) has issues. To begin with, the use of auctions brings the whole idea of FITs under question since FITs, when combined with auctions for project allocation, are in principle equivalent to auctions. Further, auctions introduce additional risk for project developers due to the resulting uncertainty about the final revenue stream [8,81]. This uncertainly could be fatal for bringing investment in a new market experimenting with a new technology. Finally, the use of auction mechanism in an immature market raises the issue of defaults due to participation by speculators and inexperienced firms that may overbid given the fact that the initial FITs were so lucrative, and costs of technology uncertain. Though the interactive nature of the policy provided room for manoeuvre evident in the bid-bond clause,[24] recently introduced in response to the irrationally high numbers of developer applications for Phase I projects, Indian solar energy would be the biggest loser if the Phase I fails due to defaults. Given these complexities, further work is required to ascertain the best possible way to fix the FIT in short-term as well as long-term.

2.1.3. Financing

Typically for solar projects, non-recourse financing is the preferred financing structure, where the lending institutions would provide debt to a special purpose vehicle set up for the project, and would have a lien on the project's cash flow. However, as this structure does not provide recourse (i.e., access) to the developers' balance sheet, banks require solid agreements for revenues from the projects.[25] This requires a thorough understanding of the techno-economic viability of the projects as well as an assessment of underlying risks [52].[26]

Securing finance for solar projects is challenging because of the inherent nature of the projects. First, unlike thermal plants, which utilise only 15% of the planned capital expenditure upfront, solar plants require 70%–80%. Second, given that solar is an infirm fuel source (due to time and weather dependence), and solar technologies are relatively new, the associated uncertainties associated makes bankers sceptical. Third, the absence of a developed bond market in India makes it inherently difficult to raise long term project finance. Finally, in India's power industry, financing of projects is closely intertwined with evacuation and distribution arrangements—a barrier in itself.

JNNSM should have weeded out the problems associated with evacuation & distribution of solar power and finance of solar projects. Indeed, the interactive nature of policy making has helped correct course to a certain extent, as evidenced by the following three examples, related to: the power sale agreement; the time required for financial closure; and the availability of site specific insolation data.

2.1.3.1. The power sale agreement. To override the problems associated with evacuation and distribution of solar power and the financing of projects, the JNNSM crafted an arrangement by which the NVVN has been designated as the nodal agency to administer the purchase and sale of solar power. NVVN will enter into power purchase agreements (PPAs) with solar power developers and pay them the tariffs determined by the CERC. The power will be blended with an equal amount of NTPC's unallocated (conventional) power – so as to make the delivered cost of solar power more financially palatable – and sold to distribution companies across the country by entering into a Power Sale Agreement [67]. It is noteworthy, that unlike conventional power sale agreements between state–owned companies, the sale agreement between NVVN and the state-owned discoms has an explicit clause on a tripartite agreement between NVVN, the state and central governments and the Reserve Bank of India, signalling low levels of confidence in the financial health of discoms [93]. In this context, the concerns about the financial health of discoms are real: it is important to note that reform actions have not, by and large, resulted in the improvements in cash flows and revenues that would have given potential investors comfort about the ability of discoms to meet their debt service obligations [6].

2.1.3.2. Time of financial closure. The JNNSM had initially outlined a stipulated time period of three months for achieving financial closure after signing the PPA. This clause was made even more stringent by stating that the performance guarantee of US $100,000 per MW would be invoked if developers fail to finance projects within this specified time. This clause had highlighted the distance of policymakers from the functioning of markets as even companies using balance sheet finance took much longer to secure financial closure.[27] Over time, policymakers have understood this issue better and, based on industry feedback, have revised this time period to six months, with the bank guarantee being implemented in a phased manner. This is further bolstered by a recent announcement to create a $108 million fund to help solar power producers arrange finances for their projects.[28]

2.1.3.3. Site specific insolation data. Despite the availability of National Renewable Energy Laboratory's satellite-imagery-based data,[29] which is at the 10-km resolution, there is insufficient (site-specific) data available for projects to be launched under Phase I.[30] This lack of information is likely to create significant difficulties for bankers who attempt to fund these projects as the 'real' efficiency of each project cannot be determined unless historical, on-site, data is available. Initially, the JNNSM had overlooked the need for, and the availability of, detailed site-specific insolation data. Once again, the interactive nature of the policy has resulted in the requirement for developers to install a pyranometer to collect irradiance and meteorological data on site which in turn will be shared with MNRE to help build a database of site specific irradiance levels.

But, despite taking these constructive measures, interviews with stakeholders reveal that the policy making process has been mostly reactive,[31] and does not completely address many aspects, ignores measures required to incentivise financiers, or (unfortunately) creating additional impediments for developers, exemplifying the "policy–implementation dichotomy" [15]. At present, commercial bankers are either ignorant or pessimistic about the take-off of solar technologies. For many, solar is '*another five years away*' as the

[24] The Bid-bond clause discourages overly adventurous bids in the reverse auction by requiring project developers to deposit amounts proportional to bids. These bonds would be seized by the government in case of developers defaulting on projects [58].

[25] See http://www.business-standard.com/india/news/banks-say-ppa-structure-for-solar-projects-not-bankable/406386/.

[26] Though we do not go into the details of all these risks, and encourage the interested reader to read Moody [52], we cover the essential ones from the perspective of JNNSM.

[27] For example, Lanco Infratech – one of India's biggest conglomerates, with a market capitalisation of $3 billion and relationships with 28 banks – took about five months to secure financial closure.

[28] See http://www.cleanbiz.asia/story/indian-cabinet-approves-ambitious-national-solar-mission.

[29] See http://www.nrel.gov/international/ra_india.html. It should be noted, however, that the NREL data can be used for preliminary site selection and hence provide some degree of confidence.

[30] Based on private communication with Mohit Batra, Global Project Finance Head—ICICI Bank; Pashupathy Gopalan, CEO, MEMC; Mr. Saibaba, CEO, Lanco Solar; and leaders of the infrastructure finance division at the Asian Development Bank (ADB) and the International Finance Corporation (IFC).

[31] Ibid—Footnote 30.

independent power producers (IPPs) focus on getting thermal capacity on stream: 100 GW of thermal power is expected to get on-stream in the next 5 years.[32]

There are many reasons behind this pessimism. The capital norms used by the CERC to calculate tariffs are unlikely to be acceptable to bankers. Discussions with bankers suggest that they are unlikely to enter into the conventional 70%–30% debt equity spilt due to risks specific to solar projects.[33] Furthermore, inherent distrust masks financial decisions as the bankers have no evidence to trust the government allocating high FITs year-on-year for the next 25 years. Bankers worry that, as costs begin to decline, the state could seek to renegotiate tariffs with developers that have constructed projects in the early phases—something that has already happened in Spain.[34] Even if the PPAs were valid for 25 years, there is uncertainty associated with receiving the requisite amount of unallocated power, despite the fact that 15% of NTPC's capacity is unallocated. This apprehension is a direct consequence of India's acute electricity shortages, with a peak deficit of 12.2% in 2009 [9]. Finally, a review of the NVVN power purchase and sale agreements by multilateral banking institutions, commercial banks, foreign investors, and developers highlights several shortcomings, and cites the PPA as "un-bankable" due to concerns related to (but not limited to):[35] coverage of outstanding debt service in the event of termination, adjudication of tariff specific issues, process for delays in commercial operations, impact of changing laws and resulting risk, etc.[36]

Against this context, the following additional measures could assist the sector's take-off by building capacity and confidence in the investor community: a multi-stakeholder approach; reducing cost of capital; bolstering the role of IREDA; capacity building in banks; and managing data deficiency risks.

2.1.3.4. A multi-stakeholder approach to policy making. Policymakers need to collaborate with commercial bankers, infrastructure financers, financial institutions, the Ministry of Finance, the Reserve Bank of India (RBI), and the Ministry of Commerce and Industry. The creation of the Power Sale Agreement based on feedback from the State Bank of India, Bank of India, and Central Bank of India is a welcome step in this direction but much more needs to be done in terms of involving other investors and, in particular, developers. One approach would be to hold regular workshops on this aspect and develop policies with continuous feedback from stakeholders, as done by the BMU (see the FITs section).

2.1.3.5. Reducing the cost of capital. For the industry to take-off, cheaper capital is required. Reducing risks outlined earlier in a systematic fashion would help reduce cost of capital and attract more capital. A potential way to accomplish this is to develop the country's bond markets by opening them to long term investors, such as pension funds and insurance companies. Once the projects have run successfully for a few years ($\sim$3) and mustered investor confidence, companies could restructure their debts as highly-rated, long term bonds.[37] Subsequently these bonds could become attractive investment instruments for institutional investors.

2.1.3.6. Bolstering the role of Indian renewable energy development agency (IREDA). A dedicated financial institution may help facilitate project finance at low cost, and boost investment into renewable energy projects. India already enjoys the privilege of having IREDA. However, historically, IREDA raised finance from commercial banks and lent to project developers at relatively high interest rates, inflating the cost of the project. Though the situation has changed over time, the interest rates charged by IREDA are still only slightly more favourable than commercial lending rates.[38] For the success of JNNSM, IREDA must receive support to raise sufficient amounts of capital at low costs. For example, it should be allowed to manage the US$108 million fund recently announced for supporting solar projects.[39] Further, in order to be more effective, it should be unshackled from the control of the MNRE, and be allowed to function as an independent entity in order to: foster product design and services; cater to a range of segments of the market; create incentives to attract top-class talent; and develop a sustainable business model to accomplish its objective of renewable diffusion. In this context, much can be learned from the operations of KfW, the German government-owned development bank, and partnering with them in promoting renewable energy in India.[40]

2.1.3.7. Capacity building initiatives for commercial banks. Although plans are afoot for agencies such as the IFC and ADB to undertake this task [72],[41] MNRE in conjunction with the RBI and Finance Ministry must prioritise the initiative to build the requisite capacity in commercial banks and financial institutions. Some banks have offered to support such projects without fully understanding the risks associated with them. In such a scenario, the failure of a few projects in the early stages of the industry's lifecycle could dissuade financers. It is necessary that financial institutions are fully equipped with skills and the supporting technologies needed to ascertain the risks and rewards from financing solar power projects.[42]

2.1.3.8. Mitigating radiation data deficiency risk. One way for the government to overcome the problem of finance is to share risk. The state might agree to make adjustments in the tariff, after financial closure, in the event that site-specific insolation levels fall short of projections. Such an approach has been successfully used in Germany to adjust the FIT for on-shore wind projects, based on eventual wind yield [42]. Such insurance from the government could enable banks to consider adopting a more progressive release of the performance bond—i.e., to structure disbursals at different milestones during the development of the project. It is possible for banks to adopt this approach since the development risks associated with solar are relatively low compared to those associated with the construction of large thermal or hydro projects – in terms of procurement of fuel supplies, and securing a host of permits and clearances.

2.1.4. Project commissioning and execution

There are many challenges associated with project commissioning: limited access to the engineering, procurement and construction (EPC) specifications of projects; a dearth of skilled labourers in India; and supply constraints (e.g., long waiting

[32] Based on private communication with the global project finance head of one of India's leading private sector banks.

[33] Based on private communication with Don Purka, Asian Development Bank.

[34] See 〈http://www.mnre.gov.in/pdf/migration-guidelines-jnnsm.pdf〉.

[35] Ibid—Footnote 30.

[36] See Schandera [80] for characteristics that make a PPA bankable: PPA counterparty (i.e., utility) should have investment grade rating; PPA tenor (life-time) has to extend the length of debt financing; PPA guaranteed dates have to match interconnection and construction schedule; PPA pricing has to be acceptable not only to lenders but also other stakeholders.

[37] Ibid—footnote 30.

[38] See 〈http://www.thehindubusinessline.in/2011/01/12/stories/2011011252860400.htm〉.

[39] Ibid—footnote 28.

[40] See 〈http://greenworldinvestor.com/2011/03/03/german-development-bank-kfw-joins-adbworld-bank-in-funding-clean-energy-in-india/〉.

[41] Also see 〈http://pid.adb.org/pid/TaView.htm?projNo=44475&seqNo=01&typeCd=2〉.

[42] ADB's support for solar power in India is an example. ADB is providing not only technical grants but also line of credit. 〈http://www.thehindu.com/business/Industry/article868433.ece〉.)

periods for delivery)[43] around balance of systems (BOS),[44] which constitute roughly 50% of the equipment cost. Further, problems associated with acquiring land and water permits are cumbersome, especially when India's agricultural output has contracted due to water scarcity and land issues dominate political debates. Another problem is the absence of evacuation lines at remote sites. The cost of building a line over one km is approximately US $14,000 and, though the policy incorporates this into the calculation of feed-in tariffs [13], it remains silent about how such links will be delivered.[45] It can be counter argued that the single-window clearance proposed by JNNSM should solve all or many of these hurdles; however, given India's extensive bureaucracy, this would be useful only if the single-window truly bypasses the red-tape, and does not end up simply identifying other pre-existing windows that are potentially the cause of delays to begin with.[46]

Another major issue, where the JNNSM is mostly silent, is the technical feasibility of blending solar power with conventional power, and the infrastructure requirements for doing so. First, there is an inherent uncertainty in generation, given the dependence on weather as well as the time of day. Presence of intermittent sources may result in higher system costs due to system balancing and reliability issues (Gross et al.,) [96]. Though the intermittency issue is not problematic as long as the share of electricity generated by intermittent source remains small in the overall mix (Giebel) [97], care should be taken to design future transmission and distribution systems that will deal with higher penetration of intermittent sources. Further it should be noted that, though the intermittency issue can be addressed by the use of storage technologies, it results in increased installed costs.[47] Second, for grid-connected distributed solar power, power can flow in two directions due to the generating site being a source as well as a sink of power: in times of the surplus demand at the installed site, the surplus is met by using electricity from the grid; however, it times of surplus supply, the surplus supply is pushed on to the grid. Managing reverse power flow increases not only costs since the grid is typically designed to push power in one direction only [5] but also brings to surface the challenge of grid security given that malicious generators may introduce grid instability using unmatched (in frequency) power [77].

Some measures could help in speeding up project commissioning and execution. These belong to the following categories: vocational training, solar parks (& site-selection), and grid standards.

2.1.4.1. Augment the skilled manpower. Ultimately for large scale development of the sector, India needs significant amounts of skilled manpower for the execution, operation and maintenance of solar projects. Specific curricula and collaboration with international and national institutes must be developed to create adequate talent supply. So far, piecemeal programmes have been instituted—these are unlikely to yield significant benefits. India's track record in vocational education and training suggests that more work needs to be done [91]. A comprehensive roadmap for solar related vocational training programmes that include establishing accreditation standards is required. Such an effort needs to be collectively embarked upon and pushed in conjunction with support from the Ministry of Human Resources Development. In this regard, much can be learned from China, which has become the global leader in solar PV manufacturing within a short time period.[48] This has been possible by focusing on talent pool management as one of the key areas in the National Medium- and Long-term Science and Technology Plan (2006–2020).[49]

2.1.4.2. Establishing solar parks. Clusters or spatial agglomerations for power producers, manufacturing companies, and component manufacturers that provide benefits from the use of common infrastructure reduce the risks associated with land, water and evacuation could help propel the rise of the industry. The active and passive collective efficiencies of clusters have been well documented over the years [98]. State governments should work with NVVN to pre-select tracts of land for solar projects in the absence of establishing fully functioning solar parks. Doing so would enable developers and NVVN to overcome the problems associated with evacuating power from remote sites and perhaps enable them to make unused arid lands productive. Much needs to be learned from the experiences of Gujarat and Rajasthan. These states are developing solar parks to overcome many of the problems related to procuring approvals.[50] They have awarded contiguous tracts of (arid) land to the Clinton Foundation, which is supported by the ADB. Though it is too early to declare success on these parks, much can be learned from international experience as well.[51]

2.1.4.3. Establishing grid standards. International emphasis on the smart grid, which combines real-time intelligence into the power network through its integration with computer networks and information technology, has sharply accelerated since it benefits consumers and society at large [92]. Further, for roof-top installations (see the Roof-top programme section) to be a success, and renewable energy broadly, developing the smart grid is necessary. As India needs to dramatically extend its transmission lines to fulfil its surging electricity demand, the country could leap-frog development by directly building smart grids in un-electrified regions. Investments in the smart grid could help arrest the significant transmission and distribution losses, reduce overall energy consumption via active demand management, and manage intermittent renewable sources in real-time. For this purpose, India must consider the IEEE guidelines for smart grids and conduct research to ascertain whether grid conditions warrant modification to international standards [39]. In this context, much can be learned from Germany, the leader in worldwide installations, with cumulative capacity of 18 GW.[52] Due to such high penetration, Germany has learned a lot about integrating solar PV into the grid, and produces very clear guidelines for the same at regular intervals.[53]

[43] Often the waiting period of inverters is 8 to 9 months.

[44] BOS players have not been incentivized sufficiently. The policy assumes they will follow the growth of the industry in India. However, the formation of balance of systems cohort is critical for the take-off of solar power.

[45] Based on private communication with Dhaval Monani, Head, Urbanization and Affordable Housing, Indian School of Business, Hyderabad.

[46] Based on private communication with Satyen Kumar, Professor, Indian Institute of Technology, Kanpur; and CTO, Lanco Solar.

[47] For example, storage can increase the cost of solar PV by as much as 75%. See http://energyselfreliantstates.org/content/addressing-frequently-asked-questions-about-solar-pv-v-concentrating-solar.

[48] See http://www.nytimes.com/2010/01/31/business/energy-environment/31renew.html as well as http://www.emberclear.com/WSJ_Top_Polluter_emerges_as_green_tech_leader.pdf.

[49] See http://www.bjreview.com.cn/business/txt/2010-07/26/content_286835.htm.

[50] See 〈http://www.biztechreport.com/story/1139-gujarat-launches-asia%E2%80%99s-first-solar-park-charanka〉 as well as 〈http://www.solarplaza.com/news/clinton-foundation-inks-pact-with-rajasthan-govt-f〉.

[51] See 〈http://www.linak-us.com/press/shownews.aspx?newsid=1353〉 in Denmark as well as 〈http://www.phoenixsolar.com/business/de/en/references/solarpark-san-clemente-villanueva-de-la-jara.html〉 in Spain.

[52] See 〈http://renewableenergyagency.com/solar.html〉.

[53] See 〈http://www.renewablesinternational.net/germany-adopts-new-grid-integration-rules-for-pv/150/452/30835/〉.

2.2. Roof-top programme

The guidelines for roof-top projects are a significant attempt to help a new technology take-off in urban areas [54]. Designed for small solar projects, (i.e., 1–3 MW) to be connected to the distribution network at voltage levels below 33 kV, the policy is predicated on the generation based incentive (GBI) mechanism, crafted by MNRE to launch grid-connected solar projects. The highlights of this policy are as follows [59]: (a) the projects would be connected to distribution network at voltage levels below 33 kV, and should be completed before March 31, 2013; (b) the local distribution utility would sign a PPA with the developer at a tariff determined by the appropriate SERC; (c) GBI will be payable to the distribution utility for a period of 25 years, equal to the difference between the tariff determined by the CERC and the Base Rate (US $.11 per kW h,[54] to be escalated by 3% every year); and (d) IREDA has been designated as 'Program Administrator' for administering the generation GBI.

Yet again our analysis suggests that this policy exemplifies the "*policy–implementation dichotomy*" [15]. The following is an analysis of many aspects of the off-grid part of JNNSM in this context, namely: sale arrangements; market infrastructure; and joint metering.

2.2.1. Proposed sale arrangements

The proposed arrangement for the sale of power from the producers to state-owned discoms may render a project as "unbankable", given inherent risks likely to play out based on the track record of India's discoms (e.g., failure by discoms to evacuate power, delayed payments, and the unwillingness of discoms to purchase solar power) and differences in the tariffs published by CERC and SERC. Further, if utility-scale producers (who are typically more financially savvy than the roof-top counterparts) are having difficultiesmeeting the 6-month financial close deadline for utility-scale projects (the Financing section), the stipulated 6-month timeline for financial closure may turn out to be too short.

2.2.2. Absence of market infrastructure in urban areas

For the roof-top programme to take-off, the state needs to ensure that the requisite market is created for manufacturers to retail in the domestic market. At present, off-grid products are not freely available at retail outlets, and need to be sourced directly from companies by consumers [49]. Ancillary policies to bolster consumer awareness, access, and affordability are also needed for the diffusion of this technology in the urban areas.

2.2.3. Joint metering

The third aspect is the disbursal of solar power certificates based on a joint meter reading exercise, which requires coordination between the developer and the discoms. The guidelines remain silent on resolution mechanisms in the case of disputes on meter readings, the probability of which is relatively high given prior consumer experiences with discoms.

To override these issues the following reforms should be considered:

2.2.4. Introduce a payment security mechanism

One way to significantly reduce the payment risk is to structure a tripartite agreement between the central and state governments, RBI, and commercial banks—something similar to what has been created for utility-scale projects, with NVVN as the nodal agency. Banks will then be provided with the cushion required to take on risks associated with unreliable and often almost insolvent discoms.

2.2.5. Establish a retail market for solar applications

Launching general public awareness campaigns, facilitating information flows, enacting minimum quality standards, and introducing demonstration projects are factors necessary to create demand and inspire confidence in a relatively new technology. In addition, the provision of low-cost finance, easy access to retail outlets, and technicians to assist with operations and maintenance are well established cornerstones of market infrastructure. Viral marketing, where a selected group of well-connected and influential people are stimulated to adopt a photovoltaic (PV) system may provide an effective strategy for driving the diffusion of PV systems through network effects. Finally, the government also needs to lead by example and use solar systems for new constructions.

2.2.6. Use net metering technologies

The case for unbundling generation, transmission and distribution has long been made. In the long run, the success of the roof–top programme will depend on the ability of distribution companies to deploy net meters for effective monitoring of the two–way flow of power. Smart meters are a win-win for utilities as well as local communities [92]. For NVVN, a well-designed net metering policy provides a simple, low-cost, and easily administered way to deal with distributed generators. Customers can benefit from net metering of small wind and solar systems if they can obtain a long-term guarantee of low utility bills.

Finally, a lot can be learned from Germany that used its policies effectively to incentivize the rooftop solar PV market through a combination of appropriate subsidies (the installers get a reasonable rate of return over 20 years), removal of barriers (there is one 1-page form for permitting and regulatory approval), automatic grid-connection, etc [90].

3. Off-grid solar policy

So far, most conventional rural electrification programmes have focused more on the numbers of villages connected to electricity than households. Many of the specifically targeted schemes for the deprived have not worked due to excessive leakages and uniform rates regardless of consumption.[55] Excessive subsidisation has made utilities financially unviable, and due to increasing financial constraints providers are reluctant to support rural electrification schemes [66].

In this context, installation of distributed solar energy systems could help in: improving water supply critical for agriculture; powering refrigerators that stock food, enabling children to study in the evenings, women to cook; conducting their household chores and undertaking other productivity enhancing activities. However, a systemic approach designed to meet the requirements of the rural market is vital for mass diffusion to occur [66]. This entails establishing and enforcing standards for technology and after sales service, provisioning of access to low cost finance, altering interest rates to meet the needs of the range of financial institutions, attaching greater emphasis to the role of self-help groups, and increasing the participation of women.

MNRE [60] summarizes the JNNSM policies related to off-grid solar, with the following objectives: promoting off-grid applications; creating awareness and demonstrating innovative use of solar systems; encouraging innovative and sustainable business

[54] All monetary figure have been converted from INR to US $ using a 50–1 conversion ratio.

[55] People below the poverty line.

models; providing support to channel partners and potential beneficiaries; creating commoditization of off-grid solar applications; and supporting various support services. The following provides an analysis of the core issues obstructing diffusion: benchmark costs; lending rates; technical standards; delivery design; and gender roles.

3.1. Low benchmark costs

A major issue with JNNSM is the determination of benchmark costs against which MNRE's subsidies will be applied [35]—US $6 per watt peak (Wp) is considered the benchmark costs, irrespective of size. The MNRE will provide 30% of these costs as capital subsidy and 50% of the same will be eligible for a loan at 5% per annum. The user must make a down payment to the tune of 20% of these costs.

However, on a per unit basis, the smaller systems are typically priced higher than the benchmark costs. These small systems (< 40 Wp) form the bulk of the systems purchased by rural households, constituting over 50% of the unit sales for SELCO and Orb Energy, the major suppliers in these markets. There are many reasons for this: first, volume discounts do not exist; second, other fixed-components account for a higher proportion, such as the costs of internal wiring of homes, compact fluorescent lamp (CFL) bulbs, labour for installation and servicing. Further, in direct current (DC) systems that are better suited in the rural context, the product includes loads for lights and fans.

In this context, the government's prescribed benchmark costs seemed to be unfavourable to the very section of the population that could have greatly benefited from this programme.

3.2. Low on-lending rate

There is currently a cap of 5% on the on-lending rate for the soft refinance provided through IREDA. The only benefit of this mechanism is that it will allow banks with significant rural banking operations to finance products they typically would not have financed. However, this has virtually precluded microfinance institutions (MFIs) that cater to some of the 41% of the unbanked adult population in the country [73]. These MFIs lend at rates of 20% per annum or higher, typically for a period of 1 to 3 years. Even if some of the MFIs adopt this programme, the disbursals could be subject to high default rates, and introducing such sharp variation in product pricing would hurt their business interests. Though the industry has come under scrutiny, and is likely to be regulated, it is unlikely for interest rates to be reduced to the level envisaged by the policy.

3.3. Absence of common technical standards

The policy does not stress on establishing and enforcing technical standards for off-grid applications like home lighting systems, lanterns, cookers, water heaters etc. Acting on this front is critical to catalyse diffusion as it caters to consumer interests and facilitates the development of an organized market in the longer term, as affirmed by the Fraunhofer Institute for Research and Innovation Systems,[56] and emphasized by Miller [49]. Such standards are necessary to establish the reliability of the product and create adequate pressure on energy service companies and manufacturers to adhere to quality and service standards, particularly in rural areas where consumers are not as informed as those in urban areas.

[56] Leading innovation research institute in Europe with a competence centre on energy policy and energy systems.

3.4. Ineffective delivery design for rural markets

The new guidelines are progressive to the extent that they dismantle the monopoly of the MNRE and state nodal agencies in the procurement and distribution of off-grid applications in rural areas. However, they still continue to depend on state actors like Power Supply Units (PSUs) in addition to not-for-profit institutions. The key problem likely to emerge from this policy is that it will not enable consumers and suppliers to transact directly. It is therefore necessary to create a market infrastructure where both parties have the opportunities to interact not only at the time of purchase but also to address after sales service needs. The growing market share of Orb Energy is testimony to the need for this continued interaction [79]. The current policy does allude to the involvement of entrepreneurs but ignores the challenges associated with fostering rural entrepreneurship. These include the lack of mass awareness and education, and the lack of skills required to raise finance, more so as the policy precludes microfinance institutions at the outset.

3.5. Neglect of gender roles and their needs

Energy poverty in India is linked closely with gender roles, earning power and the empowerment of women [40,68]. Research shows that it is important to involve women in the testing and designing of technologies as typically they are the end users—in particular, as related to energy services [40]. Men, on the other hand, are decision makers when it comes to making financial decisions and, therefore, it is imperative to involve both women and men in the technology dissemination process. Policies targeted at rural areas do need to adequately emphasize the role of women to fulfil their development goals. However, JNNSM guidelines do not discuss gender roles at all.

3.6. Other inconsistencies

The JNNSM also highlights negligence and inconsistencies. First, the RPO targets set by JNNSM need to be revised upwards from 3% to 5% to 6% for the mission to accomplish its target of 20 GW by 2022.[57] Second, the JNNSM questions the sanctity of the programme "Power for All by 2012"[58] as it envisages that a portion of the rural populace will not have access to power in 2022, hence the goal to deploy 20 million solar lighting systems by this time.

Although the policy does outline a bouquet of futuristic incentives like the RE voucher/stamp, credit linked and non credit linked capital subsidy, green bonds, viability gap funding, and front-loading of disbursements to entrepreneurs [60], these initiatives will take several years to take-off and accomplish their goals. Particularly instruments like RE vouchers may not fully help solve the problem, as their success in turn will be contingent on the UID[59] scheme and its use by state governments for distribution of subsidies and services for which a detailed effective implementation plan needs to be crafted. Even if the vouchers programme is successful, it will not help address India's chronic problem associated with faulty targeting of subsidies–subsidies in India trickle down to those close to the poverty line but not to truly deprived strata of society that exists significantly below the poverty line [74].

[57] India aspires to double its installed capacity from roughly 160–170 GW at present to 340 GW by 2020.

[58] See 〈http://www.powermin.nic.in/indian_electricity_scenario/power_for_all_target.htm〉.

[59] The unique identifier (UID) is a 12-digit number assigned to every resident of India.

In this context, elimination of benchmark costs is clear [35]. Some other measure that would enhance the distribution of off-grid applications in rural areas are as follows:

3.7. Launch a fund for distributed solar generation in rural areas

In answer to the question—where would the money for the subsidies would come from, in addition to the total budget outlay of US $44.8 million [61], the funds parked aside for the capital subsidy of 90% for special category states could be utilised to set up this fund. Modelled along the lines of the National Defence Fund [70], this fund could be administered by an Executive Committee. This committee would include participation from the Planning Commission and the Prime Minister's Office. It could be operated as a target-oriented fund whereby it is dissolved after accomplishing the target of distributing solar lanterns and micro home systems (e.g., 10 W solar panels) in the most remote regions of the country. Such an effort could help lower leakages and solve some of the targeting problems associated with red-tape, typical of government procurement and distribution programmes. In addition, if even 5% of the under recoveries on kerosene are realized and channelled to this fund it could add over US $280 million.[60]

3.8. Promoting community solar projects

Another activity is to foster community grid-connected solar. Ellensburg's Community Solar Project could provide some useful lessons because it brings together constituents across different income classes [26]. This community solar programme allows local individuals and businesses to participate directly in the solar project. Local residential and commercial utility consumers were asked to partner with the city to fund the project. In exchange for their support, the members receive compensation for each kilowatt hour of electricity produced in the form of a credit on their bill for a period of over 20 years. The contributing members may at any time sell, assign, or donate their shares to any other individual or commercial utility consumer.

Predicated on this example, the MNRE and state governments should assist small and medium enterprises aspiring to set–up micro solar projects,[61] by introducing FITs for mini-grids that will incentivise entrepreneurs and energy companies in venturing into rural areas. Consequently, this could create a market for Renewable Energy Services Companies (RESCOs) in rural areas. These RESCOs usually provide the full chain of services, including operations, maintenance and repair. Governments typically offer concessions to RESCOs for a given period of time, typically up to 15 years, and projects are awarded on the basis of a competitive bidding process. During this stipulated time period the rural energy service company has the right to exclusively provide all energy services to everyone who requests for them. Husk Power in Bihar has shown that this model can be successful[62]: it owns and operates small (30 kW) plants serving a cluster of approximately 3–5 villages. It has a completely vertically integrated model: it sets up the plants, lays the distribution network, and manages the services provided. By the time of writing this paper, Husk Power has set up more than 50 plants.[63]

Further additional forms of support should be considered for such companies. For example, special credit lines should be opened for such entrepreneurs and adequate support should be provided to acquire land, and water permissions that the state must deliver in a pre-defined period of time. Such an approach can help state governments to avail of the conditional funding introduced by the Thirteenth Finance Commission for adding renewable capacity.[64] FITs coupled with RECs can help entrepreneurs to light un-electrified areas, and in turn create employment opportunities and enhance productivity levels that will allow poor households to climb the income ladder.[65]

In effect, India needs to adopt a two-pronged approach, one driven by a near-term focus and the other driven by a medium-to-longer term focus. The near term focus comprises of reforming the current procurement and distribution programme of off-grid applications while the medium to longer term focus should be one of actually developing a well functioning rural solar market to accelerate rural development till all remote areas are grid-connected.

3.9. Interventions to address quality issues

India is well-known for its parallel markets. Miller [49] asserts that diffusion of off-grid applications in India has been hindered by government procurement and distribution programmes that do not focus sufficiently on product quality and after sales service factors essential for consumer satisfaction.

In this case, learnings from the Kenya Solar Home Systems market are instructive [24], as it is the largest private sector dominated market in a developing nation, and similar to India, its consumers are constrained by lack of quality information and are often ignorant of the brand of their module. There are several ways to remedy this problem, namely [24]: warranties, performance testing and disclosure, certification and labelling, minimum quality standards, and alternative business models.

At a minimum, India must enforce some minimum quality regulations – e.g., standards and labelling on solar products – based on a combination of domestic and international certification standards and programs. This could take a form similar to the Energy-Star rating (Wiel and Macmahon) [99], already used world-wide as well as by the Bureau of Energy Efficiency. These measures, in addition to the use of international standards, could include a mix of voluntary warranty strengthening and domestic performance testing with disclosure. Likewise, quality measures should also be enforced for balance of systems that in case of solar home systems represent more than half of the life-cycle costs and their relative importance is likely to increase [24].

3.10. Stimulate latent rural demand, enterprise and development

Research has shown that households identify a number of economic, technical, political, and socio-cultural factors related to the use of off-grid applications [85]. However, advertising, distribution, and minimum quality standards should be added to the list of critical factors.

Consumer awareness campaigns that educate users about the benefits of renewable energy such as the role it could play in combating climate change as well as reducing energy security and price volatility issues, in addition to the difficulties and (as relevant) the infeasibility of grid-service must be launched. For example, Nguyen [100] in his work in the rural and remote areas of Vietnam asserts that the levelized costs of photovoltaic energy are lower than

[60] Under recovery – i.e., effective subsidies – on kerosene has grown from US $0.75 billion in 2003–2004 to US $5.64 billion in 2008–2009.

[61] The cost of 1MW plant is estimated to be US $0.8 million as per the roof top guidelines [59].

[62] See 〈http://www.ashdenawards.org/blog/husk-s-finance-model-shows-what-success-looks-clean-energy-enterprise-india〉.

[63] Private communication, Gyanesh Pandey, CEO, Husk Power (an off-grid biomass-to-power venture).

[64] See 〈http://www.financialexpress.com/news/13th-finance-commission-suggests-green-grants-to-states/585224/〉.

[65] The exact working economics of this model need to be ascertained.

the cost of energy from gasoline generation sets and, more importantly, are cost-competitive with grid extension, especially for areas with low load density and low number of households to be electrified. These campaigns could also advertise government policies supporting the diffusion of solar energy, such as subsidies, soft-loans, and other funding agency details.

To foster rural entrepreneurship, the government should consider partnering with business schools and rural development institutes to establish programmes and institutes that provide rural entrepreneurs with tacit knowledge required to set-up and scale renewable energy businesses, and help urban entrepreneurs with the knowledge required to access and transact in these markets. In the short term, it might be worthwhile to not only train motivated rural citizens as after sales-service agents but also leverage existing rural distribution networks—e.g., the banking correspondent network programme being adopted by banks to establish a market for off-grid applications. In this context, much can be learned from the experience of Hindustan Unilever that used an extensive network of 40,000 women entrepreneurs in distant villages—previously not reachable by its traditional hub-and-spoke model to stock and sale products [37]. The after sales–service agents could be deployed at either these kiosks or could work at these distribution outlets. This in turn, could help aggregate transaction costs for all parties, and augment reach in backward regions. Further research on the economics of this approach is necessary and would be beneficial to policy makers.

Successes such as the UK's Department of International Development (DFID) rural livelihoods programme, which promoted solar lighting in villages of Andhra Pradesh, must be showcased [21]. The programme, in partnership with the National Institute of Rural Development, established Women Barefoot Solar Engineers Association (WBSEA). The WBSEA imparted training for four months to illiterate women on how to fabricate, wire, set up, and maintain solar energy systems. The process has been well adopted by many illiterate women in Andhra Pradesh, and the programme has had far reaching impact on social welfare in these villages: the trained women are able to earn a living by making and selling solar powered lights; women are able to work in well–lit homes, have the option of making brooms in the evening generating further income, and save time as they need to purchase kerosene less frequently; and the children are able to study in the evenings. In this context, a particularly interesting option is "leasing" of solar lanterns [14,75], where an entrepreneur trained by the service provider takes care of the central station and also maintains the batteries and systems.

In summary, the policy's "*rapid up-scaling in an inclusive mode*" vision for off-grid solar applications is commendable but realising it is going to be an uphill task. It calls for altering the policy in the following manner—(i) rolling back the cap on the on-lending rate of MFIs, (ii) establishing minimum common technical standards for off-grid applications, (iii) stimulating latent rural demand, enterprise and development, (iv) promoting community solar projects and (v) effectively recognising the inextricable linkages between women and energy applications in rural areas.

4. Support for innovation

4.1. Research & development

Two sections of JNNSM are devoted to R&D. The first stresses on creating enabling conditions for research and application, and dwells on three aspects: (a) the need to improve efficiencies of existing materials and devices, including balance of systems and applications; (b) to develop cost-effect storage technologies; and (c) to augment the use of nanotechnology and improved materials. To accomplish this, it advocates the institution of the Solar Energy Council, taking into consideration ongoing projects, the availability of research capabilities, and resources and international collaboration possibilities.

The subsequent section in the JNNSM elucidates a five pronged R&D strategy: (a) basic research; (b) applied research; (c) technology validation and demonstration projects including hybrid plants; (d) development of R&D infrastructure in PPP mode, and (e) support for incubation and start-ups. It also advocates the need for a high level Research Council comprising of scientists and technical experts; representatives from academic and research institutions, industry, civil society, and the government; and international experts to guide the solar technological roadmap. To support the effective functioning of this council, a National Centre of Excellence (NCE) is proposed. The NCE is envisaged to have the following mandate: (a) serve as an apex centre for testing and certification and for developing standards for the solar industry; (b) develop a national platform for networking between Indian and international academia, industry, and the government; (c) act as a funding agency to support performance-linked R&D programmes; (d) be the interface with international research institutions, high tech start-ups, multilateral programmes as and when they emerge; and (e) coordinate activities with other agencies like the Indian Meteorological Department and Indian Space Research Organisation for detailed mapping of insolation levels across the country

Further, the JNNSM seeks to bolster efforts to develop the necessary talent pool required to support diffusion. All of these suggest that many of the barriers associated with R&D are recognised and could potentially be dismantled, most notably being the creation of an apex network to facilitate the transfer of tacit knowledge and to create the lobbies required to promote specific technologies in the coming decade.

Yet, several questions and issues remain, including: should India pursue basic R&D; what incentives and legislations are required to promote R&D; and what types of measures are required to facilitate talent development?

Should India pursue basic R&D? The dominant reason to support basic research and development is to bring down the levelized cost of solar energy to the level of conventional sources.[66] This cost is typically a function of two forces: basic R&D and scale & learning effects related to production [65]. Basic R&D lowers levelized cost through more efficient solar cells. This effort is typically funded via research grants, prizes, etc. Scale & learning effects, on the other hand, lower levelized cost through more efficient processes: manufacturing and installation for module and balance-of-system, respectively. This effect is typically funded via demand subsidies, such as feed-in tariffs and renewable energy certificates. Both of these effects are crucial in bringing down the cost of solar technologies [65]. We have already discussed demand subsidies in the Utility scale solar plants section and, therefore, focus on basic R&D here.

Although R&D accounts for at least half of increases in per capita output [89], India has historically underinvested in R&D. By contrast, in 2008, 10 developed countries accounted for 80% of global R&D spending on renewable energy technologies and received over 90% of the cross border royalties and technology fees [20]. However, though the case for investing in basic R&D is clear, India needs to evaluate the distribution of its scarce resources based

[66] The levelized cost (LEC) is the cost of generating electricity for a particular system, amortized over the total electricity produced during its lifetime, and is generally measured in $/kW h. It includes all costs, such as initial investment, operations and maintenance, cost of fuel, cost of capital, etc. The LEC is the minimum price at which energy must be sold for an energy project to breakeven. This metric is commonly used to compare different types of electricity generation, since some technologies, such as solar and wind, have large initial costs but no fuel costs; while other technologies, such as coal and gas, have different characteristics.

on the country's position in the system of global solar R&D. This makes it imperative for India to evaluate its investments in basic research and evaluate the time, effort, and resources required to simply catch-up given the inherent lack of an R&D ecosystem. India needs to develop the necessary talent pool and scientific infrastructure, prior to undertaking audacious basic research efforts.

However, the process by which government departments are evaluated and funded is opaque. Typically central government ministries are rewarded based on their ability to spend the annual funds allocated to them. The lacklustre performance of the Solar Energy Centre so far makes the recent grant of US $30 million inexplicable, in particular when NCE is envisaged to be the body responsible for testing and setting technology standards. Little or no reference is made to supporting the R&D activities likely to be undertaken by the industry that has nine cell-manufacturers and roughly 20 modules-producers [83]. Finally, the industry–academia divide in India is a significant one that must be overcome (Harriss-White et al. [34], as elucidated by the report of the Steering Committee on Science and Technology for the Eleventh-Five Year Plan (Working Group Report, Strengthening Academia Industry Interface, 2006) [101].

4.1.1. *Lack of incentives to promote basic R&D*

Despite the thrust on basic R&D, the policy does not dwell on any of the areas critical to the formation of an ecosystem for basic research areas [28].[67,68] The key components of the ecosystem would include research infrastructure in terms of scientific research institutions and laboratories in a particular spatial zone; measures to attract high caliber talent, e.g., competitive compensation packages and unrivaled opportunities to undertake cutting-edge research work with leading international scientists; respect from and collaboration with the industry to drive joint efforts; regulatory mechanisms to enable moving from innovation to commercialization of technologies; and financial incentives to attract the private sector.

In this regards much can be learned from developed countries (e.g., the USA and the UK) that have experienced with many instruments to promote science and technology. A prominent incentive has been research tax credits. These reduce the cost of doing research by giving the firm a tax credit for a portion of its R&D expenditure [89], and provide an incentive to increase R&D investment. A credit provides an incentive to increase R&D investment by reducing the overall cost of the research project, making any given project potentially more profitable—it has been estimated that a 10% fall in the cost of R&D stimulates just over a 1% rise in the level of R&D in the short-run, and just under a 10% rise in R&D in the long-run [7]. In this context, it is also important to note that government R&D spending can be used to leverage private R&D spending: Hall [33] suggests that each dollar in a research tax credit appears to generate more than a dollar in private R&D spending. In fact, [25] (1995) shows that the research tax credit induces an increase in R&D spending by an amount that is significantly greater than the foregone tax revenue.

4.1.2. *Neglect of requisite legislative measures*

India lacks legislation, such as the American Bayh-Dole Act [3]—the legal framework for transfer of university generated federally funded inventions to the commercial marketplace. University patenting and licensing efforts under the Bayh–Dole Act have fostered the commercialization of many new technological advances. Prior to the Bayh Dol legislation, about 25–30 universities were actively engaged in the patenting and licensing of inventions. There has been close to a ten-fold increase in institutional participation since the Act was legislated [2].

In 2008, attempts were made to introduce an Indian equivalent, namely the Protection and Utilization of Public Funded Intellectual Property Bill. However, it was criticized on the premise that the conditions of basic research in India do not warrant the need for such legislation. This indeed reflects a classic chicken and egg problem. Antagonism to such progressive efforts will hinder the strengthening of the nation's basic research capabilities as laws like this are catalysts for basic research. The JNNSM is silent on the need for any such laws—this is inconsistent with its focus on basic R&D. Equally important is the need to strengthen the intellectual property regime to attract foreign companies so that they are willing to file patents in India.

JNNSM could learn from the US on another front. In the last decade, the US has focused on government-industry R&D partnerships to commercialize innovations. For instance, the US government, in its Energy Policy Act (2005) [102], introduced the Title XVII loan guarantee programme to support commercially proven technologies in addition to promoting innovative renewable energy technologies. As a result of this, the US government has been the guarantor for many projects, with the most recent being the US $1.3 billion guarantee to BrightSource Energy. The project will produce approximately 400 MW (MW) of clean renewable energy and will nearly double the amount of commercial solar thermal electricity produced in the US.

4.1.3. *Insufficient focus on talent development*

On talent, other than the idea of setting up a National Centre for Photovoltaic Research and Education at IIT Mumbai, the role of India's leading engineering institutes is little discussed.

In summary, JNNSM must carefully consider its approach to R&D and evaluate the outcomes each approach is likely to generate. Despite its focus on a few capacity building measures, and the inception of a national solar network, it must make bold strides to promote development to dramatically augment large-scale diffusion. A comprehensive effort to develop a strategic roadmap for India's approach to R&D needs to be developed which could provide the contours for solar technologies. This paper does not attempt to do that although it establishes the case for such an effort.

4.2. *Institutional design*

It is well known that institutional design and policy effectiveness are intertwined. A policy should incorporate the corresponding institutional context, and planning for institutional forms and rules should factor their impact on policy effectiveness [30]. Based on this premise, the measures undertaken by the CERC, FOR, and SERCs discussed earlier can be contextualised. This also makes the need for policies and supporting institutions required for the successful implementation of the JNNSM pronounced.

However, the need for an autonomous Solar Energy Authority (SEA) or an autonomous and enabled Solar Mission, embedded within the existing structure of the MNRE, populated by administrators and not scientists, reporting to the Prime Minister's Council on Climate Change (PMCCC), and tasked with driving implementation, is questionable, for the following reasons.

First, the need for SEA questions the efficacy of the MNRE. Does this mean that MNRE does not have sufficient administrative capacity for managing solar policy? If this is the case, then why not let MNRE appoint additional officials, given the proposal to staff the Mission with a bureaucrat of the rank of additional secretary? Second, the residence of SEA within the MNRE questions the autonomous status of the SEA. Appointing a mission director with the rank of an "additional secretary", tasked with achieving the goals of the mission

[67] An ecosystem is composed of heterogeneous units, embracing many different spatial and temporal scales, which may cause their interactions difficult to predict [28].

[68] See 〈www.trai.gov.in/TelecomPolicy_ntp99.asp〉.

further obfuscates governance, as his powers would be limited because he would continue to report to the Secretary, MNRE. Third, the rationale of reporting to a council that has no executive powers (i.e., PMCCC), even if it is chaired by the prime minister, is unclear. Instead the SEA could be set up as an agency with a board, as recommended by the 2nd Administrative Reforms Commission. This would provide it with the autonomy needed to function effectively by being able to recruit highly skilled resources. Fourth, the notion of instituting an empowered group – to "de-bottleneck" projects and to authorise modifications to regulations – challenges the very purpose of the group because the success of the programme is contingent on state governments and needs inherent support from the respective Chief Ministers. Further, the fact that state nodal agencies reside under the Ministry of Power at the state level, adds incremental complexity to the bureaucratic and political governance structures. At least if the empowered group was chaired by the Minister of Power at the federal level, ability to align states could be potentially higher, given the working relationship between the Ministry of Power at the central and state level. Finally, the silence on attracting talent from the public and private sectors, such as scientists, economists, engineers, and policy experts is reflective of the perpetuation of strong-walled bureaucracy. In this context, much can be learned from the UK where a similar independent body, the climate change committee, composed of scientists as well as representatives from the business and the public sector, has been advising the UK government since 2008.[69]

It appears that the purpose of establishing the SEA is to insulate but not isolate it from politics as well as from the rotating administrative staff such that it can drive effective policymaking and implementation in the longer term [64]. This is driven by the government's view that solar is a powerful technology with multiple applications (with significant benefits) beyond power generation. Even if this argument is used, SEA's political autonomy is restricted, given that it still comes under the purview of the MNRE. The MNRE already controls IREDA, which has been relatively unsuccessful in meeting its goals, as discussed earlier. Furthermore, it is inexplicable why the Ministry of Science & Technology is not actively referred to in the policy, given its charter of creating, directing and administering the nation's science and technology policy.

Conversely, establishing the SEA outside the bounds of MNRE would result in turf wars with the Ministry and would further complicate the institutional context. If the mission did report directly to the prime minister, as does the Department of Atomic Energy, then the legitimacy of the MNRE would be questioned, and the Ministry of Power is unlikely to welcome such a bold measure as it is now more involved in co-driving the JNNSM. Further, the Mission will need resources and the unstinted support of successive prime ministers.

If eventually India decides to establish the SEA, it could learn from the experience of the US, a worldwide leader in innovation.[70] It should draw lessons from successful efforts by some large U.S. private-sector research institutions and by the national laboratories [64]. These lessons indicate that the institution embodies the five elements of a successful technology innovation organisation: (a) articulating a clearly defined mission; (b) attracting visionary and technically excellent leaders; (c) cultivating an entrepreneurial and competitive culture; (d) instituting a management structure and system that balances independence and accountability; (e) and ensuring stable predictable funding. These lessons also advocate that it adopt four management principles necessary for success: (a) the organisation is insulated from political interference; (b) focuses on the development of its people; (c) benefits from funding at scale; (d) and is meritocratic.[71]

It is worthwhile to note that, based on the initial learning from the program, much of the JNNSM ownership (at least for Phase I) has been transferred to the Ministry of Power (MOP) which could create some alignment between the central and state governments. Yet it does bring into question the efficacy of the MNRE as it is left to drive the implementation of the rooftop and off-grid policies in conjunction with regulatory support from SERCs.

5. Conclusions

Although audacious and timely, the JNNSM suffers from implementation problems testifying to the policy-implementation dichotomy [15]. On the regulatory front, three measures – the RPO, the REC, and FITs – have been introduced to propel market formation. Despite the fact that they are significant milestones for India as its first grid-connected solar power policy was only introduced in January 2008, they are not likely to be as effective as originally hoped for. The enforceability of the RPO, the development of the REC market, inadequate earnings from FITs, and the injection of the protectionist clauses are concerns stemming from problems associated with the political economy. Further the pace of reform at the state level is insufficient. In the realm of R&D, although the policy emphasizes promoting basic R&D, it overlooks a discussion of laws to commercialize technologies that help the process of graduation from invention to innovation and from R&D to development and diffusion.

Disjointed policies continue to prevail; a case in point being the cap of 5% on the on-lending rate for off-grid solar applications that precludes MFIs from participating in the program. Access to securing finance is the most significant barrier. Issues such as easy access to capital, reform of IREDA, site-specific radiation data capture, limited skills and capacity to evaluate solar projects, the institution of the payment security mechanism, and instruments to surmount the financing challenges remain unaddressed by the JNNSM. Finally, the focus on educational and vocational programmes is peripheral suggesting it needs further development.[72]

In summary, despite a high degree of outcome-orientation that all sound policies strive for, the JNNSM does not pay enough attention to the implementation roadmap and the necessary policies and institutions needed to achieve the desired outcome of fast tracking the energy needed for the new industrial revolution. In this context, this paper provides suggestions on high-level approaches/measures that the policymakers could follow to make the implementation of JNNSM more effective. It also raises many research questions that will benefit from more in-depth analysis. We list some of them below:

- How should the JNNSM be funded, given that it is going to be a costly affair, and that there are looming questions about the financial viability of the discoms?
- How could the center ensure that the states comply with and enforce their respective RPOs?
- How should the floor and forbearance prices for RECs be determined such that the twin goals of providing investor certainty and cost-minimization are achieved?
- What is the best mechanism for determining FIT such that the twin goals of required deployment and cost-minimization are achieved?

[69] See 〈http://www.theccc.org.uk/〉 for more information.

[70] See 〈http://www.newsweek.com/2009/11/13/is-america-losing-its-mojo.html〉.

[71] These are based on the lessons from successful efforts by large U.S. private sector research institutions and the national laboratories.

[72] Vocational education and training in Asia: The Handbook on Educational Research in the Asia Pacific Region.

- How can the revenue streams from the REC and FIT mechanisms be made more bankable—so as to be able to attract the required amounts of debt and equity?
- How should the off-grid subsidies be designed so that they maximize diffusion of solar technologies while keeping the subsidy burden low?
- What would be best mechanism for supporting research and development of solar technologies, and what would be the required institutional mechanisms?

We hope to address these (and other open issues) in future research. We also hope that other researchers will focus on the same, and that this paper launches a lot of fruitful follow-up research.

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