NEED TO REALIGN INDIA'S NATIONAL SOLAR MISSION

Ranjit Deshmukh, Ashwin Gambhir and Girish Sant
Prayas Energy Group
March 2010
Submitted to the Economic and Political Weekly Journal for publication

INTRODUCTION

The much-awaited Jawaharlal Nehru National Solar Mission (NSM) was formally launched on January 11th, 2010, setting an ambitious target of 22,000 MW (22 GW) of solar power capacity by 2022. While, solar energy has great potential as a renewable energy source for India, in terms of resource availability, flexibility in scale and applications; it is one of the most expensive renewable energy options today. In announcing the NSM, the Government of India (GoI) has proposed to provide a very large public subsidy to promote solar energy despite its firm international stand that India is neither responsible for the climate crisis nor is it as rich as developed countries to do costly greenhouse gas mitigation. To ensure that this public subsidy optimally contributes towards fulfilling India's primary goal of development, it is essential to clearly outline in-country objectives that would be met by the NSM. Unfortunately, the NSM does not clearly articulate its key objectives and priorities.

Perspective to look at NSM

The NSM is an indicator of shift in energy policy due to resource and climate constraints. As renewable energy gets mainstreamed, we need to take a thorough look at its costs, technology ownership, optimum routes for its promotion, and equity, social, and local environmental issues. On this backdrop, we believe, that the NSM should meet the following objectives, listed according to their priority.

1. Meet the lighting and other livelihood energy needs of India's poor population that has no access to electricity.
2. Encourage indigenous technology development and manufacturing of especially those solar technologies that will establish India as a global leader in technology and help lower the international costs of solar power generation.
3. While meeting objectives 1&2, pursue options for solar capacity procurement that ensure the lowest cost to Indian electricity consumers and tax payers as well as ensure social and local environmental sustainability.

From this perspective, the success of the NSM lies in urgently providing solar lighting systems and off-grid solar power to a third of India's population that is unlikely to have reliable or any access to electricity in the near future. Its success also lies in promoting solar technologies, such as those used for solar thermal power generation that have the potential for indigenous technology development and manufacturing while also contributing to the reduction of global solar power generation costs.

In this article, we discuss the objectives, goals and policy actions of the NSM, and their discrepancies. We then suggest possible pathways to ensure widespread deployment of solar energy in an economically optimal, socially equitable, and environmentally sustainable manner while achieving India's overall development objectives. Through this article, we aim to enhance the public discourse and improve the NSM[1].

OVERVIEW OF THE NSM

The NSM is one of the eight missions under India's National Action Plan on Climate Change (NAPCC) to address climate change mitigation and adaptation. Under the NSM, a total target of 22 GW of installed solar capacity by 2022 has been set, with individual targets for grid-connected and off-grid solar electricity generation, solar lighting systems and solar thermal collectors. Some of these targets are contingent on availability of international funding under a possible climate deal.

Unfortunately, there have been several shortcomings in the evolution of the NSM. Despite assurances of a public process on all missions of NAPCC, the process of arriving at the NSM was non-transparent and non-participatory. No public consultation was held on the NSM. As mentioned earlier, the most important lacuna of the NSM is the lack of prioritisation or even a clear articulation of the objectives of the NSM, against which its actions can be judged. Moreover, the document fails to provide a concrete plan to achieve its stated targets.

Critique of objectives of the NSM

The main objective as stated in the NSM document[2] is "*to establish India as a global leader in solar energy, by creating the policy conditions for its diffusion across the country as quickly as possible.*" However, it is unclear what is meant by being a global leader, whether it is in terms of installed solar capacity, manufacturing capacity, R&D and innovation in solar energy technologies, or deployment of solar lighting systems and off-grid solar electricity generation plants.

The objective of "*creating conditions, through rapid scale-up of capacity and technological innovation to drive down costs towards grid parity*" raises the question whether India should pay for driving down cost of solar energy rather than developed countries, which are mostly responsible for historical carbon emissions. If it should, then it begs the question of which sections of Indian population should pay and to what extent. The goal of providing energy services with little or no environmental impact can be better achieved through energy efficiency measures and less expensive renewable energy generation options, the potential of which is far from being fully realized in India. Developing solar energy generation capacity *"from the perspective of energy security*" seems counterintuitive today since the addition of high cost solar power in the system will actually deprive addition of much larger quantity of low cost power and exacerbate the existing shortages, unless consumer tariff is increased. "*Promoting off-grid systems to serve populations without access to commercial energy*" is a noble objective and if implemented properly, can set a model for energy service delivery for two billion poor people in the world. But the low targets, limited subsidies, and lack of a concrete plan indicate that this objective has received low priority.

Targets set by NSM

The NSM has set several targets along with a time line. By the end of the XIIIth plan in year 2022, it aims to achieve (a) 20 GW of grid-connected installed solar capacity, comprising of large PV and solar thermal power plants and smaller rooftop PV systems, (b) 2 GW of off-grid distributed solar plants, (c) 20 million sq. meters of solar collectors for low temperature applications, and (d) 20 million solar lighting systems for rural areas. The NSM has two additional goals; (a) promote R&D, public domain information, and develop trained human resource for the solar industry, and (b) expand the scope and coverage of earlier incentives for industries to set up PV manufacturing in India.

The phase-wise and annual targets set by the NSM along with the existing installed capacities and systems till 2009 as provided by the Ministry of New and Renewable Energy (MNRE) are given in Table 1. The GoI has sanctioned targets for Phase I, while the targets for Phase II and III are indicative – to be fixed based on Phase I achievements, decline in solar energy prices and availability of international finance.

Table 1: Phase-wise and total targets of National Solar Mission

	MNRE till 2009[3]	Phase I 2010-2013	Phase II 2013-2017	Phase III 2017-2022	Total
Grid-connected solar (MW)	6	1,100* (331)	3,000 (750)	16,000 (3,200)	20,000
Off-grid solar (MW)	2.4	200 (66)	800 (200)	1,000 (200)	2,000
Solar thermal collectors (million m^2)	3.1	7 (1.3)	8 (2)	5 (1)	20
Solar lighting systems (million)	1.3**	no phase-wise targets (1.6)			20***

Note: Figures in parentheses indicate the implicit annual targets in each phase, assuming that MNRE achievements to date are a part of the NSM targets.
* The NSM document mentions a target of 1000 to 2000 MW for Phase I.
** Solar lighting systems to date include solar lanterns and solar home lighting systems.
*** Phase-wise targets are yet to be provided.

A comparison of these targets with the present installed capacities provides good insights. Achieving the grid-connected and off-grid solar capacity targets will be an enormous challenge given that even annual targets of NSM are several times more than the total installed capacity till 2009. The target of 20 million for solar lighting systems, though well short of the need, is an ambitious target when compared to the total number of systems installed to date. This translates to providing 4250 systems every day till 2022. The annual targets for solar thermal collectors in Phase III are lower than those in Phase I and II, where one would expect them to increase with every phase. Also, the total target for solar thermal collectors at the end of the XIIIth plan has been reduced to 20 million m^2 from the initial target of 30 million m^2 set by the MNRE in its XIth plan proposal.[4] Solar thermal collectors are a proven technology and are commercially available as mentioned in the NSM. Given that the overall potential for solar thermal collectors in the country is 140 million m^2, the rationale for reducing their targets in the later years of the NSM is not clear.[5]

Estimation of subsidy for the NSM

The earlier leaked drafts of the NSM document had a target of achieving 20 GW of solar capacity by 2020 and estimated that it would cost Rs 90,000 crore.[6] However, the final mission document removed any mention of financial support needed for the NSM. Here, we attempt to estimate the amount of public subsidy that has been committed under the NSM so far, roughly representing the Phase I targets. This subsidy includes direct subsidy from the budget and the subsidy that would be paid directly by electricity consumers via high tariff for electricity. The summary of the subsidy estimates is provided in Table 2.

The GoI has already committed to three major aspects of the NSM; the 1100 MW grid-connected solar plants, the Special Incentive Package Scheme (SIPS) for PV manufacturing units, and some form of capital and interest subsidy for solar home lighting systems and off-grid solar applications.

a) Of the 1100 MW of grid-connected solar target, 1000 MW will be connected at 33kV or above. This electricity will be procured at the Central Electricity Regulatory Commission (CERC) set feed-in tariffs of Rs 15.3 and 17.9 per kWh for solar thermal and solar PV respectively for 25 years[7]. The total excess tariff over 25 years, above the cost of alternative power from coal or gas (considered at Rs 4 per kWh) would be approximately Rs **57,000** crore. This considers a 60:40 split between thermal and PV plants, as proposed by NTPC during Solar Conclave (10th Jan 2010 Delhi). The Net Present Value (NPV) of this excess tariff, discounted at 10% works out to be Rs **21,000** crore (this translates to a subsidy of Rs 21 crore per MW for both thermal and PV capacity). This additional cost will be borne by electricity consumers through higher retail tariffs.

b) The remaining 100 MW of grid-connected solar capacity will be connected at below 33kV, and would mostly consist of rooftop PV. In this scheme, the additional burden over the grid power (considered as Rs 17.9 per kWh less the base price of Rs 5.5 per kWh escalating at 3% per annum) will be provided by the MNRE in the form of a Generation Based Incentive (GBI). This public subsidy over 25 years will be approximately Rs **4,100** crore and will come from budgetary allocation. It has a NPV of approximately Rs **1,700** crore.

c) A 30% capital subsidy will be provided for off-grid solar plants and other applications. In remote areas the subsidy will be 90%. Using the CEA estimate for the capital cost, the off-grid PV plants would cost about Rs 23 crore/MW.[8] Assuming a weighted average of subsidy at 50%, the subsidy works out to be Rs 11.5 crore/MW. Hence, the total capital subsidy for the 200 MW plants will be approximately Rs **2,300** crore.

d) The NSM proposes to provide solar lighting systems under the ongoing remote village electrification program of the MNRE to cover about 10,000 villages and hamlets. Taking a conservatively high average number of 100-200 households per village, 1-2 million systems would be required. Assuming an 18 W system at Rs 6,000 per system and that all systems will be provided 90% capital subsidy for being distributed in remote settlements, the total subsidy amounts to Rs **500 to 1000** crore. The rest of the solar lighting systems will be dissipated through market mechanisms and provided interest subsidy in the form of low interest loans.

e) Finally, under the SIPS scheme, the Department of Information Technology (IT) is providing a 20 to 25% capital subsidy for solar PV manufacturers to set up manufacturing plants in India.[9] The Department of IT has provided in principle clearance to 13 PV manufacturing proposals with a total investment of Rs 79,000 crore.[10] Hence, the capital subsidy under this scheme is estimated to be between Rs **16,000 to 20,000** crore, which will be provided directly through the central budget over the next ten years. Assuming uniform disbursement over ten years the NPV of the subsidy works out to be **Rs 10,000 to 12,000** crore.

Table 2: Summary of committed subsidy estimates under the National Solar Mission

	NSM component	Subsidy source	Capacity	Amount (Rs crore) Not discounted	Amount (Rs crore) NPV at 10%
1	Utility scale grid-connected solar (=> 33 kV)	Electricity consumers	1000 MW	57,000	21,000
2	Small Grid-connected solar (< 33 kV) Generation Based Incentive	Budget	100 MW	4,100	1,700
3	Off-grid solar plants (30-90% capital subsidy)	Budget	200 MW	2,300	1,900
4	Solar lighting systems (1 to 2 million lighting systems)	Budget	1-2 million	500 to 1,000	450 to 900
5	Special Incentive Package Scheme PV manufacturing capital subsidy	Budget		16,000 to 20,000	10,000 to 12,000
	Total			~ 82,000	~ 36,000

In addition to these direct subsidies, other indirect incentives are being provided such as low interest loans, as well as exemption of custom and excise duties on certain capital equipment, materials and components. We have not quantified these. The recently announced budgetary support of Rs **4,337** crore[11] for MNRE, might be used for rooftop solar, solar lighting systems, off-grid solar plants as well as for R&D and other initiatives under the NSM.

The subsidy already committed for the Phase I of NSM seems to be in the range of **Rs 82,000 crore** – a NPV of **Rs 36,000 crore,** with over a half coming from higher consumer tariffs and the rest from budgetary allocation. The NSM document quotes:

> *"The Mission strategy has kept in mind the two fold objectives, to scale-up deployment of solar energy and to do this keeping in mind the financial constraints and affordability challenge in a country where large numbers of people still have no access to basic power and are poor and unable to pay for high cost solutions."*

However, above analysis shows that only 7% of the committed subsidy is for rural and poor, in terms of off-grid solar plants and lighting systems. Hence, the NSM's stated intention about giving priority to the poor is not reflected in its actions.

In the next part of the article, we discuss the need for prioritising solar lighting systems and off-grid solutions, and the policy actions that should be urgently taken. Subsequently, we discuss the mechanisms being adopted under the NSM to promote grid-connected solar power generation and suggest pathways to promote solar technologies with indigenisation potential, lower solar electricity procurement costs and ensure social and local environmental sustainability.

SOLAR LIGHTING AND OFF-GRID SOLUTIONS

Need for solar lighting and off-grid solar systems

Solar lighting systems and kW scale off-grid solar systems can make a tremendous difference in the lives of the rural poor that have little or no access to electricity. Today, solar PV based lighting solutions (lanterns and home lighting systems) offer a cost-effective solution to quickly provide better quality lighting services to this population. Solar off-grid systems can provide lighting and power to Primary Health Centres, schools, drinking water systems, and for small income generating activities, significantly improving the quality of life in rural areas. Here, we will focus on solar lighting systems.

A significant section of the Indian population, comprising mostly of the poor, is still forced to rely on kerosene for lighting needs. According to the 63rd round report of the National Sample Survey Organization on the Household Consumer Expenditure in India (2006-07), 42.3% and 6.4% of Indian rural and urban households respectively still use kerosene as a primary source for lighting. This translates to a staggering 72 million households or 34 crore people (more than the entire population of USA).[12] Kerosene fumes are a serious health hazard, one of the contributing factors to child mortality (Smith & Mehta 2003). These households, most of which are below the poverty line, have to spend their limited cash to purchase kerosene, at times through the black market, forgoing some of their other basic needs.

Assuming an annual consumption of 50 litres per household (Mills 2005, Chaurey & Kandpal 2009), 72 million households use approximately 3600 million litres of kerosene. Replacing kerosene-based lighting with solar lighting systems will have enormous social benefits in terms of:

a) annual savings of Rs 3,600 crore for the poor[13]
b) avoiding Rs 9,300 crore in annual budgetary subsidy and the claimed under-recoveries[14] for Public Distribution System (PDS) kerosene[15]
c) avoiding 10 million tons of CO_2 emissions annually, which in theory can be worth Rs 900 crore per year in carbon credits (assuming a carbon credit rate of USD 20 per Certified Emission Reduction).[16]

NSM approach to solar lighting systems

Given the compelling need for prioritising basic lighting for the poor, it is unfortunate that the NSM only targets distribution of 20 million solar lighting systems by 2022. The target is much lower than the 72 million households that use kerosene today. In spite of the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), it is likely that most of these rural households will have little or no access to electricity in the near future, considering the supply shortage and poor state of rural distribution system. Moreover, the NSM also lacks detailing of the financial requirements and a roadmap for achieving even its limited goal.

Considering the cumulative achievements for solar lighting systems till date (0.5 million SHLS and 0.7 million solar lanterns), it is evident that a paradigm shift is needed to provide solar lighting to all this population in near future. Unfortunately, the NSM totally fails to address this. In Phase I, the NSM is planning to reply on continuation of MNRE's remote village electrification scheme, with a target of covering 10,000 villages and hamlets (approximately 1 to 2 million systems). Without a detailed roadmap, it seems the NSM is planning to rely solely on market mechanisms to achieve its stated target of 20 million by end of Phase III.

Recommendations for solar lighting and off-grid solar systems

The benefits of rapid roll out of PV based solar lighting systems for the poor are far too compelling from a social, economic, as well as ethical perspective. The NSM should substantially change its priorities with respect to solar lighting and off-grid solutions.

Rapid Dissemination of Solar Lanterns through innovative mechanisms

Although solar PV lanterns offer very basic lighting, they can be disseminated very quickly and are a good alternative to the ubiquitous kerosene lamps. The NSM should promote solar lanterns as a stopgap solution for those without access to electricity, till other solutions such as grid electricity, off-grid distributed power or larger home lighting systems are provided.

The solar lighting program should promote lanterns based on White Light Emitting Diode (WLED) due to their higher efficiency and longer life compared to CFL based lanterns. They are also cheaper due to smaller battery and PV panels. The solar lighting program should also use stringent qualifying criteria for systems and manufacturers, with emphasis on testing, quality assurance, multi-year warranty, built-in O&M contracts and after sales service.

These lanterns should be given to all houses without an electricity connection. Even the houses that are likely to be connected (but are yet to get electricity connection) should also be given these lanterns because getting grid connection and having reliable power supply is going to take time, while PV lanterns would give immediate benefits and would be useful as emergency lamps later. Robust and reliable solar lanterns will prove to be a valuable asset to the seven percent of Indian population that is nomadic (Nanjunda et al 2007). This population is roughly equal to the entire population of Germany.

Good quality solar lanterns, with replacement guarantee for a reasonable period, should be available at Rs 400 per lantern if purchased in bulk quantities[17]. Even a 100% subsidy for all the 72 million households implies a cost of Rs 3,000 crore, which is only about 8% of the subsidy already committed for the NSM. The cost of lanterns is barely a fifth of annual societal cost and more importantly less than direct annual cost born by the poor even in buying subsidized kerosene.

One promising approach is to distribute lanterns to all eligible households that come for registration under National Unique Identification (UID) scheme. The UID mechanism is being designed to "*transform the delivery of social welfare programs by making them more inclusive of communities now cut off from such benefits due to their lack of identification*."[18] The UID Authority of India (UIDAI) has stated that enrolment for the UID will not be mandatory and will be demand driven. However, the UIDAI intends to have an enrolment strategy with a pro-poor/ pro-rural approach and a focus on poor and hard to reach groups. Providing solar lanterns would incentivize the poor to come forward for registration under the UID and would be an ideal demonstration of improved delivery of energy subsidies – the said logic of the UID. Other option is to offer lanterns to all poor households through PDS system.

Redesigning promotion of Home Lighting Systems

Solar Home Lighting Systems (SHLS) typically 50 to 80 W, support multiple lights and also small loads like a TV or fan. These and larger systems can be a long-term solution for houses in remote areas where grid extension is not feasible. Presently a 90% capital subsidy is provided for SHLS to households in remote areas. The NSM should redesign the program to rapidly expand the coverage to all needy households. The NSM should develop a comprehensive program for promotion of SHLS consisting of (a) low interest loans to manufacturers and buyers, through the rural financial institutions by allowing it to be defined as 'Priority Sector Lending', (b) accreditation of manufacturers and service providers to ensure quality after sales service and avoid proliferation of substandard systems.

The NSM should draw lessons from major PV lighting projects in the world (Lumina, Lighting Africa, Lighting a Billion Lives etc)[19], and pursue a participatory process with all the important stakeholders including concerned civil society groups. A special cell guided by a high level committee should be assigned the task of drawing lessons, carrying out public consultations, and laying out an implementation road map in a time bound manner.

Funding lanterns and home lighting systems

Given the large potential for carbon mitigation, there is a good case for international financial support for this program under NAMA (Nationally Appropriate Mitigation Action) or through carbon credits. However, considering the enormous national saving, social and environmental benefits, it will be a big mistake to make the poor wait for uncertain international support while domestic resources are used predominantly for grid-connected systems. Hence, NSM should use domestic subsidy for this urgent social need.

GRID-CONNECTED LARGE SOLAR POWER PLANTS

The largest component of the NSM is the 20 GW target of grid-connected solar electricity capacity, which will mainly come from utility scale grid-connected large solar power plants (hereon referred to as large solar plants).

Objectives for large solar plants

Being the largest component of NSM that will require the highest share of subsidy, it is essential to ensure that it meets the three basic objectives.

1. Develop and promote those solar technologies that provide an advantage through indigenous manufacturing and technology development while also significantly contributing towards lowering global solar power generation costs,
2. Minimize cost to consumers, and
3. Ensure social and local environmental sustainability.

We examine the NSM goals and policy mechanisms to promote large solar plants from the perspective of these three objectives.

NSM approach to large solar plants

The demand for grid-connected solar electricity will be driven using the regulatory process. The State Electricity Regulatory Commissions (SERC) are expected to set solar specific Renewable Power Purchase Obligations (RPO) that will mandate distribution companies to procure a set amount of solar electricity as a percentage of their overall electricity purchase. The utilities, in turn, will pass the financial burden of the high cost solar power on to their consumers.

Although state utilities are free to procure solar electricity through competitive bidding or at feed-in tariff specified by their respective SERC; for Phase I, the NSM has devised a mechanism that makes this unlikely. Under this mechanism of NSM, the trading arm of National Thermal Power Corporation (NTPC), called NTPC Vidyut Vyapar Nigam Ltd. (NVVN) will procure the first 1000 MW of solar electricity at the CERC set feed-in tariffs. The NVVN intends to procure 600 MW of solar thermal and 400 MW of PV plants. The NVVN will then bundle this solar electricity with electricity from 1000 MW of unallocated NTPC coal plants and sell it to the state utilities to fulfil their solar RPOs. To better utilize the areas with high solar radiation and overcome existing open access issues, states will be allowed to purchase solar electricity from solar power companies situated in other states via solar specific Renewable Energy Certificates (REC).

Technologies to promote – Solar thermal v/s PV

The principle objective of promoting grid-connected solar in India should be to promote indigenous manufacturing and technology development, while also contributing towards lowering global power generation costs; and not just rapid solar capacity addition to mitigate greenhouse gases, which can be better achieved through energy efficiency and other less expensive renewable energy generation options. From this perspective, building PV based large plants by providing high tariffs is beneficial only if the demand it generates results in reducing the cost of PV. However, the annual global PV market is expected to reach 20 GW by 2010.[20] The relatively small demand of 400 MW of PV over the three years of Phase I is not likely to make a big dent in global PV demand. Besides, PV costs are expected to decline significantly in coming years due to international demand and technology improvements (Bank Sarasin 2009). As far as providing incentives to domestic PV manufacturers is concerned, the Department of Information Technology under the SIPS scheme has already committed to providing about Rs 11,000 crore capital subsidy (NPV) for setting up manufacturing units in India, without any export controls. Hence, while solar PV costs are high, India need not build large solar PV plants just to drive demand. As discussed before, accelerating PV based lighting and off grid plants can be the Indian contribution to stimulate PV demand.

On the other hand, the cost of generation for solar thermal is lower than PV, as also seen in the tariffs set by CERC. Solar thermal plants have several advantages. The option of thermal storage can generate electricity during the evening peak, thus providing a promising solution for base load and dispatchable power. Indian engineering and manufacturing firms can leverage their existing expertise in cost optimisation and conventional steam-based electricity generation to lower cost of solar thermal plants. Besides, the total global installed capacity of solar thermal plants was less than 1 GW at the end of 2009[21]. Demand for solar thermal plants in India (which could be as much as 1 GW during Phase I) will lead to a significant contribution to global demand. This will also give a clear signal of large capacity addition and will encourage solar thermal companies to set up manufacturing bases in India.

In Phase I, of the 1000 MW capacity target, 90% should be used to promote solar thermal technology because of its cost advantage, thermal storage and indigenisation potential. Recognising the need to encourage diversity, the remaining 100 MW should be used to promote emerging solar PV technologies such as concentrating PV.

Economics – Finding the appropriate tariff

MNRE, States and CERC tariffs

Over the last few years, various schemes for utility scale solar generation were initiated. In 2007, MNRE announced its generation based incentive (GBI) scheme for deploying 50 MW solar capacity. It assumed maximum tariffs of Rs 13 and 15 per kWh for solar thermal and PV respectively.[22] In 2009, the Gujarat government, under its Solar Power Policy, offered even lower feed-in tariffs (along with the benefit of accelerated depreciation) for solar thermal and PV electricity. Several SERCs have also announced feed-in tariffs for solar electricity. The Rajasthan Electricity

Regulatory Commission (RERC) issued an order in 2008 to fix the feed-in tariff at Rs 13.2 and 15.2 per kWh for solar thermal and PV projects respectively.[23]

The details of these schemes are provided in Table 3. All these schemes received overwhelming responses. The MNRE and Gujarat government schemes received proposals several times more than the capacity caps that they had set, indicating that the tariff set by them were acceptable to the solar promoters.

Table 3: Different Solar tariffs and response for solar PV and thermal.

	PV tariff (Rs/kWh)	Solar thermal tariff (Rs/kWh)	Ceiling capacity (MW)	Proposals received (MW)	Projects Allotted (MW)
MNRE 2007 (10 year tariff)	15	13	50	2000 [24]	29 [25]
Gujarat Solar Policy 2009 (12 & 13 year tariff) [26]	13 & 3 (till Dec 2010) 12 & 3 (till Dec 2014)	10 & 3 9 & 3	500	5312 [27]	716 [28]
Rajasthan ERC 2009 (10 year tariff)	15.8 (till Dec 2010) 15.2 (Jan-March 2010)	13.8 13.2	-	3392 [29]	66
CERC 2009 (25 year tariff)	18.4 (2009-10) 17.9 (2010-12)	13.5 15.3			

After these three schemes, CERC announced feed-in tariffs in 2009 for projects that would be commissioned during 2009-10 (Rs 13.5 and 18.4 per kWh for solar thermal and solar PV respectively for 25 years).[30] Further, CERC revised the tariffs to Rs 15.3 and Rs 17.9 per kWh for projects to be commissioned during the next two years – 2010-12.[31] According to the National Tariff Policy, CERC should provide guidelines, as reference for the SERCs to set their own tariffs, in case competitive bidding is not done for renewable energy sources. However, in this case, CERC tariffs assume extra significance since the NVVN intends to procure 1000 MW of solar electricity at these tariffs.

Solar power generation costs, especially for solar PV, have been dropping significantly over the last few years. However, rather than lowering the feed-in tariffs, CERC announced higher tariffs than the previous schemes, as seen from Table 3. Moreover, CERC fixed the tariffs for not just one but the next two years. This could be justified for solar thermal projects, which may have gestation periods of two years but not for solar PV with its project gestation periods of less than a year. Further, capital costs of solar PV have been assumed almost constant at ~17 crore per MW from 2009-12 despite its rapidly declining costs (Figure 1 shows a module price reduction of 30% for crystalline Si and 24% for thin films over 2009-12). As indicated in Table 3, the previous schemes had received overwhelming responses in the form of 10.7 GW of proposals, in spite of their lower tariffs, which indicates that CERC tariffs are higher than required.

Even the Gujarat Electricity Regulatory Commission's (GERC) 2010 order offered lower tariffs for solar electricity (Rs 9.3 and Rs 12.5 per kWh plus the benefit of accelerated depreciation).[32] While GERC has adopted similar capital cost norms as CERC (mainly for PV), it has assumed lower interest on loans, return on equity and discount rate, and a slightly higher plant load factor. If NVVN were to acquire the first 1000 MW of solar capacity at GERC tariffs instead of CERC tariffs (compensating for accelerated depreciation benefit)[33], then Rs 5,400 crore would be saved (discounted at 10% over 25 yrs). This amount can be used to increase grid-connected solar capacity by 20 to 30 percent or used to distribute a lantern free of cost to 72 million households two times over!

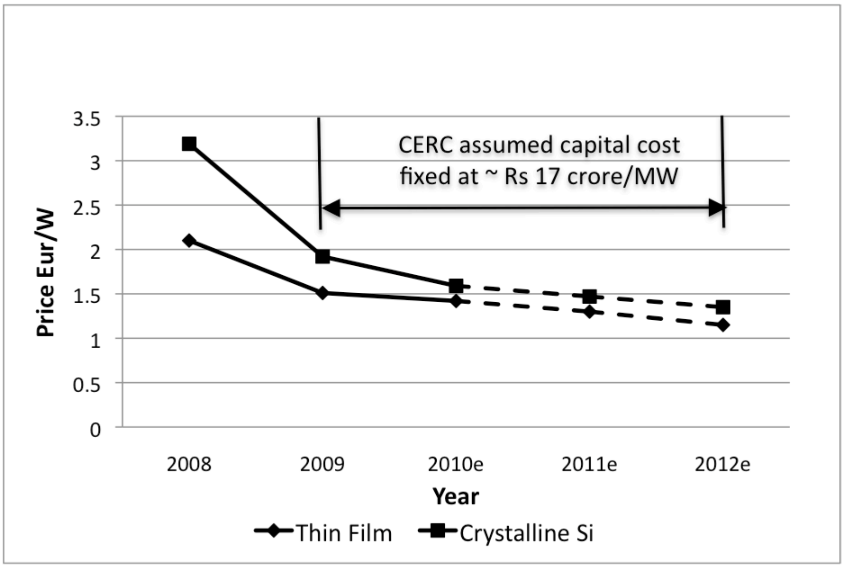

Figure 1: Declining price per watt for solar PV (Bank Sarasin 2009). ('e' indicates estimated)

Migration policy to offer CERC tariff

The MNRE has formulated a "*migration scheme*", which allows projects that have acquired land and have signed Power Purchase Agreements (PPA), or have filed petition with their respective SERCs, to "*migrate*" under the NSM scheme i.e. sell their electricity to NVVN and avail the higher CERC tariff.[34] A total of 811 MW of solar capacity (29 MW by MNRE, 66 MW by Rajasthan and 716 MW by Gujarat government) had been approved and sanctioned prior to the NSM being announced. This capacity, which is in the pipeline, is close to the NSM's Phase I target of 1000 MW. All these projects and some more from other states could potentially "*migrate*", thus getting more favourable contracts than what the promoters had agreed to. The MNRE does not offer any rationale why change of contract to a higher tariff is deemed to be necessary. The urgency in executing this scheme (projects to be submitted within 45 days of scheme announcement, and MoUs signed within a month after that)[35] also seems unjustified. Such migration ensures a creditworthy buyer for solar promoters, namely NVVN, while making consumers pay more.

Feed-in tariffs vs competitive bidding

Due to the differences in the various solar thermal and PV technologies, their development stages and their suitability in Indian conditions, it is difficult to predict their cost and subsequently, define an appropriate feed-in tariff. Assuming a low cost of generation and hence offering a low feed-in tariff might not attract industry. On the other hand, assuming a high cost of generation and subsequently a high feed-in tariff will result in attracting too many projects and doling out excessive public subsidies.

Hence, there are two approaches for price discovery of large solar plants. In the price-based approach, utilities are mandated to buy all the solar electricity at a fixed feed-in tariff. There is no ceiling on installed capacity and the feed-in tariffs are revised based on the response and falling costs of generation. The second approach is quantity-based, where a capacity ceiling or quota is fixed and met through a competitive bidding process. However, under the NSM, both the price (CERC feed-in tariffs) and quantity (1000 MW for Phase I to be procured by NVVN) are fixed. Given the large response to the previous MNRE and state schemes that offered lower tariffs, the project proposals under the NSM are expected to cross the Phase I capacity target. Without transparent and objective selection criteria, the NSM runs the risk of facing complications in project selection, leading to possibility of favouritism, resistance, and potential delays (as seen in the Independent Power Producer era).

The mechanism of feed-in tariff without a capacity ceiling has been successful in countries like Germany, mainly due to strict degression rates (year on year tariff reduction for new projects based on previous capacity addition and present cost realities) for the feed-in tariffs based on extensive factual data of project costs. However, the lack of a fixed capacity ceiling exposes consumers to excessive financial burden in the event of a big response to the offered feed-in tariffs. This is especially true in the case of India, where there is a lack of adequate cost of generation data in the public domain. On the other hand, an appropriately designed tariff-based competitive bidding, with a ceiling tariff, would find the lowest possible tariff. This process will ensure the lowest cost to consumers, and avoid controversies and delays in project allocation. Technical capability and financial soundness as preconditions will ensure that only serious bids are considered. Such an approach is being followed by many utilities in the US.

It is essential to note here that there are several different solar thermal technologies under development, with varying potential for indigenous manufacturing and long term cost reduction. A purely price based competitive bidding would benefit only a few technologies while excluding others that are in the initial stages of development. Hence, a technology-wise competitive bidding could be adopted to encourage multiple solar thermal technologies.

Procurement options

NTPC bundling

During Phase I, the NSM proposes to bundle solar power with the cheaper unallocated generation from NTPC's old coal stations. For each MW of solar capacity signed by NVVN, the Ministry of Power (MoP) shall allocate an equivalent MW of capacity from the unallocated quota of NTPC stations. Hence, during Phase I, 1000 MW of solar capacity will be clubbed with 1000 MW of NTPC coal plants. The NVVN is planning to buy solar power at the CERC determined tariff. The bundled power will then be sold to state distribution utilities at the average price. The NSM argues that this mechanism would "*minimize the impact on tariff*".

Assuming plant load factors (PLF) and tariffs specified in CERC norms for solar thermal and PV[36], a 60:40 mix of thermal and PV power, 1.9 billion units of solar power will be bundled with 7.9 billion units of NTPC power (assumed tariff of Rs 2.00 per kWh, PLF of 91%), and will result in a pooled tariff of Rs 4.7 per kWh.

This cost is more than twice the original cost of NTPC unallocated power. Hence, this mechanism will not avoid high cost of solar, as argued in NSM document.

The original rationale for the unallocated quota of NTPC Central stations was to provide low cost dependable power for emergency purposes. Due to power shortages in the country, the unallocated NTPC power will always be in demand. It could have been used for several objectives such as removing load shedding in the most backward areas, or ensuring reliable supply in some of the rural areas. This low cost power could have been used to incentivise state utilities that sign long term PPAs with proper demand supply projections, or incentivise T&D loss reduction. It is noteworthy that GoI has chosen not to do any of this but has used it to promote the highest cost renewable energy option.

Bundling this power with solar electricity helps solar promoters find a bankable centralized buyer without having to wait for the SERCs and state utilities to act. But simultaneously it also gives eminence to the much higher CERC solar tariffs over the lower tariffs set by other agencies.

Solar specific Renewable Power Purchase Obligations

The demand for grid-connected solar electricity will be driven by solar specific RPOs. The RPOs for each state are to be set by their respective SERCs. The NSM proposes to modify the National Tariff Policy 2006 to mandate SERCs to set solar specific and non-solar specific RPOs.

However, different states are at different stages of economic development. A uniform RPO mandated for all the states, as a percentage of their respective total electricity purchase, will put excessive financial burden on states that are poor. For example, Maharashtra industrial and commercial electricity consumption is 32 times greater but its overall electricity consumption is only 17 times more than that of Bihar[37]. Since share of high tariff consumption (industrial and commercial) is large, Maharashtra utility should be able to better afford high solar RPO than that of Bihar. Hence, if RPOs are to be set, then they should be set according to industrial and commercial rather than overall electricity consumption.

In fact, if Electricity Act or Tariff Policy is to be amended, then it is worth considering a RPO in financial terms rather than in electricity terms. Under such scheme, all consumers would pay a predefined percentage of tariff for promoting renewable energy.

Solar specific Renewable Energy Certificates

Other than selling their electricity at fixed preferential feed-in tariffs to distribution companies, solar power generators have an additional option under the NSM. Solar generators can sell their electricity to the home state and separately sell the environmental attributes associated with renewable energy, in the form of solar specific RECs, to any utility or obligated entity. According to the CERC regulations, the electricity sale to the distribution company in the home state, where the project is developed, will be at the average cost of power purchase by the distribution company.[38] In addition, the solar power generators can sell their RECs (1 REC is equivalent to 1 MWh of electricity) on a Power Exchange to any distribution company or entity to fulfil their RPO obligation. The RECs will be valid only for one year and the CERC will determine the band of a floor and a ceiling price for the RECs, which will be periodically reviewed. This mechanism allows state utilities to purchase solar RECs from generators in other states with a better solar resource and thus address the issue of disparity in solar potential across different states.

However, unlike the PPAs that assure a fixed feed-in tariff for 25 years, this mechanism does not guarantee price for the solar power generators over the life of the project. Solar plants being set up today, will require today's high prices over the life of their projects in order to be financially viable. But the plants that are set up in the future, at lower cost, can make do with lower REC prices. Hence, this will result in an unacceptable risk to solar generators and the REC mechanism will not take off. Other possibility is equally problematic. If REC mechanism does take off, then REC price will not come down with falling cost of solar technologies, because older generators will determine prices. In this scenario consumers will be forced to pay high cost for next 25 years, while actual costs come down. The large benefit of cost reduction will be passed on to generators and not consumers. Hence, this whole mechanism needs to be reviewed.

Social and environmental issues

Although solar electricity is renewable, it can generate considerable social and local environmental conflicts if ill planned. With 5-10 acres required per megawatt (NEEDS 2005, NEEDS 2008), solar power is one of the most land intensive electricity generation options. An appropriately designed land use policy will minimise land conflicts, such as those seen in large infrastructure projects.

High water usage, mainly for condensing the steam is a major concern for solar thermal technology, especially since it will be deployed in arid and desert areas. However, dry air-cooled condensing plants can substantially reduce the water usage with some cost increases.[39] Dry condensing plants should be a pre-requisite for large solar thermal plants being set up in water-starved areas.

In order to ensure social and environmental sustainability, normative water and land use standards should be declared. This will prevent excessive land acquisition by project developers and ensure minimum water usage. In fact, land leasing should be made mandatory for utility scale solar power plants in order to provide an equitable solution to the original landowners. A programmatic Environment Impact Assessment and Land Use Plan should be made mandatory for all solar projects. This will delineate areas where solar projects can and cannot be developed taking into consideration all social and environmental aspects. Such an exercise is being currently done for the Western States in USA.[40]

Phase I should be used to map solar resources in detail, and GoI should develop "Solar Parks" (as mentioned in the NSM document) in high solar resource locations with adequate water availability. Providing access to land and water, in addition to power evacuation and environment clearances, will not only ensure social and environmental sustainability but also reduce project developers' risks leading to lower tariffs, effective bidding, and rapid project development.

GRID-CONNECTED ROOFTOP SOLAR PHOTOVOLTAIC

Rationale for rooftop PV

Historically rooftop PV systems have been promoted in countries with high residential electricity tariffs like Germany, Japan and USA etc, mainly as a means of driving demand for PV, in order to bring down costs of PV. However an Indian rooftop PV program, at this stage in the global PV development curve, will not create a significant demand for solar PV, since the biggest demand will be generated by the international markets, utility scale power plants and off-grid plants. Hence the objective to promote rooftop PV in India, which is not clearly outlined in the NSM needs further debate and clarification.

NSM approach to rooftop PV

The NSM has set a target of 100 MW of grid connected solar power which will be connected to the grid below 33 kV, which is most likely to come from rooftop PV systems. According to the NSM, rooftop PV systems will be eligible to receive the CERC fixed feed-in tariff, both on solar power consumed by the operator and that fed into the grid i.e. all the solar power generated by the system. A generation-based incentive (GBI) will be paid to the utility by MNRE to cover the difference between the solar tariff determined by CERC, less the base price of Rs 5.5 per kWh with 3% annual escalation. The New Delhi Power Limited has already proposed a rooftop PV program with a target of 50 MW for 10,000 customers.[41]

Limit rooftop PV to a pilot program

Rooftop PV systems are quick to deploy and can be installed on already existing roof spaces. They also provide small project developers to enter the market. Rooftop PV systems are argued to have the potential to reduce transmission and distribution losses due to on-site electricity generation and reduce the need for long transmission lines from central power stations. However, analysis of the actual installation of PV systems in California suggests that it has not significantly reduced the cost of transmission and distribution infrastructure (Borenstein 2008). Electricity from decentralized rooftop PV systems is also more expensive than utility scale solar PV projects. Since each rooftop system is a separate project, labour, transaction and implementation costs are seen to be high. In addition, these systems will not be installed in the most optimum solar insolation sites. The economics for rooftop solar worsens if there is a high frequency of grid outages (which is the case in many places in India), which necessitates the need for battery storage.

In addition, the argument as stated in the NSM that rooftop PV systems on commercial buildings would avoid the use of diesel generators does not hold to a large extend. If these systems were to replace diesel generators, they will need battery storage, which will increase their capital costs. On the other hand, if there is no load shedding, there is no use for diesel generators and rooftop PV systems will not displace diesel. In case, they actually save diesel use in DG sets, used by affording consumers, then there is no need for public subsidy.

International experience also indicates that the mechanisms to promote rooftop PV need to be devised carefully. Spain provided excessive tariffs during the first two years of its rooftop PV program, and when the tariffs were revised, there was a bust in the Spanish solar market. California, which started its net metering program in 1995, is presently re-examining costs of net metering to ratepayers and the state.[42] Hence time may not be right for large-scale rooftop PV deployment in India.

To evaluate performance of rooftop PV and work out the options for rooftop PV in India, a small pilot program should be set up in a high insolation and high tariff location. The systems in the pilot program should be monitored for their performance and total onsite electricity consumption, and check if the logic of reduced diesel consumption and cost savings is achieved without excessive subsidy burden on general public. Commercial consumers with Time of Day metering and high tariffs will have an incentive to install rooftop PV systems even with a low feed-in tariff. Hence incentive should be much lower for these systems.

A more equitable and better approach to promote rooftop PV is to mandate large commercial consumers to either buy solar electricity or generate it through rooftop PV, equivalent to their consumption above the consumption represented by efficient building standards. This will also help promote energy efficiency in buildings with large energy use. This should be a part of Electricity Act amendments.

CONCLUSION

The NSM is a departure from the past, as India start to mainstream climate considerations in energy planning, and allocates a large public subsidy of Rs 36,000 crore (NPV), for promotion of solar. But the NSM objectives are unclear and actions are not aligned with India's development needs.

Despite their immense socio-economic benefits, solar lighting systems for the poor and off-grid systems are not a priority under NSM. If good quality solar lanterns are given to the 72 million households that use kerosene for lighting – a population equal to that of USA, it would require only Rs 3,000 crore, or 8% of committed subsidy. The social payback of this investment is less than three months! The priorities of NSM need immediate modification, to address India's rural energy poverty. Solar lanterns should be distributed using innovative mechanisms like UID registration. A public process should be initiated to quickly develop a comprehensive plan for implementation of solar home lighting systems and off-grid solutions.

Large grid-connected solar power plants with a target of 1 GW are the focus under Phase I and will receive almost 60% of the committed subsidy. These should be used predominantly to promote solar thermal technologies, given their several advantages for India.

The allocation of low cost NTPC power to promote solar, instead of other competing social objectives, is not in line with principles of 'inclusive growth'. This does not reduce the impact of higher solar tariffs, as argued by the NSM. It creates a bankable single buyer for solar projects while giving eminence to CERC decided solar tariffs.

But CERC tariffs seem much higher than justified. Despite a much lower tariff, earlier schemes of MNRE, Gujarat, and Rajasthan received immense response – 10.7 GW worth of proposals of which 811 MW were sanctioned. If NVVN were to acquire the first 1000 MW of solar capacity at GERC tariffs instead of CERC tariffs, then an additional burden of Rs 5,400 crore on electricity consumers would be avoided – sufficient to give two lanterns to the 72 million households! Like earlier schemes, NTPC too will attract many more proposals than its target, resulting in a possibility of favouritism, and consequent delays as was seen in the era of Independent Power Producers. In face of rapidly declining solar costs, NTPC should adopt tariff-based competitive bidding for individual solar thermal technologies. Migration of projects from earlier schemes to NTPC should be allowed only under their existing contractual tariffs.

Considering importance of solar energy for our future, the lack of clearly defined objectives and aligned roadmap of NSM is a concern and calls for a transparent public process to formulate it. Further, greater coordination between state and central governments is required to realize a unified and coherent solar vision for India. Ensuring all of the above can help realize a socially equitable, environmentally sustainable and economically optimal solar mission.

Acknowledgements

We would like to thank Prof T L Sankar, Dr Surya Sethi, Dr P K Mishra, Dr C Govindarajalu, Gevorg Sargsyan, Dr Harish Hande, Dr Hemant Lamba, Dr Amol Phadke, Ranjit Bharvirkar, Akanksha Chaurey, Mihir Mysore, and our colleagues at Prayas (Energy Group) for their valuable comments.

About the authors

All authors are with the Prayas (Energy Group), Pune.

Contact

Ranjit Deshmukh at ranjit@prayaspune.org, +91-20-25420720

References

K.R.Smith, S.Mehta, 2003, "The burden of disease from indoor air pollution in developing countries: comparison of estimates," International Journal of Hygiene and Environmental Health, Vol 206, Nos 4-5, pp. 279-289.

E. Mills, 2005, "The specter of fuel based lighting," Science, Vol 308, No. 5726, pp. 1263-1264.

A. Chaurey and T.C. Kandpal, 2009, "Carbon abatement potential of solar home systems in India and their cost reduction due to carbon finance," Energy Policy, Vol 37, Issue 1, pp. 115-12.

P. Purohit, 2009, "CO2 emissions mitigation potential of solar home systems under Clean Development Mechanism in India," Energy, Vol 34, pp. 1014-1023.

Nanjunda D.C., Steven Wind, Annapurna M., 2007, "Nomadic and Denotified Tribals of Karnataka (India): Excluded, Isolated and Forgotten," IUB Journal of Social Sciences and Humanities, Vol 5, No1

Bank Sarasin, 2009, "Solar Industry-The first green shoots of recovery: Comparison of technologies, markets and companies," Bank Sarasin Report November 2009.

NEEDS, 2008, "Final report on technical data, costs and lifecycle inventories of solar thermal power plants," available at http://www.needs-project.org/

NEEDS, 2005, "Final report on technical data, costs and lifecycle inventories of PV applications," available at http://www.needs-project.org/

Severin Borenstein, 2008, "The Market Value and Cost of Solar Photovoltaic Electricity Production," Centre for Study of Energy Markets, January 2008, Working Paper 176

Notes

[1] See comments by Prayas on the draft NSM, 5th Nov 2009; available at www.prayaspune.org/peg.
[2] National Solar Mission document, pp.2, http://mnre.gov.in/pdf/mission-document-JNNSM.pdf; accessed on January 18th, 2010.
[3] Ministry of New and Renewable Energy cumulative achievements as on 31st October 2009; http://mnes.nic.in/; accessed on 15th January 2009.
[4] Ministry of New and Renewable Energy, 2006, XIth Plan Proposals; available at http://mnes.nic.in/pdf/11th-plan-proposal.pdf
[5] Akshay Urja, Oct 2009; Volume 3, Issue 2, pp 48; available at http://mnes.nic.in/akshayurja/contents.htm; accessed on 15th January 2009.
[6] Draft document of National Solar Mission; available at http://www.indiaenvironmentportal.org.in/files/solar%20mission.pdf; accessed on January 18th, 2010
[7] Central Electricity Regulatory Commission (Terms and conditions for tariff determination from renewable energy sources) (First Amendment) Regulations, 2010 released on 26th February 2010; available at http://cercind.gov.in/2010/ORDER/February2010/53-2010_Suo-Motu_RE_Tariff_Order_FY2010-11.pdf.
[8] CEA mentions costs of PV systems in the range of Rs 16-19 cr /MW for rooftop PV. We have added cost of 30-40% as batteries would be required for off-grid solar plants; available at http://cea.nic.in/god/dpd/report_rooftop.pdf; accessed on January 18th, 2010
[9] The SIPS scheme proposes a 20% and 25% capital subsidy in Special Economic Zones (SEZ) and non-SEZ areas respectively; Department of Information Technology notification on SIPS, 2007; available at http://www.mnes.nic.in/notification/notification-210307.pdf; Guidelines for SIPS, 2007; available at http://www.mit.gov.in/download/guidforsips.pdf; accessed on January 18th, 2010.
[10] Right to Information Act application to Department of Information Technology regarding Special Incentive Package Scheme; received in February 2010.
[11] MNRE press release, December 2009; available at http://mnes.nic.in/press-releases/press-release-11122009.pdf; accessed on January 18th, 2010.
[12] National Sample Survey Organization, 2006-07 - 68.08 million rural households with 4.8 persons per household and 3.68 million urban households with 4.3 persons per household use kerosene as a primary source of lighting.
[13] Assuming a PDS kerosene cost of Rs 10 per liter.
[14] The Oil Marketing Companies (OMC) pay trade/import parity price to refineries when they buy kerosene. The difference between the trade / import parity and the regulated selling price (excluding taxes, dealer commission) results in the under-recoveries in oil companies, the burden of which has been shared by the Government (oil bonds), upstream oil companies (offer of discount on crude oil sold to the oil marketing companies) and OMCs themselves.
[15] The GoI provides an annual budgetary subsidy of nearly 1000 crore for PDS kerosene. Source: Ministry of Petroleum and Natural Gas; "Basic Statistics on Indian Petroleum & Natural Gas 2008-09"; available at http://petroleum.nic.in/petstat.pdf.
The under-recoveries for PDS kerosene are to the tune of Rs 28,225 crores. Source: Economic Survey 2008-2009, Energy Infrastructure and Communications; available at http://indiabudget.nic.in/es2008-09/chapt2009/chap95.pdf
[16] A kerosene emission factor is 2.63 kg CO_2/liter (Purohit 2009). A carbon credit rate of USD 20 per ton CO2 and an exchange rate of Rs 45/USD results in carbon credits worth Rs 850 crore every year.
[17] Various companies (Selco, Thrive, Dlight, Barefoot and others) today provide solar WLED lanterns, some of which already have retail prices as low as Rs 500.
[18] See Unique Identification Authority of India, "Creating a unique identity number for every resident in India – Draft Approach," version 1.1; available at http://uidai.gov.in/
[19] http://light.lbl.gov/ ; http://www.lightingafrica.org/; http://labl.teriin.org/
[20] See Photon International, 2009, Issue 12, pp.108.
[21] Present installed capacity is only 679 MW, of which, 354 MW was installed in the 1980s. Global Concentrated Solar Power Industry Report 2010-2011, Nov 2009; available at www.csptoday.com/globalreport/CSP-Report-Brochure.pdf.
[22] Under this scheme, MNRE offered a GBI of Rs 10 and 12 per kWh for solar thermal and PV respectively, and the balance of the actual tariff for each project was to be paid by the respective utilities.
[23] RERC Solar Tariff Order dated 2.4.2008; available at http://www.rerc.gov.in/Order/Tariff_for_Solar_Power_Order2APR08.pdf

[24] The Hindu article, September 2008; available at http://www.thehindu.com/2008/09/29/stories/2008092955951700.htm; accessed on January 18th, 2010.
[25] Dr. Farooq Abdullah, Union Minister for New and Renewable Energy, Statement in Parliament, 23rd November 2009; available at http://mnre.gov.in/pdf/Minister-announced-JNNSM.pdf
[26] Solar Power Policy-2009, Government of Gujarat, January 2009; available at http://www.geda.org.in/pdf/Solar%20Power%20policy%202009.pdf
[27] Memorandums of Understanding worth a total solar capacity of 3527 MW (1645 MW solar thermal and 1882 MW solar PV) were signed during the Vibrant Gujarat Global Investor's Summit (VGGIS) and Expressions of Interest adding to 1785 MW (465 MW solar thermal and 1320 MW solar PV) were received after the VGGIS. Source: Presentation at the MNRE Solar 2010 conclave by Mr D J Pandian, Principal Secretary (Power) Govt of Gujarat, "Initiative of Gujarat for implementation of solar power projects"; available at http://www.mnes.nic.in/solar%20energy%20conclave%202010/solar-energy-conclave-2010-13.pdf.
[28] Out of the 716 MW of allotted projects, 365 MW are solar PV and 351 MW are solar thermal; Details available at http://www.geda.org.in/pdf/solar_allotment_webnote.pdf.
[29] Presentation at the MNRE Solar 2010 conclave by Mr. Shreemat Pandey, Principal Secretary (Energy), Govt. of Rajasthan, "Potential and Opportunity for Development of Solar Energy in Rajasthan"; available at http://www.mnes.nic.in/solar%20energy%20conclave%202010/solar-energy-conclave-2010-14.pdf.
[30] Central Electricity Regulatory Commission (Terms and conditions for tariff determination from renewable energy sources) Regulations, 2009 released on 3rd December 2009; available at http://cercind.gov.in/2009/November09/284-2009_final_3rdDecember09.pdf; CERC revised these tariffs for the year 2010-11 to Rs 17.91/kWh and Rs 15.31/kWh for solar PV and thermal respectively.
[31] Central Electricity Regulatory Commission (Terms and conditions for tariff determination from renewable energy sources) (First Amendment) Regulations, 2010 released on 26th February 2010; available at http://cercind.gov.in/2010/ORDER/February2010/53-2010_Suo-Motu_RE_Tariff_Order_FY2010-11.pdf.
[32] GERC Solar Power Tariff Order 2010; available at http://www.gercin.org/docs/What's%20New%20in/Final%20Draft%20no.2%20of%202010%20Solar%20Order.pdf
[33] Accelerated depreciation benefit is estimated as Rs 2.46 and Rs 2.96 per kWh for solar thermal and PV respectively in CERC (Terms and conditions for tariff determination from renewable energy sources) (First Amendment) Regulations, 2010. While calculating the savings, the CERC tariffs have been reduced by the accelerated depreciation benefit, and then compared to the GERC tariffs.
[34] Guidelines for Migration of Existing Under Development Grid Connected Solar Projects from Existing Arrangements to the Jawaharlal Nehru National Solar Mission (JNNSM); available at http://www.mnes.nic.in/pdf/draft-guidelines-jnnsm.pdf
[35] Migration scheme was announced during the Solar Conclave on 11th January 2010. Project proposals for migration scheme are to be submitted before 26th February 2010, referred to 'zero date'. MoUs are to be signed one month from 'zero date'.
[36] CERC is proposing feed-in tariffs of Rs 14.6 and 16.6 per kWh for thermal and PV respectively for year 2010-11. CERC specified PLFs are 23% and 19% for thermal and PV respectively.
[37] Calculations based on 2006-07 electricity data from the Central Electricity Authority.
[38] CERC Terms and Conditions for recognition and issuance of Renewable Energy Certificate for Renewable Energy Generation Regulations, 2010; available at http://cercind.gov.in/regulation/REC_2010.html
[39] See Factsheet of Solar Energy Industries Association, "Utility scale solar power – Responsible water resource management," available at http://seia.org/galleries/pdf/factsheet_water_use.pdf
See Report to Congress, U.S. Department of Energy, "Concentrating Solar Power Commercial Application Study: Reducing Water Consumption of Concentrating Solar Power Electricity Generation," available at http://www.nrel.gov/csp/pdfs/csp_water_study.pdf
[40] See Presentation by Janet Lawson, Bureau of Land Management, "Solar Programmatic Environmental Impact Statement"; available at http://solareis.anl.gov/
[41] See the report from Central Electricity Authority, "Report of subgroup I on grid interactive rooftop solar PV system," New Delhi, December 2009; available at http://www.cea.nic.in/
[42] http://www.greentechmedia.com/articles/read/cal-lawmakers-propose-smaller-increase-for-net-metering/