Decarbonising the Indian Railways

Scaling Ambitions, Understanding Ground realities

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Council on Energy, Environment & Water

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Policy Brief
April 2017
ceew.in

A policy brief on 'Decarbonisation the Indian Railways: Scaling Ambitions, Understanding Ground realities'.

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Executive Summary

As India transitions to a low-carbon emissions pathway, the Indian Railways has set a goal of reduction in emissions intensity of 33% by 2030 from 2005 levels. This includes focus on improvement of rail traction energy and fuel efficiency of 8% - 13% from 2013 levels. In recent years, the Indian Railways has taken significant strides to increase the share of renewable energy in its electricity mix, which includes solar and wind, to reduce energy costs as well as carbon emissions.

The Indian Railways announced its 1 GW solar target in 2015 and had achieved an installed capacity of about 37 MW of wind and 16 MW of solar across railway operations until March 2017. The Railways has also tendered close to 255 MW of rooftop solar projects, of which 80 MW has already been awarded. In addition, the Railways are in the process of tendering about 250 MW of land-based solar projects, of which 50 MW have been awarded.

With the Indian Railways already on track to achieving its 1 GW target, with the same momentum it could potentially achieve 5 GW by 2025, with about 1.1 GW coming from rooftop projects and about 3.9 GW from utility scale projects. This would result in 25% of the Railways' electricity mix coming from renewables by 2025. At the same time, the Indian Railways would need an investment of about USD 3.6 billion to meet the 5 GW target.

It was expected that the 1 GW target would serve as a signal for financiers and solar developers to come forward and participate actively in bidding for tenders floated by the Railways, for installation of solar projects. While the initial response was overwhelming, there have been concerns raised on various issues ranging from technical and financial to policy aspects.

If the Railways were to consider the 5 GW target, one of the first steps for its successful implementation, is to develop an understanding of the policy and regulatory scenario across various states, so as to understand the opportunities and challenges for solar developers to set up projects. This study uses a comprehensive assessment framework including extensive stakeholder consultations to understand better the factors that would incentivise solar developers to bid for solar projects tendered by the Railways. The comparison of the state solar policies also provides insights on the ease of doing business, if the project sites were to be located in these states. The study finds that Madhya Pradesh ranks the highest for utility-scale projects, while Karnataka, ranks highest in the case of rooftop projects.

It is important to note that for both utility-scale and rooftop projects, technical considerations emerge as the most important criteria for developers, followed by financial incentives and regulatory parameters. Some of the enabling parameters include: (i) Optimum requirements for evacuation infrastructure; (ii) Exemption of open access charges; (iii) Fiscal incentives applicable under the state industrial policies; and (iv) Availability of energy banking services at low charges.

This study also highlights Railways-specific challenges faced by solar developers, such as stringent performance requirements for solar panels, unscheduled interchange charges, land approvals for evacuation infrastructure, and untested business models in the case of traction electricity. With the Railways being notified as a deemed distribution licensee, it enables the transporter to avail of open access provisions and procure power at lower costs. This would also mean that the Railways could potentially migrate from state utilities, leading to a revenue loss for the power distribution companies, which has been a barrier in the open access approval processes at the state level for the Railways.

Going forward, the Railway Board, along with state governments and electricity regulators (both centre and state) will have to work together to facilitate a smooth ecosystem for ensuring developer and investor confidence. Some of the key suggestions include:

(i) Railways to develop technical and regulatory guidelines for renewable integration for traction operations, which would involve agreements between the Railways, State Utilities, and Solar Developers.

(ii) Standardisation of PPAs to be developed jointly with central and state electricity regulators.

(iii) With regards to open access, state regulators will have to resolve the issue of clearances for the Railways to operate as a distribution licensee. This will be critical for the transporter to bring down the costs of power procurement.

(iv) Railways to create a platform for regular engagement with solar developers so as to understand and reconcile any of their concerns, with regards to technical and regulatory requirements.

If the Railways were to scale their ambitions, it would take India a step closer towards achieving its 175 GW renewables target by 2022, as well as its INDC commitment of 40% non-fossil fuel installed power capacity. This is an effort not just about lowering energy bills, but has larger implications on low carbon transport and climate change.

1. Introduction

India has a population of about 1.26 billion people spread over a vast geography. Mobility will play a key role with urbanisation and the growth of cities. India has set up one of the largest and most complex transport networks in the world (GoI, 2013[1]). The transport sector is and will continue to remain a critical enabler of development and would also have to grow in a sustained manner for the country to meet its developmental objectives.

The Indian transport sector is growing rapidly and as per the estimates of the National Transport Planning and Development Committee (NTDPC), it is expected that the overall passenger traffic will increase by 15% per annum (with passenger rail at 9% per annum) and freight traffic will increase by 12% and 8% per annum for rail and road, respectively. This presents a unique opportunity to follow a low carbon pathway for the transport sector in alignment with India's NDC targets as well. The country has already embarked on a process to move towards such a trajectory through a large number of initiatives across different modes of transport.

India has focused its low carbon initiatives on the development of Railways, Waterways, Mass Rapid Transport Systems and other forms of public transport. Initiatives such as the Dedicated Freight Corridors[2] (DFCs) and Sagarmala projects[3] are aimed to increase the share and volume of freight traffic on the more energy efficient rail and water based transport modes.

The Indian Railways, also known as the lifeline of India, plays a major role as not only a preferred mode of transport for the masses, but also facilitates socio-economic development through movement of passengers and freight. In the context of low carbon transport, a modal shift towards rail will be an important step[4].

The Indian Railways has already begun taking steps in this direction to strengthen rail transport to increase its modal share in freight traffic from the current 36% to 45%, as stated in its Vision 2020 document[5], a goal that would be facilitated with the commissioning of two Dedicated Freight Corridors before 2020. The Indian Railways carries nearly 23 million passengers and around 1 billion tonnes of freight per day spread across a vast geographical area[6], on account of which it is also the single largest consumer of energy. If India is to further increase the share of railways in passenger and freight mobility, the energy requirement can also be expected to grow[7].

As per the Railway Budget 2014-15, fuel costs accounted for around 18% of the total railways' expenditure[8]. To facilitate a focused approach towards environmental sustainability, the Indian Railways established the Environment Directorate in 2015. Since then, a series of measures have been announced by the Ministry

1 Government of India, 2013. Indian Railways Carry Passengers Equivalent to Almost The Population of Entire World. Press Information Bureau, Government of India. (URL: http://bit.ly/2mzgQ86)

2 The DFC project will enable the Indian Railways to improve its customer orientation and meet market needs more effectively. Creation of rail infrastructure on such a scale is also expected to drive the establishment of industrial corridors and logistic parks along its alignment. (URL: http://dfccil.gov.in)

3 The prime objective of the Sagarmala project is to promote port-led direct and indirect development and to provide infrastructure to transport goods to and from ports quickly, efficiently and cost-effectively. It aims to develop access to new development regions with intermodal solutions and promotion of the optimum modal split through expansion of rail, inland water, coastal and road services. (URL: http://bit.ly/2mWgXy6)

4 STAP, 2013. Advancing Sustainable Low-Carbon Transport Through the GEF. Scientific and Technical Advisory Panel, United Nations Environment Programme (UNEP).

5 Ministry of Railways (2009), Railway Vision 2020 Document, Ministry of Railways, Government of India

6 https://www.railsaver.gov.in/en_scenario.html

7 Climate Policy Initiative (2016), Decarbonization of Indian Railways, The New Climate Economy, Climate Policy Initiative

8 http://www.prsindia.org/administrator/uploads/general/1456931078_Railway%20Budget%20detailed%20Analysis%202016.pdf

of Railways, which include energy efficiency, electrification of traction lines, and increasing the share of renewable energy, particularly solar, in the electricity mix, among others.

1.1 Energy Consumption across the Indian Railways: Towards Renewables

The Indian Railways have a vast connectivity with over 66,030 route-kilometers of which nearly 30,000 kilometers have been electrified as of 2016[9]. To meet both its traction and non-traction requirements, the Indian Railways (IR) consumed about 1.8% of India's total power generated in 2014-15, which amounts to about 18.25 billion units of electricity for that year[10].

Traction energy is the energy required for hauling electric and diesel passenger and freight locomotives across the railway network. Non-traction energy is the energy required to run railway operations which include diesel loco sheds, railway workshops, railway stations, level-crossing gates, railway offices and buildings, among others. Traction energy consumes nearly 85 percent of the total railway energy consumption, whereas non-traction energy accounts for the remaining 15 percent. While improving traction energy efficiency and lowering costs for traction energy would help bring down the costs significantly, given its larger share in the railway energy consumption mix, it is also a longer-term intervention. Improving traction efficiency of locomotives involves significant costs in replacement of stock and research and development. A short and medium term measure is certainly to involve efforts in reducing the cost of power procurement for traction electricity. At the same time, integration of renewables is easier for non-traction applications as compared to traction operations, largely due to the technical challenges in ensuring reliable, high voltage power from renewable energy sources for traction.

In its Vision 2020 document, the Indian Railways had outlined a plan to electrify up to 33,000 route-kilometers by 2020, which was estimated to lead to a demand of 15000 MW of power by 2032[11]. There was nearly a 54 percent increase in the budget outlay towards traction electrification between 2014-15 and 2015-16 (GoI, 2016) In the year 2015-16, electrification of 1600 route kilometres was commissioned with the railways intending to cover 2000 route kilometres in the year 2016-17. The Railways has now set a target of carrying 90% of the traffic on electric traction in the next five to seven years. At the same time, the Railways has also embarked on a mission to electrify another 24000 route kilometres (which is about 90 percent of the Railways' Broad Gauge network) in the next five years, by 2020-21[12].

Even though the traffic haul for diesel and electric is equal, since entire route lengths are not electrified, diesel locomotives need to be hauled up to connecting points between electrified and un-electrified networks or patches[13]. As of 2013-14, IR consumed 2.6 billion litres of diesel, which accounted for 70% of the railways' fuel bill[14]. As part of its efforts to improve operating ratios and revenues, efforts have been made across energy efficiency, rolling stock, and traction electrification, with a focus on reducing the cost of bulk power procurement.

Thus, with these in consideration, the Indian Railways is working towards two objectives: first, reducing the cost of power procurement; and second, increase the share of renewables in the electricity mix.

9 http://www.core.indianrailways.gov.in
10 http://www.newindianexpress.com/nation/2017/feb/24/new-system-soon-to-check-train-delays-on-ghazibad-kanpur-route-1574245.html
11 http://indiainfrastructure.com/confpdf/brochure-energy-needs-of-indian-railways-april2016.pdf
12 http://pib.nic.in/newsite/PrintRelease.aspx?relid=157400
13 Public Accounts Committee (2015-16), Environment Management in the Indian Railways – Stations, Trains and Tracks, Thirty Eighth Report of the Public Accounts Committee (2015-16), Sixteenth Lok Sabha, Government of India
14 Singh S P (2015), Indian Railways gets cracking on environment protection, fuel bill, Business Standard (http://www.business-standard.com/article/economy-policy/railways-gets-cracking-on-environment-protection-fuel-bill-115012900178_1.html)

Reducing the Cost of Power Procurement

The Ministry of Railways in November 2016 launched 'Mission 41k', which aims to save INR 41,000 crore in the next decade in railways' energy costs[15]. As of 2015, around INR 2,500 crores of savings in the energy bill had been achieved[16], with the Indian Railways' operating ratio[17] almost reaching 90%.

However, with nearly 65% of the freight and 50% of the passenger trains operating on diesel traction, the operating costs incurred by the railways are still quite high[18]. Current efforts towards improving fuel efficiency of diesel locomotives through technological interventions are only a short-medium term measure, with a long-term strategy being the transition towards a greater share of electric traction.

Leveraging regulatory support with respect to open access provisions in electricity procurement would be effective in driving down the power procurement costs incurred by the Railways. With a few states already giving the Railways clearance to procure cheaper power through the open access route, this could lead to a potential savings of INR 41,000 crore over the next decade[19], when coupled with renewables integration. With wheeling and evacuation charges forming a bulk of the power procurement costs, and given the special need of the railways to evacuate power at a distance from the plant site, it would be prudent to explore renewable energy options for traction power. This would particularly be of interest to the Indian Railways since Open Access charges have been waived off for renewable sources by many states.

Increasing the Share of Renewables

With the solar prices falling significantly in the recent years, it makes an economic case for the railways to further reduce their electricity costs and at the same time, increase the share of renewable energy, particularly, solar, in their energy consumption mix. Furthermore, as mentioned earlier, open access procurement of power from renewables could further bring down the cost of power for the railways, with solar tariffs being at par or lower in many cases than the conventional grid tariff for the Railways (Ramji, 2015[20]). If these benefits for renewables are to be reaped, it should be done within the control period of the state solar policies.

With the objective of increasing the share of renewables in the railways, the Union Minister for Railways in the 2015-16 Railway Budget announced a target of 1GW of solar by 2020 (rooftop and ground-mounted) on railway land and railway buildings, primarily for railway consumption, to be set up by developers at their own cost with either subsidy or Viability Gap Funding (VGF) support from the Ministry of New and Renewable Energy (MNRE). An assessment by Ramji et al (2016), found that there exists a gross potential of 1 GW for rooftop solar across the Railways and another 1.2 GW if 5% of the vacant land available with the railways were to be used for utility-scale solar PV[21]. As of 2015-16, Railways have set up 11 MW of solar power plants across various establishments, with other projects in the pipeline[22].

To undertake the deployment of green energy projects for the Indian Railways, the Ministry of Railways and RITES Ltd, formed a joint venture company called Railway Energy Management Company Ltd (REMCL).

Some recent initiatives include a 1 MW solar power plant at Katra railway station in Jammu, 30 kWp rooftop solar plant at Rail Bhawan in Delhi, and 2.1 MW solar PV plant at the Rail Coach Factory in Rae Bareilly in Uttar Pradesh, to name a few.

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15 http://pib.nic.in/newsite/PrintRelease.aspx?relid=157400
16 Ramji, A et al (2016). Energy Policy Roadmap for the Indian Railways. Council on Energy, Environment and Water; June 2016.
17 Calculated as ratio of working expenses to gross earnings
18 Ramji, A et al (2016). Energy Policy Roadmap for the Indian Railways. Council on Energy, Environment and Water; March 2017 (unpublished).
19 Ministry of Railways (2017), Mission 41k – The Pivot for IR's Regeneration, Ministry of Railways, Government of India (URL: http://www.indianrailways.gov.in/Mission_41K.pdf)
20 Ramji, A. (2015). Greening the tracks: Achieving the 1 gigawatt solar PV target of the Indian Railways; Policy Brief, Council on Energy Environment and Water.
21 Ramji, A et al (2016). Energy Policy Roadmap for the Indian Railways. Council on Energy, Environment and Water; June 2016.
22 Environmental Sustainability – Role of Indian Railways, Annual Report 2015 – 16, Ministry of Railways, Government of India

On account of the success of the current initiatives of the railways, and given its large land availability and its estimated solar potential to be higher than the 1 GW target, a scaling of ambitions could be possible. The Indian Railways in its Vision 2020[23] document had set a target of utilising 10% of its energy requirement from renewable sources by 2020, but with its total electricity demand expected to grow by about 4 times by 2030, an increase in the share of renewables in the overall electricity mix of the railways would go a long way in facilitating the road to decarbonisation of the rail sector. In addition, the Union Rail Minister in November 2016 announced that the Indian Railways had set a target of 40% of cumulative electricity generation capacity through renewable energy by 2030[24]. Based on the solar potential estimates, it is proposed[25] that the target be scaled to 5 GW of installed solar capacity to be achieved by 2025, with the possibility of leveraging international finance through multilaterals or as climate finance. It is expected that about 1.1 GW will come from rooftop projects while the remaining 3.9 GW will come from utility scale projects. This target of 5 GW would see the Indian Railways procuring about 25% of its electricity demand from solar by 2030.

1.2 Achieving the 5GW Target

When the 1 GW solar target for the Indian Railways was announced in 2015, it was expected that this would serve as a signal for financiers and solar developers to come forward and participate actively in bidding for tenders floated by the railways, for installation of solar projects. While the initial response was overwhelming, there have been concerns that have been raised on various issues ranging from technical, financial and policy/regulatory aspects. It must be noted that it being the first time for the railways to take up such an exercise, it has been continuously making efforts to smoothen the process for developers to make the investment opportunity an attractive one. Scaling the solar target to 5 GW[26] is an ambitious exercise and requires an in depth understanding of the policy landscape for solar projects across states in India. The insights from it would inform a coherent strategy for the Railways to put in place an effective ecosystem to achieve the 5 GW target.

Solar energy integration can take place across traction as well as non-traction operations. While, non-traction energy constitutes only around 15% of the railways' total energy consumption, it provides for easier integration of solar as compared to traction operations. There are multiple challenges involved in the direct integration of solar energy for traction, like- high voltage requirements for long durations, which have been discussed in the subsequent sections of this report. While the Indian Railways is looking to increase its portfolio of renewable energy, the risks associated with financing for such projects need to be recognised and evaluated. In addition to risks, timelines of such projects should be aligned such that some of the larger projects are undertaken early on, especially in areas where larger land banks can be identified. However, it is imperative to also decide on the project development model – build, own and operate model, the RESCO model[27], or the CAPEX model[28].

Based on railway operations and land availability, twelve states have been identified across India, where in rooftop and utility scale projects could be taken up to meet the 5 GW target for solar. With the railway zones cutting across administrative boundaries of states, it is important to understand some of the state-specific technical, regulatory and policy parameters within the respective state solar policies that could either facilitate or hinder the setting up of solar projects for railway operations at various sites. Such large scale RE integration by the Railways can be a seen as a positive signal to the renewables market in India, but at the same time, addressing the concerns of various stakeholders which include, solar developers, railway authorities, state power regulators and power utilities, among others, is important to the success of this project.

23 Ministry of Railways (2009), Railway Vision 2020 Document, Ministry of Railways, Government of India

24 Ministry of Railways, Government of India (2016). Minister of Railways inaugurates International Conference on Decarbonisation of Indian Railways - Mission Electrification. Press Information Bureau, Government of India. (URL: http://bit.ly/2m9ANXK)

25 Based on discussions between UNDP and Ministry of Railways, Government of India.

26 Refer to Annexure I

27 Renewable Energy Service Company (RESCO) Model: Under this model, the consumer can install a solar power plant and not pay anything upfront. A power purchase agreement is signed between the installer and the consumer at a mutual price (tariff).

28 Capital Expenditure (CAPEX) Model: The end consumer can own the asset and claim accelerated depreciation and save taxes.

This policy document assesses the technical, financial and regulatory framework within the state solar policies that could be leveraged by the Indian Railways to create an ecosystem that can facilitate the achievement of the 5GW solar target, and how best they can phase the implementation across various states depending on the ease of implementation.

1.3 RE integration across Railways: Lessons from across the World

In an attempt to promote and decarbonise rail transport, many countries across the world are making efforts to integrate renewable energy (particularly solar) within their railway networks. Some have undertaken successful pilots in integrating solar for traction, whereas some have successfully been powering railway stations using solar energy. Although India would feature among the most ambitious countries to be attempting 5GW from solar for its railway network, there are lessons from the implementation of similar projects across the world that could be applicable to India.

Network Rail, which has been electrifying the United Kingdom (UK) rail network, met with a unique challenge where the grids supplying power to train companies, especially those in rural areas, had reached their peak limit (due to distributed energy generation and supplying power to multiple points of consumption). Their Renewable Traction Energy team found a solution by connecting solar panels directly to the traction electricity lines, thus by-passing the grid. This project intends converting the system into a 'third rail' system, where there is an electrical line passing along the tracks on the ground, supplying DC power to the train. The DC power supplied matches the DC power generated by the solar panels, and thus eliminates the need for conversion to AC or for integration with the main grid[29].

In Italy, Green Rail has been involved in innovative sleepers for railways, and has recently developed Green Rail Solar, wherein the track sleepers are equipped with a solar PV module which can generate up to 150 kWh of solar energy for every track kilometre, which can either feed to the railway station or the electricity grid[30].

Another country integrating renewable energy into its traction operations is Chile, where the Santiago Metro will run on 60% renewable energy (42% from solar and 18% from wind). The 100 MW solar power project that will contribute 42% of the metro energy needs is being set up by SunPower and Total[31].
Given that the technical challenges with respect to the integration of renewables within the railway network, especially for traction operations, have similar elements across the world, such solutions could be tested in the Indian context, which could also involve collaborative efforts with global players and other country railway networks.

29 O'Neill, N. (2017). Imperial researchers collaborate on project to supply solar power to UK trains. Imperial College, London. (URL: http://bit.ly/2irw1kQ)
30 Smart Rail World (2016). 8 global rail projects harnessing the power of solar energy. (URL: http://bit.ly/2gJT4ZB)
31 Smart Rail World (2016). The Metro becoming the world's first to run on mainly renewable energy. (URL: http://bit.ly/2mPVTHL)

2. Methodology

The twelve states that have been identified for the Railways' 5 GW target include: Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Telangana, Andhra Pradesh, Karnataka, Odisha, Maharashtra, Madhya Pradesh, Gujarat, Rajasthan and Chhattisgarh. Prior to making an assessment of the respective state solar policies and regulations, they were categorised based on their potential for rooftop and utility scale projects. This was done primarily based on the following parameters:

- Utility scale solar potential based on the availability of railway land in the state (Ministry of Railways, Government of India)
- Rooftop solar potential of the railways in the state (CEEW 2016)

Assuming the land requirement for a 1 MW scale solar project to be about 5 acres, the potential of utility scale projects was estimated for each state. The rooftop solar potential across different states had already been estimated by Ramji et al. (2016)[32]. Subsequently, each state was categorised as having the potential for utility scale projects or rooftop projects or both.

For a state to be considered to have high utility scale potential, a minimum of 25 MW of potential utility scale projects was set as the threshold. One of the considerations for this was based on the understanding that to power a traction sub-station on solar, a plant of 25 MW capacity would be required. This does not mean that states with utility scale potential of less than 25 MW should not have such projects. This benchmark is used only as being indicative of the predominant nature of solar projects that the Railways should be focusing on initially in the select states. Table 1 shows the classification of states based on the type of solar project(s) that may be undertaken by the Indian Railways[33].

Table 1: Focus states for utility-scale (U) or rooftop (R) solar projects

State	Project Type (U/R)
Madhya Pradesh	U
Gujarat	U+R
Uttar Pradesh	U
Andhra Pradesh	U
Rajasthan	U+R
Maharashtra	U+R
Orissa	R
Karnataka	R
Jammu and Kashmir	R
Chhattisgarh	R
Telangana	R
Himachal Pradesh	R

Source: CEEW Analysis; Railway Board, Ministry of Railways, Government of India

32 Ramji, A. (2015). Greening the tracks: Achieving the 1 gigawatt solar PV target of the Indian Railways; Policy Brief, Council on Energy Environment and Water.

33 This classification is indicative and subject to change as ground realities in terms of land availability and other factors evolve.

For successful implementation of the 5 GW solar target, one of the first steps is to develop an understanding of the policy and regulatory scenario across the selected states, so as to identify the opportunities and barriers. The objective is to identify those states which have well-defined policy and regulatory frameworks, thus, providing an enabling environment for solar developers to set up projects. Based on this assessment, the Indian Railways can prepare a phase-wise implementation plan in order to achieve the 5 GW solar target.

As part of the assessment, the renewable energy policies of states (specifically, state solar policies), guidelines of the Ministry of New and Renewable Energy (MNRE), power sector policies and regulations, as well as financial and fiscal incentives for ease-of-doing-business, have been considered. These parameters have been assessed from the perspective of different solar developers, so as to identify any potential risks perceived by them and develop a strategy to mitigate any regulatory, technical or financial risks to the best extent possible.

2.1 Solar Policy and Regulatory Assessment Framework

Based on a review of various state solar policies, the assessment framework has been developed to reflect a comprehensive comparison of state policies, while the choice of parameters within the framework has been driven by two considerations: first, their relevance to solar projects in the context of the railways, and second, availability of data. It is recognised that there may be other nuanced factors that could impact project implementation which have been left out of the scope of this assessment and could be incorporated when project specific assessments are being conducted. For each project type, the assessment parameters have been sub-categorised under three broad headings: Technical, Financial, and Regulatory.

Subsequent to a preliminary review of various state solar policies, the assessment framework developed was shared with different solar developers for their feedback. The revised assessment framework was then used as an anchor for a stakeholder engagement which included a Delphi exercise, wherein developers assigned weights to the various parameters. The results of the Delphi exercise would provide insights into the relative importance of different parameters in the decision-making of solar developers to come forward and participate actively in bids for solar projects. With the assessment framework also including some railway specific parameters, the Delphi exercise went one step further to understand the concerns of solar developers when it comes to commissioning solar projects in the context of the Indian Railways.

The Delphi exercise essentially involved a structured questionnaire (as detailed in Section 2.2), with various solar developers simultaneously weighting the parameters based on their perception of the relative importance of the assessment parameters. After the first round of weighting, the results of the exercise were shared with the developers for their feedback, based on which the assessment parameters were changed. With this final set of assessment parameters, the Delphi exercise was carried out again, with developers assigning weights. These final weights were then utilised to score the solar policies of various states, with the objective of ranking them, so as to enable the Railways to develop a phase-wise plan for the implementation of the 5 GW solar target, as well as prioritise rooftop and utility scale projects in different states.

The objective of the Delphi exercise and state solar policy analysis is to find convergence between developer expectations and state policies, so as to facilitate an enabling and effective ecosystem for integration of renewables across the railways. The Delphi exercise gives insights on the parameters that solar developers consider as important to their decision making towards bidding for solar projects. Some of these parameters may also include provisions under the respective state solar policies. Thus, the results of the Delphi exercise would help the Railways understand better the factors that would incentivise solar developers to bid for solar projects tendered for the railways. The comparison of the state solar policies, on the other hand, provides insights on the ease of doing business, if the project sites were to be located in these states. This comparison would help the Railways strategise an effective implementation plan and resolve any regulatory issues with states where such projects are to be undertaken.

2.2 Assessment Parameters for Utility and Roof-top Projects

2.2.1 Utility-Scale Projects

1. **Financial Parameters**

   i. Feed-in-tariff (FiT) with Accelerated Depreciation (AD): Feed-in-tariffs are set differently by different states. This was chosen as a parameter to understand if a lower FiT, especially with AD, acts as an incentive for developers.

   ii. Incentives under the State Industrial Policy: This includes the rebates and benefits that states provide to solar power producers like exemptions in land tax, electricity duty etc. as an attempt to promote the industry.

   iii. Delay in Payments to solar developers: Payment delays are a significant risk to developers. This parameter attempts to understand how developers value tenders that include penalties for delays in payment, or other incentives like a letter of credit, etc.

   iv. Curtailment Risk: Future risk of curtailment of power due to grid congestion especially in high renewable penetration areas, can upset project cash flows and return expectations. This is to assess how developers weight risk of curtailment by the State Load Despatch Centre to the power producer.

2. **Technical Parameters**

   i. Evacuation requirements (33/66/132 kV): Evacuation at high voltages requires approval from the transmission and distribution utilities, and different states have different evacuation requirements based on connected plant capacity.

   ii. Forecasting and scheduling requirements: To understand if stringent forecasting and scheduling requirements are seen as useful or restrictive; it is especially important from the Railways' point of view since scheduling by the off-taker would help developers plan long term requirements, and vice versa, with the Railways being able to plan better based on forecasting accuracy.

   iii. Clearances for laying evacuation infrastructure from the project site to the grid: To ascertain how important these clearances are perceived to be by developers, especially as they can cause delays in commissioning of solar plants.

   iv. Distance from the Point of Interconnection: This was included during the Delphi exercise since it was highlighted by developers as an important criterion for selection of projects, especially since the transmission infrastructure up to the interconnection point has to be laid by the developers.

   v. Project site conditions: This parameter too was added during the Delphi exercise in the railway-specific context, since developers noted that information about the land geography and topography was important before a project was commissioned. This is of importance in the railway-specific context since railway land will be utilised for such projects.

3. **Regulatory/Policy Parameters**

   i. Efficacy of Single Window Clearance: This parameter was included to understand if Single Window Clearance was an incentive to developers since most state solar policies mention its provision.

   ii. Unscheduled Interchange Charges: Since these charges vary significantly from state to state, it is important to understand if developers see these charges as a criterion for choosing one state over another, when it comes to bidding for solar projects.

   iii. Open Access Charges (Applicable POC charges, Transmission and Distribution charges and losses, additional surcharge, etc.): Since the charges vary from state-to-state, it is important to understand the relative importance of OA charges compared to other criteria while selecting a state to do business.

2.2.2 Rooftop-Scale Projects

1. **Financial Parameters**
   i. Feed in Tariff (FiT): Since feed-in-tariffs vary with states, this parameter is used to assess if lower FiTs as a price ceiling are an incentive for developers.
   ii. Central Subsidies: These are largely provided as capital subsidies for domestic rooftop generators. This parameter has been chosen to understand the importance of subsidies in the era of auctions.
   iii. State Incentives (including electricity duty exemption and other tax rebates): Within the ambit of the state policies on industry and solar, different states have provided incentives in the form of duty and tax exemptions.

2. **Technical Parameters**
   i. Contracted Demand (Capacity of plant as percentage of contracted load): This parameter was used to understand if developers consider the contracted demand criteria of states when deciding which state to set up a plant in.
   ii. Distribution Transformer Capacity (Cumulative capacity allowed at a DT as percentage of peak capacity): With net metering of rooftop solar PV in place, the local grid could get overloaded with solar power. States have regulations on the cumulative capacity allowed as a percentage of the peak capacity of the distribution transformer.
   iii. Project site conditions: This parameter was included during the Delphi exercise since developers noted the importance of location, tree cover, irradiance, etc. at the project site, and particularly relevant to railway rooftop projects.
   iv. Access to roof: This parameter too was included during the Delphi from a railway-specific context since such projects would have to be undertaken on existing rooftops of railway offices, railway buildings, loco-sheds, etc. Ease of access to rooftops was pointed out as important for both the commissioning of the project as well as regular operation and maintainance.

3. **Regulatory/Policy Parameters**
   i. Efficacy of application process: The parameter was chosen to assess the importance developers give to delays in the application process, and whether this is as important as other parameters when it comes to choosing a particular state while bidding for projects.

2.3 State Solar Policy Assessment

Based on whether a state had been categorised as having a predominantly rooftop or utility scale solar potential, comparisons have been made between the respective state solar policies. Thus, for all the states categorised under rooftop projects, comparisons have been made based on their state solar policies specific to rooftop projects, while those categorised under utility-scale projects have been compared across the state policy for utility scale solar projects. As part of the assessment, state solar policies (including net-metering policies, if notified), solar tariff orders, State Electricity Regulatory Commission (SERC) orders, Central Electricity Regulatory Commission (CERC) orders, and MNRE guidelines have been carefully studied. The detailed comparison of state solar policies and regulations are given in Annexure-I and II of this report.

After the assessment framework and choice of parameters was finalised to ensure a standardised comparison across state policies, each parameter was assigned a score of ‘0’, ‘0.5’ or ‘1’ based on how competitive an incentive is, or how stringent a restriction is. For each parameter, a cut-off was set to decide the scores of state policies. The cut-off was decided based on average values of parameters across all the states (Table 2).

Table 2: Scoring criteria for parameters

Assessment criteria	Parameters	Scoring criteria
Fiscal incentives to promote RE in a state	Levelised cost of tariff with AD / without AD (in /kWh) (FIT)	Below 5: 1 Between 5 and 6: 0.5 Above 6: 0
	Are incentives under state industrial policy applicable to Solar projects?	Yes: 1 No: 0
Sharing of CDM benefits		100% with generator then 10% passed on to Distribution licensee till 50/50: 1 No benefits: 0
Technical grid parameters for evacuation from plant site	Evacuation at Extra High Voltage (approved by transmission/ distribution utility)	Below 5MW- 33kV and above 5MW- 132kV: 1 Upto 10MW-33kV and above 10MW- 132kV: 0.5 Above 10MW- 66kV: 0
	Plant capacity connected to transmission grid	
Unscheduled Interchange (fees to be paid to the DISCOM if you draw more than the contracted load)		Less than 20% deviation- below 0.4/kWh and less than 35% deviation- below 0.5/kWh: 1 Else: 0
State screening committee	Yes or No	Yes: 1 No: 0
Security deposit	Bank guarantee (in Rs.)	Less than 3 lacs/MW: 1 Upto 10 lacs/MW: 0.5 Above 10 lacs or Performance guarantee: 0
Open access charges for RE (POC losses and charges, T&D charges and losses, cross-subsidy surcharge, additional surcharge, electricity duty, wheeling and miscellaneous charges	POC losses and charges	NA: 1 If applicable: 0
	T&D charges and losses & wheeling	If exempted: 1 If exempted for plants injecting below 33kV: 0.5 If applicable: 0
	Cross-subsidy surcharge/additional surcharge/electricity duty	Exempted for 10 years: 1 Exempted for upto 5 years: 0.5 If applicable: 0
Energy banking	Duration of banking	100% for 12 months: 1 Drawals only at night: 0.5 No banking: 0
	Energy settlement	Monthly: 1 Yearly: 0
	Banking charges	Below 3% energy delivered: 1 3% - 5%: 0.5 Above 5% or No banking: 0
Time-frame for which the open access charges apply or do not apply for RE projects	Control period for Solar Energy regulations	Up to 2019: 1 2018-2019: 0.5 Before 2018: 0
Net metering	Whether Yes or No	Yes: 1 No: 0
Central Subsidies	Rooftop for domestic consumers	30% Capital subsidy: 1 Below 30% capital subsidy: 0
Sharing of CDM benefits		100% with generator then 10% passed on to Distribution licensee till 50/50: 1 100% Distribution licensee: 0
Contracted demand	For residential and Industrial, commercial and others	Above 100% of sanctioned load: 1 Between 80% and 100%: 0.5 Below 80% sanctioned load: 0
Distribution transformer capacity	Cumulative capacity allowed at a distribution transformer as a % of peak capacity	Above 60%: 1 Between 60% and 40%: 0.5 Below 40%: 0

Source: CEEW Analysis; Various State Solar Policies, Government of India

These scores can be used to contrast one state solar policy with another on a clause-by-clause basis. Finally, a weighted average of the scores for all the parameters is taken, where the weights assigned to each parameter have been adopted from the results of the Delphi exercise.

The final scores have been used to rank states which can be used as a basis for guiding the Indian Railways to develop a phase wise implementation strategy. States with higher scores or ranks can be targeted in the first phase of implementation. For the other states, depending on the parameters which score low, the Railways can flag those issues with the respective states and resolve them in time for the subsequent phases of the implementation plan for the 5 GW target. This state policy comparison could also help the Railways in effecting mid-course corrections in terms of their choice to tender rooftop or utility scale solar plants in a particular state.

3. Understanding Solar Developer Perspectives

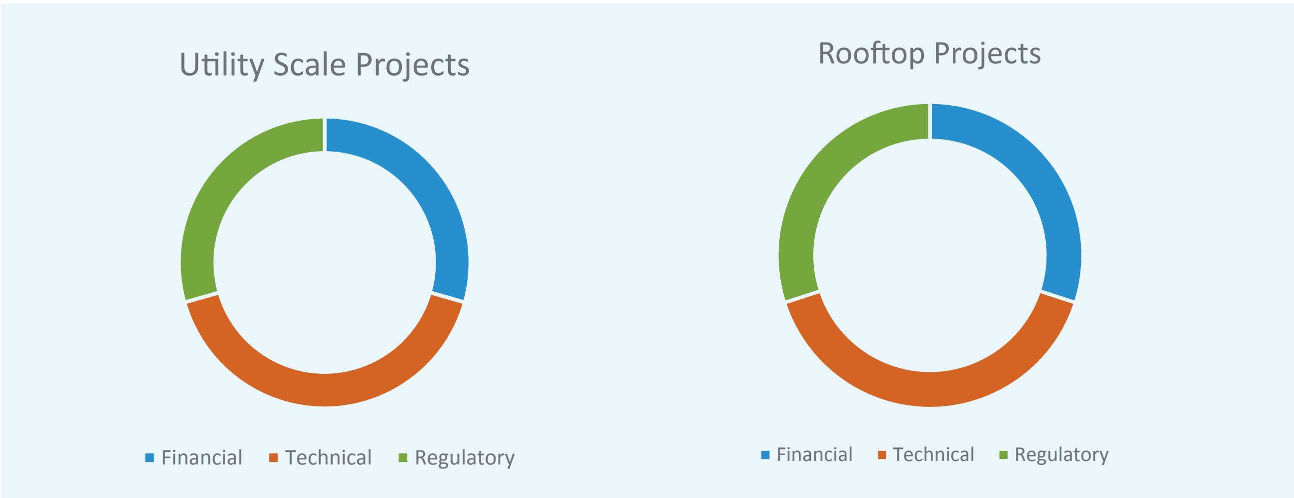
The Indian Railways has distinguishing features with respect to its energy requirements, notably – the need for 24x7 reliable power supply and short term variations in power demand across its network requiring smart power scheduling and dispatch strategies. In view of rising energy demand and uncertainty in power tariffs, the Indian Railways has identified the need for an aggressive push towards alternate fuels and energy sources[34] as well as identify potential opportunities for energy savings and realise a cost-effective energy system with least environmental impact[35].

In the context of the 5 GW solar target, it is important to understand the concerns of solar developers so as to best address these in the tender documents for the solar projects being commissioned by the Railways.

Prior to assigning the weights to the individual parameters, the Delphi exercise required developers to weight the three assessment categories, namely, financial, technical and regulatory. It is interesting to note for both utility-scale and rooftop projects, technical parameters emerge as the most important, followed by financial incentives and regulatory parameters.

Figure 1 shows the final combined weights of the three assessment categories for utility projects, while Figure 2 shows the same for rooftop projects.

Figure 1: Assessment category weights for utility scale solar projects and rooftop scale solar projects



Source: CEEW Analysis

34 Ministry of Railways (2015), White Paper - Indian Railways: Lifeline of the Nation, Ministry of Railways, Government of India
35 Public Accounts Committee (2014), Environment Management in the Indian Railways – Stations, Trains and Tracks, Third Report of the Public Accounts Committee (2014-15), Sixteenth Lok Sabha, Government of India

These results are in congruence with the fact that solar bids are becoming increasingly competitive and financial incentives have been rendered comparatively less significant[36]. Increasingly, and in the context of the Railways, as indicated in the results of the Delphi exercise, technical requirements are seen as a greater barrier to the deployment and commissioning of projects.

Grid parameters and evacuation voltage criteria play a very significant role since transmission infrastructure from the plant to the pooling sub-station has to be laid by the developers, and the evacuation voltage requirement (whether HT or LT lines) determine the land parcels required. Higher voltage evacuation systems require higher capital expenditure. However, evacuating at very low voltages is also not preferred by developers, owing to high transmission losses. In addition, grid sub-station capacity also plays a role, especially when existing transformer capacities cannot cater to multiple solar plants in a region feeding into the same sub-station, which requires augmenting of transformer capacity. All of the above add to delays in the commissioning of plants, thus leading to increased project costs.

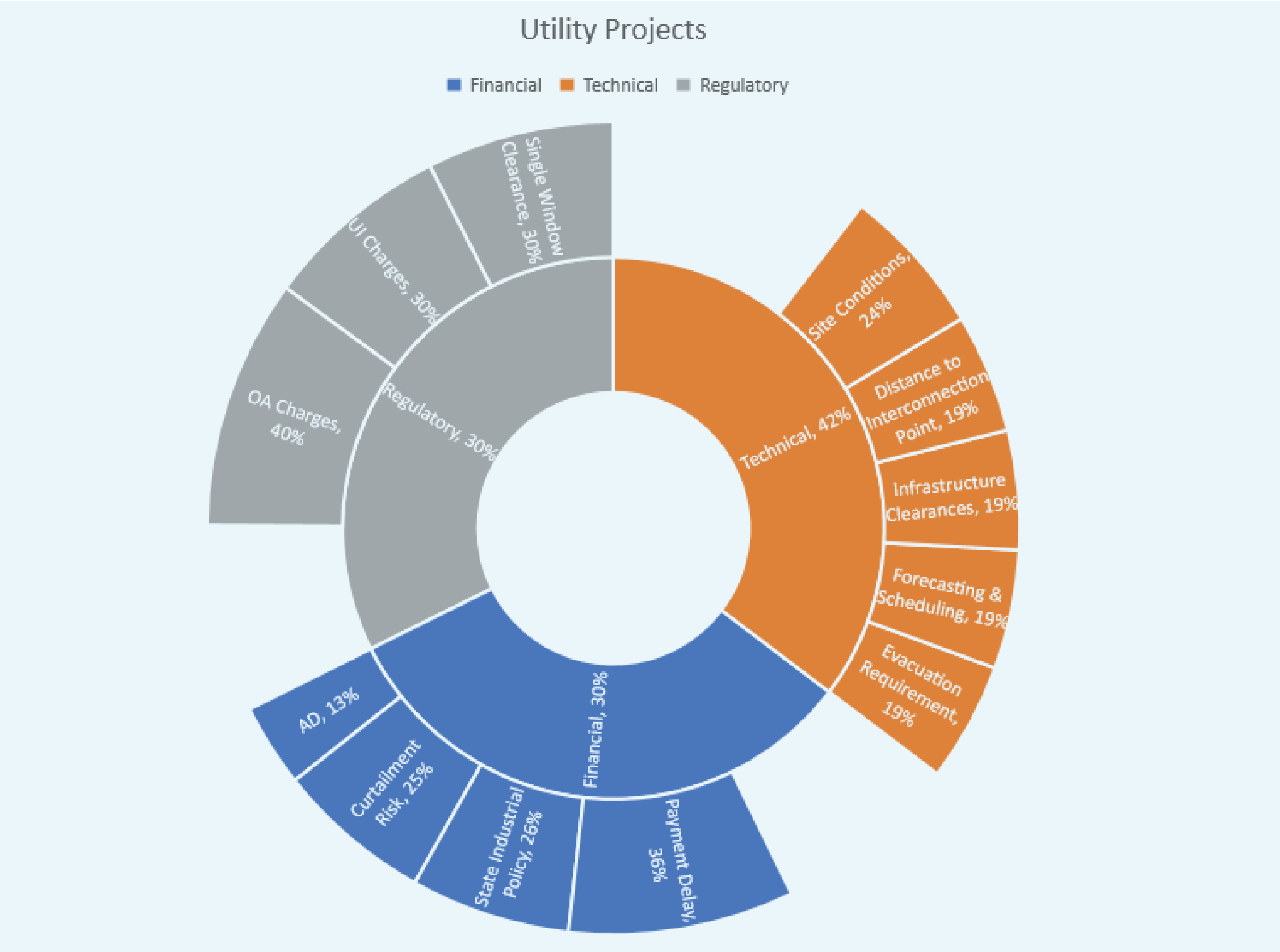
Financial incentives continue to carry about 1/3 of the total weight assigned, primarily due to two concerns. Firstly, some developers are yet to see confidence in the solar market in the near future and its competitiveness, with one of the key questions being whether the current trends in solar prices are here to stay or are a temporary phenomenon. Secondly, certain developers who tend to be risk-averse continue to prefer some form of financial support from the government, either in the form of subsidies or tax exemptions.

Subsequent to weighting the overall assessment categories, the developers weighted the individual parameters within each of these categories, separately for utility and rooftop projects. Based on interactions with various stakeholders during the course of this assessment, it has been understood that certain parameters take precedence over others based on the type of project (utility or rooftop) being commissioned, for example, the capacity of the Distribution Transformer is crucial for rooftop projects, whereas it does not affect utility projects. Similarly, wheeling and banking is an important parameter for a utility-scale project, whereas rooftop projects are currently not affected due to their smaller scale. Thus, the assignment of weights is different for the individual parameters under utility-scale projects and for rooftop projects.

Figure 2 shows the Delphi results for utility projects. In the case of utility projects, technical parameters are given the highest weightage followed by the others. Within technical parameters, information on site conditions is given the highest weight, with developers being of the perspective that with better information on site conditions, their decision on bidding for projects, costs involved and the tariff structures are better carried out, as it is difficult to survey each site before bidding for a project. Under financial parameters, payment delays are seen as the highest risk, followed by the incentives under the State Industrial Policy and risk of curtailment by the State Load Despatch Centre (SLDC). Open Access charges are seen as driver of decision-making among solar developers, when it comes to their assessment of regulatory parameters.

36 Based on interviews with solar developers

Figure 2: Delphi weights for utility scale project parameters



Source: CEEW Analysis

Figure 3 shows the results from the Delphi exercise for rooftop projects. In this case as well, similar to utility projects, technical parameters are given the most importance. Under technical parameters, information on site conditions (similar to utility projects) and the ease of access to the roof are seen as important drivers. Feed in Tariff and Open access charges are seen as the other important factors in the case of rooftop projects as well.

Figure 3: Delphi weights for rooftop scale project parameters

Source: CEEW Analysis

Table 3 and 4 provide the weights assigned to the various individual parameters for both utility and rooftop projects, as part of the Delphi exercise.

Table 3: Weights for parameters based on Delphi exercise (utility scale projects)

	Utility	
Category	Parameter	Weights (%)
Financial	Accelerated depreciation	4.12
	State Industrial Policy	7.89
	Payment Delays	12.00
	Risk of Curtailment	8.57
Technical	Evacuation parameters	6.91
	Forecasting and scheduling	6.51
	Clearance for evacuation infrastructure	6.81
	Distance from interconnection	7.21
	Site conditions	10.61
Regulatory	Efficacy of single window clearance	10.93
	Unscheduled Interchange charges	7.20
	Open Access Charges	11.24

Source: CEEW Analysis

Table 4: Weights for parameters based on Delphi exercise (rooftop projects)

Rooftop		
Category	Parameter	Weights (%)
Financial	Feed-in-tariff	13.20
	Central subsidies	9.86
	State incentives	9.52
Technical	Contract demand	8.01
	Distribution Transformer Capacity	7.81
	Site specifications	12.12
	Access to roof	10.11
Regulatory	Efficacy of application process	13.06
	Open Access Charges	16.31

Source: CEEW Analysis

During the stakeholder discussions with solar developers, some other key issues emerged in the context of both rooftop and utility projects. In the case of rooftop projects, the notification of a net metering policy and the processes involved in implementing it are seen as a barrier. Also, the percentage of the peak demand that can be contracted (as a function of the DT capacity) plays an important role in the choices developers make while bidding for rooftop projects.

Apart from some of the state-specific parameters, certain project-specific parameters such as distance from the interconnection point, site conditions, and access to the roof were also flagged as important factors. Another important factor was the availability of land, particularly in the case of utility projects. Availability of a large single patch of land with a fairly consistent terrain is critical, or flattening the ground could lead to higher project costs. The current efforts to map the land available across the various railway zones will go a long way in facilitating better participation by developers as well as realising costs closer to actuals.

The stakeholder consultation with solar developers and the Delphi exercise have been used to better understand the relative importance of parameters of the state solar policy assessment framework as well. Some of these parameters could not be included in the assessment framework for comparison of state solar policies since they are more project-specific and local in nature, thus, not finding mention in the state solar policy document. These include risk of curtailment, distance from the interconnection point, and site conditions like geography of the land, etc. for utility scale projects, and access to the roof and site specifications like irradiance, etc. for rooftop projects. However, they are important factors to be considered for the Railways to design a more comprehensive tender document, to help developers make a more informed decision.

4. Towards Better Processes: Railway Specific Issues

In the recent past, two tenders of 100 MW inviting bids for solar projects have been floated by the Railways, with one tender being announced by the Railway Energy Management Company Limited (REMCL) and the other by Central Electronics Limited (CEL). Despite significant interest in the pre-bid meeting, the first tender saw only about 60 MW being bid for. It was realised that there were certain reservations on behalf of the solar developers that led to the gap between the pre-bid and the actual bid. At the same time, these concerns cannot be assessed in isolation, and must be understood in the context of the Indian Railways and their limitations as well. Thus, the stakeholder discussion which saw participation from various solar developers, including some who have participated in Railway tenders as well, was an important step to understand their views on railway-specific opportunities and challenges for solar projects. Some of the issues and challenges highlighted during the stakeholder discussions were not necessarily specific to the railways but to the solar sector as a whole.

4.1 Financial

An important concern raised was regarding the payment guarantee mechanism or rather lack of it, which has been seen as a significant risk in the solar sector as a whole. Provision of a letter of credit is seen as an assurance by developers in case of any delay in payments since such delays can affect the working capital for developers as well as their repayments to their creditors. However, compared to other distribution licensees, the Indian Railways is seen as a well-rated DISCOM. This is important particularly in the case where financiers see payment delays as a significant risk, which in turn affects the interest rates at which developers would get loans or for that matter, the quantum of credit itself.

4.2 Technical

Of all the technical constraints and challenges that were perceived by developers, there was consensus on one of the requirements in the tender documents, that of the Capacity Utilisation Factor (CUF). The current requirement expects a CUF of 16%, which is seen as an industry standard. Developers were of the opinion that the CUF needs to be brought down to a range of 12-14%, especially in the case of solar rooftop projects being taken up at railway workshops and locomotive sheds. At such sites, the use of chemicals and other compounds on the premises, also leads to these compounds mixing with the air and settling on the solar panels, thus significantly reducing the CUF. Also, there should be a provision for lower CUF allowances with time, as plants start ageing and lack proper maintenance. It was also pointed out that even though many developers have stringent CUF generation requirements as part of their PPAs, they don't get CUF guarantees from the Operations and Maintenance contractors.

Another suggestion specific to railway projects was to include as many details of the sites being included in the tender document, to facilitate better decision making while bidding. For example, in the case of the 100 MW tender, it is tedious for developers to visit every site, and some of the railway stations listed are in remote locations, thus, adding to the costs for developers while preparing the bid document. Inclusion of GPS coordinates of the station, with details of the available infrastructure would go a long way in making the process more efficient.

The third important issue raised was the lack of information on the assessment of the DT load capacity in an area where the site is located, particularly in the case of rooftop projects.

4.3 Regulatory and Policy

Among other regulatory challenges raised by developers, the lack of clarity on part of the developers was regarding the status of the Indian Railways as a Distribution Licensee. Despite the Central Electricity Regulatory Commission (CERC) ruling upholding the status of a deemed distribution licensee of the Indian Railways, various State Regulatory Commissions have raised objections in the interest of the concerned state utilities. Some of the states have allowed the Railways to operate under Open Access as a Distribution Licensee, while many have not. If the state recognises this status of the Railways, it is seen as a plus by solar developers.

Another concern raised by developers was the control period for which the Open Access charge waiver would be applicable (in some states it is only for 5 years). It was suggested that this period be negotiated by the concerned stakeholders before setting a control period within a state.

Also, getting land approvals for setting up evacuation infrastructure based on the plant-specific technical parameters and conforming to the state-specific guidelines was pointed out as a cumbersome process. These approvals become further complicated based on whether the evacuation voltage conditions required high tension or low tension wires, and if the land for which clearance is being sought, is residential or vacant land. It was suggested that in the context of solar projects for the Railways, the Indian Railways could facilitate the necessary clearances.

With regards to rooftop solar projects, the developers suggested that the role of the Indian Railways in facilitating a more efficient process for obtaining the necessary clearances for net metering would be useful.

A regulatory concern raised by developers pertained to UI charges. It was proposed that instead of levying high UI charges, a differential price between the quoted tariff and the DISCOM tariff could be charged as the UI penalty.

Some additional suggestions were regarding the flexibility in Power Purchase Agreements. Since many of the plants and rooftop sites are spread out across different railway zones, while the PPAs are drafted by the Railway Board, there is little flexibility given to different zones to make site-specific modifications to the agreements. However, after much deliberation, it has been established that since the Railways do not have any nodal ministry at the state level, a centralised approach is currently the best way forward.

4.4 Business Models

- In addition to the existing business models, which mostly include RESCO models, the developers were asked to suggest other business models that would be attractive to them, particularly when implementing solar projects in the context of the Indian Railways.
- If the CAPEX model is considered, it will be for a plant capacity of 50-60 MW, which is small as a proportion of the total solar target. Also, owing to the high operating ratios of the Railways, it doesn't make sense to invest in CAPEX models
- Instead of having a tariff bid, a reverse bid could be attempted with the DISCOM tariff as the benchmark. Also, if the discount or differential between the tariff quoted by developers and the DISCOM tariff can be maintained, even if not in absolute terms, as a percentage of the increase in the DISCOM tariff being passed on to solar developers, it would be an incentive for developers
- Under utility projects, it is important to target bulk consumers and allow them to operate under Open Access, since in some cases solar tariffs are much lower than the utility tariffs that are applicable to the Railways.

5. Deemed Distribution Licensee Status and Open Access

The Indian Railways has been involved in construction, operation and maintenance of electric lines, for traction or any other distribution purpose in connection with the working of railway, based on provisions under Section 11 of the Railways Act, 1989. IR has been engaged in transmission and distribution of electricity, for its functions including traction and non-traction loads. The railways were given the status of "Deemed licensee" in May, 2014. IR was seeking to benefit from the license, by availing long and medium term open access for purchase of electricity. Energy costs constitute about 25% of the working expenses of the Indian Railways and procuring from open access markets can significantly reduce the cost of power and enhance the operating margins (Garg, 2016).[37]

However, "Deemed licensee" status was contested by the state transmission & distribution utilities and electricity regulatory commissions as it would mean that IR would not have to pay additional surcharge to the state utilities. This surcharge is paid to compensate the utility for losing a consumer, while they can continue to serve low-paying consumers.

In November 2015, CERC ruled that IR is a "deemed licensee" and is not liable to pay any surcharge to the state utilities (CERC, 2015).[38] Yet, state utilities in Uttar Pradesh, Chhattisgarh, and West Bengal continue to levy a surcharge on the Railways. IR has paid a total of INR 2,500 crores, to various state utilities. To waiver this surcharge, a No-objection- Certificate (NOC) has to be issued to the railways for grant of long/medium term open access (Financial Express, 2016).[39] State utilities of Gujarat and Maharashtra, which have previously raised their objections to the deemed licensee status of IR have subsequently given their nod for use of transmission lines for wheeling electricity.

The railways have identified the following methods, in an attempt to reduce their cost of power procurement (Garg, 2016)–

- Purchase cheaper electricity via open access
  - 50 MW power in UP via IR's electricity network connected to Central Transmission Utility
  - 500 MW procured from Ratnagiri power plant, for consumption in Maharashtra, MP Gujarat and Jharkhand
  - 90 MW from Tata power in Mumbai area.
  - 585 MW procured up for consumption in Northern, Eastern and Central regions (NOC obtained from the states of MP and Rajasthan)
  - 400 MW procured for consumption in the Southern states
- Migrate from DISCOMs by investing in Captive power plants
  - IR's first captive power plant in Nabinagar, Bihar. The plant is developed in a joint venture with NTPC, plant capacity is 1000 MW (250 MW*4 units).
- Have a transmission network, for wheeling power from various generating stations

37 Garg, S. (2016) Indian Railways Energy Policy and Management, (p. 25), New Delhi, Indian Railways
38 CERC (2015, November 05). Order on Grant of Connectivity, long Term Open Access and Medium Term Open Access in the inter-State Transmission and related matters to the Indian Railways, New Delhi, CERC.
39 Financial Express. (2016, August 30). How state electricity boards are holding Indian Railways to ransom

- Move to renewable energy, to reduce carbon footprint

In an attempt to reduce their electricity bills, the railways are moving towards gaining energy security. Construction and maintenance of a dedicated transmission line, which is used for wheeling power from the inter-state transmission network, will help railways ease any evacuation constraints. Transmission limitations are cited as one of the major reasons for rejection of NOC applications of open access consumers. With the states warming up to railways' plan to procure cheaper power, long/medium term open access will them reduce their operational costs.

DMRC procuring power from Rewa Ultra Mega Solar Park

DMRC has signed to purchase power from the Rewa project; 150 to 200 MW of green power daily for electric traction purposes. DMRC procures its power under a long term open access agreement, to be wheeled from interstate transmission lines. These agreements have been backed by a payment guarantee, from the state government. Record low tariffs have been achieved in the reverse auction bidding. The Indian Railways could benefit from the experience of this project, to design similar guarantees for developers to encourage aggressive bidding.

6. Ranking of States Based on their Solar Policies

Inputs from solar developers facilitated scoring the states across various parameters. For example, evacuation infrastructure requirements are usually specified as the voltage of the transmission lines that are connected to particular plant sizes. While higher voltage transmission lines minimise losses and would lead to efficient wheeling of electricity, high voltage or extra high voltage (EHV) lines have greater land requirements and would also need more approvals and clearances for their construction, thus delaying the process from deployment to commissioning. Also, the capital costs for EHV infrastructure is significantly higher. However, developers were of the view that evacuation at higher voltages for large- scale plants (10 MW and above) is preferred. After careful consideration, the threshold of 10 MW was taken to assess evacuation infrastructure requirements of states. Very small plants (3 - 5 MW) requiring to evacuate at high voltages were awarded a low score, as were high capacity plants requiring evacuation at low voltages.

Based on the methodology explained in Section 2.3, using the weights from the Delphi exercise and the scores from the policy assessment, an overall ranking of states was done to understand the ease of doing business for solar developers (Table 5).

The results of the analysis show that Madhya Pradesh was ranked the highest for utility scale projects, followed by Rajasthan and Andhra Pradesh. In case of rooftop projects, Karnataka was ranked the highest, followed by Telangana, with the former having a detailed net-metering policy and the latter notifying a map of all sub-stations within each district with their transformer and grid capacities, thus ensuring transparency in information flow[40].

Table 5: Solar policy assessment of states

	Score		Rank	
	Utility	Rooftop	Utility	Rooftop
Andhra Pradesh	43.43		3	
Madhya Pradesh	56.06		1	
Uttar Pradesh	26.07		5	
Gujarat	41.68	19.67	4	3
Rajasthan	45.38	15.87	2	4
Karnataka		22.75		1
Telangana		19.77		2
Chhattisgarh		14.86		5
Odisha		5.00		8
Jammu & Kashmir		10.85		7
Himachal Pradesh		14.85		6

Source: CEEW Analysis

Successful solar deployment in states tends to be enhanced by a precedence of successful bids. The findings from this assessment are resonated in the solar utility project allocations from July 2015 to December 2016,

40 Based on interactions with solar developers

where Andhra Pradesh, Telangana, Karnataka and Rajasthan have allocations of around 3 GW, 2.4 GW, 2.7 GW and 1 GW respectively[41]. The only outlier in the findings of this assessment is Madhya Pradesh when compared to previous allocations, however, the recent bid for the 750 MW Rewa Ultra Mega Power Plant is evidence of the conducive business environment for solar in the state of Madhya Pradesh.

These scores of the states are a culmination of their policy scores and the parameter weights. States with higher scores could be seen as having a greater enabling environment than others. Some states have been ranked lower either due to gaps in the policy that may not be conducive for solar projects, particularly in the context of the Railways, or the incentives they offer are not given significant weight by solar developers. For example, Accelerated Depreciation (AD) was not seen as important by developers as compared to other parameters, thus states with lower FiT inclusive of AD were not assigned a higher score.

With regards to utility-scale solar projects, the three states of Madhya Pradesh, Rajasthan and Andhra Pradesh scored the highest, in that order, in terms of ease of regulations for doing business (Table 5). These could be attributed to the following parameters:

- Optimum requirements for evacuation infrastructure
- Exemption of Open Access charges
- Fiscal incentives applicable under the state industrial policies
- Availability of energy banking services at low charges

Thus, if the Railways is looking to set up utility scale projects in other states where at a later stage such potential may be identified, these parameters provide a guiding strategy in terms of the key incentives the state must provide for developers to see projects as attractive.

Similarly, in the rooftop segment, Karnataka, Telangana, Gujarat and Rajasthan emerge as the favourable options, in that order (Table 5). Factors contributing to this are:

- Higher contracted demand
- Higher DT capacity

Both the factors emphasise the need for states to have district-wise maps of the grid and transformer capacities before floating tenders for rooftop solar deployment, especially with net-metering. If deployment of rooftop solar projects on railway colonies or offices were to taken up on a large-scale, they would need to prioritise areas where high transformer capacity is available, or if not, plan for setting up their own sub-stations and transmission infrastructure in areas where adequate capacity is not available.

The results of this assessment could help the Railways identify key parameters that developers consider while bidding for solar projects and thus, can take these up with states where such incentives may be lacking. This would help the Railways to ensure that at the start of each phase, most regulatory and policy issues are resolved and an enabling environment is created for developers to participate actively. A strategic effort in this regard would take the Indian Railways a step closer to achieving their objective of becoming a low carbon transit system.

41 Bridge to India (2017). India Solar Decision Brief (2017) 'Analysis of utility scale solar tenders in India'. Bridge to India, March 2017.

7. Scaling Ambitions: The Road Ahead

Since the announcement of the 1 GW solar target of the Indian Railways, tenders for close to 130 MW of renewable energy projects have already been awarded, while another 375 MW of solar projects are in the process of being tendered. The Railways is well on track towards achieving its 1 GW target for solar by 2019, which would help the Railways achieve about 10% of its electricity mix from renewables. Scaling the same to 5 GW of solar could see the Railways' electricity mix have close to 25% coming from solar. While the Railways can keep increasing this share by continuing to procure renewables-based power from the state utilities or Independent Power Producers, the 5 GW target of solar is the gross potential across the Indian Railways, including both rooftop and utility projects, thus being chosen as the scale of ambition.
Given its vast operations, for both traction and non-traction purposes, the Railways provides a unique opportunity for solar developers, with about 1.1 GW from rooftop and 3.9 GW from utility scale projects. The Indian Railways is a guaranteed consumer and has a growing electricity demand, which should mitigate any perceived off-taker risks that project developers or investors may see.

There are a few key policy challenges for the Railways to go ahead with its plan for integration of renewables. These include: (i) restrictions around the net metering policy in states, (ii) improving cost viability by bringing down the cost of connection from the solar plant to the Central Transmission Utility (CTU) or State Transmission Utility (STU), (iii) providing banking facility for use of RE power in the night, (iv) facilitate open access in states, and, (v) explore the possibility of a Payment Guarantee Mechanism for Railway RE projects.

The idea of a Payment Guarantee Mechanism would be a good step forward, and future work around designing the same in the context of the Railways will go a long way in improving investor confidence. Setting aside funds for de-risking investments made in renewable energy projects would give the sector the much-needed impetus.

Going forward, the Railway Board, along with state governments and electricity regulators (both centre and state) will have to work together to facilitate a smooth ecosystem for ensuring developer and investor confidence. One of the first steps for the Railways would be to develop technical and regulatory guidelines for renewable integration for traction operations, which would involve agreements between the Railways, State Utilities, and Solar Developers. The regulatory guidelines would have to be developed jointly with central and state electricity regulators. With regards to open access, state regulators will have to resolve the issue of clearances for the Railways to operate as a distribution licensee. This will be critical for the transporter to bring down the costs of power procurement. Further, as highlighted in the findings of this study, the Railways should create a platform for regular engagement with solar developers so as to understand and reconcile any of their concerns, with regards to technical and regulatory requirements. These would go a long way in instilling developer and financier confidence for investment in renewables for the Railways.

To achieve the 5 GW target, the Railways would need an investment of about USD 3,610 million or INR 24,200 crore. This window of opportunity to invest in large scale solar projects across the length and breadth of the Indian Railways, can act as a catalyst not just for the Railways' energy savings, but for the renewables sector in India.

Energy Security is key for transport security. As we transition to a low carbon future, resource efficiency, especially on account of energy, is going to be critical. The Indian Railways is moving from a conventional transport services provider to embark on a path towards becoming a low carbon sustainable mass transport system.

The constant effort to scale ambitions is the need of the hour. With the Railways already having an MoU with the Ministry of Science and Technology, Government of India, together with other ministries such as MNRE, could set up an R&D fund for taking forward path breaking research on energy efficiency and renewables integration in the Railways.

Last but not the least, this effort of the Railways would take India a step closer towards achieving its 175 GW renewables target, as stated in its Nationally Determined Contributions submitted to the UNFCCC, prior to the Paris Climate Conference in 2015. This is an effort that is not just about lowering energy bills, but has larger implications on low carbon transport and climate change.

Annexures

Annexure – I
Estimated Gross Solar PV potential across various identified railway operations

	Railway Unit	Capacity (MW)	Costs
1	Diesel Loco Sheds	36.87	221.22
2	Railway Workshops		
2.1	Rooftop PV	245.13	1470.78
2.2	Workshop Land	135.06	810.36
3	Car Sheds	220.96	1325.76
4	Electric Loco Sheds	34.21	205.26
5	Production Units		
5.1	Rooftop PV	184.06	1104.36
5.2	PU Land	174.54	1047.24
6	Railway Stations		
6.1	Already proposed (REMCL)	5.25	31.5
6.2	Additional potential	79.7	478.2
7	Level Crossing Gates (LCGs)	6.1	36.6
8	Street Lights	0.22	1.32
9	Railway Offices (Proposed by Ministry of Railways)	0.76	4.56
10	Total (1-9)	1122.86	6737.16
11	Land-based PV projects	3877.14	17447.13
12	TOTAL (10-11)	5000	24184.29

Source: CEEW Analysis

Annexure – II
Comparison of state solar policies for utility-scale and rooftop projects

	Assessment criteria		Gujarat (U+R)	Source	Rajasthan (U+R)	Source
Financial	Fiscal incentives to promote RE in a state	Levelised cost of tariff with AD / without AD (in /kWh) (FIT)	5.74/6.30	GERC Order No. 3, 2015, GERC Order No. 3 of 2015,(Table: Levelized tariff for megawatt-scale and kilowatt-scale photovoltaic systems commissioned between July 1, 2015 and March 31, 2018)	4.85/5.40	RERC Order, 2016-17
		Are incentives under state industrial policy applicable to Solar projects?	Yes	Gujarat Solar Power Policy 2015	Yes	Rajasthan State solar policy 2014
Technical	Technical grid parameters for evacuation from plant site	Evacuation at Extra High Voltage (approved by transmission/ distribution utility)	66kV/66kV/132kV and above	GERC electricity grid code, 2013	33kV/132kV and above	Rajasthan State solar policy 2014
		Plant capacity connected to transmission grid	50 MW/70MW/more than 70MW	GERC electricity grid code, 2013	5MW and less/ more than 5MW	Rajasthan State solar policy 2014
	Clearance for developers to lay electrical infrastructure from RE project sites to the grid	Concerned authority (depending on location of interconnection point)	Gujarat Energy Transmission Co. Ltd/ DISCOM/CTU		Rajasthan Vidyut Prasaran Nigam Ltd/ DISCOM/CTU	
	Unscheduled Interchange (fees to be paid to the DISCOM if you draw more than the contracted load)		Max charges for deviation: For 20% deviation, 0.35/kWh [for 0.01Hz deviation (50.05-50Hz freq)] & For 33% deviation, 0.20/kWh [for 0.01Hz deviation (below 50HZ to 49.70HZ)]	https://sldcguj.com/commercial/uploaded/WEEK%20FROM%2019-OCT-15%20TO%2025-OCT-15.pdf	Deviation 15-25%: 0.5/kWh; 25-30%: 1/kWh; above 35%: 1.5/kWh	http://rerc.rajasthan.gov.in/cnpl/PDFs/F&S%20Regulations.pdf
Regulatory	State screening committee	Yes or No	No		Yes (varies with project type and size)	http://rips.girnarsoft.com/menupdf/Rajasthan-Solar-Energy-Policy-2014-10.pdf
	Security deposit	Bank guarantee (in Rs.)	25 lacs /MW (for PPAs signed with obligated entities)	Gujarat Solar Power Policy 2015	10 lacs/ MW for projects under REC/ Captive/sale to third party/OA	Rajasthan State solar policy 2014
			5 lacs/ MW (with/without PPA with obligated entity)	Gujarat Solar Power Policy 2015	All other projects goverened based on PPAs	Rajasthan State solar policy 2014
Financial	Sharing of CDM benefits		100% retained by generator in the first year, 10% passed on to DISCOM every year until shared 50:50	GERC Order No. 3, 2015, GERC Order No. 3 of 2015 (Section 4.14)	Shared 25:75 between distribution licensee and generator	http://rerc.rajasthan.gov.in/Regulations/Reg79.pdf

	Assessment criteria		Gujarat (U+R)	Source	Rajasthan (U+R)	Source
Regulatory	Open access charges for RE (POC losses and charges, T&D charges and losses, cross-subsidy surcharge, additional surcharge, electricity duty, wheeling and miscellaneous charges	POC losses and charges	NA upto 31st March, 2019	http://powermin.nic.in/sites/default/files/webform/notices/waiver_of_inter_state_transmission_charges_and_losses.pdf	NA upto 31st March, 2019	http://powermin.nic.in/sites/default/files/webform/notices/waiver_of_inter_state_transmission_charges_and_losses.pdf
		T&D charges and losses & wheeling	Transmission charges: Rs. 0.11/kWh; transmission losses: 4.81%; wheeling charges: 33kV: 0.72/kWh, 11kV: 0.72/kWh	http://www.gercin.org/uploaded/document/cc4a7bc1-c2e6-4c02-8124-6f3c5fbc1f5f.pdf	Transmission charges: Rs. 0.19/kWh; transmission losses: 4.15%; wheeling charges: EHV: 0.01/kWh, 33kV: 0.11/kWh, 11kV: 0.32/kWh	http://www.rvpn.co.in/Open%20Access/Transmission%20and%20other%20charges.pdf
		Cross-subsidy surcharge/additional surcharge/electricity duty/misc	NA (re-check this)	GERC Order No. 3, 2015	surcharge NA for solar	http://rerc.rajasthan.gov.in/Regulations/Reg79.pdf
	Energy banking	Duration of banking	Banking facility available only to captive generation projects not operating under REC; not for third party sale	http://mnre.gov.in/file-manager/Compendium/Data/GUJARAT%204.pdf		http://www.rerc.rajasthan.gov.in/Regulations/Reg79.pdf
		Energy settlement			Monthly	
		Banking charges			2% of banked energy	
	Time-frame for which the open access charges apply or do not apply for RE projects	Control period for Solar Energy regulations	July 2015 to March 2018	GERC Order No. 3, 2015	April 2014 to March 2019	http://rerc.rajasthan.gov.in/Regulations/Reg79.pdf
Financial	Net metering	Whether Yes or No	Yes (@APPC)	Gujarat Solar Power Policy 2015	Yes (@FIT for that year)	http://mnre.gov.in/file-manager/Compendium/Final/RAJSTHN%203.pdf
	Central Subsidies	Rooftop for domestic consumers	30% Capital subsidy	http://pib.nic.in/newsite/mbErel.aspx?relid=134026	30% Capital subsidy	http://pib.nic.in/newsite/mbErel.aspx?relid=134026
	Sharing of CDM benefits	Residential (railways colonies, etc.)	100% retained by consumer/generator	Gujarat Solar Power Policy 2015	100% retained by distribution licensee	http://mnre.gov.in/file-manager/Compendium/Final/RAJSTHN%203.pdf
		Railway buildings, offices, sheds, etc.	100% retained by consumer/generator	Gujarat Solar Power Policy 2015	100% retained by distribution licensee (provided they pass it on to consumers)	http://mnre.gov.in/file-manager/Compendium/Final/RAJSTHN%203.pdf
Technical	Contracted demand	For residential and Industrial, commercial and others	Upto a max of 50% of Consumer's sanctioned load	Gujarat Solar Power Policy 2015	80% of Consumer's sanctioned load, max of 1MWp	http://mnre.gov.in/file-manager/Compendium/Final/RAJSTHN%203.pdf
	Distribution transformer capacity	Cumulative capacity allowed at a distribution transformer as a % of peak capacity	65%	https://connect.torrentpower.com/tplcp/media/cms/solarpolicy/regulations-2016.pdf	30%	http://mnre.gov.in/file-manager/Compendium/Final/RAJSTHN%203.pdf

Annexure – III
Comparison of state solar policies for utility scale projects

	Assessment criteria		Andhra Pradesh (U)	Source	Madhya Pradesh (U)	Source	Uttar Pradesh (U)	Source
	Fiscal incentives to promote RE in a state	Levelised cost of tariff with AD / without AD (in / kWh) (FIT)	4.88	http://www.aperc.gov.in/aperc1/assets/uploads/files/da926-01.pdf	5.45	http://www.mperc.nic.in/080816-SMP-25-16-solar.pdf	7.06	UPERC CRE Regulations, 2014
		Are incentives under state industrial policy applicable to Solar projects?	Yes	http://nredcap.in/PDFs/Pages/SOLAR_POWER_POLICY.pdf	Yes	http://www.mprenewable.nic.in/solarp.pdf	Yes	upneda.org.in/sites/all/themes/upneda/pdf/SPOLICY-ENG-1-AMEND -01-08-14.pdf
Technical	Technical grid parameters for evacuation from plant site	Evacuation at Extra High Voltage (approved by transmission/ distribution utility)	33kV/ EHT-132kV,220kV, 400kV	https://www.apspdcl.in/ShowProperty/SP_CM_REPO/Pages/Downloads/Solar%20Applications/Application%20for%20Soloar%20Projects	33kV	http://www.mperc.nic.in/250314-solar-ext.pdf	11kV/33kV/132kV	UPERC CRE Regulations, 2014
		Plant capacity connected to transmission grid	10MW and less/ above 10MW	https://www.apspdcl.in/ShowProperty/SP_CM_REPO/Pages/Downloads/Solar%20Applications/Application%20for%20Soloar%20Projects	up to 2MW	http://www.mperc.nic.in/250314-solar-ext.pdf	upto 1MW/1-10MW/above 10MW	UPERC CRE Regulations, 2014
	Clearance for developers to lay electrical infrastructure from RE project sites to the grid	Concerned authority (depending on location of interconnection point)	Andhra Pradesh Trans Co./ DISCOM	http://nredcap.in/PDFs/Pages/SOLAR_POWER_POLICY.pdf	MPPTCL/DISCOM	http://www.mprenewable.nic.in/solarp.pdf	UPTCL/DISCOM	upneda.org.in/sites/all/themes/upneda/pdf/SPOLICY-ENG-1-AMEND -01-08-14.pdf
	Unscheduled Interchange (fees to be paid to the DISCOM if you draw more than the contracted load)		Deviation: 10-20%, 0.5/unit; 20-30%, 1/unit beyond first 20%; >30%, 1.5/unit beyond first 30%	http://www.aperc.gov.in/aperc1/assets/uploads/files/9bdd5-draft-regulation.pdf	No infromation currently		No information currently	
Regulatory	State screening committee	Yes or No	Yes, project monitoring committee	http://nredcap.in/PDFs/Pages/SOLAR_POWER_POLICY.pdf	Yes	http://www.mprenewable.nic.in/solarp.pdf	Yes	upneda.org.in/sites/all/themes/upneda/pdf/SPOLICY-ENG-1-AMEND -01-08-14.pdf

	Assessment criteria		Andhra Pradesh (U)	Source	Madhya Pradesh (U)	Source	Uttar Pradesh (U)	Source
	Security deposit	Bank guarantee (in Rs.)	2 lacs/MW	https://www.apspdcl.in/ShowProperty/SP_CM_REPO/Pages/Downloads/Solar%20Applications/Application%20for%20Soloar%20Projects	5 lacs/MW for Category II& III projects (third party sale, captive use and REC mechanism projects)	http://www.mprenewable.nic.in/solarp.pdf	Performance bank guarantee as per project tenders	http://upneda.org.in/sites/all/themes/upneda/pdf/SPOLICY-ENG-1-AMEND-01-08-14.pdf
Financial	Sharing of CDM benefits		No CDM benefits		100% retained by generator in the first year, 10% passed on to DISCOM every year until shared 50:50	http://www.mperc.nic.in/080816-SMP-25-16-solar.pdf	100% retained by generator in the first year, 10% passed on to DISCOM every year until shared 50:50	http://www.mperc.nic.in/080816-SMP-25-16-solar.pdf
Regulatory	Open access charges for RE (POC losses and charges, T&D charges and losses, cross-subsidy surcharge, additional surcharge, electricity duty, wheeling and miscellaneous charges	POC losses and charges	NA upto 31st March, 2019	http://powermin.nic.in/sites/default/files/webform/notices/waiver_of_inter_state_transmission_charges_and_losses.pdf	NA upto 31st March, 2019	http://powermin.nic.in/sites/default/files/webform/notices/waiver_of_inter_state_transmission_charges_and_losses.pdf	NA upto 31st March, 2019	http://powermin.nic.in/sites/default/files/webform/notices/waiver_of_inter_state_transmission_charges_and_losses.pdf
		T&D charges and losses & wheeling	T&D charges and losses (distribution losses exempted only for plants injecting at 33kV and below) exempted for solar	http://nredcap.in/PDFs/Pages/SOLAR_POWER_POLICY.pdf	Transmission and wheeling charges exempted	http://www.mperc.nic.in/080816-SMP-25-16-solar.pdf	Charges apply as per UPERC tariff orders	UPERC CRE Regulations, 2014
		Cross-subsidy surcharge/additional surcharge/electricity duty/misc	Cross-subsidy surcharge exempted for 5 years from DOC (Date of Commissioning), electricity duty also exempted	http://nredcap.in/PDFs/Pages/SOLAR_POWER_POLICY.pdf	Electricity duty exempted for 10 years from DOC	http://www.mprenewable.nic.in/solarp.pdf	Charges apply as per UPERC tariff orders	UPERC CRE Regulations, 2014

	Assessment criteria		Andhra Pradesh (U)	Source	Madhya Pradesh (U)	Source	Uttar Pradesh (U)	Source
	Energy banking	Duration of banking	100% banking, 12 months of the year; drawals from 1 April to 30 June and 1 Feb to 31 March	http://nredcap.in/PDFs/Pages/SOLAR_POWER_POLICY.pdf	100%, 12 months	http://www.mprenewable.nic.in/solarp.pdf	100%, drawals only between 5pm-10pm	UPERC CRE Regulations, 2014
		Energy settlement	Monthly	http://nredcap.in/PDFs/Pages/SOLAR_POWER_POLICY.pdf	yearly	http://www.mprenewable.nic.in/solarp.pdf	monthly	UPERC CRE Regulations, 2014
		Banking charges	2% energy delivered	http://nredcap.in/PDFs/Pages/SOLAR_POWER_POLICY.pdf	2% energy delivered	http://www.mprenewable.nic.in/solarp.pdf	6% of energy delivered in case of grid connected, 12.5% for captive plants	UPERC CRE Regulations, 2014
	Time-frame for which the open access charges apply or do not apply for RE projects	Control period for Solar Energy regulations	Up to 2018-19	http://www.aperc.gov.in/aperc1/assets/uploads/files/658d9-transmissiontarifforderfor3rdcontrolperiod.pdf	31st March 2019	http://www.mperc.nic.in/080816-SMP-25-16-solar.pdf	31st March 2017	http://upneda.org.in/sites/all/themes/upneda/pdf/SPOLICY-ENG-1-AMEND-01-08-14.pdf

Annexure- IV
Comparison of state solar policies for rooftop projects

	Assessment criteria		Karnataka (roof)	Source	Telangana (roof)	Source	Chhattisgarh (roof)	Source	Odisha (roof)	Source	J&K (roof)	Source	HP (roof)	Source
Financial	Net metering	Whether Yes or No	Yes (@FIT for that year)	KA-Solar_Rooftop_Photovoltaic_Tariff-ORDER-dated-02.05.2016	Yes, upto 25 years	http://tnredcl.telangana.gov.in/PDFs/Solar_Net_Metring/Net_Metring_Policy_summary.pdf	Yes	http://rooftopsolar-india.com/wp-content/uploads/2015/12/Chhattisgarh-Net-Metering-Policy-and-Guidelines.pdf	Yes	http://mnre.gov.in/file-manager/Compendium/Data/ODISHA%201.pdf	Yes	http://jakeda.jk.gov.in/links/Solar%20Rooftop%20Policy%20(JAKEDA)%20.pdf	Yes	http://mnre.gov.in/file-manager/Compendium/Final/HP%204.pdf
	Central Subsidies	Rooftop for domestic consumers	15% Capital subsidy	KA-Solar_Rooftop_Photovoltaic_Tariff-ORDER-dated-02.05.2016	30% capital subsidy +20% state subsidy for rooftop installation upto 3kW	http://tnredcl.telangana.gov.in/PDFs/Solar_Net_Metring/Net_Metring_Policy_summary.pdf	30% Capital subsidy	http://cserc.gov.in/pdf/Draft%20RT%20Solar%20Tariff%20Regulation.PDF			30% Capital subsidy	http://jakeda.jk.gov.in/links/Solar%20Rooftop%20Policy%20(JAKEDA)%20.pdf	50% of Capital subsidy	http://mnre.gov.in/file-manager/Compendium/Final/HP%204.pdf
	Sharing of CDM benefits	Residential (railways colonies, etc.)	100% retained by generator in the first year, 10% passed on to distribution licensee every year until shared 50:50	KA-Solar_Rooftop_Photovoltaic_Tariff-ORDER-dated-02.05.2016	100% retained by generator in the first year, 10% passed on to distribution licensee every year until shared 50:50	http://www.tserc.gov.in/file_upload/uploads/Regulations/Final/tserc/2016/Regulation-06of2016.pdf					100% passed on distribution licensee	http://jakeda.jk.gov.in/links/Solar%20Policy%20for%20J&K.pdf		
		Railway buildings, offices, sheds, etc.												

	Assessment criteria		Karnataka (roof)	Source	Telangana (roof)	Source	Chhattisgarh (roof)	Source	Odisha (roof)	Source	J&K (roof)	Source	HP (roof)	Source
Technical	Contracted demand	For residential and Industrial, commercial and others	150% of Consumer's sanctioned load, max of 1MWp	KA-Solar_Rooftop_Photovoltaic_Tariff-ORDER-dated-02.05.2016	Residential: 100% of sanctioned load, max 1MWp; Industrial&commercial: 80% of sanctioned load, max 1MWp	http://www.tserc.gov.in/file_upload/uploads/Regulations/Final/tserc/2016/Regulation-06of2016.pdf	Beyond 100% of sanctioned load developers need to pay for augumetation infrastructure	http://rooftopsolarindia.com/wp-content/uploads/2015/12/Chhattisgarh-Net-Metering-Policy-and-Guidelines.pdf	100% of sanctioned load	http://mnre.gov.in/file-manager/Compendium/Data/ODISHA%201.pdf	50% sanctioned load, max 1MWp	http://jakeda.jk.gov.in/links/Solar%20Rooftop%20Policy%20(JAKEDA)%20.pdf	80% of sanctioned load	http://mnre.gov.in/file-manager/Compendium/Final/HP%204.pdf
	Distribution transformer capacity	Cumulative capacity allowed at a distribution transformer as a % of peak capacity	80%	http://rooftopsolarindia.com/wp-content/uploads/2015/12/Karnataka-Guidelines-to-BESCOM-officials1-1.pdf	50%	http://www.tserc.gov.in/file_upload/uploads/Regulations/Final/tserc/2016/Regulation-06of2016.pdf			30%	http://mnre.gov.in/file-manager/Compendium/Data/ODISHA%201.pdf	20%	http://mnre.gov.in/file-manager/Compendium/Final/J&K%205.PDF	30%	http://mnre.gov.in/file-manager/Compendium/Final/HP%204.pdf

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