The Nand & Jeet Khemka Foundation

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Solar Rooftop Policy Coalition

Unleashing private investment in rooftop solar in India

The Climate Group

SHAKTI
SUSTAINABLE ENERGY
FOUNDATION

Solar rooftop policy coalition

The Solar Rooftop Policy Coalition was formed in January 2015 by the Nand and Jeet Khemka Foundation and the UK Department for International Development with The Climate Group and the Shakti Sustainable Energy Foundation joining soon after. These organisations were motivated by the opportunity to support government to realise its ambition for rooftop solar. These partners provided funding, practical and intellectual support, without which this project would not have been possible.

Project team

The core team was made up of experts from The Nand and Jeet Khemka Foundation, The Climate Group, Bridge To India, and Meghraj Capital Advisors. The project team consisted of:

- Phil Marker (Project Director)
- Mudit Jain
- Rakesh Jha
- Jasmeet Khurana
- Vivek Mishra
- Vinay Rustagi
- Shilpi Samantray
- Jay C. Shiv

Parimita Mohanty also contributed during the research phase of the project. The project drew on Bridge To India modelling work, extending and deepening these models.

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Location: Rooftop solar installation at Indian Habitat Centre, Lodhi Road, New Delhi

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Upendra Tripathy
Secretary
Government of India
Ministry of New and Renewable Energy

सत्यमेव जयते

Preamble

The Government of India has set out ambitious target of 175 GW of renewable power by 2022, of which 100GW will be from solar, and of that 40 GW will be from grid connected solar rooftops. There are many challenges but we are working hard to achieve this.

It is the speed of cost reduction in solar that gives us cause for optimism. In just 2010, solar power costs were around Rs 17/kWh. Whereas, on 4th November, 2015 it was confirmed that the lowest bid under the latest round of solar mission bidding for installations in Andhra Pradesh was just Rs 4.63/kWh.

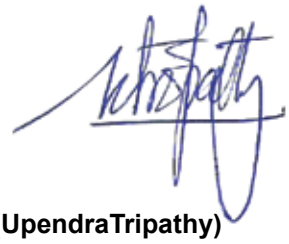
These cost reductions are also bringing the solar revolution home to rooftops of businesses, residences and other buildings. Solar rooftops are already growing fast with installed capacity set to be over 500 MW by the end of the year. 26 states have net metering regulations in place and a number of utilities are taking proactive steps to support rooftop solar. Net metered solar rooftop is now economic for commercial and industrial customers, without subsidy, in many states with more crossing this threshold every year.

And the Government of India is leading by example by installing solar roof tops widely on government buildings, airports, railways network, educational institutions, residential sector and all types of buildings. This initiative will not only support the solar rooftop sector, but will also save energy and reduce costs for government. The Government is providing Central Financial Assistance upto 30% for selected categories and upto 70% for special category states including islands.

The solar revolution is well underway and solar rooftop is poised for exciting growth. This growth will not just bring energy benefits and reduce carbon emissions, but will create jobs, skills and – by 'bringing solar home' can contribute to a change in the way people think about energy.

The Ministry of New and Renewable Energy is committed to seeing solar rooftop flourish for the benefit of India. This is why I welcome this report from the Solar Rooftop Policy Coalition (The Khemka Foundation, DFID, The Climate Group and The Shakti Sustainable Energy Foundation). I believe that the report will help us to formulate the strategy for meeting the ambitious target. Analysis, challenge, feedback and new ideas are always welcome from all quarters.

I congratulate the coalition and the project team and look forward to further constructive debate prompted by these ideas.



(UpendraTripathy)

Foreword

The Solar Rooftop Policy Coalition was born towards the end of 2014, shortly after the Government of India announced a target for rooftop solar of 40 GW by 2022. The Khemka Foundation and DFID agreed to work together, linking up with The Climate Group, to study how the government's ambition could be achieved. The Shakti Foundation joined soon after as the fourth funding partner.

The objective of this report is to provide substantive analysis on how to unleash the potential of the private sector in the rooftop solar sector. We started with a belief that much more private investment was possible and necessary given pressure on public finances. The report aims to support and inform decision-makers involved in setting policy and regulation on rooftop solar in India and to contribute to the debate amongst industry and think tanks.

From the start, we have sought to make this report a collaborative effort. We spoke to dozens of organisations and experts in India and around the world to 'crowd in' expertise and ideas. Over twenty organisations kindly agreed to contribute as Coalition Partners, bringing in ideas and commenting on drafts. Over a hundred people participated in consultation events in Mumbai, Hyderabad and Delhi.

We want to thank Mr. Tarun Kapoor and Dr. A K Tripathi from MNRE, and state government officials such as Dr. Amarpal Singh from the Punjab Energy Development Agency for their advice and guidance. We are grateful for the hard work of the project team, made up of experts from the Khemka Foundation, Bridge to India, The Climate Group and Meghraj Capital Advisor.

In the aftermath of a successful climate deal in Paris, the focus must be on implementation. This is one contribution to this effort: a labour of love from organisations who share the Government of India's belief in the importance of rooftop solar for India. We hope the analysis and recommendations will support the efforts of decision-makers working to make the rooftop solar revolution a reality.

Uday Khemka
Founding Trustee,
The Nand and Jeet Khemka Foundation

Sandy Sheard
Counsellor, Energy and Climate
British High Commission

On behalf of the Solar rooftop policy coalition

Executive Summary

Rooftop solar has significant potential to contribute to India's renewable energy targets and energy security. The Government's target of 40 GW of solar rooftop capacity by 2022 has injected increased ambition into the sector. The 40 GW target requires 86% growth each year which is faster than the growth in mobile phone connections during the 2000s. However there is significant scope for accelerating adoption of rooftop solar and this report sets out measures that could double progress towards the government's target.

I. Poised for growth: good progress with regulation

The Ministry of New and Renewable Energy (MNRE), state governments and regulators have made good progress with net metering policies and regulations and 25 states now have net metering regulations. Capital subsidies have supported the market but their impact has been reduced because of limitations in the funds available. Accelerated depreciation has also been a driver but has deterred some important capital sources.

Net metered rooftop solar is now viable for commercial and industrial consumers in seven states without subsidy, with more reaching tariff parity each year as solar costs decline and tariffs rise.

II. Scope to double growth by 2022

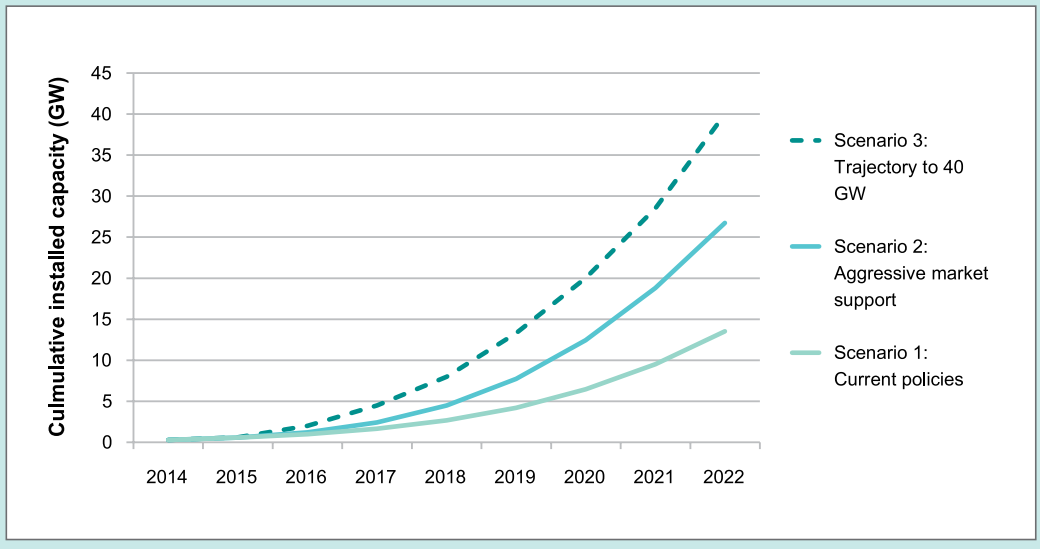
Globally, rapid growth of rooftop solar has been reliant on government subsidies and subject to boom and bust as subsidies are introduced and withdrawn. We believe India has a unique opportunity to leapfrog to sustained market-led growth in a way which can set an example globally. Our modelling suggests that current measures would lead to installed capacity of 13.5 GW by 2022. However, strong measures to accelerate market-led growth can nearly double progress by 2022, to additional 26 GW without further fiscal incentives[1] (see figure I). Our report contains over 50 recommendations that we believe will make this difference.

MEASURES TO ACCELERATE MARKET-LED GROWTH CAN DOUBLE ROOFTOP SOLAR CAPACITY BY 2022

Unleashing this revolution in distributed solar could also offer significant spill-over benefits through technologies, skills, business models and experience that can accelerate India's progress towards providing electricity for all by 2022.

1. These measures would require government expenditure, but at a fraction of the cost of subsidy (see chapter 9 for more details).

Figure I: Scenarios for installed capacity of rooftop solar in India to 2022



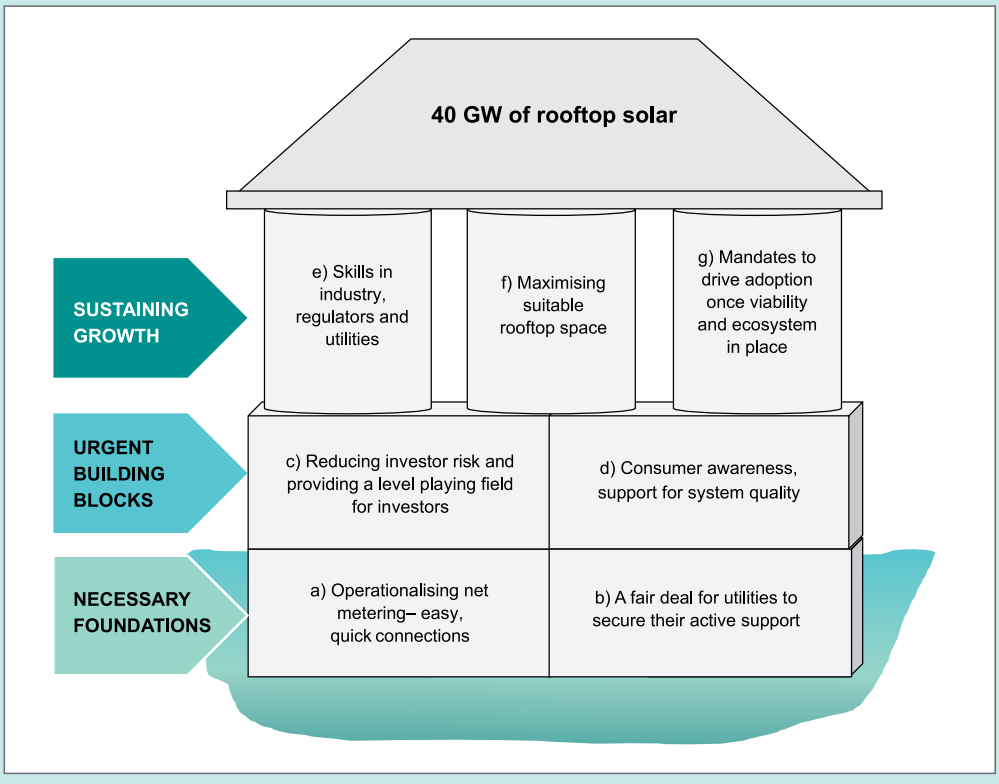
III. Gross Vs Net Metering

One debate that continues to rage is the merits of net metering vs gross metering. We cover this in more detail in chapter 2. We believe that net metering is important to maximising progress towards 40 GW because: i) net metering regulations are in place in most states; ii) net metering strongly supports viability which is important in a sector which is still yet to take off and iii) net metering is easy for consumers to understand. As viability strengthens, adjustments to net metering (eg. a medium term grid services charge) can ensure a fair deal for utilities as well as rooftop owners. Several states are experimenting with gross metering regulations. Provided these regulations also support viability to encourage adoption, these innovations are welcome.

IV. Building sustained growth

There are seven priorities that need to be addressed to unleash the potential of private investment in rooftop solar. Operationalising net metering (a), will require active support from utilities (b), which are two necessary foundations for the rooftop solar market. Without these foundations, market growth will be severely constrained. With these foundations in place, the building blocks of investors and consumer confidence (c) and (d) are needed to realise the growth potential. Sustaining rapid growth means anticipating and addressing potential constraints including skills (e), sufficient realisable rooftop space and (f) continued drivers such as mandates (g) to support adoption. Figure I illustrates these.

Figure II: Key priorities to maximise private sector growth in rooftop solar



The necessary foundations for market growth are:

a) Operationalising net metering – easy, quick connections

Strong progress has been made putting in place net metering regulations. But in practice, these regulations are not yet operational in most places. Timescales for interconnections are uncertain and take many months. Utilities need to invest in systems and trained staff to facilitate new connections.

REGULATORS SHOULD SET TARGET TIMESCALES FOR NEW CONNECTIONS

The three recommendations we think matter most here are:

- *Regulators should set and monitor target timescales for new connections, and should sanction non-compliance.*
- *Transparent data is needed on interconnections. Regulators should require utilities to publish data on applications, interconnection times, refusals and transformer loading.*
- *Regularly update the Forum of Regulators Draft Model Regulation to develop consistency and best practice across states. States should draw on draft model regulations when updating state regulations.*

GOVERNMENT SHOULD OFFER A PACKAGE OF INCENTIVES TO UTILITIES TO SECURE THEIR ACTIVE PARTICIPATION IN ROOFTOP SOLAR

b) A fair deal for utilities

Net metering supports viability by maximising the benefits to rooftop owners – and in many cases utilities lose a contribution to their fixed costs. Therefore, we believe government needs to offer a package to utilities that addresses their medium term concern about losing revenue, offers short term incentives, and sends clear regulatory and political signals.

The US has seen regulatory battles between utilities and rooftop solar advocates over the so-called utility death spiral. However, the context in India is fundamentally different, with a growing power market. The financial impact of rooftop solar on utilities is relatively small at low penetrations (and other issues such as under-pricing of power are far more important).

We recommend that Government should put in place a package of incentives for utilities addressing short term and medium term issues:

- *Introduce a medium term grid services charge on new net metered rooftop consumers to compensate utilities for grid services.*
- *Adjust RPO rules so generation from rooftop counts as 1.3 times that from ground mounted towards RPO compliance to boost the sector.*
- *Set up fund to support early-adopting utilities to make investments in infrastructure, training and systems for rooftop solar.*
- *Send firm political and regulatory signals to utilities that active support for rooftop solar is mandatory.*

We do not believe that technical challenges with the grid will significantly hinder progress towards the government's 40 GW target. Rooftop solar will require changes in the design and operation of distribution grids, but proven technologies exist to address these challenges. Most grid experts accept that until rooftop solar exceeds 5% of grid power (after 2022), the grid integration problems will be limited and highly localised. Rooftop solar also offers opportunities through avoiding some infrastructure costs by managing demand as well as through end-of-grid voltage support.

THE BIGGEST DETERRENT TO INVESTORS IS THE PROBLEM OF CONTRACT ENFORCEMENT

As well as ensuring these solid foundations for the rooftop solar market, it is important to urgently address the building blocks for growth:

c) Reducing investor risk and providing a level playing field for all investors: The biggest deterrent to investors is the problem of contract enforcement. Government needs to help make third party business models work. Tax incentives need to provide a level playing field for all investors to avoid deterring important sources for investment.

- *Empower a local level quasi-judicial authority to resolve disputes related to denial of access to roof by the roof owner to the project developer.*

- *Government should undertake or commission consultations on a credit default mechanism to boost investment.*
- *Provide waiver of stamp duty charges for registration of roof lease agreements (as the rooftop value is otherwise nil, this will not result in loss of significant revenues for the exchequer).*
- *Utilities to act as buyer of last resort (at discounted price) in case of disputed private power-purchase agreements.*
- *Devise all rooftop policies including any financial support measures so as to create a level playing field between different classes of investors including consumers-owners of rooftop systems.*
- *Phase out accelerated depreciation or make the benefit available to all investors, and generation-based, when the current provision ends in 2017.*

d) Consumer awareness, support for system quality: High quality consumer information is important and should be outsourced to neutral, trusted bodies who can help consumers make effective choices about systems and suppliers.

- *State Nodal Agencies should support independent consumer bodies to provide high quality consumer information.*

Once the market foundations and building blocks are in place, three pillars can drive sustained growth

e) Skills in industry, regulators and utilities: achieving 80-100% annual growth will be impossible without major investment in skills. Government will need to support and lead this with the immediate priority being skilled staff for utilities and regulators.

- *Urgently roll out skill development in rooftop solar for regulators.*
- *Work with utilities to identify their urgent skills requirements and ensure supply of skilled staff can meet demand.*

f) Maximising suitable rooftop space: Currently, projects are delayed due to the absence of policies on rooftop solar by urban local bodies, resident welfare associations, industrial area bodies and other local groups. A sustained campaign is needed to put in place ‘deemed permissions’ for rooftop solar. Building regulations should encourage design of buildings to maximise suitable roof space.

- *Amend planning rules to make new buildings more ‘rooftop ready’.*
- *State Nodal Agencies should work with urban local bodies to put in place ‘deemed permissions’ with local authorities to facilitate rooftop solar approvals.*

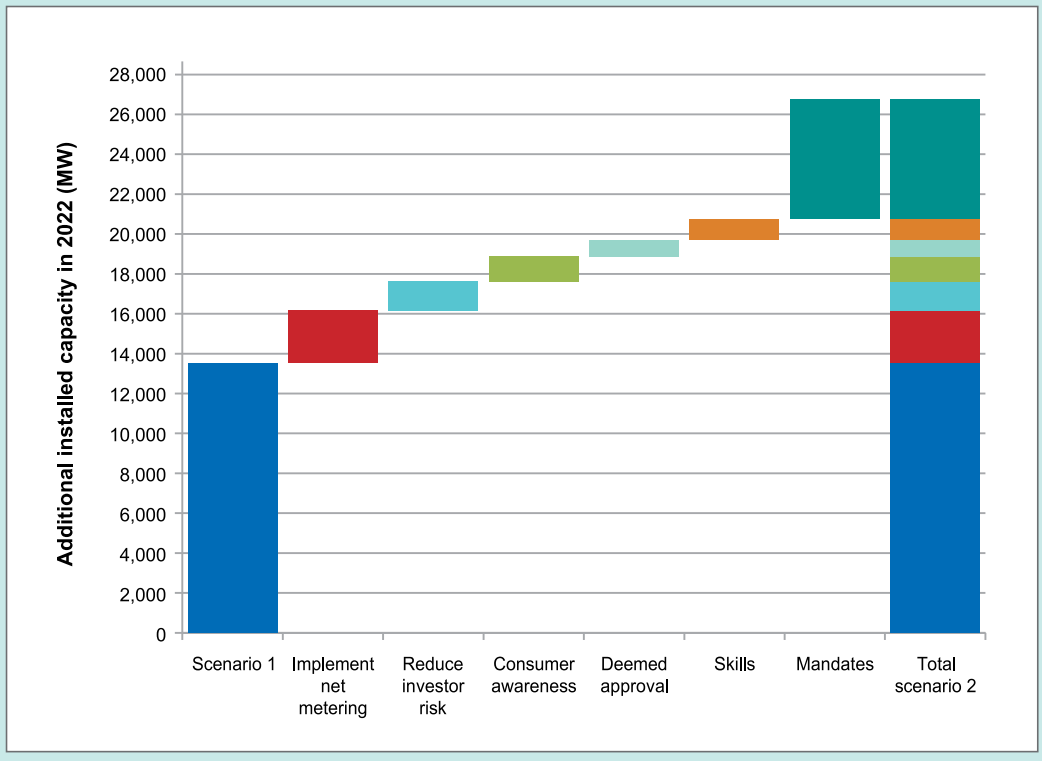
MANDATES CAN ENCOURAGE ADOPTION, BUT ONLY ONCE VIABILITY AND ECOSYSTEM ARE IN PLACE

g) Once other measures in place, mandates can support adoption: mandates are a powerful tool to encourage adoption once rooftop solar is economic for consumers but only once the other measures to stimulate the market are in place. Mandates should first be introduced for new buildings and then for retrofitting.

- *Introduce mandates requiring rooftop solar for new buildings of all types over 500 square yards across India.*
- *States to adopt retrofit mandates once viability established and ecosystem in place to support additional adoption.*

Our modelling suggests that addressing these seven priorities for market growth could double adoption of rooftop solar by 2022.

Figure III: Impact of priorities in additional MW by 2022



V. Making best use of scarce government resources

One of the most challenging questions to answer in this study was whether government should offer additional incentives[2]. We have identified measures that we think can double market-led growth. In theory, additional subsidy could further boost the market in the next few years, helping to build the ecosystem and drive faster growth. But our analysis suggests that further subsidies would be poor value for money because much of the subsidy benefit would go to projects that would have happened anyway. Carefully targeted state-level subsidies may still have a stronger case but their value for money should be carefully analysed before going ahead.

- *Marginal benefits of additional subsidy are diminishing, so further direct fiscal subsidy would not be good value for money.*
- *Non-subsidy measures offer better value for money and should be the first priority for the funds available to MNRE for rooftop solar (ahead of the 30% subsidy).*
- *If states are considering subsidies, they should assess carefully the value for money and additional capacity that can be expected before going ahead.*

DO NOT PROVIDE FURTHER FISCAL SUBSIDY TO REACH THE 40 GW TARGET

Existing resources can be stretched further. In particular, it is important that resources are prioritised for measures that support market-based growth which offer much greater value for money than subsidy. We estimate that the measures recommended in this report would cost less than Rs 1,000 crores. These costs should be the priority for the Rs 5,000 crores of central funds allocated for rooftop solar over the next five years.

THE PRIORITY FOR GOVERNMENT RESOURCES SHOULD BE NON-SUBSIDY MEASURES

VI. Conclusion

It is absolutely clear that rooftop solar has a bright future in India but there is significant potential to accelerate progress. The recommendations in this report could double progress towards the government's 2022 target. Our most important recommendations are summarised overleaf.

2. We use the terms incentives and subsidies interchangeably. Both mean any type of direct government financial benefit for rooftop solar systems such contributions for capital purchase or generation, tax benefits or below-market lending rates.

Summary of key recommendations

No[3].	Recommendation	Cost/ difficulty	Impact	Authority
a) Operationalising net metering – easy, quick connections				
R 1	Regulators should set and monitor target timescales for new connections, and should sanction non-compliance	L	H	State regulators
R 2	Transparent data is needed on interconnections. Regulators should require utilities to publish data on applications, interconnection times, refusals & transformer loading	M	H	State regulators
R 5	Regularly update Forum of Regulators Draft Model Regulation to develop consistency and best practice across states. States should draw on draft model regulations when updating state regulations	M	M	Forum of Regulators, State regulators
b) A fair deal for utilities				
R 17	Government should put in place a package of incentives for utilities addressing short term and medium term issues but sending clear regulatory and political signals that compliance is mandatory	M	H	MNRE, Ministry of Power, State Governments
R 18	Introduce medium term grid services charge on new net metered rooftop consumers to compensate utilities for grid services	M	H	MNRE, Ministry of Power
R 19	Adjust RPO rules so generation from rooftop counts as 1.3 times that from ground mounted towards RPO compliance to boost the sector	M	H	MNRE
R 20	Set up fund to support early-adopting utilities to make investment in infrastructure, training and systems for rooftop solar	M	M	MNRE, Ministry of Power
R 21	Send firm political and regulatory signals to utilities that active support for rooftop solar is mandatory	H	H	Central & State Governments
c) Reducing investor risk and providing a level playing field for investors				
R 22	Empower a local level (quasi)-judicial authority to resolve disputes related to denial of access to roof by the roof owner to the project developer	M	H	MNRE, Ministry of Law & Justice
R 23	Government should undertake or commission consultations on a contract default insurance mechanism to boost investment	H	H	MNRE
R 25	Provide waiver of stamp duty charges for registration of roof lease agreements (as the rooftop value is otherwise nil, no significant loss of revenues for the exchequer)	L	H	Respective State Governments

3. These numbers correspond to the recommendation numbers in the chapters and in the list in chapter 9.

R 26	Utilities to act as buyer of last resort in case of disputed private power purchase agreements	M	H	State regulators
R 28	Devise all rooftop policies including any incentives to maintain a level playing field between different classes of investors including consumer-owners of rooftop systems	M	M	Central, State Governments, State regulators
R 29	Phase out accelerated depreciation or make the benefit available to all investors, and generation - based, when the current provision ends in 2017	M	H	Ministry of Finance
d) Consumer awareness, support for system quality				
R 32	State Nodal Agencies should support independent consumer bodies to provide high quality consumer information	L	M	SNAs
e) Skills in industry, regulators and utilities				
R 37	Urgently roll out skill development in rooftop solar for regulators	L	M	MNRE/FOR/ CERC
R 38	Work with utilities to identify their urgent skills requirements and ensure supply of skilled staff can meet demand	M	M	MNRE
f) Maximising suitable rooftop space				
R 39	Amend planning rules to make new buildings more ‘rooftop ready’	L	M	MNRE
R 41	State Nodal Agencies should work with urban local bodies to put in place ‘deemed permissions’ with local authorities to facilitate rooftop solar approvals	L	L	State regulators
g) Once other measures in place, mandates can support adoption				
R 44	Introduce mandates requiring rooftop solar for new buildings of all types over 500 sq yards across India	M	H	MNRE
R46	States to adopt retrofit mandates once viability established and ecosystem in place to support additional adoption	H	H	MNRE, MoUD
Recommendations on subsidy				
R 47	Marginal benefits of additional subsidy are diminishing, so further national direct fiscal subsidy to reach the 40 GW target would not be good value for money	L	H	MNRE, Ministry of Finance
R 48	Non-subsidy measures offer better value for money and should be the first priority for the funds available to MNRE for rooftop solar (ahead of the 30% subsidy)	M	H	MNRE, Ministry of Finance
R 50	If states are considering subsidies, they should assess carefully the value for money and model the additional capacity that can be expected before going ahead	M	M	MNRE

1 CHAPTER

INTRODUCTION TO ROOFTOP SOLAR IN INDIA

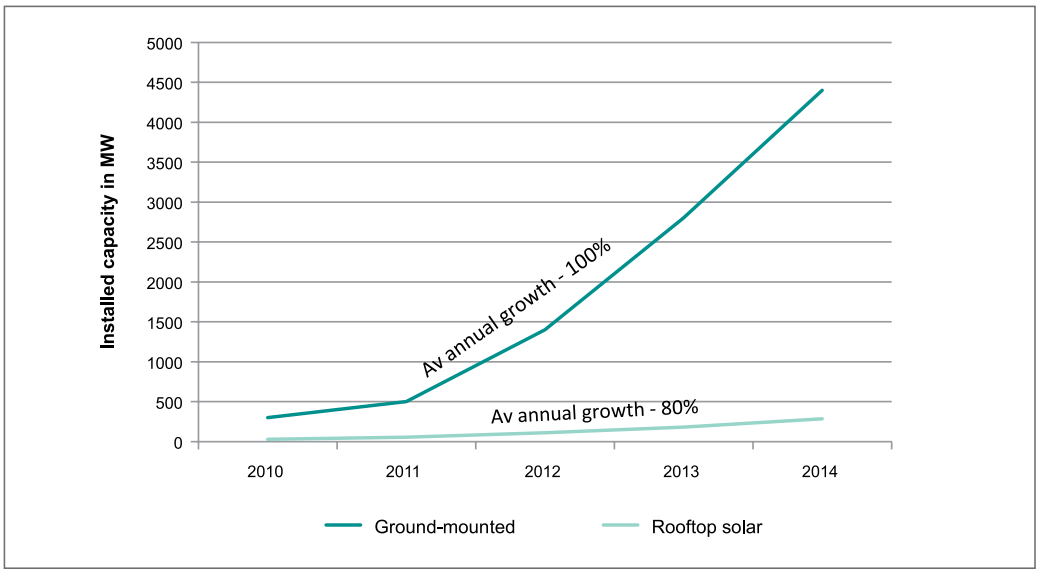
1.1 Introduction

India's energy demand is set to grow rapidly as India manages the energy challenges of a rapidly growing economy, access to electricity for 300 million people, and growing energy imports. Renewable energy is an important contributor to meeting this energy demand and to India's energy security, in addition to the environmental benefits.

Solar power is India's largest renewable energy resource. Over the past ten years, solar power has grown rapidly driven by government policy and declining costs, propelling the solar industry into the mainstream of energy policy. From 2009, the Jawaharlal Nehru National Solar Mission and state policies helped bring down the cost of generation. With the recent most bid of Rs 4.63 per unit for a utility-scale solar PV project in Andhra Pradesh under the National Solar Mission, solar costs have fallen 75% from 2010 levels.

As figure 1.1 shows, ground-mounted solar has driven solar growth. Rooftop solar is perhaps 3-5 years behind ground-mounted solar in terms of level of interest, comfort with the technology, contractual terms, availability of finance and ecosystem capacity.

Figure 1.1: Cumulative installed capacity for ground-mount and rooftop solar[4].



Photovoltaic rooftop solar[5] has the potential to be a significant addition to India's renewable energy mix, providing as much as 120 GW of domestic energy production

4. Source: MNRE (utility-scale), Bridge To India (rooftop)
5. Solar thermal systems for heating hot water are also established rooftop solar technologies but these are not the focus of this report.

capacity (see chapter 2). In the long term as new technologies such as building-integrated photovoltaics become cheaper and more widespread, this potential could increase further.

The objective of this report is to identify what would need to be done to secure the private investment needed to get to 40 GW of rooftop solar by 2022.

We also devote a chapter to looking at how scaling up private investment in rooftop solar can benefit rural electrification.

1.2 Why rooftop matters to India

Rooftop solar has particular advantages as an energy source for India. It also has some limitations. The table 1.1 summarises the advantages and disadvantages of rooftop solar[6].

Table 1.1: Advantages and disadvantages of rooftop solar

Advantages	Disadvantages
Makes use of space that otherwise may be unused, avoids need for additional land dedicated to energy production	Solar makes only a small contribution to India's evening peak demand, so largely does not substitute for peak power requirements
Produces power near point of consumption, makes use of existing grid infrastructure	Smaller rooftop systems mean higher unit costs than for utility scale solar.
Will help drive progress towards a smarter grid (higher efficiency, lower loses, higher quality, greater real-time power management)	Rooftop solar can generate two-way flows in the distribution grid, requiring changes to grid management and infrastructure
Can grow organically, not dependent on a few big projects	For utilities, net metered rooftop solar means slower growth in electricity demand
Involves households and businesses in power generation, can increase awareness of power consumption	Rooftops have multiple uses and trade-offs with other uses may be needed.
Creates significant numbers of jobs	

1.3 Government vision and roadmap

In November 2014, the Government of India announced its intention to increase its target for solar installed capacity from 20 GW to 100 GW by 2022[7]. This 100GW target, including a target of 40 GW from solar rooftops, was formally approved by Cabinet on 17 June 2015.

6. See also this report on IFC for more on the advantages of rooftop solar: IFC 2014, "Harnessing Energy from the Sun: Empowering Rooftop Solar Owners. White Paper on Grid-Connected Rooftop Solar Photovoltaic Development Models".
7. Government of India, 2015 (http://pib.nic.in/newsite/PrintRelease.aspx?relid=122566)

Rooftop solar installed capacity reached 525 MW in October 2015[8]. This means that reaching 40 GW will require increasing current capacity 76 times, or annualised growth of 86% every year till 2022. As a comparison, this would exceed the 80% a year growth rate of mobile telephone subscribers in India between 2000 and 2009[9].

REACHING 40 GW WILL REQUIRE GROWTH OF 86% A YEAR TO 2022, FASTER THAN GROWTH IN MOBILE TELEPHONES

The fastest international adoption rate for rooftop solar has come from Germany which grew its installed capacity at a rate of 54% between 2006 and 2012. This was on the back of very generous feed in tariffs which were scaled back and in the subsequent two years annual growth dropped to 10% and 5%. China is set to overtake Germany this year as the country with the largest rooftop solar installed capacity.

1.4 Solar Rooftop Policy Coalition guiding principles

The Solar Rooftop Policy Coalition applied the following guiding principles for developing the analysis and recommendations:

- Focus on market-led growth: maximising adoption of rooftop solar because it is in individuals' and companies' economic interests;
- Minimise government fiscal burden: making rooftop solar growth financially, operationally sustainable, minimising subsidy and administrative burdens;
- Fair to all stakeholders: including investors, rooftop owners, utilities and non-rooftop solar power consumers;
- Quantitative, practical and evidence and experience-based: taking an analytical, not an advocacy, approach to rooftop solar.
- Offer solutions wherever possible, not just more analysis of problems.

1.5 About this report

The focus of this report is on grid-connected rooftop solar. This can include distributed solar systems on the roofs of buildings, carports, walkways, sheds and other buildings. It can also include unused ground in the premises of businesses. So-called 'solar gardens' - as opposed to utility-scale solar farms - which aggregate distributed ground-mounted or rooftop solar from lots of sites (wheeled through the distribution grid) to provide power to large consumers could become an important contributor to the 40 GW target. Such model will merit further work but are outside the scope of this report.

The methodology for this report was as follows:

- Literature review – over 100 reports and papers on rooftop solar and related topics.
- Stakeholder interviews – discussions with over 50 Indian and international experts.

8. Bridge To India, "India Solar Rooftop Map 2016", http://www.bridgetoindia.com/reports/
9. Telecoms Regulatory Authority of India, 2014 (http://trak.in/tags/business/2007/06/19/indian-telecommunication-story-from-10-million-to-150-million-mobile-subscribers-in-5-years/)

- Modelling – models of the market and project finances were used to test ideas, develop scenarios and quantify impacts of recommendations.
- Consultations – around 120 people participated in consultation events in Mumbai, Hyderabad and Delhi that tested, critiqued and refined ideas.
- Technical review – a coalition of 25 organisations provided ideas, critiqued the recommendations and reviewed the draft report.

Chapter two describes the current status of rooftop solar in India. Chapter three covers the technical and regulatory issues. Chapter four focuses on the challenges for utilities. Chapter five looks at attracting large-scale private investment. Chapter six examines the role of mandates to drive adoption in the medium term. Chapter seven explores subsidy issues. Chapter eight looks at how scale up in rooftop solar might offer spill-over benefits to the off-grid sector. Chapter nine look at scenarios for rooftop solar, and summarises the recommendations from the overall report.

2 CHAPTER

CURRENT STATUS OF ROOFTOP SOLAR IN INDIA

2.1 Status of deployment

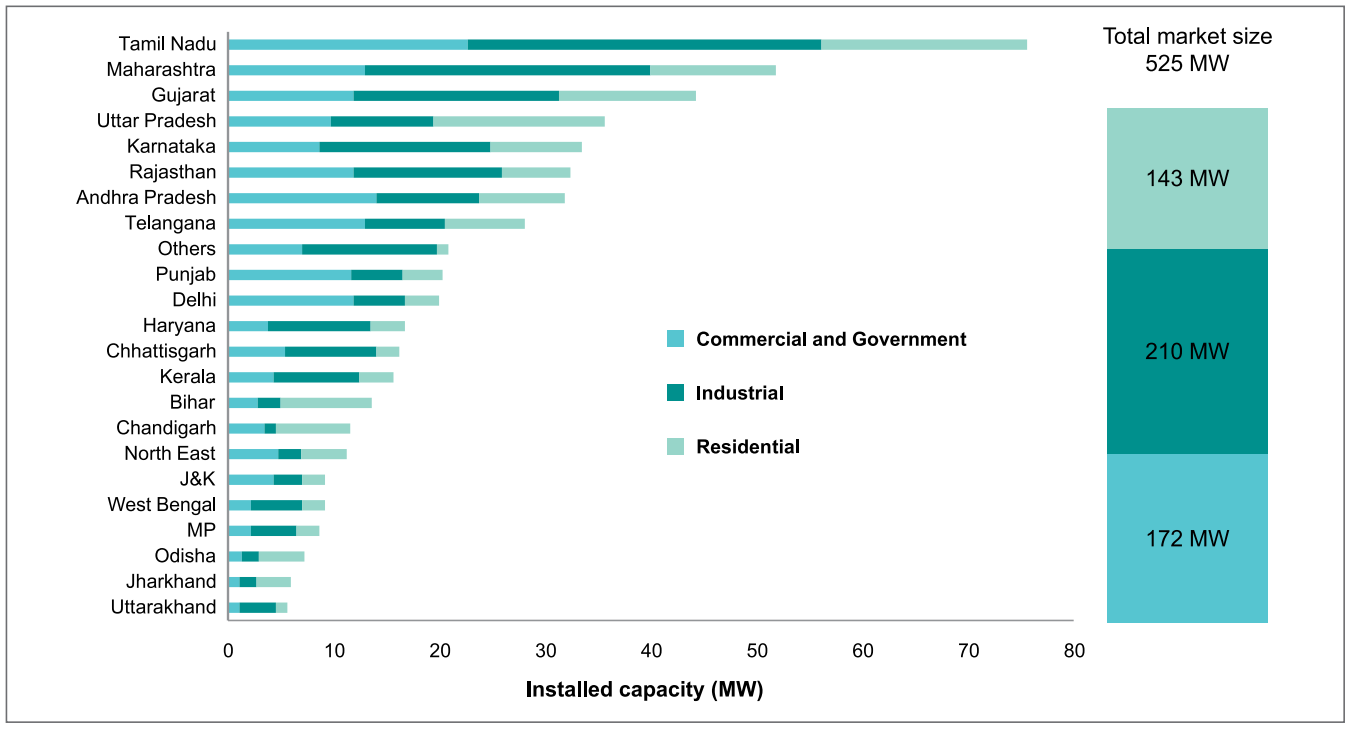
India has an installed rooftop solar capacity of approximately 525 MW[10]. This accounts for less than 10% of the installed utility scale solar capacity and a very small portion of the total power consumption in the country.

Currently, Tamil Nadu, Maharashtra, Gujarat, Uttar Pradesh, Karnataka, Andhra Pradesh and Telangana are leading states in terms of rooftop solar capacity addition in the country.

TAMIL NADU, MAHARASHTRA, UTTAR PRADESH AND KARNATAKA ARE LEADING ROOFTOP SOLAR CAPACITY ADDITION

Drivers of adoption vary across these states. The market in Tamil Nadu has been driven by diesel abatement, increasing power tariffs and a relatively high level of public awareness with respect to renewables. In Gujarat, the government has supported a substantial and high profile pilot using gross metering. Government, regulators and state utilities in Andhra Pradesh and Telangana have proactively supported net-metering. Adoption in Maharashtra has been driven by the high power tariffs in the state.

Figure 2.1: State wise installed capacity for rooftop solar



10. India Solar Rooftop Map 2016 – Bridge To India

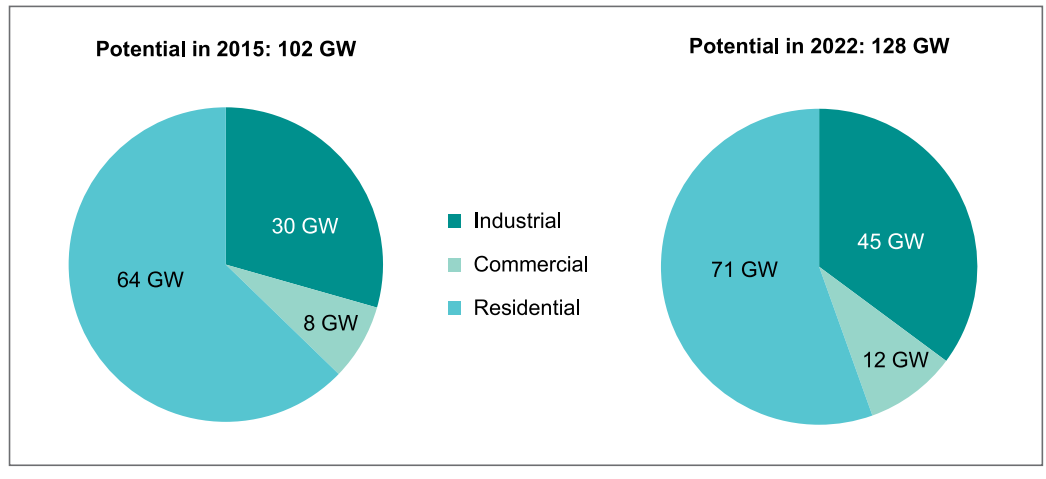
Due to higher tariffs, industrial and commercial consumers will be the biggest adopters of rooftop solar in the next few years. By technology, commercial and industrial consumers have largely opted for grid-connected systems in the past and residential consumers have opted for a mix of completely off-grid, grid connected without any storage and grid connected with storage.

2.2 Rooftop solar potential

One key parameter for rooftop solar is availability of suitable rooftop space[11]. This means rooftop space that is unshaded, not used for other purposes and structurally suitable for mounting rooftop solar. Realisable rooftop potential in the country is the highest for residential consumers, followed by industrial and then commercial consumers.

We estimate the residential rooftop technical potential in 2014 at 64 GW growing to 71 GW by 2022. The technical potential for industrial consumers is estimated at 30 GW in 2014, increasing to 45 GW in 2022. The commercial segment accounts for the lowest share of rooftop space but have been early adopters due to high power tariffs. The technical potential for the commercial segment has been calculated at 8 GW in 2014 and increasing to 12 GW in 2022. This brings the total estimate of potential in 2022 to 128 GW (see figure 2.2).

Figure 2.2: Rooftop solar potential by space availability in 2015 and 2022



TECHNICAL CAPACITY IS NOT A CONSTRAINT TO ACHIEVING THE GOVERNMENT'S 40 GW TARGET

The analysis shows that at 128 GW, the realisable technical potential for rooftop solar is much higher than 40 GW and therefore is not expected to be a constraint for achieving the government target.

11. For methodology, see Bridge To India: (2014) Beehives or elephants? How should India drive its solar transformation?

2.3 Current policies and incentives

When India announced its National Solar Mission in early 2010, only a very small portion of 2,000 MW was earmarked for rooftop solar along with other off-grid solar applications. Since then, the central government has primarily used capital subsidy and accelerated depreciation policies to incentivise rooftop solar. Incentives are discussed in greater detail in Chapter 7.

2.3.1 Capital subsidy

The central government's capital subsidy scheme has been in operation for several years now. While this scheme helped early installations to become viable, lack of funds for subsidy in recent years has led to the mechanism becoming a bottleneck. The Solar Energy Corporation of India has implemented a variation of this scheme since 2013 under which it has allocated subsidy for rooftop solar installations to EPC companies and RESCOs through a bidding mechanism.

Under the capital subsidy schemes so far, capacity of 44.5 MW has been commissioned and subsidy has been sanctioned for an additional 316 MW as of April 2015[12] .

Some state governments such as Kerala and Chhattisgarh have successfully run schemes where additional subsidy was provided to consumers over and above the central government subsidies.

The central government's capital subsidy scheme and allocations through the Solar Energy Corporation of India for rooftop solar are expected to continue. MNRE has increased the allocation for the scheme to Rs 5,000 crore from Rs 600 crore in 12th Plan period (2012-17). The government will provide financial assistance of 30 per cent of the benchmark cost of grid connected rooftop solar systems on four categories of building - residential, institutional, government and social sector.

2.3.2 Priority sector lending

The Reserve Bank of India has announced a scheme to include renewable power installations up to the project size of Rs 15 crore for priority sector lending. This is expected to lower the cost of finance for rooftop solar installations.

2.3.3 Concessional lending

The World Bank, Asian Development Bank and KfW are in advanced discussions to offer concessional loans through Indian banks to the rooftop solar sector. If they lead to availability of significantly lower lending for rooftop solar projects, these loans will be strongly welcomed by developers and investors.

12. Status of grid-connected solar photovoltaic rooftop projects sanctioned to states/Union Territories/Solar Energy Corporation of India/Public Sector Undertakings and other government agencies – 20 April 2015, MNRE

2.3.4 Tax benefits

There is a provision to avail a 10 year tax holiday on sale of solar power and profitable corporate rooftop system owners can also avail the benefit of accelerated depreciation.

2.3.5 Home loan and home improvement loan

For residential installations, there is a provision to include the cost of solar installation as a part of the home loan or home improvement loan through public banks. This provision is to be made available through all commercial banks.

2.3.6 Net-metering

The central government has been encouraging state governments to offer net-metering to consumers. 25 states and union territories have issued policy or regulations on net metering. The implementation of net-metering is still in a nascent stage and only a handful of states have begun implementation.

2.4 Grid tariff parity

GRID TARIFF PARITY IS THE MOST IMPORTANT DRIVER OF ADOPTION FOR COMMERCIAL AND INDUSTRIAL CUSTOMERS

Grid tariff parity for solar is the most important driver for commercial and industrial rooftop solar in the country. For a large number of such consumers rooftop solar has already achieved parity with their grid tariffs. As viability continues to improve, adoption will increase as well.

Grid tariffs in the Indian power market are broadly divided into four categories: commercial, industrial, residential and agricultural. These tariffs vary state-wise and also vary by type of connection (voltage, time of day, power consumption etc) within the four segments.

Commercial consumers usually pay the highest tariffs followed by industrial, residential and agricultural. Government buildings, municipal corporations, educational institutions, railways and other differentiated categories of power consumers usually pay tariffs higher than residential consumers.

Typically, solar installations for commercial and industrial consumers do not have a battery backup but they are synchronized with diesel gen-sets that are available at most locations. In many cases where there are significant power cuts for commercial and industrial consumers, saving in diesel costs can also become an important driver for adoption of rooftop solar.

Figure 2.3: Grid parity status for commercial consumers in India (October 2015)

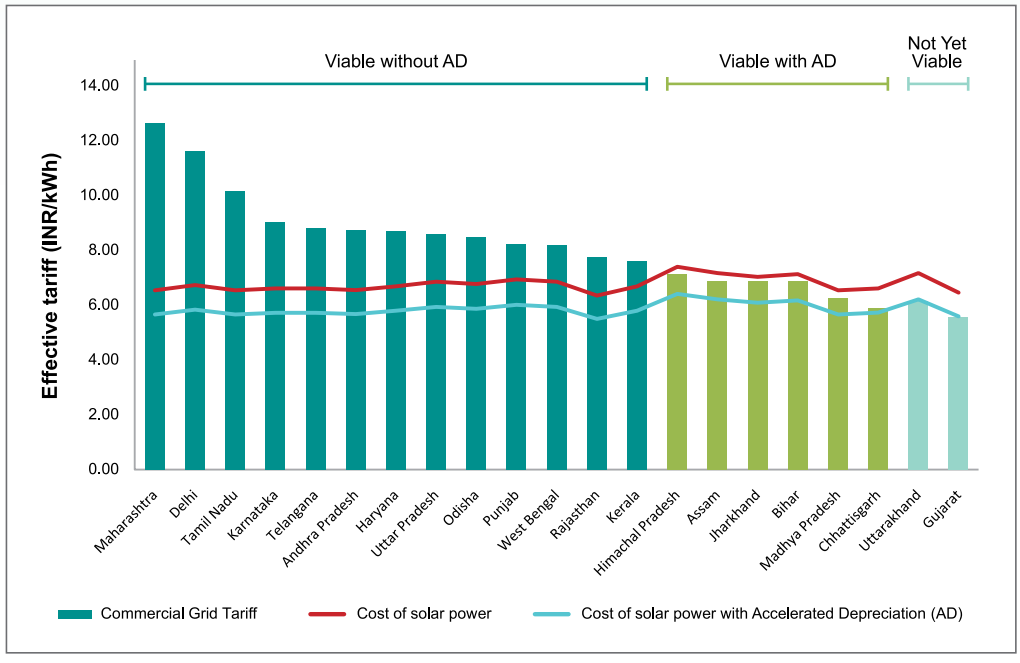


Figure 2.4: Grid parity status for industrial consumers in India

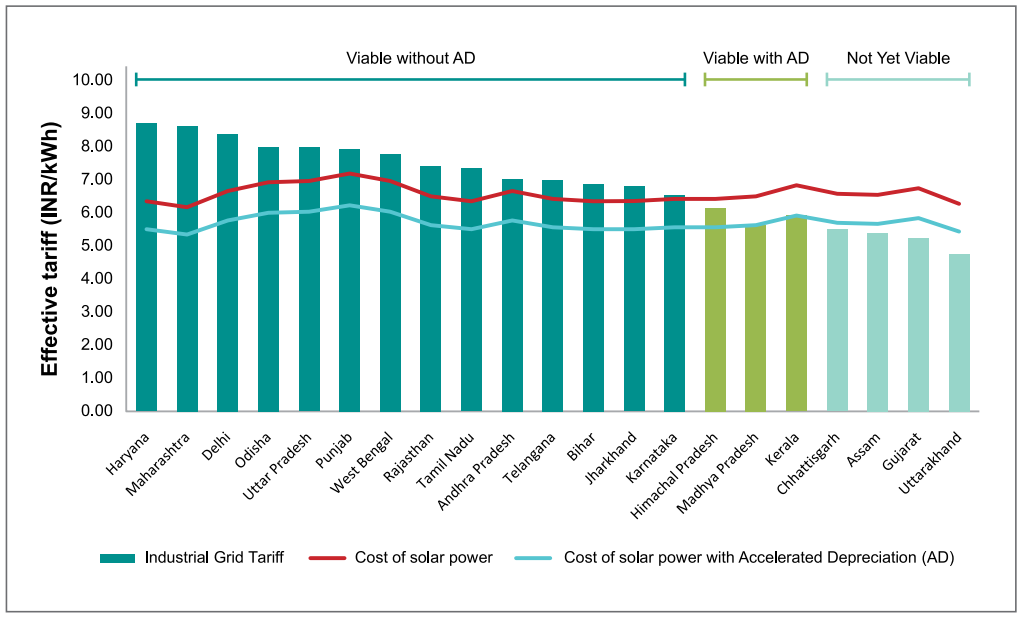
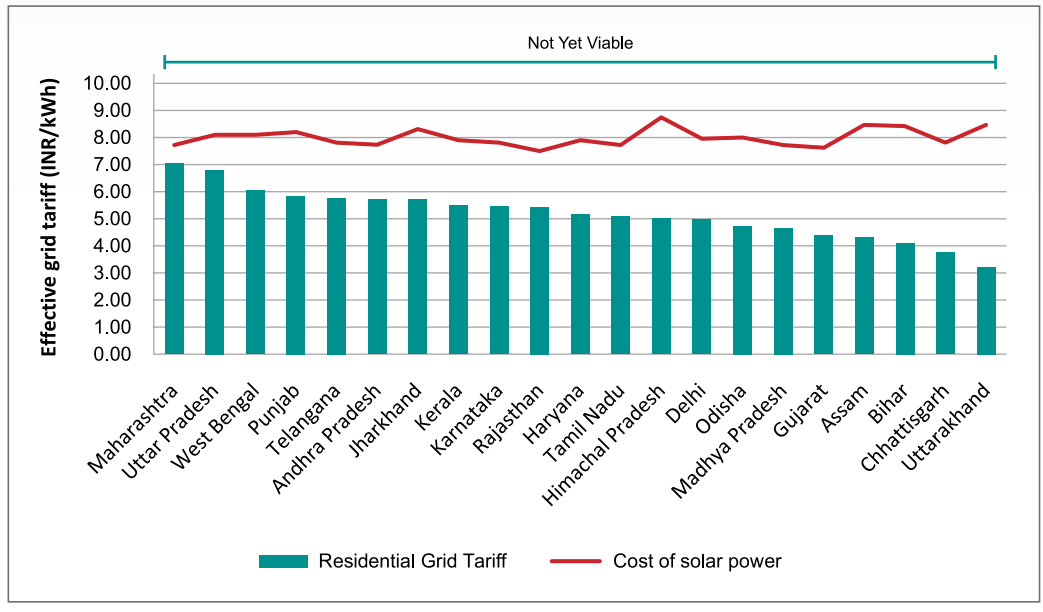
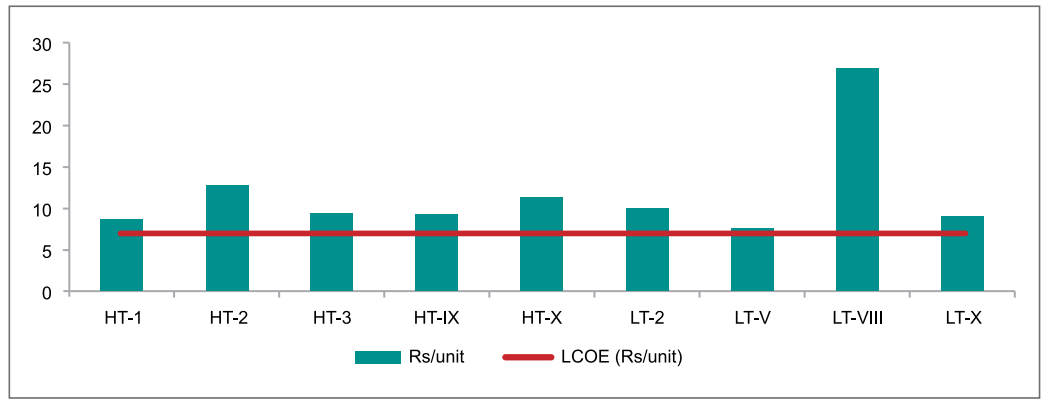


Figure 2.5: Grid parity status for residential consumers



Figures 2.4, 2.5 and 2.6 indicate the parity status of rooftop solar against grid tariffs for different categories of customers. This presents a simplified view of the parity status as tariffs are further sub-divided and installing solar for certain category of consumers within the commercial consumer category might be more attractive than others. An example has been provided below.

Figure 2.6: Tariffs of select categories of consumers in Maharashtra[13]



FOR RESIDENTIAL CUSTOMERS, FINANCIAL VIABILITY IS IMPORTANT, BUT OTHER FACTORS CAN INFLUENCE DECISIONS TOO

For residential consumers, financial viability is important but other factors such as need for power, convenience (primarily on account of avoiding diesel gen-sets) and environmental concerns can influence decisions too.

13 HT-1- Industry, HT-2 -Commercial, HT-3 -Railways, HT-IX - Public Services, HT-X - Ports, LT-2 - Non-Residential, LT-V - Industry, LT-VIII - Advertisements & Hoardings, LT-X - Public Services

2.5 Business models

There are three fundamental business models under which rooftop solar can be deployed.

2.5.1. Capex model (Capital expenditure model)

Currently, the most prevalent model for rooftop solar installations is the capital expenditure (capex) model where the rooftop owner buys the rooftop solar system. The customer may or may not take a loan to fund part of the investment and may or may not have availed capital subsidy. This model has the advantage of being simple and uncomplicated, but it does mean the rooftop owner takes the risk of the project. Around 90% of all rooftop based solar project capacity installed so far in India falls under this category. The capex model has been the prevailing model in Germany where low cost loans (as well as generous subsidies) have helped propel the market.

2.5.2 Opex model or third party model

In the Opex (operational expenditure) or third party model, a renewable service company (or RESCO) invests capital in the rooftop solar system and sells power to the rooftop owner/occupier at a rate lower than their grid tariff but at a rate which enables the RESCO to make a profit. This model is often called the Opex model because the rooftop owner pays for the system over a number of years during its operation. The 'third party' refers to the company entering the typical relationship between building owner and distribution utility as the third party. These projects account for around 10% of the rooftop solar installed capacity. Key advantages of this model are that the technical risk is taken by the RESCO and the rooftop owner does not need to invest the capital upfront. The third party model can help bring institutional investment into the rooftop solar sector (see chapter 5). The Opex model has been important in the US where this model along with tax breaks proved attractive to large numbers of consumers.

2.5.3 Lease model

A third option is the lease model, in which the customer leases the system from an installer/developer but pays for it over time. This lease may be either a finance lease or an operating lease. At that point, the asset is fully transferred to the customer. So far, the lease model has not been prevalent in India because of the way taxes currently apply to lessors (see chapter 5).

2.6 International experience of business models

The rooftop solar market in most countries has been driven by government policy and particularly by level of government subsidy. For instance, a 2004 feed in tariff policy in Germany is widely credited with making Germany the largest solar market globally and feed-in-tariff-specific business models evolved. Easily available bank loans were also important to the success of the capex model in Germany.

In the US, while many consumers opted to own their rooftop solar installations, companies such as SolarCity created business models to sell power from rooftop installations to consumers and for that the company raised money from institutional investors who could then avail tax credits on their investments. These business models, combined with net metering policies, high rates for residential consumers and performance based incentives (e.g. the California Solar Initiative) drove rapid adoption.

2.7 Variations to business models

In addition, there can be other variation to business models.

1. Aggregation: Government or another agency may act as an aggregator of projects to bring in economies of scale, a roof may be leased to a third party (or right to use given to a third-party). Utilities could act as aggregators and several are making plans to play this role.

2. Purchaser of power: Whilst in many cases the utility will be the purchaser of surplus power, where regulations allow, part or all of the power produced may be to a sold to third party, wheeled through the local grid.

2.8 Gross and net metering

One important issue about policy or regulation is the choice of net vs. gross metering, an issue that is the cause of much debate and quite a lot of confusion. Gross vs. net metering – as the name suggests – is more about the way power from rooftop solar is accounted and paid for, than about the fundamental system design. Under gross metering all power generated by the rooftop solar panels is exported to the grid. Power consumed in the building is paid in the same way as for all other consumers.

Net metering means that the power from the solar panels is consumed behind the meter and any excess exported to the grid. If the consumption is greater than that provided by the solar system, grid power is consumed to make up the difference.

The amount of energy generated and consumed is identical for both systems. The only difference is to the finances. If the tariff for buying and selling power to the grid is the same, even the finances would be identical.

2.8.1 Gross metering

Gross metering regulations are in place in several states. The best known example is in Gandhinagar in Gujarat where the rooftop solar policy has been based on a gross metering arrangement. Andhra Pradesh, Uttar Pradesh, Goa and some of the union territories of India also allow gross metering although these have not yet led to operational projects. The key benefit of gross-metering is that different tariffs can be set for power supply and sale of solar power.

2.8.2 Net metering

Net metering regulations are in place in most states in India. Governments and regulators across India have put a lot of work into framing net metering regulations. The key benefit of net-metering is that it is very simple to understand and implement. Under net metering the customer's tariff becomes the effective sale price for solar power.

2.8.3 The choice of net vs. gross metering

There is a vigorous debate about whether gross or net metering is better. This debate is often misplaced, as it is often the detailed rules that matter most. Gross or net metering can be made more or less generous to rooftop owners by adjusting the tariffs offered and the detailed rules in place. Some states have put in place regulations for both gross and net metering.

Gross metering allows a fixed price to be charged for rooftop solar. This can be particularly useful before viability if government is providing a feed in tariff or once viability is widely in place, at which point prices reflect the value of solar production to the utility.

Net-metering maximises benefits to the rooftop owner and so increases viability. We support the emphasis by government and regulators on net metering because it will help drive adoption and growth during this period while viability is still developing. In the future, the benefits from rooftop solar can be shared with utilities by imposing a medium term service charge (see our recommendation in chapter 4). This already happens in countries such as the US and Australia. However, gross metering regulations that similarly support viability (for example through a feed-in tariff) can also be successful.

WE SUPPORT THE EMPHASIS ON NET METERING BECAUSE IT WILL DRIVE ADOPTION WHILE VIABILITY IS STILL DEVELOPING

The majority of recommendations in this report apply whether net or gross metering is used.

3 CHAPTER

POLICY, REGULATIONS AND TECHNICAL ISSUES

This chapter examines the legislation, regulations and policies that shape rooftop solar in India. The chapter presents key policy and regulatory recommendations to improve the investment environment and help achieve the 40 GW target.

3.1 Policy and Regulatory landscape

The key legislation affecting the rooftop solar market are the Electricity Act 2003, its proposed amendment (currently in draft), and the proposed Renewable Energy Act. Changes are also proposed under the National Tariff Policy and National Electricity Policy. Apart from the central government policies, states in turn formulate programme specific policies and regulations (see table 3.1).

Table 3.1: Relevant legislation, policy and regulation for the rooftop solar sector

	Centre	State
Legislation	Electricity Act 2003- mandates state regulators to promote renewable energy by connectivity with grid, sale of electricity and purchase of electricity by distribution licensee	Mandates under the Electricity Act 2003 have resulted in various policy and regulatory measures promoting renewable energy at the state level, such as determination of preferential tariffs for procurement of green power, RPO etc.
	Amendment of the Electricity Act 2003	Renewable Generation Obligation for the generator equivalent to 10% of the total thermal power installed capacity The Act allows for exemption of renewable energy generators from paying open access charges
	Renewable Energy Act (draft) – potential assessment, creation of Centre and state level funds, implementation thrust to RPO	State regulators mandate yearly solar and non-solar RPO for obligated consumers
Policies	Country-level target for setting up of 40 GW of rooftop solar by 2022	Central government has suggested state-level targets in line with overall RPO targets. States may accept these targets.
	Fiscal and financial support (primarily capital subsidy, interest rate subvention and accelerated depreciation)	Some of the states offer additional fiscal support to rooftop solar in the form of capital subsidy or feed-in tariff
	Other special schemes or programmes – for e.g. rooftop solar on govt. buildings	Promotion of rooftop solar for institutions, government buildings

Regulation	National Electricity Policy 2005 and National Tariff Policy 2006	State specific regulations set rules and guidelines for business models, eligibility of consumers, connectivity norms, penetration limits at the transformer level, buy back of surplus energy if applicable, energy accounting and settlement etc.
	Forum Of Regulator guidelines - on business models, procurement of power,	
	CEA – technical standards (e.g. for Connectivity of Distributed Generation Resources.	
	Installation and Operation of Meters' Regulation 2006 and amendments	
	Measures of Safety and Electricity Supply Regulations, 2010	

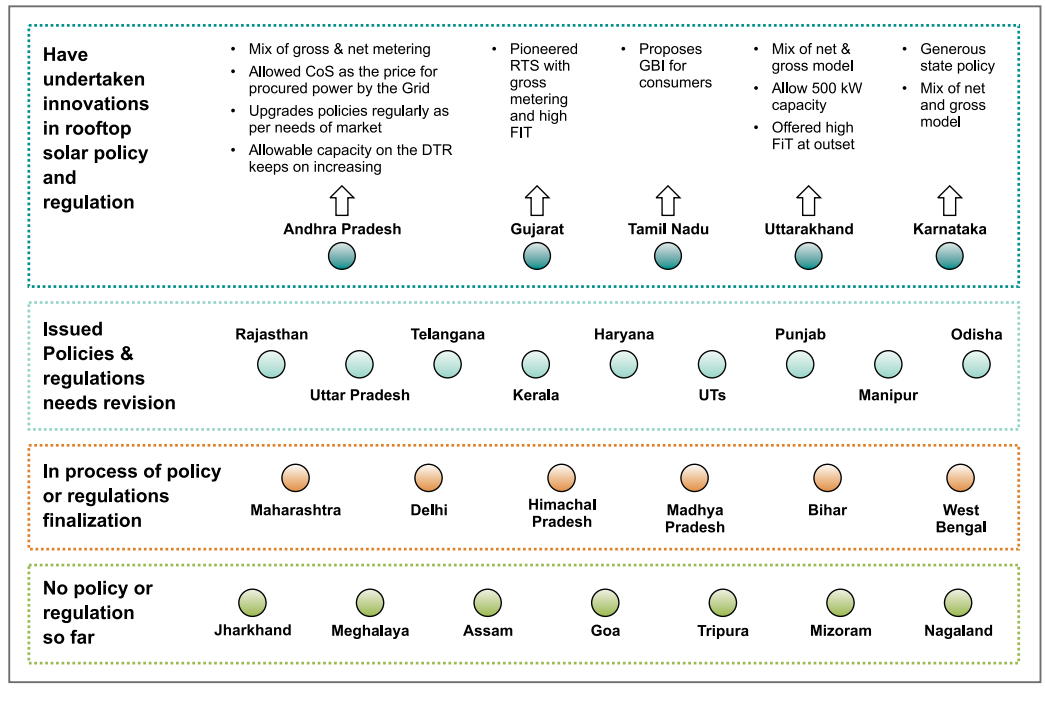
3.1.2 State regulation specific to rooftop solar

25 STATES IN INDIA HAVE POLICY OR REGULATION FOR ROOFTOP SOLAR

Following the guidelines and mandates of the central policies and regulations, states have been formulating their own policies and regulations for rooftop solar. At present, 25 states in India have issued policy or regulations specific to rooftop solar. There is considerable variation in the framing of these regulations between states. In 2013, the Forum of Regulators produced a draft model regulation on rooftop solar which a number of state regulators have drawn on to formulate regulations.

Different states are at different stages of development of their regulations. The figure below summarises the status of policy content and implementation for select states.

Figure 3.1: Categorising states by their rooftop solar policies and regulation



3.2 Operationalising net metering regulations

THE IMMEDIATE PRIORITY IS TO OPERATIONALISE THE REGULATIONS THAT HAVE BEEN SET

Whilst state regulations can be improved, the immediate priority is to operationalise what already exists. In many cases, net-metering regulations exist on paper but in practice getting a net-metering connection approval involves overcoming lack of clarity of process at the utility level and multiple permissions, resulting in long delays. Addressing this problem requires operational guidelines that help utility staff connect new consumers, procedures to interpret key regulations such as loading of distribution transformers and ensuring simple mechanisms for handling customer requests and queries.

Regulators should set clear timeframes for interconnections. We propose that initially new connections should be completed within 60 days and, once systems are established, this can be reduced to 30 days. It is important that regulators require utilities to collect and publish data on the time for new interconnections. Finally, regulators should sanction non-compliance with effective penalties.

There should also be widespread efforts to make the process simple and user-friendly. A number of states are introducing single window clearance mechanisms which make the process easier for consumers – for example Punjab has a good website guiding consumers through the process. Such processes should be the norm to make interconnections easy to undertake.

No	Recommendation	Cost/ difficulty	Impact	Authority
R 1	Regulators should set and monitor target timescales for new connections, and should sanction non-compliance	L	H	State regulators
R 2	Transparent data is needed on interconnections. Regulators should require utilities to publish data on applications, interconnection times, refusals and transformer loading	M	H	State regulators
R 3	Utilities should urgently develop interconnection guidance for staff and ensure adequate staff are trained	M	H	Utilities
R 4	Online, single window clearance processes should be the norm	L	M	State Nodal Agencies

3.3 Towards a second generation of net metering regulations

There is a lot of variation in the detailed rules around state policies. This is to be expected given state policies need to be adapted to the energy mix, economic situation and political objectives of governments in each state. There is also an important element of experimentation taking place given best practice is still evolving. So one

size fits all is not desirable if it reduces the ability of state officials to innovate better policy or regulatory ideas.

However, variation has a cost as it fragments the market and makes it harder for businesses to build models that can scale up and work across state borders. So, it is desirable to move towards a smaller set of choices or rules that enable states to adapt policies to their needs but avoids variation for variation's sake.

There is a need to evolve a second generation of state net metering regulations that learn from the best examples that exist already. These should be enshrined by updating the Forum of Regulators Draft Model Regulation on Net Metering which can be drawn upon by states when their regulations are reviewed. States with regulations getting good feedback from the industry need not rush to make changes. Whereas states where regulations are not leading to expected adoption can draw on the revised guidelines more quickly.

One area where updated regulations can increase the options for rooftop solar is by allowing groups of persons/societies to set up 'Group Captive' net metering projects for supply of power to households of group members. Distribution utilities may deduct the above energy from the bills of participants on a proportionate basis. This can be particularly attractive for multi-dwelling buildings.

Additionally, future regulation could helpfully allow rooftop solar projects in one location to be adjusted against consumption in other premises within the operating area of the same distribution utility. In other words, a business with a warehouse and a factory might generate excess rooftop solar power at the warehouse and this could count against consumption at both the factory and warehouse.

Finally, regulators could allow large consumers to purchase solar power from multiple rooftop (or small ground-mounted) systems with the power wheeled through the grid.

No	Recommendation	Cost/ difficulty	Impact	Authority
R 5	Regularly update Forum of Regulators Draft Model Regulation to develop consistency and best practice across states. States should draw on draft model regulations when updating state regulations	M	M	Forum of Regulators state regulators
R 6	Future regulation could allow group net metering projects and multiple location benefits to allow more consumers to undertake rooftop solar	L	L	State regulators

3.4 Managing rooftop solar impact on the distribution grid

The current distribution grid was designed to carry electricity in one direction from large generators to end consumers. Rooftop solar creates the potential for two-way flows

as surplus power from rooftop systems flows back into the system. This can create problems for grid operators because reverse flow has, until now, been a sign of a system fault and triggers safety features. There are two ways to deal with this problem: i) by regulation to avoid two way flows on the grid and ii) technical changes to grid infrastructure to allow two-way flows to be safely managed.

Upgrading grid infrastructure will take time and current net metering regulations have been designed to restrict or eliminate two-way flows by:

- Limiting allowable system size to 80-100% of a consumer's sanctioned load;
- Limiting or prohibiting sale of surplus power to the grid (beyond the total consumption of the consumer);
- Setting maximum loadings of rooftop solar capacity on transformers to limit the likelihood of local rooftop solar production exceeding local consumption.

OVER TIME RESTRICTIONS ON ROOFTOP SOLAR SHOULD BE PROGRESSIVELY LIFTED AS THE GRID IS STRENGTHENED

These regulations are necessary to manage rooftop solar in a stable distribution grid. However, restrictions limit the market. Over time restrictions on rooftop solar should be progressively lifted as the grid is strengthened to allow two way flows safely. Reducing restrictions on allowable system size and export to the grid are important to maximise use of rooftop solar potential.

The regulations limiting loading of solar rooftop capacity on individual transformers are particularly challenging to implement and require good training and clear implementation guidelines for utility staff to interpret the rules effectively. There are three main challenges:

- Thresholds for rooftop solar capacity on individual transformers varies from 15% to 50% in different state regulations. 15% of capacity is a very conservative level and refusals on the basis of crossing this level would likely be unnecessary.
- Some utilities lack reliable data on transformer loading and most do not have this in a form that can easily be shared with consumers in a user-friendly way.
- Lack of trained staff to interpret these rules, risking unnecessary refusals or delays to connections.

Information on transformer loading needs to be public so consumers can see if the rules would restrict them from connecting a new system in their premises. This information needs to be accurate, up to date and user-friendly.

REGULATORS SHOULD MAKE CLEAR THERE WILL BE A PRESUMPTION THAT INTER-CONNECTIONS WILL BE ALLOWED

To reduce uncertainty, regulators should make clear that there should be a presumption that interconnections will be allowed unless clear harm to the grid or other users can be demonstrated. Any refused connections should be explained in writing and shared with the regulator and State Nodal Agency.

Over the long term, technical solutions can significantly increase the safe loading of rooftop solar on transformers allowing the permitted thresholds to be raised.

In the future, the way loading on transformers is measured may be re-examined. The thresholds are set in terms of rated transformer capacity but what matters more is minimum daytime load. Internationally, several US states allow connections up to 120% of the minimum day time load of the distribution network. In India, Kerala has already framed its regulation by allowing up to 80% of the minimum day time load and its experience will be worth following to see if it should be more widely applied.

No	Recommendation	Cost/ difficulty	Impact	Authority
R 7	Utilities should make easy-to-understand maps and databases available on their websites showing connected capacity against the threshold limit of transformers	L	M	State regulators, utilities
R 8	Regulators should make clear that new rooftop solar systems should be connected unless the utility can show serious harm to the grid	L	M	State regulators, utilities
R 9	In case of refusal to connect, the utilities should quickly provide reasons in writing copied to the regulator and State Nodal Agency	L	L	Utilities, state regulators, SNA
R 10	If transformer thresholds are approached or reached, utilities should consider ways to continue to connect consumers, such as sanctioning a higher allowable load (where safe to do so) or upgrading the transformer	M	L	Utilities

3.5 Reducing restrictions on export of surplus energy

Most premises with rooftop solar will consume more power than they produce during a year so will continue to be net consumers of grid power. However some, which have large roof space and low electricity demand, have the potential to be net exporters of power to the grid. For such premises, restrictions on sale of surplus power prevent them from maximising their rooftop generation capacity.

Almost all Indian states restrict the amount of energy that can be sold by rooftop solar installations. Some states allow 100% of annual consumption as ‘energy banking’ and some 90%, some have the settlement period as six months and some a year. These rules avoid utilities having to make payments to rooftop solar system owners for net export of power to the grid. There is also a practical issue as utility billing systems are designed to receive payments from large numbers of consumers, rather than make payments to them. Significant changes to billing systems will be needed so utilities can manage payments to rooftop solar consumers as generators of power.

However, these problems are not insurmountable and several states have allowed sale of surplus power to the utility at a reduced price. So far, Andhra Pradesh, Telangana,

Karnataka, Uttarakhand and Gujarat allow sale of surplus power at the average cost to serve, average power purchase cost or at a set feed-in tariff. Energy banking should be allowed up to 100% of consumption over a settlement period of one year. The restrictions on the export of power should be phased out over 1-2 years. The price of power exported beyond 100% of consumption should reflect the value of the avoided cost of energy (broadly the APPC price plus the cost of the avoided transmission and distribution loses).

No	Recommendation	Cost/ difficulty	Impact	Authority
R 11	State net metering regulations should allow energy banking of 100% of consumption calculated over a year	L	L	Utilities, State regulators
R 12	Restrictions on export of power should be phased out, with surplus saleable at a price that reflects the avoided cost of energy	M	M	State regulators, utilities

3.6 Completing technical standards

From the perspective of distribution utilities, rooftop solar systems can create a number of technical challenges related to the quality of power, safety of interconnection and the intermittent nature of power. These issues have been well documented by several reports[14].

The Central Electricity Authority (CEA) is responsible for the setting technical standards for rooftop solar systems. They have already produced standards that are appropriate for India. The next steps are to ensure that any gaps in standards are addressed, consistency across states is ensured and the standards are effectively disseminated.

3.6.1 Meters

The CEA has mandated metering standards throughout the country. However some regulators have specified metering standards which are not fully in line with the prescribed guidelines of CEA. For example, the states of Punjab and Uttarakhand have prescribed for a single meter whereas Tamil Nadu mandates three meters - a solar meter (for Generation Based Incentive), renewable energy bidirectional meter and a check meter (for capacity greater than 20 kW).

Metering guidelines, especially the features of the meters for data to be recorded should be common across India. This will help lower costs through standardised production. This is important as demand has exceeded meter manufacturing capacity in many states.

14. See Grid Integration of Distributed Solar Photovoltaics (PV) in India-A review of technical aspects, best practices and the way forward by Prayas; Harnessing Energy from the Sun: Empowering Rooftop Owners, White Paper on Grid Connected Rooftop Solar Photovoltaic Development Models 2014 by IFC

CEA should develop a meter standard for low cost bidirectional 'rooftop-ready' meters with the aim of bringing the cost down to the same level as unidirectional meters. In the present context there is limited availability of bi-directional meters so distribution utilities continue to require multiple unidirectional meters. This could be avoided if cheaper bidirectional meters are available. The ambition should be to bring the cost of bidirectional meters to the same level or lower than the cost of existing unidirectional meters.

3.6.2 Inverters

Inverters are another essential part of rooftop solar systems. They convert power to the voltage and type needed, manage the quality of power and isolate the system in case of grid failure or under/over voltage. Most inverters available in the Indian market include the following technical features – harmonic current injection, DC injection, Flicker control, and anti-islanding. Additional features of reactive power support, low voltage ride through, and frequency regulation can be added to the existing features of inverters at without any significant extra cost to the consumers.

3.6.3 Deliberate islanding

Rooftop solar inverters have 'anti-islanding' features to disconnect the system from the grid if grid power fails. This is a safety feature to protect utility staff maintaining the distribution network because rooftop systems can generate enough voltage and current to cause injury or death to utility staff. However, it can be frustrating for users installing an expensive solar system to discover it shuts down when the grid fails. In peri-urban areas, tier 2 or 3 towns and rural areas, frequent power cuts can mean that rooftop solar is not viable if systems shut down for significant periods each day.

Designing rooftop solar systems to operate when the grid fails is known as deliberate islanding. The problem comes in designing systems that allow rooftop solar systems to produce power while the grid is down, but which allow systems to be safely and reliably shut off when utility staff are undertaking maintenance work on the grid.

The need is to find ways to both ensure safety (which must be paramount) and to allow systems to operate during grid outages. If this challenge can be overcome, this will help expand the market for grid-connected rooftop solar into areas outside the main metros and into smaller towns and cities that face power cuts.

No	Recommendation	Cost/ difficulty	Impact	Authority
R 13	Harmonise metering regulations across states	L	L	CEA and State regulators
R 14	Develop bi-directional meter standards and encourage research into low cost manufacturing	M	L	CEA

R 15	Additional inverter features that could inculcate better grid discipline should be made mandatory by CEA	L	L	CEA
R 16	Develop systems that can safely allow deliberate islanding and specify necessary standards	M	M	CEA, State regulators

3.7 Long term challenges of integrating rooftop solar into the grid

The technical challenges related to the interconnection of rooftop solar and their solutions are well documented in various national and international reports. A recent study by the US National Renewable Energy Laboratory suggests that at penetrations up to 5% of variable renewable energy, integration of renewable energy does not pose any complex system integration issues. In Germany, at times solar photovoltaic output has peaked at nearly 40% of instantaneous demand and provided approximately 21% of the total daily generation (Gerke 2013). Our report is not primarily a technical one, so our focus has been only to examine whether the technical issues create obstacles to the achievement of the 40 GW target set by the Government of India.

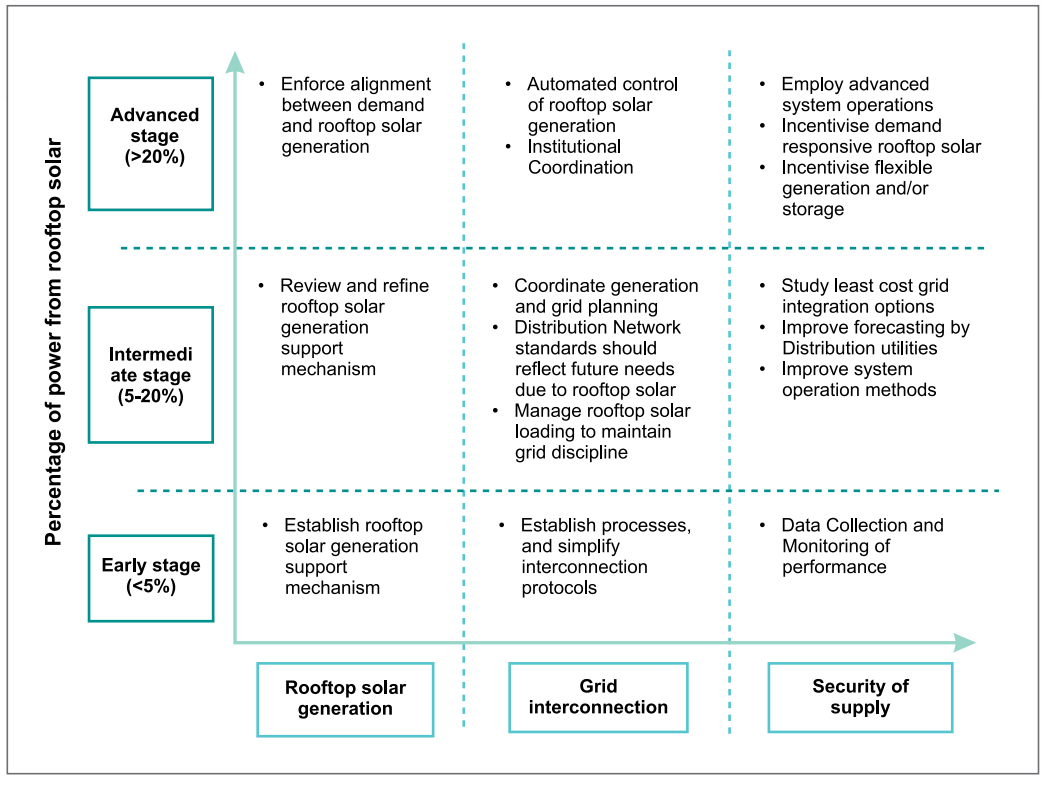
Bi-directional flows will become more commonplace as the level of rooftop solar increases beyond 2022 and distribution grid infrastructure will need to be able to manage these flows. Other technical challenges that rooftop solar creates for distribution grid operators are:

- Variations in voltage: Fluctuations in rooftop solar output can lead to voltage variations. This can be managed by good inverters. However, rooftop solar generation can also help support voltage at the end of distribution lines through reactive power injection. This can be particularly valuable in rural areas.
- Variations in frequency response: Inverters are mandated to trip if the frequency varies beyond specific limits. However this can result in simultaneously tripping of all the inverters connected to the grid, making it harder to maintain grid stability. Additional inverter features can be specified to avoid this problem.
- Variability of rooftop solar: rooftop solar can fluctuate quickly with cloudy conditions. This can cause the amount of generation from rooftop solar to vary significantly, requiring grid operators to maintain alternative generation capacities.

Solutions for these problems exist. Design features such as On Load tap Changer for Medium Voltage/Low Voltage transformer, booster transformers along long feeders, reactive power support through Static Volt-Ampere Reactive Compensators and revised protection settings for bi-directional flows will need to be incorporated in new design criteria. Many of the changes can be integrated into routine maintenance or upgradation programmes to reduce costs. CEA should review the planning criteria and standards for the distribution network to take account of future needs of rooftop solar

and integrate these into standards. Figure 3.2 indicates the responses that will be needed to manage increasing levels of rooftop solar.

Figure 3.2: Illustrative regulatory actions for increasing rooftop solar deployment



If 40 GW of rooftop solar is operational by 2022, about 4% of India's energy will come from rooftop solar. However, an average of 4% of energy from rooftop solar means a higher proportion during the day, and an even higher proportion on sunny days when demand is low. In addition, some localities will have more rooftop solar than others so grid challenges in local areas are likely.

GRID INTEGRATION SHOULD NOT BE SEEN AS A MAJOR OBSTACLE TO GROWTH OF ROOFTOP SOLAR

Therefore, utilities will need to plan for changes to infrastructure in some areas where rooftop solar is concentrated. But despite this, during our consultations, utility representatives argued that grid integration should not be seen as a major obstacle to growth of rooftop solar and achievement of the 40 GW target.

More significant challenges will emerge after 2022, as penetration levels of renewable energy rise further. So it is important that research and upgradation of the grid is planned now in order to build up the grid capacity to absorb variable renewable energy. However, this issue is wider than just rooftop solar and needs to be tackled from the perspective of wider planning for renewable energy deployment.

4 CHAPTER

DISTRIBUTION UTILITIES AND ROOFTOP SOLAR

Distribution utilities are critical to the success of rooftop solar. They are responsible for connecting rooftop solar systems safely into the grid, managing the technical challenges of rooftop solar power and (in most cases) being the purchaser of rooftop solar power. It is vital to ensure that utilities have the right incentives to support rooftop solar power. Without their active support, it will not be possible to achieve the government's 40 GW target.

DISTRIBUTION UTILITIES ARE CRITICAL TO THE SUCCESS OF ROOFTOP SOLAR

This chapter explores the economics of rooftop solar from a utility perspective and sets out options and recommendations for strengthening the incentives for utilities to proactively support rooftop solar.

4.1 Utility finances and rooftop solar

4.1.1 Structure of utility finances

Distribution utilities in India face enormous financial challenges unrelated to rooftop solar. These challenges largely stem from political pressure to keep electricity tariffs down – particularly for residential and agricultural consumers. As a result, most utilities in India are loss-making with some notable exceptions. The cumulative losses of Indian utilities have now reached over Rs 380,000 crores ($57 billion)[15].

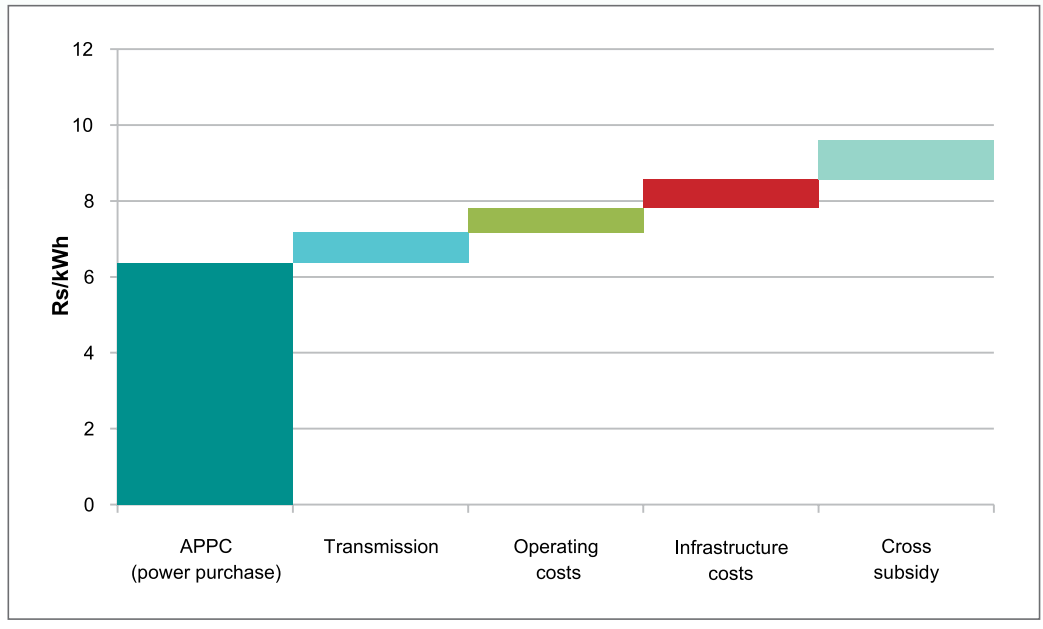
As a result, utilities can be understandably reluctant to accept losses on rooftop solar because it worsens their already dire finances.

Utilities have expressed concern about rooftop solar because they believe that the adoption of solar rooftop by commercial, industrial and higher-tariff residential consumers will lead to revenue loss. This is because these consumers pay higher tariffs and therefore contribute to the fixed costs of utilities and to cross subsidy of unrecovered cost from low-tariff residential and agricultural consumers.

In the current cost plus regulatory framework, Regulatory Commissions allow for recovery of costs of the utilities (power purchase, transmission, operation & maintenance, interest, depreciation and return on equity) through retail tariffs. A tariff breakdown for a typical Industrial consumer is shown in figure 4.1.

15. Government of India (2015) http://pib.nic.in/newsite/PrintRelease.aspx?relid=130261.

Figure 4.1: Tariff breakdown for industrial consumer



4.1.2 Regulatory battles over rooftop solar in the US

Rooftop solar in the US has sparked fierce battles between the rooftop solar industry, consumer groups and power utilities in states such as Hawaii, California, Texas and Arizona. The core concern is that rooftop solar is reducing demand for utility power which shrinks the base from which the utility recovers its fixed costs. As a result its tariffs creep up incentivising more consumers to install rooftop solar, causing the problem to worsen. This has been dubbed the 'utility death spiral'.

However, the situation in India is different because India remains a growing electricity market so the short and medium term impact of rooftop solar in India is likely to be slightly slower growth rather than a shrinking customer base. Therefore, fears that rooftop solar poses a major threat to utilities in India are overblown.

4.2 Costs and benefits of rooftop solar for utilities

Rooftop solar creates both challenges and opportunities for distribution utilities related to revenue, technical and administrative issues:

4.2.1 Costs to utilities from rooftop solar

Revenue loss including cross-subsidy

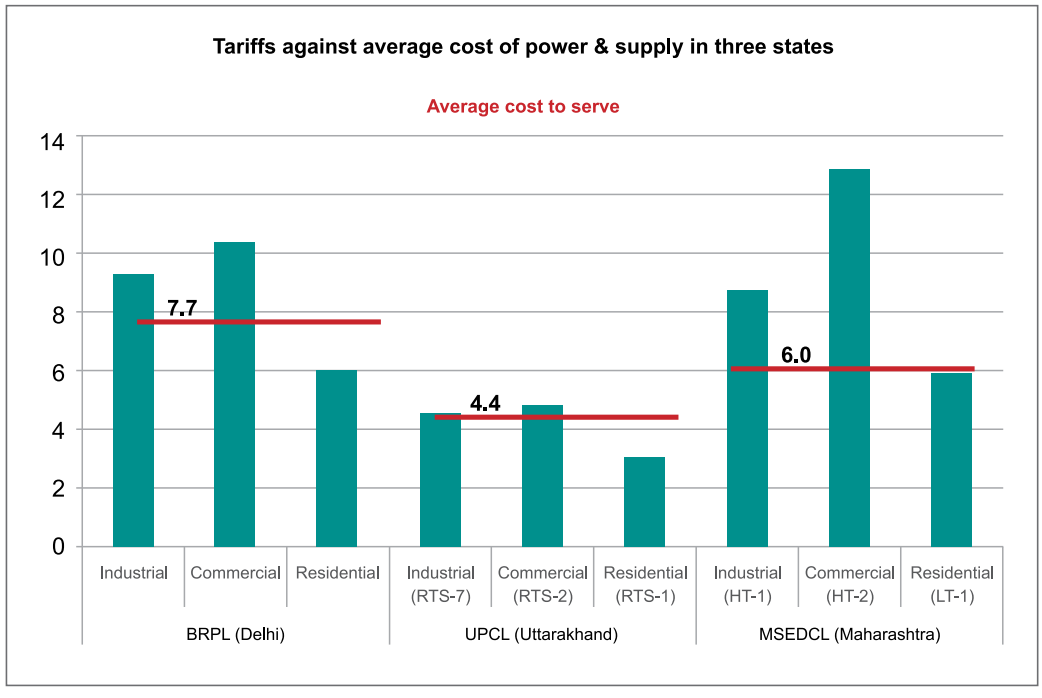
Industrial, commercial and higher-consuming-residential consumers have the strongest incentives to install rooftop solar because they pay the highest tariffs.

When such a consumer substitutes rooftop solar for grid consumption, the utility loses a contribution to its fixed costs as well as a contribution to cross-subsidy of consumers who pay less than the average cost to serve (typically agricultural and poorer residential consumers) .

Figure 4.2 shows how tariffs for industrial, commercial and residential consumers compare with the average cost to serve for three example utilities.

If a utility has unrecovered cost or reduced revenues as a result of rooftop solar, the costs will be recovered through higher tariffs for remaining customers. The question of the impact of rooftop solar on utility finances thus becomes more about the impact of rooftop solar on the tariffs of non-rooftop solar consumers.

Figure 4.2: Variation in tariffs for different customer segments in three states with average cost of power and supply



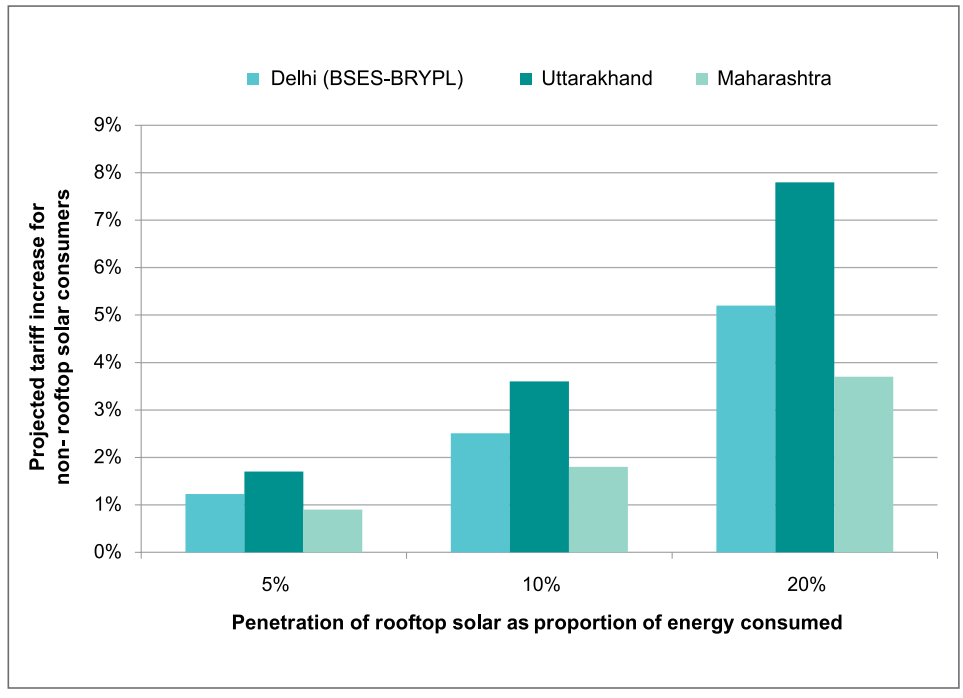
The Electricity Act 2003, National Electricity Policy and Tariff Policy provides for rebalancing of retail tariffs of various consumer categories over a period of time to reflect the actual cost to supply to that consumer category (in other words, an intent to reduce or phase out cross-subsidy). However, given the political sensitivities to tariff increases, it is unclear how quickly cross-subsidy can be reduced. Amendments proposed to the Electricity Act provide for waiving cross subsidy surcharge on renewable energy including rooftop solar.

So, given rooftop solar is likely to lead to some increase in tariffs for other consumers, the key question is how large will this impact be? Figure 4.3 models this for three

THE IMPACT OF ROOFTOP SOLAR ON NON-ROOFTOP SOLAR TARIFFS IS LESS THAN 4% UNTIL PENETRATION OF ROOFTOP SOLAR BECOMES VERY HIGH

utilities. These projections show that the impact on non-rooftop solar tariffs is less than 4% until the penetration of rooftop solar becomes very high (20% of power consumed). With 40 GW of rooftop solar, the penetration would be less than 5% of power consumption so the increase in tariffs in 2022 would be less than 2%.

Figure 4.3: Projected impact of net metered rooftop solar on tariffs for non-rooftop solar consumers[16]



Cost of grid integration

Chapter 3 noted the technical and regulatory challenges of increasing rooftop solar. As the rooftop solar penetration increases, greater changes to the local network are likely to be required. Discussion with utilities suggests that at 5% of the penetration of rooftop solar grid infrastructure challenges are likely to be localized. Further work will be needed to properly assess the costs of upgrading grid infrastructure due to rooftop solar, but we do not expect these costs to be an obstacle to achieving the 40 GW target. Whatever the precise costs, there is significant scope for reducing these costs by good network planning. Regulatory Commissions should recognize the necessity of these changes and provide for appropriate changes in the distribution planning code.

Administration costs

There will be some administration costs that are specific to rooftop solar. Utilities

16. These calculations model the impact of different penetrations of net metered rooftop solar in the market at constant utility tariffs and costs. The calculations are for a static market, assuming no growth in electricity sales. The loss of revenue (adjusted for avoided energy cost) on account of reduced grid consumption due to rooftop solar is assumed to be compensated through increased tariffs for non-rooftop solar consumers.

will incur costs for approval, implementation and inspection of rooftop solar grid connections. There will be a cost for upgrading billing systems to effectively manage net metered rooftop solar. As with the infrastructure costs, this cost can be reduced by building changes into planned upgrades of software and systems.

Of these costs for utilities, the most significant are the loss of revenue and cross-subsidy.

4.2.2 Benefits of rooftop solar to utilities

Avoided energy

The energy generated by rooftop solar consumers displaces the power procured by utilities from other energy sources at that point of time. The benefits depend on the value of the power displaced. The avoided cost is highest during peak hours and lowest during off-peak hours.

Avoided generation capacity

If rooftop solar can reduce the peak demand of consumers, this can reduce the amount of power generation capacity needed to meet peak demand. The closer the match between the demand and supply curves, the more 'capacity value' rooftop solar has in reducing the need for peak power capacity. However, for much of India, with an evening peak demand, the capacity value of rooftop solar will be limited. That may change over time if demand patterns change and a daytime peak becomes more prominent. Determination of the precise impact of solar generation on capacity requirements will require detailed study for each utility[17].

Reduction in transmission and distribution losses

Rooftop solar generates energy in the same locality as consumption and thereby reduces the energy transmitted and distributed over transmission and distribution network. Technical losses in India are estimated to be in the range 10 to 15 percent of the energy injected into the transmission system. These can be much higher when the transmission lines are congested.

Avoided distribution infrastructure

In some localities, rooftop solar may reduce or slow growth in demand and allow utilities to avoid or delay upgrading distribution infrastructure to a higher capacity. These benefits depend on the exact nature of local supply and demand and existing infrastructure, but can be significant.

Utilities and rooftop solar as a business opportunity

Utilities are well placed to develop business opportunities from rooftop solar. For

17. For a good example, see Energy and Environmental Economics Inc, 2015: Business models for distributed energy resource development: A case study with Tata Power Delhi Distribution Limited.

example distribution utilities could, with regulatory permission, provide services related to marketing, supply, installation, operation and maintenance and certification of rooftop solar. Distribution utilities could offer rooftop solar installations (with tie-ups with EPC companies) for consumers.

Reduction in RPO compliance cost

The generation by rooftop solar can reduce the RPO compliance cost of the utilities for two reasons; i) self-consumption and supply of surplus power into grid by rooftop solar consumers reduces the procurement of conventional power which reduces the RPO obligation; and ii) utilities get credit for the entire generation of net metered rooftop solar towards their RPO obligation.

4.3 Addressing utility incentives

The biggest financial concern for utilities from rooftop solar is loss of revenues for cross-subsidy and fixed costs rather than infrastructure or technical issues. Utilities have mandated social responsibilities for providing power on demand and meeting their universal service obligation to consumers in rural and urban areas. Fulfilling these responsibilities incurs costs. If rooftop solar consumers do not share these costs then they will fall to other consumers. Section 4.2.1 showed that the likely impact on tariffs for other consumers was likely to be modest, at least up to 2022 (perhaps around 2%). However, utilities cannot be expected to carry loses on rooftop solar into the long term if we want them to play a proactive role in supporting the sector.

4.3.1 Scope to give utilities greater share of benefits as viability strengthens

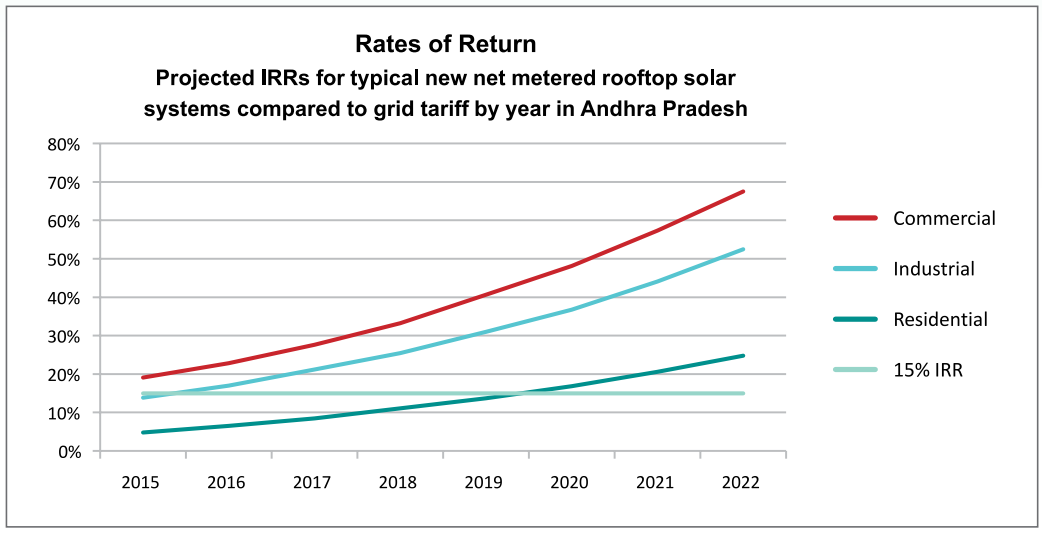
Net metering increases the viability of rooftop solar by giving the rooftop owner the lion's share of the benefits. This is important during this period when viability is still being established. But by 2020, modest gains from net metering will turn into very healthy gains. Therefore, as viability strengthens there is scope for the benefits of rooftop solar to be shared with utilities so they have a long term incentive to support the industry.

AS VIABILITY STRENGTHENS THERE IS SCOPE FOR THE BENEFITS OF ROOFTOP SOLAR TO BE SHARED WITH UTILITIES...

Figure 4.4 projects rates of return for new rooftop solar systems (taking Andhra Pradesh as an example). It shows that rooftop solar is expected to be viable for all segments by 2020, with rates of return for commercial and industrial consumers in Andhra Pradesh reaching 48% and 36% respectively around 2022[18].

18. The graph shows the lifetime rate of return for a new system commissioned in the relevant year. It dose not suggest that profits for a rooftop system installed in 2015 increase over time!

Figure 4.4: Projected rates of return for new net metered systems



4.3.2 What a package to address utility incentives might include

We believe government needs to put in place a package of incentives for utilities to proactively support rooftop solar that include carrots and sticks:

1. **A medium term grid services charge:** Under net metering, rooftop owners enjoy important benefits from the grid. We propose that in the medium term, once viability is established, rooftop owners should pay for these benefits. A regulated charge for grid services could compensate utilities for services such as energy banking, interconnections, infrastructure investment necessary and additional billing costs necessary for rooftop solar. This charge could be levied in a number of ways, but we recommend a charge per unit as the easiest for consumers to understand. The timing and level of the charge would need to be calculated, but might be in the region of Re 1/unit and could be introduced from 2019 or 2020 for new commercial and industrial consumers and for new residential rooftop solar consumers a year or two later.

   Such a charge could also recover a contribution to cross-subsidy. However, this is a political decision and given the government's commitment to reducing cross-subsidy, we have not recommended this here.

2. **Adjusting RPO benefits:** Encouraging rooftop solar as a cost-effective way of meeting RPO can provide a shorter term incentive. We propose that solar rooftop generation counts as greater value compared to ground-mounted solar in terms of solar RPO compliance, giving a boost to rooftop solar while the industry matures. A multiplier of 1.3x would reflect the avoided transmission and distribution losses (a comparative advantage of rooftop solar that would otherwise be lost given decisions to waive wheeling charges for wider renewable energy).

UNDER NET METERING, ROOFTOP OWNERS ENJOY IMPORTANT BENEFITS FROM THE GRID. IN THE MEDIUM TERM, ROOFTOP OWNERS SHOULD PAY FOR THESE BENEFITS

3. **Fund for infrastructure, systems and training investments:** We propose a fund to help finance early investments by utilities in infrastructure, training and systems to scale up rooftop solar. This can support proactive utilities. The size of the fund can be decided by government, but it should be substantial enough to be a credible incentive for utilities, so we recommend a fund of at least Rs 500 crores. The fund could be paid out to utilities who have both: a) made necessary investments in rooftop solar; and b) have achieved significant capacity addition.

4. **Firm political and regulatory signals:** Regulators should be proactive about ensuring that utilities play their part in rooftop solar, for example by setting interconnection timescales and ensuring utilities comply and publish data on connection times (see chapter 3). However, political signals also matter given that utilities are mostly state-owned companies. Ministers in the centre and states should underline their expectation that utilities actively support rooftop solar.

No	Recommendation	Cost/ difficulty	Impact	Authority
R 17	Government should put in place a package of incentives for utilities addressing short term and medium term issues along with clear regulatory and political signals	M	H	MNRE, Ministry of Power, State Governments
R 18	Introduce medium term grid services charge on new net metered rooftop consumers to compensate utilities for grid services	M	H	MNRE, Ministry of Power
R 19	Adjust RPO rules so generation from rooftop counts as 1.3 times that from ground mounted towards RPO compliance to boost the sector	M	H	MNRE
R 20	Set up fund to support early-adopting utilities to make investments in infrastructure, training and systems for rooftop solar	M	M	MNRE, Ministry of Power
R 21	Send firm political and regulatory signals to utilities that active support for rooftop solar is required	H	H	Central & State Governments

4.4 Wider changes to electricity markets could affect rooftop solar

In addition to issues specific to rooftop solar, there are a number of wider changes to electricity markets that could have a significant impact on the sector. Some of the more obvious of these are:

- **Improved utility finances:** ‘Project UDAY’, the Government of India mechanism to reform utility finances will be very important if successfully implemented, and would be beneficial for rooftop solar.
- **Increasing competition in the distribution sector:** If the government were to allow more consumers to choose their electricity provider, this would have far-reaching implications for the power sector. This could potentially be positive for rooftop solar by separating the network operator who is crucial for rooftop solar from the retail utility which is in some senses a competitor to rooftop solar.
- **‘Unbundling’ of tariffs to charge consumers more accurately for the services they use:** This could include changes to the balance between fixed and variable costs for electricity consumers which are being considered by some regulators. If tariff were reduced and fixed costs increased, the viability of net metered rooftop solar would decrease proportionately to the tariff reduction.
- **Reduced cross-subsidy:** This would largely be a positive for rooftop solar if it led to greater financial security of utilities and more market-based pricing.
- **Greater use of time of day tariffs:** Likely to be largely positive as daytime tariffs would likely be quite high, even if the highest tariff periods would be the evening peak when rooftop solar systems are not generating.
- **Complimentary measures:** The Regulatory Commissions, the Central and State Governments along with the rooftop solar program should also encourage demand response programs, distributed storage and integration of other complementary renewable energy sources.
- **Changes in the distribution planning code:** The Regulatory Commissions along with CEA should revisit the existing distribution planning code to take account of distributed generation in the distribution grid.
- **Improved long term planning:** Utilities are investing in better demand projection, assessment and cost-benefit analysis of supply options and long term infrastructure planning. Further investments will bring benefits to the whole electricity sector including rooftop solar.

5 CHAPTER

ATTRACTING PRIVATE INVESTMENT & SUSTAINING GROWTH

5.1 Investment requirement

At a weighted average capital cost of Rs 75,000 per kWp, the rooftop solar sector will need aggregate capital investment of approx Rs 300,000 crores ($45 billion) for 40 GW capacity by 2022. This investment amount can be further broken down roughly into 30% equity (equivalent to Rs 90,000 crores) and 70% debt (equivalent to Rs 210,000 crores). These are very significant amounts and to put these in perspective, the estimated debt requirement is about 40% of the present total bank credit to the entire power generation and distribution sector.

THE ROOFTOP SOLAR SECTOR WILL NEED CAPITAL INVESTMENT OF APPROXIMATELY $45 BILLION TO ACHIEVE 40 GW

Given the fiscal constraints of the government and large scale of investment required, the bulk of the funding for rooftop solar will need to come from private investors and lenders. This will not only drive market innovation in business models and financing but will also help manage risks and deploy capital efficiently.

In this chapter, we look at how India can create an attractive financial and operating environment for various classes of private financiers to attract necessary investment in the sector, as well as factors necessary to sustain scale up.

5.2 Sources of financing

Table 5.1 looks at different potential sources of financing for the rooftop segment and the drivers and constraints for each (with the largest sources highlighted):

Table 5.1: Drivers and constraints for different funding sources for rooftop solar

	End consumers	Third party investors (private equity funds, Independent Power Producers)	Banks	Government	Development financial institutions and not-for-profit sector (ADB, World Bank, CSR funds)
Form of financing	Capital purchase for self-consumption	Third party investment	Debt financing	Financial support mechanisms, interest rate subvention, FITs, GBI, subsidies etc	Grants, low cost debt funding
Drivers	Captive energy at a competitive price	Economic viability, growth potential, favourable government policy		Energy security, reduced strain on transmission and distribution infrastructure	Energy access, social and environmental benefits, reduced strain on transmission and distribution infrastructure
Financing appetite	Low-Medium For most residential consumers, the upfront cost of a rooftop solar system (Rs 2.50 lacs for a 3 kW system) is unaffordable. Corporate and institutional consumers may have the capacity but typically want to use their capital for core business needs.	High Corporate developers and dedicated funds for investing in rooftop solar projects have become extremely successful in other countries e.g., USA (SolarCity) and have large investment appetite.	High Banks have large lending appetite and are potentially the most important source of financing for the sector. The government has already taken steps to get greater interest from banks by according priority sector status to the sector and also including rooftop loans within the ambit of mortgage financing.	Low Government has provided subsidy for rooftop projects in the past but subsidies are being phased out because of fiscal constraints. However, government entities such as railways, public sector units, tax offices, schools and colleges are likely to get sufficient funding for their on-site rooftop projects.	Low These investors have relatively much lower financing appetite and are likely to focus on pilot initiatives and rural electrification opportunities in view of their social development objectives.
Cost of financing, pa	10-12% for residential consumers, 16-20% for corporate consumers	16-20%	10-12%	7-8%	8-10% (in Rupee terms)
Needs and concerns	Alternate uses of rooftop, reliable/ high quality installation, availability and cost of debt financing, net metering	Dispute resolution, contract enforcement, property access rights, net metering and interconnection policies, robust grid, clear policy framework, level playing field, clarity on ancillary charges, easier access to debt financing			Focus on select socio-economic segments
Constraints	High upfront cost, lack of technical and operational knowledge	Availability of enough rooftops to achieve scale	Power sector exposure	Limited financial ability	Limited funds

Amongst all these sources, the biggest contribution is likely to come from third party investors and banks.

5.3 Considerations of private investors and financiers

For private investors, the key decision making factors are as follows:

- Cost of rooftop solar and its competitiveness vis-à-vis grid tariff;
- Willingness and ability to make necessary investment and assume related operational and technical risks; and
- Availability of rooftops and willingness of owners to commit rooftop to long-term use.

5.3.1 Cost of rooftop solar and its competitiveness vis-à-vis grid tariff

Cost of rooftop solar and its competitiveness vis-à-vis the grid tariff is the most important market driver from a consumer and private investment perspective particularly in the Indian context. Whilst some consumers are motivated by environmental concerns, financial cost/benefit judgements determine whether or not to go ahead for most investors.

Grid tariffs in India are rising at rates ranging between 3-10% per annum. With distribution utilities being in severe financial distress and the proposed amendments to the Electricity Act 2003 giving regulators more powers to independently determine grid tariffs, grid tariffs are likely to keep increasing at significant rates in the short-to medium-term. Against this backdrop, there is already a strong consumer pull towards rooftop solar in India. In particular, as commercial and industrial consumers subsidise residential consumers in India, these consumers have already reached grid parity in many states as shown in Chapter 2. The rooftop market in India is therefore expected to be led by commercial and industrial consumers in the next 3-4 years.

5.3.2 Willingness and ability to fund upfront capital costs of rooftop solar

The high capital cost of solar systems – approximatly Rs 75,000 per kWp – remains a formidable barrier in the growth of the sector particularly for the residential segment. Consumers can justify easily the recurring cost of rooftop solar as they consume power over a period of time, but upfront financing of capital cost is a major deterrent and likely to remain so despite reducing costs of rooftop solar systems. Even business consumers with sufficient financing capacity are often reluctant to invest in solar systems because they typically want to preserve their capital for core business needs. Highly reputed and cash rich companies such as Nestle, Glaxo Smithkline, Daimler and ACC are believed to prefer this route for implementing rooftop solar solutions in their facilities.

Internationally, the third party investment business model has been extremely successful and has been a key driver of rooftop solar growth in many countries. For

THIRD PARTY INVESTMENT MODELS CAN NOT ONLY SPEED ADOPTION OF ROOFTOP SOLAR, BUT ALSO MOBILISE THE LARGE SCALE FINANCE NEEDED

example, 60% of residential systems installed through the California Solar Initiative in 2014 used third-party financing arrangements[19].

Third Party Investment models can not only speed adoption of rooftop solar but also mobilise the large scale of finance needed. Private equity investors and solar project developers have huge investment appetite. There are other important benefits of facilitating third party business models – such investors bring more innovation in the market and push the boundaries of technical design, procurement, operational know-how and financing.

The third party model has already shown considerable promise in India with about 50 MW of rooftop capacity being developed under this model in the last 2 years. Many Independent Power Producers and corporates including Amplus, Cleanmax, IL&FS, JBM, Malpani Group, Rattan India, ReNew, SUN AMP, SunEdison and Tata Power have already entered this market.

It seems reasonable to believe, consistent with experience in other countries, that third party investors should play a critical role in rooftop sector in India.

5.3.3 Consumers unwilling to commit rooftop and/or slow to make decisions

Many consumers are unwilling to adopt rooftop solar because they use rooftop for alternate uses or want flexibility to add more floors to their buildings at a later date. There are various other reasons for consumers' reluctance to go for rooftop solar:

- The payback period for self-investment is very long at about 6-8 years;
- Third party investors require minimum contract periods of typically 15 years, which are deemed too long by many consumers;
- Lack of knowledge or experience of the technology;
- There is a (reasonable) expectation that solar technology costs will keep coming down and hence, it may be better to defer a decision;
- In many cases, lack of a pressing need and decision making inertia means that rooftop solar decision is postponed.

Whilst improving viability of rooftop solar will drive faster adoption, a concerted effort is needed to tackle all of these obstacles.

5.4 Perspective of third party investors and banks

Despite huge promise, the third party investment model presents unique and significant challenges in the Indian context. We believe that in view of the huge investment potential of this model, it is absolutely critical to address concerns of third party investors and financial institutions.

19. Source: National Survey Report of PV Power Applications in USA 2014, PVPS, IEA

5.4.1 Reducing risks to contract enforcement through better dispute resolution mechanisms

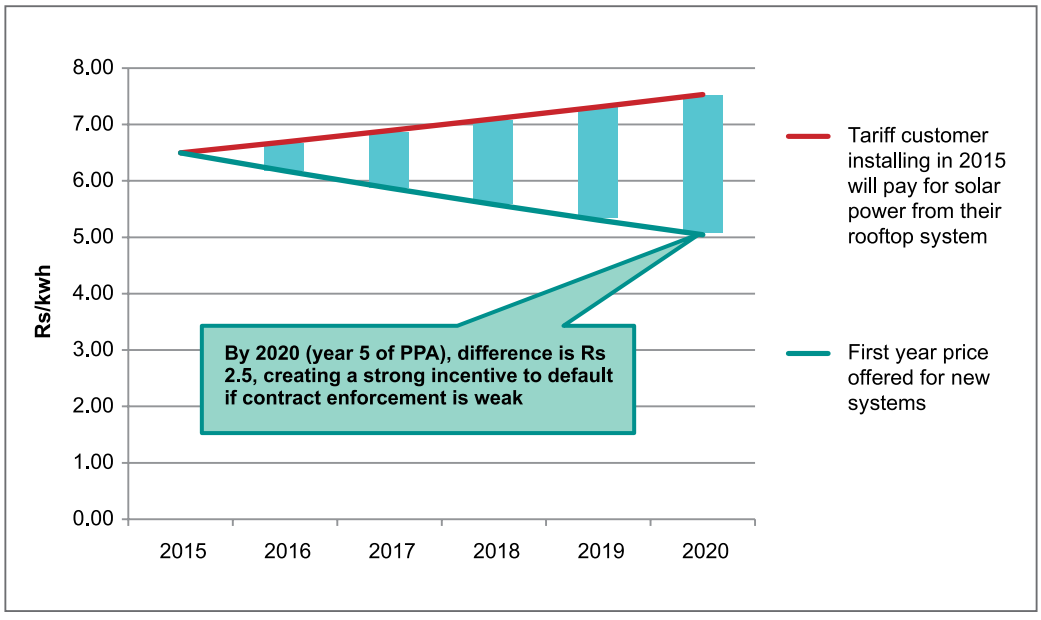
The issue of contract enforcement is the most serious concern for third party investors. Sanctity of contracts is generally regarded as low in India. The legal process is cumbersome and very costly, resulting in time consuming process of contract enforcement. The long dispute resolution and recovery process is frustrating for even institutional players like banks who fail to recover their loans resulting in high share of distressed portfolios. In World Bank's Ease of Doing Business rankings, India has been ranked at 186 out of 189 countries on Contract Enforcement.

Rooftop power purchase agreements typically have a term of 15-25 years, consistent with the period required to earn the expected return. The risk of disputes between any two parties over such a long period is very high particularly because solar costs fall, the consumers have a temptation to renege on the contract and buy cheaper power from other sources

THE RISK OF DISPUTES BETWEEN PARTIES DURING 15-25 YEAR CONTRACTS IS SIGNIFICANT

Based on market evidence, commercial consumers need to pay about Rs 6.50/ kWh escalating at 3% per year for a 100 kW system. If overall solar rooftop costs fall at 5.2% annually, as widely predicted, then the same customer could potentially sign a new agreement with another developer at Rs 5.0 in 2020 and Rs 3.9 in 2025 providing him with a strong incentive to default (see figure 5.1). The default risk increases over time presenting the biggest challenge for third party investors in rooftop sector.

Figure 5.1: Declining costs of new systems create risk of default when contract enforcement weak



A project developer with assets installed on someone else's premises is particularly exposed to default risk because of limited physical control over over the premises where the assets are installed. Consequently, while the power developer has legally valid access rights over the rooftop, it bears the risk of denial of access by the premises owner. Moreover, given the relatively small individual installation sizes (a 100kW system cost is approximately Rs 0.75 crores), the cost and time required to pursue legal remedies to enforce the property/access rights is not seen as justifiable.

On 23 October 2015, the President of India promulgated a 'Commercial Courts, Commercial Division and Commercial Appellate Division of the High Court's Ordinance, 2015' (Commercial Court Ordinance). The Commercial Court Ordinance aims at setting up separate courts to adjudicate 'commercial disputes' in a time bound manner. The phrase 'commercial dispute' has been defined in a broad manner and will include almost all types of disputes arising between a power developer, premise owner and lenders. The Commercial Court Ordinance envisages setting up Commercial Courts in all districts and provides for an appellate mechanism separate from the typical appeal procedure provided in the civil procedure code. It is expected that effective implementation of the Commercial Court Ordinance will lead to speedy dispute resolution. However, these commercial courts will adjudicate disputes only over Rs 1 crore. This ordinance is valid only up to 6 weeks from the date of reassembly of the Parliament and will need to be passed by the Parliament to give it the effect of permanent legislation. This measure would certainly help third party investors and lenders in mitigating the risk of poor contract enforcement but the high threshold (Rs 1 crore) is a limitation for rooftop solar.

Table 5.2 shows additional potential solutions to the problem of poor legal enforcement. Each solution has its own unique set of implementation and/or jurisdictional challenges.

Table 5.2: Some options for addressing contract enforcement risk in rooftop solar:

Option	Comments
Developing a specialised credit insurance scheme specifically for the rooftop sector;	Complex to establish. Few precedents, risk that developers will weaken client selection criteria to win more business
Building a credit rating database accessible to rooftop project developers for all end consumers including corporate and institutional entities;	Would take a very long time to operationalise; needs strong support from Ministry of Finance and banking sector
Enforcing payment collection through utilities and/ or empowering them to terminate grid connection in the event of payment default to rooftop project developers;	Enactment required at state level, problem of who could judge when default has occurred except courts
Empowering a local level quasi-judicial authority to provide immediate relief by enforcing the investors' contractual rights.	Relatively easy to enact as a precedent already exists (see below)

Of these options, the last one – concerning empowerment of local level quasi-judicial authority – is considered the most practical, particularly as there is already a precedent for this - a similar process is contemplated under Section 163 of the Electricity Act, 2003 where a distribution/ transmission licensee or a person authorised by the distribution/ transmission licensee can approach the Executive Magistrate to issue a special order allowing it to enter any premises for carrying out the necessary works or removing electric supply lines lawfully placed by the distribution/ transmission licensee on that premises. Further, the draft Renewable Energy Act, 2015 recognises decentralised power generation specifically as a separate category and contemplates constitution of a new body or designation of an existing body, at a state level, to act as 'nodal agency' for implementing the terms of the Renewable Energy Act. The Government could consider either empowering the 'nodal agency' to exercise quasi-judicial powers or separately empowering a local officer like a District Collector, with quasi-judicial powers, to resolve disputes between the parties in the limited situation of denial of access to the rooftop system by the roof owner to a third party project developer or its lenders.

Credit insurance, linked to credit rating of project developers, is also an attractive concept worth further examination. Such a scheme would allow project developers with robust in-house credit assessment process to avail credit insurance at attractive terms. But developing such a mechanism purely for the rooftop solar sector would be challenging and careful consultation would be needed to ensure that it balanced the interests of different stakeholders and that there was sufficient demand. Government involvement would be important to provide confidence, for example by providing a corpus to underwrite the mechanism during initial years. The costs would need to be carefully considered, but could be expected to offer better value for money than direct subsidy.

No	Recommendation	Cost/ Difficulty	Impact	Authority
R 22	Empower a local level quasi-judicial authority to resolve disputes related to denial of access to roof by the roof owner to the project developer	M	H	MNRE, Ministry of Law and Justice
R 23	Government should undertake or commission consultations on a contract default insurance mechanism to boost investment	H	H	MNRE

5.4.2 Removing barriers to lease models

Facilitating rooftop leasehold rights to third party project developers is also a powerful, although not a sufficient, remedy to facilitate stronger legal protection for them. At present, creating leasehold rights is deemed to be extremely complex because of opaque, multi-tier property rights in many situations and prohibitive tax structures – rooftops are assigned the same 'circle' rates for calculating stamp duty taxes as other properties in the area. Consequently, there is substantial upfront tax burden for the

project developers wiping out most of the economic benefit of rooftop solar, even if the rooftops have no alternative use and would be worthless otherwise.

Following measures are recommended to make the process of creating leasehold rights easier:

No	Recommendation	Cost/ Difficulty	Impact	Authority
R 24	Grant automatic consent for creation of sub-lease over rooftops from government, quasi-government and private bodies such as industrial development organisations	L	M	Relevant central and state government departments
R 25	Provide waiver of stamp duty charges for registration of roof lease agreements (as the rooftop value is otherwise nil, this will not result in loss of significant revenues for the exchequer)	L	M	Respective State Governments

5.4.3 Alternative power sale options

TO REDUCE RISKS OF DEFAULT FOR PRIVATE PPAS, UTILITIES CAN PLAY AN IMPORTANT ROLE BY ACTING AS OFF-TAKER OF LAST RESORT

Since the contract default risk in long-term PPA based models is deemed very high, mitigating this risk will be a significant support for the third party sale model and to the rooftop segment overall. In the case of PPAs with private power consumers, utilities can play an important role by acting as off-taker of the last resort by being ready to buy power at a pre-determined price which protects interests of both parties in the case of a PPA contract default. If the rooftop solar price is set at a fixed pre-determined discount to the price the utility would normally pay for rooftop solar (the discount compensates the utility for uncertainty of supply), the utility can make a small profit on sale of power if they are required to step in. The third party investor would accept a lower price in return for substantial risk mitigation.

No	Recommendation	Cost/ Difficulty	Impact	Authority
R 26	Utilities to act as buyer of last resort (at discounted price) in case of disputed private PPAs[20]	M	H	State regulators

5.4.4 Clarity over miscellaneous charges including taxes and duties

At present, there is no clarity on applicability of various charges (cross subsidy surcharge, electricity duty, transmission and distribution charges and losses) payable by grid connected rooftop projects, in particular projects implemented by third party investors. The rules are very complex and vary from state to state and over time. Investors and lenders need transparency on this issue to assess economic viability and undertake risk analysis.

20. A small premium over APPC can be justified because rooftop solar power is produced at the place of consumption with minimal T&D losses to be incurred by the Utilities.

Some states including Karnataka, Telangana and Madhya Pradesh have already announced various promotional policies announcing waiver from such ancillary charges. Such measures improve grid price competitiveness of rooftop solar and can attract new capital into the market.

No	Recommendation	Cost/ Difficulty	Impact	Authority
R 27	Provide complete certainty over applicability of taxes, duties and other charges (cross subsidy surcharge, electricity duty, transmission and distribution charges and losses) for rooftop installations for a minimum period of 15 years	L	M	State regulators

5.4.5 Financial level playing field

Currently, there is a disparity in the market whereby a captive power generator or tax-paying business investor can effectively claim a cash incentive equivalent to up to 26.4%[21] (33% of 80% depreciation rate) of capital cost of a rooftop installation under the Accelerated Depreciation policy, but the benefit is not available to third party investors and Independent Power Producers using Special Purpose Vehicle structures since they don't have sufficient taxable profits.

Accelerated depreciation benefit distorts the market because investors who cannot avail of the benefit find it hard to compete. This risks excluding pools of capital that India needs to attract if the 40 GW target is to be achieved, such as foreign investors, pension funds and not-for-profit institutions.

ACCELERATED DEPRECIATION BENEFIT DISTORTS THE MARKET BECAUSE INVESTORS WHO CANNOT AVAIL OF THE BENEFIT FIND IT HARD TO COMPETE

Accelerated depreciation also creates perverse incentives to inflate project capital costs and pay low attention to long-term operational and quality assurance measures. It also slows down project development due to time and effort taken in devising tax-efficient structures, with associated transaction costs.

In future, all major policy initiatives should be developed such that they provide a level playing field to all categories of investors. There are broadly three options in relation to the accelerated depreciation benefit for rooftop solar:

- Phase it out in 2017 when the current provision ends;
- Replace the current approach with tradeable and generation-based tax credits or some other form of tax credits that can benefit all investors equally;
- Offer alternative incentives specifically to projects not availing accelerated depreciation that provide equivalent benefit.

In relation to accelerated depreciation, our recommendation is to phase out this benefit as soon as possible (it is currently expected to be available until March 2017) grid

21. The precise benefit to an investor depends on their specific tax position, including whether they have profits from other parts of their business.

parity for commercial and industrial consumers will be achieved in most parts of India by that time. The alternative would be to provide compensating benefits, in the form of tradeable, generation-based tax credits.

No	Recommendation	Cost/ Difficulty	Impact	Authority
R 28	Devise all rooftop policies including any financial support measures so as to create a level playing field between different classes of investors including consumers-owners of rooftop systems	M	M	Central and state governments, state regulators
R 29	Phase out accelerated depreciation or make the benefit available to all investors, and generation - based, when the current provision ends in 2017	M	H	Ministry of Finance

5.5 Debt financing support for rooftop sector

The government has taken important steps to get domestic banks and institutions to lend to the rooftop sector:

THE GOVERNMENT HAS TAKEN IMPORTANT STEPS TO GET DOMESTIC BANKS AND INSTITUTIONS TO LEND TO THE ROOFTOP SECTOR

- Classification of rooftop as priority sector;
- Making rooftop installations eligible for debt finance as part of mortgage financing thereby increasing the availability of debt as well as reducing the cost for residential consumers;
- Concessional debt funding by IREDA and State Bank of India through the support of international institutions such as ADB, WB and KfW;

These measures are indeed much needed and extremely desirable for the sector. However, in practice, debt availability is still a constraint for rooftop installations and a strong effort is required to operationalise the various schemes.

The government, and particularly MNRE, can play a vital influencing role here. Educational measures including for example, seminars and specific studies on operational robustness of solar technology can help lenders become more comfortable with the sector risks. That should, in turn, lead to them providing more attractive terms for debt financing of rooftop projects.

The other aspect of debt financing which will become very important as the sector grows is standardisation of project documentation. Lack of market standard documents is challenging for lenders as it is not possible to conduct detailed legal due diligence for each individual installation, which is typically 100 kW (equivalent to debt amount of Rs 45 lakhs). Standardisation of documents will also be very helpful for other modes of sector financing including investment trusts, securitisation and refinancing. The government needs to play an important role to give credibility to the template documents particularly within public sector banks and financial institutions.

No	Recommendation	Cost/ Difficulty	Impact	Authority
R 30	Assist lenders and educate them on technical and operational robustness of rooftop solar projects to encourage them to improve debt availability and terms for the sector	M	M	MNRE, Ministry of Finance, RBI
R 31	Government should support the development of standard contracts to facilitating refinancing markets and growth of rooftop solar	M	H	MNRE, Ministry of Finance

5.6 Building consumer awareness and confidence

Unlike utility-scale solar where decisions are driven by industry experts and government policy, rooftop solar related decisions are typically made by non-experts – end consumers, rooftop owners and/ or building/estate managers. It is important to help these entities understand rooftop solar costs, benefits and operational issues so that they can have realistic expectations and make good decisions[22]. The information that consumers need includes:

- The quality, cost and pros and cons of various systems available;
- The rooftop solar potential on their building (taking account of location, shadows, orientation etc);
- Limitations of solar energy;
- The process for metering and interconnecting with the grid

Helping consumers discern good quality systems with suitable configuration is very important particularly as rooftop systems are not readily available in standard configurations. There is also a lack of well-known quality brands for rooftop systems. Consumers can get a lot of technical information from solar vendors and installers but this may not be very high quality. Without independent sources to verify the information from vendors, consumers do not know what information they can trust. There is a critical need for independent, reliable sources of information that consumers can trust.

THERE IS A CRITICAL NEED FOR INDEPENDENT, RELIABLE SOURCES OF INFORMATION THAT CONSUMERS CAN TRUST

Government can help build confidence in rooftop solar systems in multiple ways:

a) Creating educational materials and tools, in online and print forms: Government agencies and utilities can also use these tools to promote rooftop solar.

b) Creating standard rating systems and testing facilities throughout the country: A rating system akin to the Bureau of Energy Efficiency systems for energy efficiency of appliance would be very helpful.

c) Encouraging development of voluntary consumer data-bases to allow consumers to post their real experience of vendors and quality and/or operational issues: Such tools can be of enormous help to other consumers considering adopting rooftop

22 Claudy, M., Michelsen, C., O'Driscoll, A. and Mullen, M: Consumer Awareness in the Adoption of Microgeneration Technologies: an Empirical Investigation in the Republic of Ireland. Renewable and Sustainable Energy Reviews, Vol. 14, (7), 2010 pp.2154–2160.

solar.

No	Recommendation	Cost/ Difficulty	Impact	Authority
R 32	State Nodal Agencies should support independent consumer bodies to provide high quality consumer information	L	M	SNAs
R 33	Encourage set up of voluntary databases of system performance to build up consumer performance data (wiki-type databases)	M	L	SNAs/MNRE
R 34	Encourage development of solar maps, system ratings and other tools to support consumers consider adopting solar rooftop	L	M	MNRE

5.7 Skills and capacity

One important area for sustaining rapid market-growth is skills. The availability of skilled personnel to design, install and maintain rooftop solar systems will be a bigger challenge than for other renewable technologies because with small system sizes, rooftop solar is more labour-intensive than ground-mount solar. However, the upside of this is that the rooftop solar industry will generate more employment than other generation technologies. The Council for Energy, Environment and Water and the Natural Resources Defence Council have estimated that reaching 40 GW of rooftop solar would generate 500,000 short term jobs and 140,000 long term jobs across India[23].

During the consultations for this report, developers and utilities underlined that skills are expected to become a significant barrier to scale up. There was agreement that the private sector will need to provide the majority of the skills training, but that government had an important role to play. The type of interventions that are needed include:

- Supporting curricula, accreditation and standards for training and qualifications relevant to rooftop solar;
- Supporting the set-up of solar training institutes;
- Urgently promoting training activities for utilities and regulators – the top priority bottleneck.

The government is taking action on this through the Sector Skill Council for Green Jobs and has allocated Rs 220 crore over ten years. It will be important that the skill requirements of rooftop solar feature strongly in the strategy and execution of this body.

In addition to the availability of skilled staff to design, install and maintain rooftop

23. NRDC-CEEW (2015): 'Clean Energy Powers Local Job Growth in India'

solar in the industry as a whole, capacity in specific institutions will be important for developing the sector successfully. Utilities, banks and regulators are key institutions and the type of skills they need include:

- Understanding of rooftop solar and how it interacts with the distribution system (including accurate assessment of how grid integration can be managed)
- Technical understanding of rooftop systems and ability to judge and apportion the costs of upgrading infrastructure
- Ability to model the impact of rooftop solar on utilities and therefore to set tariffs and a grid-services surcharge.

It is important that central and state governments are ambitious about skill development for rooftop solar. However, the costs, whilst significant, are not prohibitive, particularly compared to the costs of subsidies. For example, if 50,000 people need to be trained to undertake safe installation at a cost of Rs 10,000 per trainee, the cost would be around Rs 50 crores. And as these costs will largely fall to the private sector and utilities, the costs to government will be much less.

Further work will be needed to elaborate the best ways to support the skills challenges that will arise in the rooftop solar sector (this has not been the major focus of our work for this report), but facing this challenge will be important for sustained growth in the sector.

No	Recommendation	Cost/ Difficulty	Impact	Authority
R 35	Ensure that rooftop solar is a priority for the Sector Skill Council for Green Jobs	M	M	MNRE
R 36	Through the Sector Skill Council, support accreditation, certification and expansion of solar training institutes	M	M	MNRE
R 37	Urgently roll out skill development in rooftop solar for regulators	L	M	MNRE/FOR/ CERC
R 38	Work with utilities to identify their urgent skills requirements and ensure supply of skilled staff can meet demand	M	M	MNRE

6 CHAPTER

AVAILABILITY OF ROOF SPACE AND MANDATES

6.1 Maximising suitable roof and other space

Total rooftop solar capacity potential in 2022 is projected to be 128 GW based on estimates of existing rooftop space and projected rates of new building[24]. Physical availability of rooftops is not a constraint but there are multiple policy and legal restrictions that limit application of rooftop solar even where rooftop owners are otherwise willing. Government agencies can help in maximising available rooftop space through following measures:

THERE ARE POLICY AND LEGAL RESTRICTIONS THAT LIMIT APPLICATION OF ROOFTOP SOLAR, EVEN WHERE ROOFTOP OWNERS ARE WILLING

- Amending building codes to improve suitability of new buildings for rooftop solar. These would require architects and builders to maximise south (or west) facing roof space and ensure that roofs are structurally ready to support rooftop solar. Such measures to make new buildings 'rooftop ready' should apply to all segments and buildings over a minimum size.
- Planners looking at zoning should also take account of rooftop solar when considering height restrictions or other decisions so they can avoid measures that will unnecessarily affect rooftop solar deployment.
- Mounting structures used for rooftop solar systems should not result in violation of Floor Space Index norms.
- Deemed permissions from relevant planning authorities and government departments (industrial planning authorities, special export zones, municipal authorities, cantonment authorities and others) should be available for installation of rooftop solar systems. This avoids consumers being put off due to multiple bureaucracies to secure permission for a rooftop solar system.
- Solar systems installed on car parks, walkways, sheds and even ground-spaces available within premises should qualify as rooftop solar systems under various policy frameworks. In some areas, so-called solar gardens may be important opportunities: small scale distributed solar at ground-level. All of these systems should come under rooftop solar regulations.
- Ensure regulations support so-called solar gardens. These are distributed solar systems on rooftops or ground-mounted where power from many sites is wheeled through the grid and purchased by a private purchaser. Such solar-gardens enable space to be used where it is available and could become an important contributor to meeting the 40 GW target.

24 See chapter 2

No	Recommendation	Cost/ Difficulty	Impact	Authority
R 39	Amend planning rules to make new buildings more 'rooftop ready'	L	M	MNRE
R 40	Allow mounting of solar panels on unused ground space within premises under rooftop solar rules	L	L	State regulators
R 41	State Nodal Agencies should work with urban local bodies to put in place 'deemed permissions' with local authorities to facilitate rooftop solar approvals	L	M	State Nodal Agencies, urban local bodies, local government
R 42	Rooftop solar mounting structures should not result in violation of Floor Space Index norms.	L	M	

6.2 Mandates for rooftop solar

One of the tools that government can employ to promote rooftop solar is mandating owners of certain categories of buildings to install rooftop solar. The public policy argument for mandates is that there is public benefit from requiring people to take actions that they also benefit from (so subsidies would be less appropriate) but might not prioritise themselves. Examples from other spheres include mandates for health and safety measures, energy efficiency, access for differently-abled persons or controlling pollution. Building codes are a widely known example.

Experience from other sectors shows that whilst increasing economic viability will lead to faster adoption, there are still many consumers who may not adopt even when it would be economically beneficial for them to do so. Efforts to promote energy efficiency show that many energy consumers do not take energy saving measures even when they would save money by doing so. This is often because, the savings from taking a measure are not great enough to make this a high priority for them. In such cases, where there is a wider public benefit at stake, mandates can make sense to drive adoption.

The argument against mandates is that they restrict customer choice, impose costs on businesses, can damage competitiveness, and are economically inefficient. Poorly implemented mandates, or those without workable enforcement mechanisms can also lead to widespread non-compliance and therefore are ineffective.

Table 6.1: Pros and cons of mandates as tool for changing consumer behaviour

Pros	Cons
Mandates help correct distortions when benefits to society are greater than the benefits to the individual.	Mandates can be unpopular, particularly if they impose increased costs on business or households.

Can overcome inertia by consumers who may not adopt even when the economics are favourable.	Poorly implemented mandates can lead to widespread non-compliance, making the mandate counterproductive.
Little fiscal burden on government.	Mandates can have unintended consequences, for example mandates that require installation of rooftop solar will not necessarily ensure that these installations are maintained and used effectively.

6.3 Existing examples of mandates for rooftop solar

There are a number of examples of mandates for rooftop solar around the world. A number of states in the US have introduced mandates requiring new buildings to integrate rooftop solar (or other renewable generation within their premises)[25]. In March 2015, the French parliament passed a law requiring new commercial buildings to partially cover roofs with plants or production of renewable energy (rooftop solar)[26].

Some US states do not specify rooftop solar directly, but require very low net power consumption from buildings, leaving it to architects and building developers to decide whether the requirements should be met with energy efficiency measures or by rooftop solar. However, such mandates – whilst offering more choice – are also more complex to interpret, implement and enforce.

In September 2014, Haryana introduced a mandate requiring buildings to install rooftop solar by September 2015. The Government order from the Haryana State Renewable Energy Department specified minimum sizes of mandatory rooftop solar to be fitted to buildings over a certain type or electricity load. The order was notified on 3 September 2014 with a compliance period of one year and warned that non-compliance could lead to penal action under the Energy Conservation Act 2001.

Table 6.2: Details of Haryana mandate for rooftop solar 2014

Building type	Solar rooftop plant size required
- Retrofit of rooftop solar on residences over 500 sq yrds;	1kW or 5% of load
- Education buildings with a connected load over 30kW	5kW or 5% of load
- Government buildings with connected load over 30kW	2kW or 5% of load
- Hospitals, industrial, commercial buildings with connected load over 50kW	2kW or 5% of load
- Housing complexes covering more than 0.5 acres	10-40kW or more
- Government water lifting stations with connected load o 100kW or more	50kW or 3% of load
Coordinating agency: Haryana State Renewable Energy Department	

25 H.E. Dillon, C.A. Antonopoulos, A.E. Solana, B.J. Russo and J. Williams (2012): Could Building Energy Codes Mandate Rooftop Solar in the Future?

26 http://www.assemblee-nationale.fr/14/amendements/2064/AN/987.asp

The Haryana Government has shown leadership in introducing a mandate for rooftop solar. Anecdotal evidence, so far, suggests that it has stimulated interest in rooftop solar but compliance is still very poor. This is mainly because other measures that are necessary for adoption (such as operationalisation of net metering and a strong ecosystem) were not yet in place. The one-year deadline for compliance may have been too short and a timescale of eighteen months may be better (accompanied by a public awareness campaign throughout the period).

6.4 How and when should mandates for rooftop solar be introduced?

There are several ways mandates can be used to support rooftop solar:

- Adjusting building codes to make new buildings 'rooftop ready'. This means ensuring that new roofs have structural capacity to bear the additional load of solar panels if fitted, designing roofs to maximise the suitable space for solar including situating rooftop services to avoiding unnecessary shading;
- Mandating new buildings to have a minimum amount of rooftop solar linked to the areas of the building;
- Mandating existing buildings of certain types to install a minimum amount of rooftop solar linked to the building size or load demand.

The sequencing of the introduction of mandates is important. For mandates to be a success, several factors need to be in place:

- Net metering regulations need to be in place and operational;
- The utility needs to have capacity (systems and trained staff) for new interconnections and demand for the power;
- A well-prepared communications campaign needs to be in place to inform rooftop owners of the mandate and how they can comply;
- The ecosystem should have capacity to meet the increased demand caused by the mandate.

WE RECOMMEND STATES INTRODUCE MANDATES FOR RETROFITTING ONCE THE ECONOMICS ARE SOLIDLY FAVOURABLE

Mandates will have little impact if these factors are not in place because compliance will either be impossible or too difficult, resulting in non-compliance. Mandates are a way to multiply the impact of other measures in this report. They are not a short-cut which can be used instead of such measures.

Our analysis suggests a phased approach to mandates makes sense, starting with mandates for new buildings and then for retrofitting existing commercial and industrial buildings. The initial step should be mandating rooftop solar for new commercial and industrial buildings over 400 square yards to be fitted with rooftop solar. If the costs of installing a new rooftop solar system during building construction are 15% cheaper than retrofitting, it means that rooftop solar for new commercial and industrial consumers

would be economic in the majority of states by 2017 and in virtually all states by 2019. Given this, there are strong benefits from having a national approach with the same mandate for new buildings enacted by all states. With lead times for consultation and preparation, and the time states will need to enact such a mandate, work on a national mandate for new buildings should start now to enable introduction in 2017.

Mandates for retrofitting existing buildings are likely to be more challenging. The timing and political context for their introduction matters. We recommend states introduce mandates for retrofitting once the economics are solidly favourable. This means the timing of introduction will depend largely on the rise in tariffs. Figure 6.1 indicates, based on projections, when we would recommend each state introduces mandates for retrofitting commercial and industrial buildings (assuming mandates are introduced one tariffs are 20% greats than power from solar rooftop).

Figure 6.1: Year in which industrial tariffs rise become more than 20% higher than cost of rooftop solar.

	2016	2017	2018	2019	2020	2021	2022
Andhra Pradesh			Yes	Yes	Yes	Yes	Yes
Bihar				Yes	Yes	Yes	Yes
Chandigarh						Yes	Yes
Chhattisgarh							Yes
Delhi		Yes	Yes	Yes	Yes	Yes	Yes
Goa							Yes
Gujarat						Yes	Yes
Haryana				Yes	Yes	Yes	Yes
Himachal Pradesh							Yes
Jammu and Kashmir							Yes
Jharkhand				Yes	Yes	Yes	Yes
Karnataka		Yes	Yes	Yes	Yes	Yes	Yes
Kerala					Yes	Yes	Yes
Madhya Pradesh					Yes	Yes	Yes
Maharashtra	Yes	Yes	Yes	Yes	Yes	Yes	Yes
North Eastern states							Yes
Odisha		Yes	Yes	Yes	Yes	Yes	Yes
Punjab			Yes	Yes	Yes	Yes	Yes
Rajasthan			Yes	Yes	Yes	Yes	Yes
Tamil Nadu		Yes	Yes	Yes	Yes	Yes	Yes
Uttar Pradesh		Yes	Yes	Yes	Yes	Yes	Yes
Uttarakhand							
West Bengal		Yes	Yes	Yes	Yes	Yes	Yes

6.4.2 Enforcement

Credible enforcement is critical to securing compliance. Penalties should be clear, fair, credible and sufficient in magnitude to incentive compliance. Options for penalties include a fixed fine per month or year of non-compliance or a higher charge for power. In the case of a fixed fine, this should also link to the minimum size of installation that should have been installed – so that penalties are proportionately higher for larger premises .

MANDATES ARE A POWERFUL TOOL BUT THEY ARE NOT A SILVER BULLET. EVEN THE BEST MANDATES DO NOT LEAD TO 100% COMPLIANCE

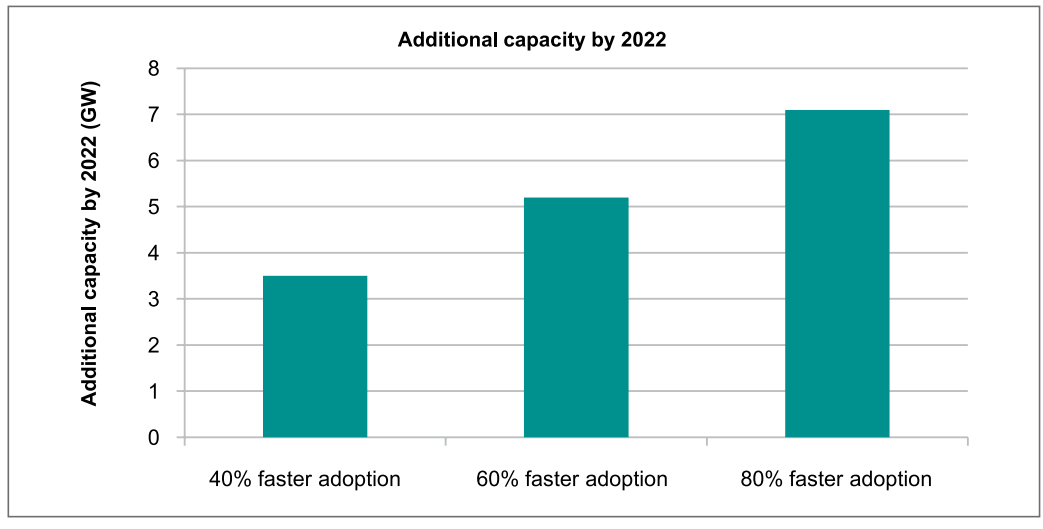
6.5 How much impact will mandates for rooftop solar have?

The impact of mandates will depend on how the mandate is implemented. If a mandate is well-timed, well-designed, introduced with clear political will and well-explained to consumers then compliance can be expected to be higher.

Mandates are a powerful tool, but they are not a silver bullet. Even the best mandates do not lead to 100% compliance. Studies of compliance with building codes or energy efficiency mandates show that it can take many years to achieve widespread compliance and vigorous enforcement is crucial. Rooftop solar does have one advantage over other technologies for authorities responsible for enforcing mandates, in that satellite images can readily show where rooftop systems exist and where they do not (albeit not whether they are operational).

In order to assess the potential impact of mandates, we have considered three estimates for their effect on adoption rates of rooftop solar. The three estimates consider adoption to be 40%, 60% or 80% higher due to the mandate. Figure 6.2 shows the impact of these estimates on projected capacity by 2022. We have taken the middle estimate (increasing adoption rates by 60%) in our modelling of the impact of our recommendations.

Figure 6.2: Scenarios for impact of mandates on rooftop solar capacity in 2022[27]



27 Note: these figures for the additional capacity mandates could bring by 2022 assume other measures recommended in this report are implemented and the impacts multiply. If mandates were implemented without these other measures, the additional capacity would be less.

6.6 Applying mandates effectively

Mandates can form a valuable part of the government's strategy for rooftop solar in India. To have the most impact, there should be long term visibility for how mandates will be introduced. Mandates should only be introduced once regulations are operational, the economics are favourable and the ecosystem is in place to support increased demand. A clear strategy should be prepared and published, setting out how mandates will be used, when they are likely to be introduced and what segments they are likely to cover. The idea is to make mandates as predictable as possible, helping industry and rooftop owners plan for compliance.

We recommend that for retrofitting, mandates should focus on the commercial and industrial sector where rates of return are highest.

No	Recommendation	Cost/ Difficulty	Impact	Authority
R 43	Prepare and publish long term strategy for using mandates to support rooftop solar	L	M	MNRE
R 44	Introduce mandates requiring rooftop solar for new buildings of all types over 500 sq yards across India	M	H	MNRE
R 45	Prepare model rooftop solar mandate with good practice for (state) retrofit mandates for commercial, industrial, government and institutional buildings.	M	M	MNRE, MoUD
R 46	States to adopt retrofit mandates once viability established and ecosystem in place to support additional adoption	H	H	MNRE, MoUD

7 CHAPTER

FISCAL INCENTIVES

Subsidies or fiscal incentives are financial aid or support extended to an economic sector (or institution, business, or individual) generally with the aim of promoting economic and social policy. In the case of rooftop solar, the role of fiscal incentives is to encourage new and early investments by institutions, businesses and individuals.

This chapter explores the key decisions for government regarding subsidy for the rooftop solar sector. The chapter focuses on decisions at the central government level, although the same considerations would apply to a state government or even a municipal authority considering subsidy for rooftop solar:

- What are the objectives of subsidy
- How would the subsidy be timed (start and finish)
- How would the subsidy be targeted
- What type of subsidy would work best to achieve the objective
- Finally, once these questions are answered is further subsidy for rooftop solar good value for money?

7.1 Past experience

India has been incentivizing the solar sector for the past several years now. This has helped India become one of the top ten solar markets globally and has helped drive scale and reduce costs. However, over the past couple of years, there have not been sufficient funds available to meet demand for the government's 30% capital subsidy scheme. This led to consumers waiting long periods for subsidies and deferring adoption of rooftop solar, and therefore to a loss of confidence in the subsidy scheme.

The general perception in the market is that many of the consumers who deferred their decision would have gone solar had the subsidies not been in place at all. For good reason, the businesses involved with installation of rooftop solar believed that the market could actually grow faster without any incentives. This led to the removal of capital subsidies for the commercial and industrial segments.

Subsidies can never be perfectly effective. In 2014, when MNRE was offering 30% capital subsidy for rooftop solar systems, a subsidised system would cost around Rs 65 per kW, whereas, an unsubsidised system cost around INR 75/kWp, a difference of 15%. This meant that only half of the benefit of the subsidy was being passed to the consumer. There was some justification for this because the channel partners who sold systems were taking on the risk of delay in disbursement of the subsidies by government. However this also illustrates the imperfections of subsidy.

This experience provides us with two key lessons for future: i) incentives are useful only if there is enough fiscal provisioning for increased demand; and ii) steps should be taken to minimise administrative costs of disbursing any incentives.

7.2 Objectives of incentives

The objective of subsidy should be clear so that the impact of subsidy can be clearly measured. Subsidies can have very different objectives:

- Maximizing capacity addition and therefore bringing scale to the sector to help reduce prices and progress towards the 40 GW target;
- Making additional sections viable (e.g. residential sector) to launch the market earlier than would otherwise have happened;
- Helping poorer or not-for-profit sections benefit from rooftop solar

Subsidies aimed at these three different objectives would be focused very differently and would have different impacts. The recently announced schemes by the government seem to focus on the second sub-objective, i.e., ensuring that different customer segments get tipped over the viability mark. While industrial and commercial consumers can get accelerated depreciation and lower interest rates, residential and institutional consumers can get a capital subsidy.

7.3 Maximising the effectiveness of subsidies

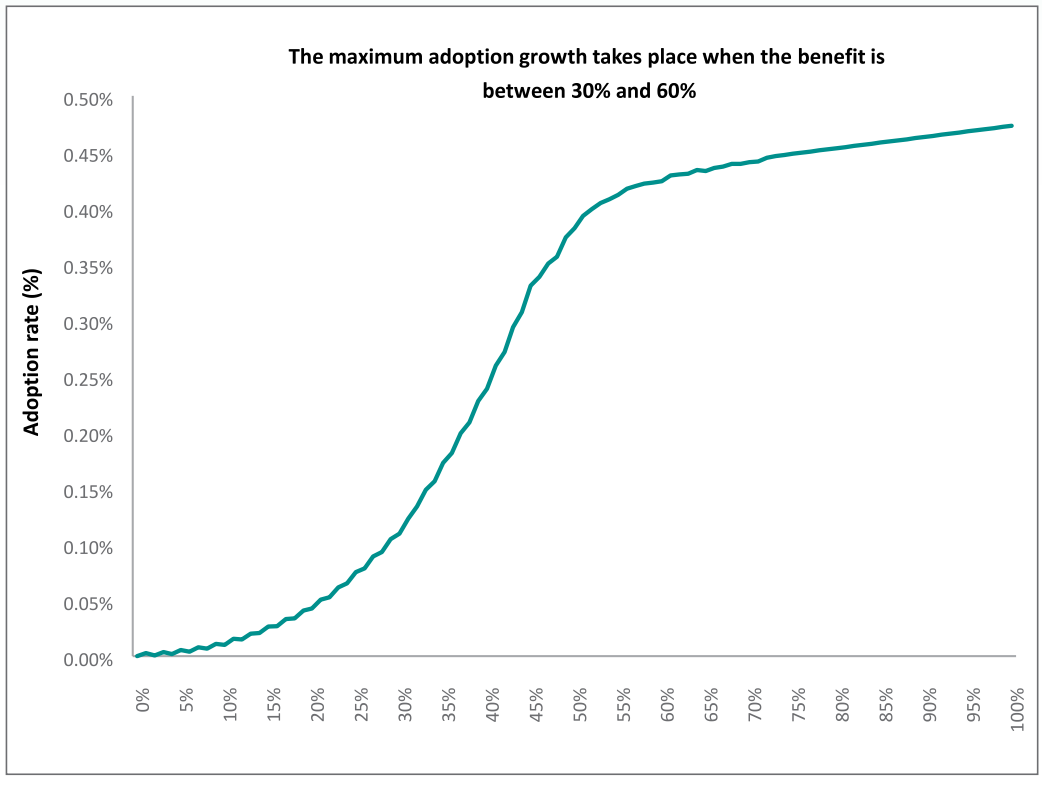
There are three ways in which the effectiveness of subsidies can be maximised:

- Timing: establishing (and removing) subsidy at the times that will have the most impact.
- Targeting: focusing the subsidy on the right states, segments and consumers to have impact.
- Type: choosing the most effective type of subsidy.

Studies of the adoption of new technologies, including rooftop solar, which are driven by viability over existing technologies, show that the adoption will follow an 'S' curve. In the initial stages of the market until rooftop solar is cheaper than conventional power by 20%, adoption will be minimal driven by consumers for whom the economics are not the main driver. As viability increases adoption accelerates and increases rapidly at around 30% viability. Beyond a particular point of viability, it would again stabilize, making an 'S' curve as shown in figure 7.1 below[28].

28 Annex 1 has more details on how this S-curve is derived.

Figure 7.1: Probable adoption curve for rooftop solar in India



Structuring incentives to just make systems viable will only produce slow adoption. Applying the same subsidy to viable consumers to push them into the steep part of the curve will lead to faster adoption. This can mean incentivizing industrial and commercial consumers over the residential consumers. However, given the problems with lack of funds, market players have argued for withdrawing subsidies for commercial and industrial consumers, so reverting to a subsidy strategy for these segments risks further confusing the market.

7.4 Timing of incentives

The timing of incentives is critical. There are choices to make about when to subsidise. If the objective of a subsidy is to accelerate adoption of a socially beneficial technology, the process will follow a distinct trajectory:

- Research, innovation and commercialisation: Incentives will be largely grant-based and focused on developing promising technologies into manufactured products and commercialising the technologies.
- Proving the concept: Incentives should focus on proving the scalability of technologies and commercial demonstration projects.

- Developing the market: Shift incentives to bring some consumers into viability to support commercialisation.
- Scaling up: Broad based incentives to accelerate adoption, achieve cost-reductions from economies of scale and accelerate adoption.
- Market maturity: There should a calibrated withdrawal of subsidies as viability becomes firmly established. Beyond this, there should be a focus on making the market work, reducing risks and other tools such as mandates can be used to maximise adoption.

The rooftop solar market in India is well advanced against this process, albeit that the market remains in its infancy, with the focus now firmly on scaling up and moving towards market maturity. Any subsidy should be applied quickly to have maximum impact.

7.5 Targeting of incentives

…THE CHALLENGE IS TARGETING SUBSIDIES TO THOSE CUSTOMERS FOR WHOM SUBSIDY WILL MAKE THE DIFFERENCE BETWEEN ADOPTION OR NOT

Be it kerosene, LPG, electricity or food subsidies, targeting any subsidy is challenging. In the case of subsidies aimed at encouraging adoption of technology, like rooftop solar, the challenge is targeting subsidies to those consumers for whom the subsidy will make the difference between adoption or not.

Every customer that avails of subsidy, but would anyway have adopted rooftop solar anyway represents expenditure with no impact on the subsidy objectives. This can make subsidies that are universally available (for example, national subsidies or tax breaks) very expensive.

There are three main ways in which subsidies for rooftop solar in India can be targeted:

1. Targeting or differentiating subsidy levels by states: Different states in India have different cost of power and relatively lower or higher irradiation levels. Viability for solar is largely a construct of these two parameters. Therefore, targeting subsidies by states can help achieve better targeting. For example, power tariffs in Maharashtra are higher and the consumers in the state do not require the same incentives as the consumers in Uttarakhand, which has lower tariffs. A differentiated incentive regime can help optimize the delivery of incentives.

   There are perverse incentives to avoid: Targeting rooftop solar subsidies to states with lowers power tariffs (and lower viability) could be considered to be rewarding states that have failed to appropriately price power.

   Targeting by segment – Industrial, commercial, residential and agricultural consumers all pay different tariffs across all Indian states. If the objective is to increase the number of consumers who can go solar, subsidies can be provided to agricultural and residential consumers so as to drive adoption in segments that would otherwise be unviable. However, if the objective is to maximise adoption

for the least amount of money, it might make sense to incentivise industrial and commercial consumers to push rapid adoption.

2. Targeting by customer category – Some subsidies apply to particular categories of customers only. India already has accelerated depreciation benefits that target profitable tax-paying businesses. Under the solar mission, some subsidies have been provided at different rates to projects not making use of accelerated depreciation.

7.6 Types of incentives

Incentive types can broadly be divided into categories: i) those accounted for in reference to capital invested, i.e., capital subsidy (sometimes also called and structured as viability gap funding),ii) income tax benefits[29], import/local duty waivers that reduce effective capital costs, iii) interest rate subvention and, iv) those that reward generation from the project, i.e., generation based incentives and preferential feed-in-tariffs. The way the subsidy is administered can also have significant impact on the ease of implementation and costs of implementing incentives. Table 7.1 summarises the pros and cons of the commonly used incentive types and their variations.

THE WAY SUBSIDY IS ADMINISTERED CAN ALSO HAVE A SIGNIFICANT IMPACT ON EASE AND COST OF IMPLEMENTATION

Table 7.1: Pros and cons of different subsidy types for rooftop solar.

	Pros	Cons
Feed in Tariff	• Utilities make money beyond parity • Attractive to consumers • Fair to all investors	• Difficult to implement • Utility support crucial • Legacy payments issue
Generation Based Incentives	• Can be targeted and waned off • Attractive to consumers • Fair to all investors	• Difficult to implement • Utility support crucial
Capital subsidy	• Process already in place • Easy to implement	• Mixed experience from the past due to lack of funds • Does incentivise generation
Interest rate subvention	• Relatively easy to implement • Attractive to investors	• Rates need to be significantly discounted • Does not incentivise generation
Accelerated depreciation	• Process already in place • Easy for government to implement	• High cost to government • Discourages investors who cannot avail benefits • Does not incentivise generation (as currently framed)
Tradable and generation - based tax credits	• Opens up all pools of capital inflow	• High cost to the government as revenue forgone

29 Tax benefits can be linked to generational instead of to capital purchase. The US has production tax credits that provide a tax benefit when power generation targets are met.

7.7 How can subsidies be best structured?

If government decides to provide subsidy to deliver faster progress towards the 40 GW target, how could these subsidies be most effectively structured? Our analysis suggests:

- Objectives: To reach 40 GW the government would have to aggressively focus on capacity addition. This would mean designing subsidies to push consumers into the steepest part of the adoption 'S-curve'.
- Timing: Focused on driving additional adoption early and increasing the base for market growth. Withdrawal of subsidies is a significant challenge as international experience is littered with examples of adoption crashing after the withdrawal or reduction of subsidies. Therefore, gradual and predictable withdrawal would be important.
- Targeting: To drive maximum adoption, the focus would need to be on encouraging additional adoption by commercial and industrial consumers. Subsidy would be focused on states with greatest potential for scale-up of rooftop solar and higher tariffs (see chapter 9). Subsidies would be differentiated by state to maximise their impact. This 'fine-tuning' would help maximise value for money.
- Type: Our analysis suggests that universal subsidies such as tax incentives – some kind of tradable tax credit – would be easy for government to implement, but would be very expensive because consumers would avail them whether or not they would have adopted rooftop solar anyway. Generation-based incentives are more complex to administer, but may be easier to target and they incentivise the production of energy.
- Policy certainty: For subsidies to be effective, the market has to have complete confidence that subsidies will be paid out as promised and on time (including that the funds are available).

THE MORE SUBSIDY MADE AVAILABLE, THE LOWER THE VALUE FOR MONEY OF EACH ADDITIONAL RUPEE SPENT

7.8 Value for money of rooftop solar subsidy

The more subsidy the government makes available, the lower will be the impact of every rupee spent. Figure 7.2, drawing on analysis from the market model, shows this impact.

Figure 7.2: Diminishing returns from subsidy for rooftop solar

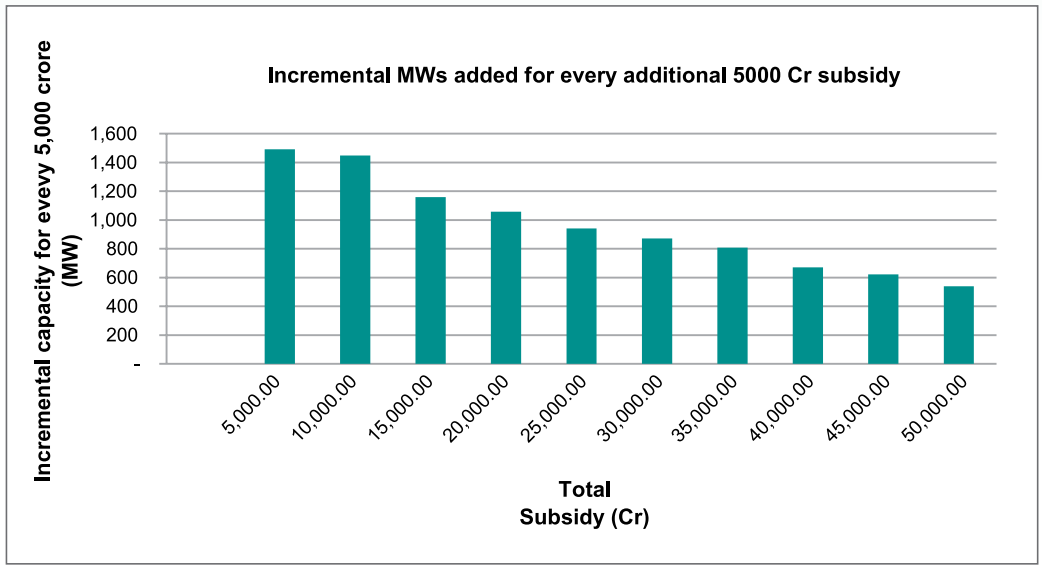


Figure 7.2 shows a fundamental problem with further subsidy for rooftop solar. Our market model suggests that subsidy of Rs 5,000 crores would result in additional capacity of about 1.5 GW, which means a cost per MW of Rs 3.3 crores. However, funds directly invested as the equity contribution to rooftop solar projects would have a cost per MW of Rs 1.85 crores. So the government would have greater impact by taking these funds and directly investing them in solar rooftop projects than it would by providing subsidy.

Why is this the case? The most important reason is that much of the subsidy will benefit consumers who will anyway adopt rooftop solar, reducing the amount of additional capacity that the subsidy will produce. Modelling scenarios with-subsidy and without-subsidy allows us to estimate the additional capacity a subsidy might generate.

The Government has announced that Rs 5,000 crores will be available for rooftop solar subsidies up to 2019. Given the diminishing benefits of additional subsidy, we do not recommend any further direct subsidies after this current allocation.

Carefully targeted state level subsidies may provide better value for money. If states wish to accelerate their rooftop solar markets, and are considering subsidy, we recommend that: a) they design the subsidies in line with the approach in section 7.7; b) that they undertake careful modelling of the expected impact of subsidies as compared to a no-subsidy scenario to assess the value for money of the planned subsidy.

7.8.2 Making best use of existing funds

THE FIRST CALL ON GOVERNMENT FUNDS SHOULD BE NON-SUBSIDY MEASURES TO FACILITATE MARKET-LED GROWTH

Our recommendation is that the first call on government funds should be the non-subsidy measures to facilitate market-led growth in rooftop solar listed in this report. These measures offer much greater value for money for government than direct subsidy.

7.9 Recommendations

Our key recommendations for fiscal incentives are:

No	Recommendation	Cost/ Difficulty	Impact	Authority
R 47	Marginal benefits of additional subsidy are diminishing, so further national direct fiscal subsidy to reach the 40 GW target would not be good value for money	L	H	MNRE, Ministry of Finance
R 48	Non-subsidy measures offer better value for money and should be the first priority for the funds available to MNRE for rooftop solar (ahead of the 30% subsidy)	M	H	MNRE, Ministry of Finance
R 49	The government should review the capital subsidy and consider whether it is value for money and if so, maximise the targeting and ensure funds are available	L	M	MNRE
R 50	If states are considering subsidies, they should assess carefully the value for money and model the additional capacity that can be expected before going ahead	M	M	MNRE

8 CHAPTER

CAN SCALING UP ROOFTOP SOLAR BENEFIT ENERGY ACCESS?

8.1 Introduction

In addition to energy security, India also faces a huge challenge of providing access to modern energy, particularly electricity, to around 300 million people who currently do not have access to grid power. The Government of India has targeted up to 20 GW of off-grid installations by 2022, including 20 million of solar lights in its National Solar Mission.

Distributed solar power has huge potential to contribute to both energy security and energy access. Although the technologies that are used in grid-connected and in off-grid systems are significantly different, there may be substantial spill over benefits and learning between these sectors. This chapter is best seen as an addendum to the rest of the report as an initial exploration of how expansion of rooftop solar could benefit rural electrification.

ALTHOUGH THE TECHNOLOGIES IN GRID-CONNECTED AND OFF-GRID SYSTEMS ARE DIFFERENT, THERE MAY BE SUBSTANTIAL SPILL-OVER BENEFITS BETWEEN THESE SECTORS

8.2 Off- Grid Solar Photovoltaic Applications in India

Off-grid technology and applications include:

- Solar lanterns
- Solar home lighting system/solar photovoltaic micro–grids
- Solar mini-grids
- Solar photovoltaic based irrigation pump sets
- Off- grid solar photovoltaic for telecom towers

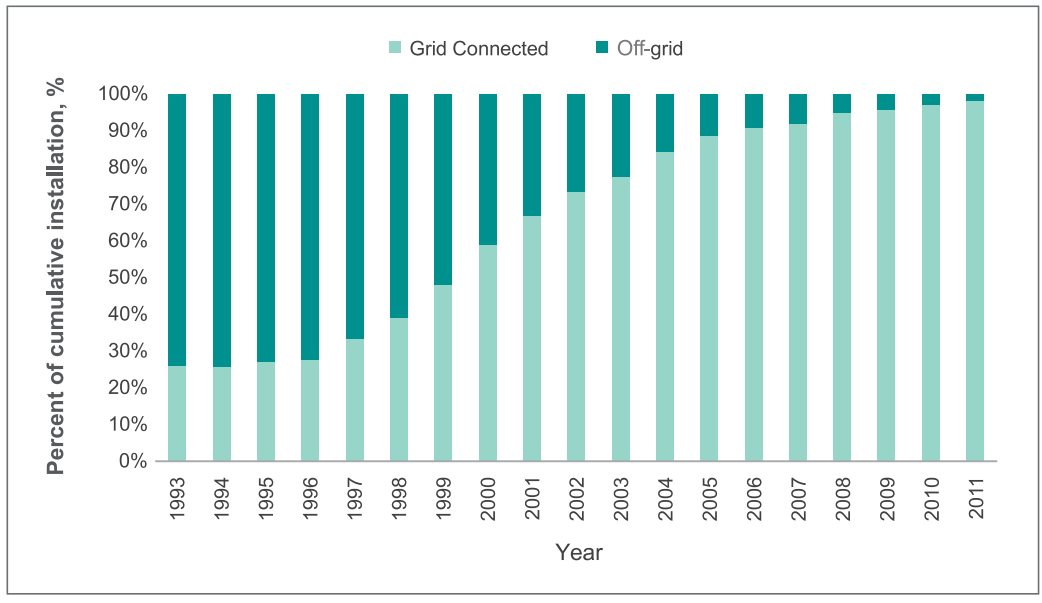
The World Resources Institute estimates that decentralized renewable energy enterprises offer in India a market opportunity of $2 billion per year. The International Energy Agency estimates that the 400 million people without access to electricity in the country spend over $60 billion annually on energy (primarily inefficient sources such as kerosene).

8.3 Off-grid vs On-grid

Off-grid systems are well known. For decades, they have been an important means to supply electricity in remote areas including rural villages and islands that are not connected to a national electricity grid[30]. Following figure shows the ratio of off-grid versus grid connected solar photovoltaic deployment between 1993 and 2011.

30. IRENA. (2015). Off Grid Renewable Energy Systems: Status and Methodological Issues. IRENA. Retrieved July 26, 2015, from http://www.irena.org/DocumentDownloads/Publications/IRENA_Off-grid_Renewable_Systems_WP_2015.pdf

Figure 8.1: Ratio of off-grid versus grid connected solar photovoltaic deployment between 1993 and 2011[31]



The figure above shows that until recently, off-grid systems accounted for a large share of solar photovoltaic deployment. However by 2000, grid-connected solar was half of the total and this proportion has risen sharply since, reflecting the rapid scale-up of utility scale solar. Installed capacity of off-grid solar photovoltaic installation has been increasing but at a much slower rate.

Nevertheless, off-grid applications are developing more rapidly in several countries than in the past and some targeted support has been implemented. For example, Bangladesh installed an impressive over three million solar home systems by May 2014 representing a total installed capacity of around 135 MW[32].

Given that volumes of grid-connected installations so heavily dominate the solar sector, spill over effects could be significant if they drive reductions in cost and accelerate innovation in technology, deployment and operations and financing.

8.4 Scope for technology convergence?

Currently, the only component that is standard to both grid-connected and off-grid systems is the panel. Aside from that, grid connected and off-grid solar systems use different components. However there are a number of factors that could narrow these technological differences and increase the scope for a more integrated market – which could reduce costs in the off-grid sector more quickly. These factors include:

31. IEA. (2012). Trends In Photovoltaic Applications-Survey report of selected IEA countries between 1992 and 2011. International Energy Agency (IEA). Retrieved September 6, 2015, from http://apache.solarch.ch/pdf/trends_2012.pdf
32. Ayre , J. (2014). Bangladesh Installed 3 Million+ New Residential Solar Systems. Retrieved from CleanTechnica Web site: http://cleantechnica.com/2014/11/19/bangladesh-installed-3-million-new-residential-solar-systems-since-may/

- Changing consumer demand: Rural and remote consumers are demanding not just power for lighting but also for entertainment, mobile charging, internet access, agricultural activities and income generation[33]. There is growing demand for AC power for modern appliances.
- Inverter technology advances allowing sophisticated power management features at low cost.
- Scope for on-grid solar systems to contribute to better end-of-grid voltage management.
- Demand for a safe solution that allows deliberate islanding of on-grid systems (see chapter 3). If a safe solution is found, this will increase the utility of on-grid solar in rural areas.
- Advances in storage technologies. If low cost storage can be delivered by the early 2020s, this further multiplies options for system design and application and will narrow the differences between on-grid and off-grid systems.

8.4.1 Inverters

On-grid and off-grid systems use different designs of inverters. However, there is a scope for development and improvement in inverters which can work across on-grid and off-grid applications. Most importantly, high level voltage fluctuation in rural areas requires special features in inverters which are not easily available in the market. Inverters are required which can handle a wide range of voltage fluctuation from 160V to 220V in order to achieve grid synchronisation. Rooftop solar systems would then be able to bolster end-of-grid voltage when they are connected to the grid.

8.4.2 Balance of System Component:

Balance of system component manufacture and supply are important parts of the solar system value chain and account for a significant share of system costs[34]. Balance of system includes racking, cables/wires, switches, enclosures, fuses, ground fault detectors and more.

There is both need and scope for significant reduction in balance of systems costs. As rooftop solar scales up, use of common components between grid-connected and off-grid systems may offer cost reduction opportunities.

8.4.3 Energy storage

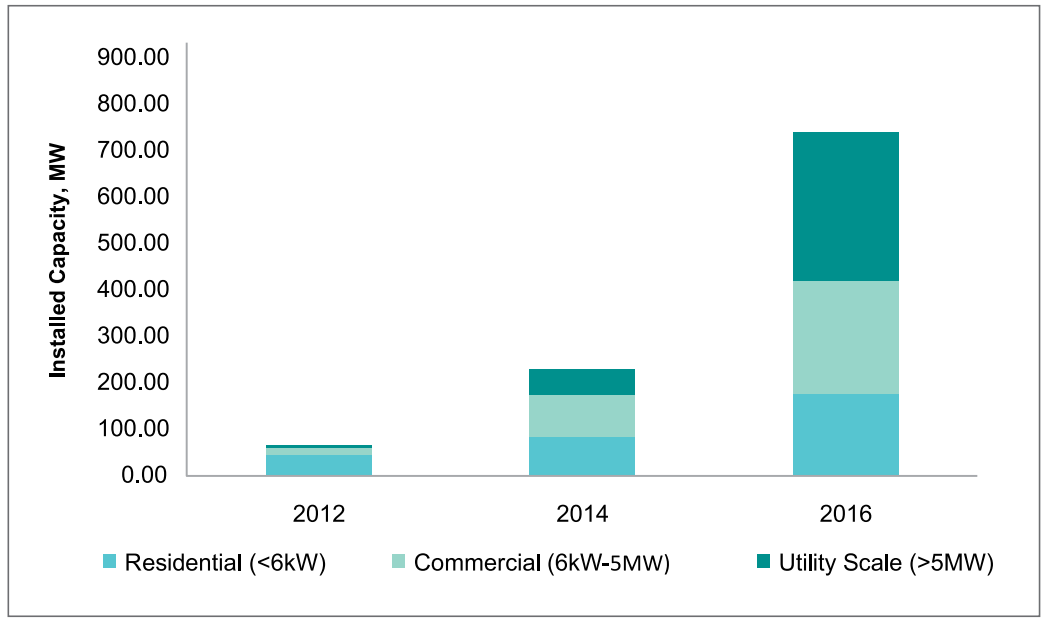
Energy storage technology is undergoing significant transformation with developments in battery storage efficiency and type. A recent report published by Deutsche Bank predicts that energy storage, the “missing link of solar adoption” will be cheap enough

33. Interview with Professor S.P.Gonchaudhuri, July 2015
34. IEA. (2013). Trends 2013 In Photovoltaic applications - Survey report of selected IEA countries between 1992 and 2012. International Energy Agency (IEA). Retrieved August 8, 2015, from http://iea-pvps.org/fileadmin/dam/public/report/statistics/final_trends_v1.02.pdf

and technologically ready to be deployed on a large-scale within the next five years. Their analysis indicates that the incremental cost of storage will decrease from around Rs 9/kWh to around Rs 1.3/kWh over the same period[35].

Adoption of grid connected solar with energy storage may increase scope for convergence of grid connected and off-grid systems. Figure 8.2 suggests that annual installation of grid-connected photovoltaic systems with energy storage will grow more than threefold to reach 775MW globally in 2016 with collective contribution from all three major market segments i.e. residential, commercial and utility scale[36].

Figure 8.2: Growth in annual installation of grid-connected photovoltaic systems with energy storage[37].



8.5 Business models

Business models for rooftop solar and off-grid solar are quite similar:

- A capital purchase model where the system is brought and owned fully by the household or business – with or without a loan;
- An operating cost model where the system is owned by an energy services company who provides the energy service and is paid in instalments through the life of the system.

35. RenewEconomy. (2015). Energy storage to reach cost 'holy grail', mass adoption in 5 years. Retrieved from RenewEconomy Web site: http://reneweconomy.com.au/2015/energy-storage-to-reach-cost-holy-grail-mass-adoption-in-5-years-18383
36. IHS Technology. (2015). Top solar power industry trends for 2015. IHS. Retrieved August 9, 2015, from https://www.ihs.com/pdf/Top-Solar-Power-Industry-Trends-for-2015_213963110915583632.pdf
37. Ibid

The scale up of rooftop solar business models is likely to generate learning that will help reduce operating and project development costs in the off-grid segment – despite the differences in systems, customer types and other factors. In remote areas, operation and maintenance is a particular challenge. As the grid-connected rooftop solar sector scales up, there will be a huge training investment in operation and maintenance staff and this will need to come with considerable innovation in models for efficient and effective operation and maintenance. Integrating skill development plans offers opportunities to maximise benefits for both for the on-grid and off-grid sectors, albeit that the precise technologies and customer needs in each may be distinct.

The proposed amendment in the Electricity Act 2003 of Government of India will push regulators to design special tariffs for standalone solar rooftop systems which can also be connected to the grid. Such special tariff could be expected to lead to scaling up of rooftop solar systems. Nevertheless, the overall model needs to be demonstrated and evaluated for consumer satisfaction and commercial viability.

8.5.1 Rooftop solar offers opportunities for utilities to reduce costs in rural areas

Generally, urban tariffs are higher than rural tariffs for all the consumption slabs. On a per consumer basis, the fixed costs of setting up the infrastructure are higher in the rural areas. Losses due to longer feeder lines to remote villages push costs up further. Therefore, the average costs of supply in the rural areas are typically higher than in urban areas.

When you take account of other challenges such as power theft, recovery cost, and potential for voltage stabilisation, costs of serving customer can be higher than the revenue generated. In such cases utilities would gain from supporting rooftop solar to reduce demand. Utilities should develop models to encourage rooftop solar in rural areas as part of their efforts to serve those areas.

The Government of the state of Karnataka recently announced the ambitious Surya Raitha programme which allows net metering by farmers and can be seen as an important example where utilities can play an important role in linking grid-tied solar systems and rural energy access. The programme supports solar pumping systems for irrigation and will enable farmers to sell excess power generated to the government. Under the scheme, a farmer can install a solar power-run pump-set on his farm with 90 per cent subsidy from the government. The government will purchase excess power generated by the farmer at Rs. 9.56 per unit (if the farmer has not taken subsidy); Rs. 7.20 per unit (if the farmer has taken subsidy). This programme is for irrigation pump sets on dedicated irrigation feeders[38].

ROOFTOP SOLAR COULD BE A USEFUL TOOL FOR UTILITIES TO REDUCE DEMAND IN RURAL AREAS WHERE COST TO SERVICE IS HIGH

There is real scope for innovation of new business models for grid connected rooftop solar systems in rural areas that will benefit consumers and utilities. These innovations could include development of off-grid solar systems that are 'grid-ready' and can connect to the grid when power supply and the grid network allows.

8.6 Recommendations

List of recommendations is provided as follows:

No	Recommendation	Cost/ Difficulty	Impact	Authority
R 51	Encourage research into the technology spillovers between grid-connected and off-grid distributed solar systems.	L	M	MNRE, DST
R 52	Develop inverter technologies adapted to rural contexts that can be mass produced cheaply	L	M	MNRE, DST
R 53	Utilities should develop business models for rural, grid-connected distributed solar to reduce costs of serving rural communities	L	M	MNRE/ State nodal agencies
R 54	Explore how a separate solar tariff for rural communities could boost distributed solar, support energy access and work for utilities	L	M	State regulators
R 55	Develop practical systems and standards for supporting end-of-grid voltage with rooftop solar	L	M	MNRE, CEA
R 56	Integrate skill development approaches for the grid-connected and off-grid sectors to maximise the benefit of each	L	L	MNRE

38. The Hindu. (2014, September). Surya Raitha to light up farmers' lives. Retrieved August 21, 2015, from The Hindu Web site: http://www.thehindu.com/todays-paper/tp-national/tp-karnataka/surya-raitha-to-light-up-farmers-lives/article6371094.ece

9 CHAPTER

SCENARIOS, CONCLUSIONS AND RECOMMENDATIONS

Our estimates of the impact of recommendations are based on modelling of the rooftop solar market. A huge amount of work went into building an accuracte and realistic model. The model is built up state by state, based on projections of solar, power and diesel cost, calculating the viability for consumers and therefore the proportion of them who will switch to rooftop solar. Trying to make a model realistic also means more and more complexity, so the model inevitably involves large numbers of assumptions. The full details of the model and the assumptions used are in annex 1.

9.1 Scenarios for growth of rooftop solar

We developed three scenarios:

Scenario 1: Current policies

Scenario 1 takes into account of all existing policies and measures. It assumes that rolling out net metering continues and that current policies are implemented effectively. It takes account of the impact of capital subsidies at 30% targeted on the residential, government and institutional sectors, the interest rate subvention planned by the World Bank, ADB and KfW, and accelerated depreciation until 2017.

Scenario 1 envisages reaching 13 GW by 2022 which means annual growth averaging 68% a year, which is impressive growth in any industry.

EXISTING POLICIES WILL ACHIEVE 13 GW BY 2022

Scenario 2: Aggressive market support

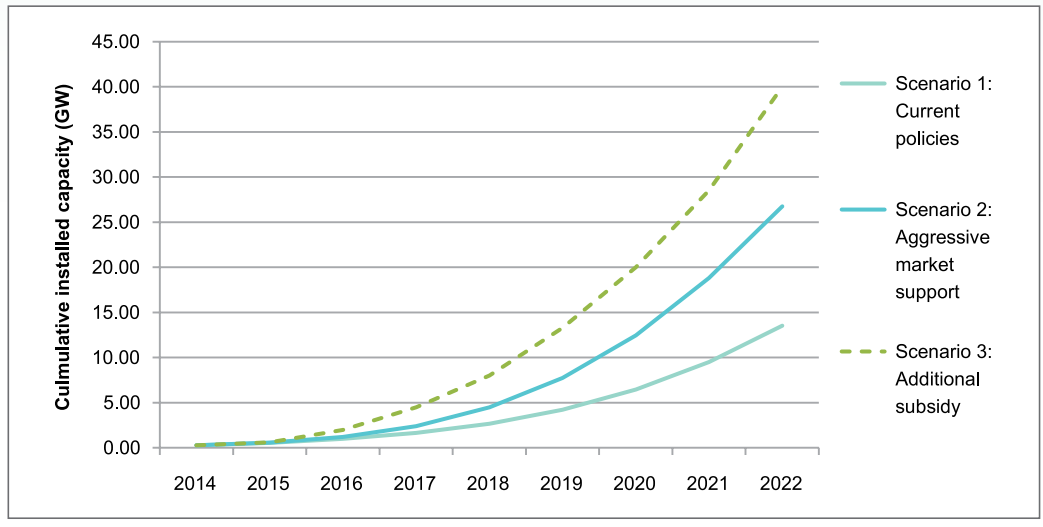
Scenario 2 looks at the impact of government taking all possible actions except for direct fiscal incentives for end users/systems. This scenario assumes the recommendations in this report are implemented effectively. It assumes mandates are implemented using the median scenario set out in chapter 6.

Scenario 2 indicates that aggressive central and state government support to optimise the market in rooftop solar and reduce risks for investors could enable the rooftop solar sector in India to achieve installed capacity of 26 GW by 2022.

Scenario 3: 40 GW scenario

We also plotted a pathway to 40 GW as part of our analysis (see figure 9.1).

Figure 9.1: Scenarios for the rooftop solar market to 2022



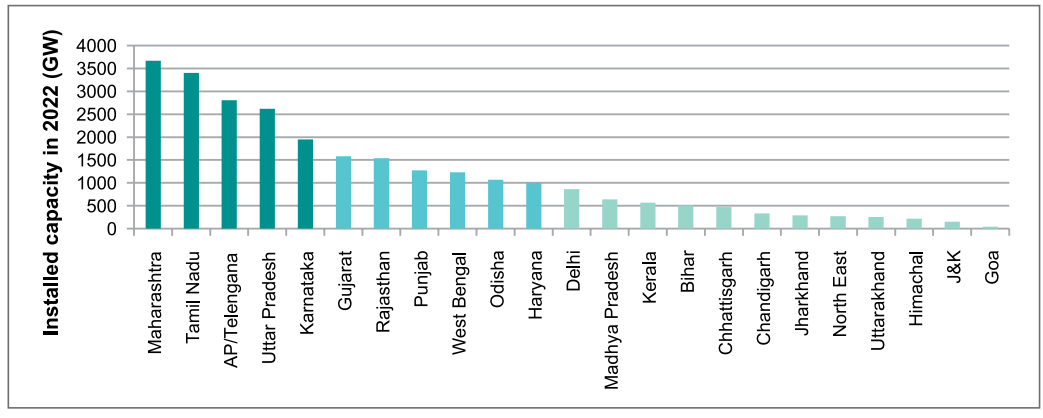
9.2 Analysis of predicted growth of rooftop solar

9.2.1 States

FIVE STATES WILL ACCOUNT FOR 60% OF ROOFTOP SOLAR CAPACITY

Rooftop solar will not grow at the same rate in all states. As Chapter 2 noted, the growth will be driven by three main factors: the electricity tariffs which impact viability, the amount of rooftop space in different segments (for example, more prosperous and industrialised states have more rooftop space) and the quality of state policies and their implementation. We cannot predict which states will implement policies best, but modelling the other two factors shows clearly that there are 11 states that are likely to install 1 GW or more and account for 90% of rooftop solar in 2022. The five states which account for up to 60% of expected rooftop solar capacity are Maharashtra, Tamil Nadu, Andhra Pradesh/Telangana[39], Uttar Pradesh and Karnataka.

Figure 9.2: Predicted state contribution to 2022 rooftop solar target

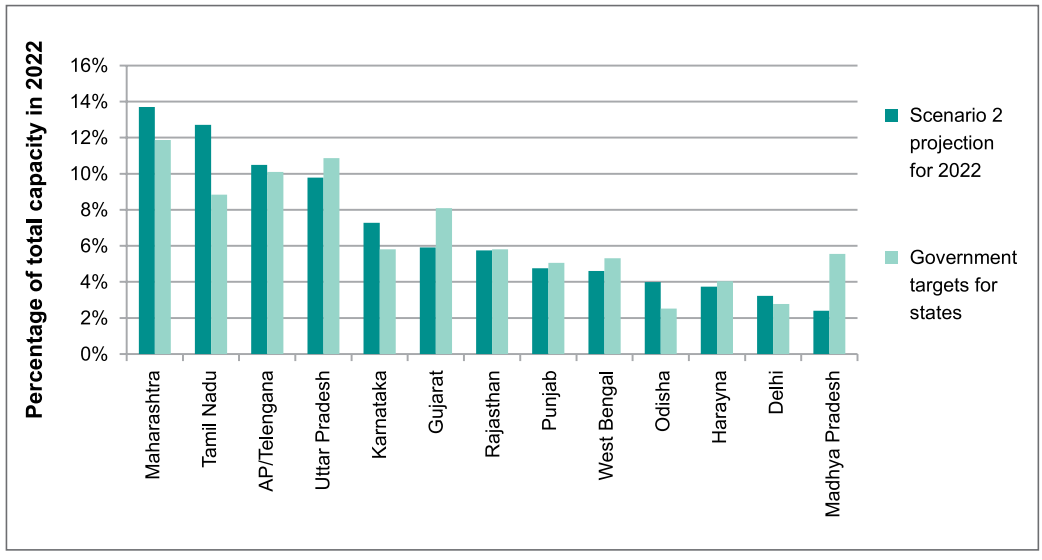


39. Our model is based on data that pre-dates the bifurcation of Andhra Pradesh and Telengana. Both have good rooftop solar potential. Taken separately, they would be in the second category with expected capacity addition about the same as Punjab or West Bengal.

This shows that government (and other stakeholders keen to promote rooftop solar) should concentrate efforts on the priority states. This does not mean abandoning the other states but working with the priority states to get policies and practices right will help achieve faster progress towards the 40 GW target. And it will benefit other states by offering learning and models that can accelerate progress.

The government has published targets for states to contribute to the 40 GW target, based partly on electricity consumption and state RPO targets. These match reasonably closely to the predicted installed capacities from our modelling. The main differences are Madhya Pradesh and Gujarat where the government has assigned a higher share of its target than our model predicts, and Tamil Nadu which has been assianed a lower share of the 40 GW target than our model suggests. (see figure 9.3).

Figure 9.3: Correlation between predicted share of national capacity in 2022 and government targets for top thirteen states

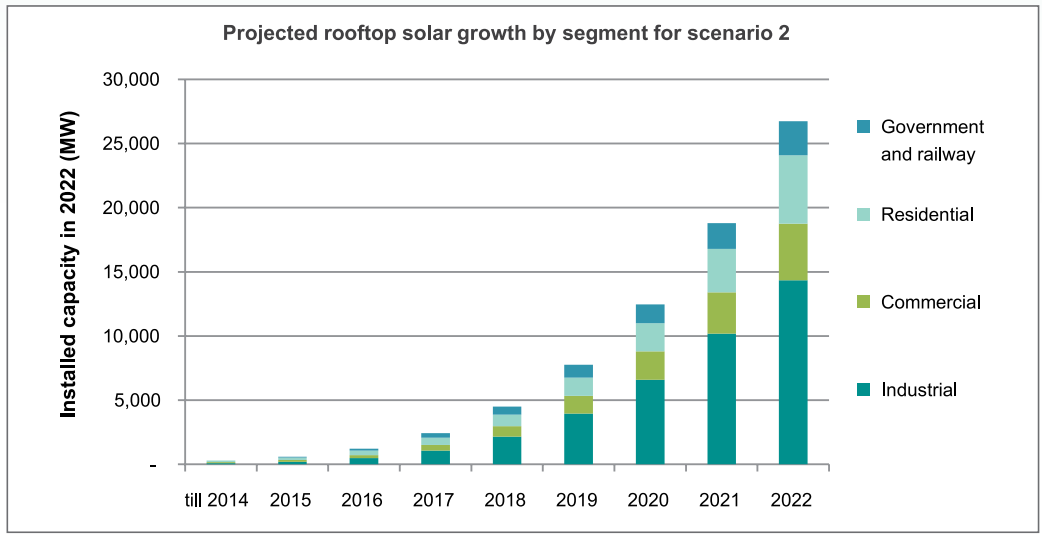


9.2.2 Segments

Progress towards the 40 GW target will depend strongly on the performance of the commercial and industrial sector. The industrial sector will have the biggest share of the rooftop solar market although the commercial sector is an important early adopter because their high power tariffs make rooftop solar particularly attractive.

PROGRESS TOWARDS THE 40 GW TARGET WILL DEPEND STRONGLY ON THE PERFORMANCE OF THE COMMERCIAL AND INDUSTRIAL SECTOR

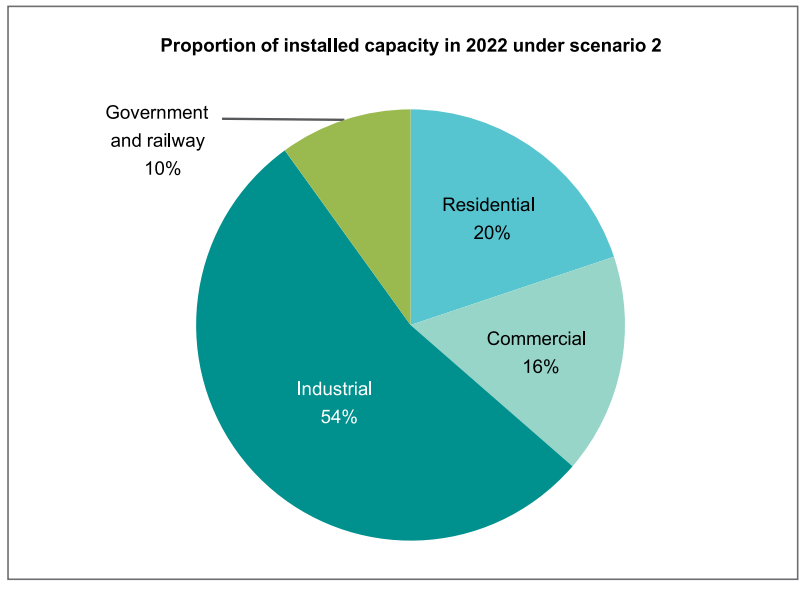
Figure 9.4: Projected rooftop solar growth by segment for scenario 2



By 2022, the industrial sector will account for over half of the rooftop solar market (see figures 9.4 and 9.5). After 2020, the residential sector will develop and grow strongly as viability increases and rooftop space starts to become a limiting factor for the commercial and industrial sector.

One important sector is government and railways. The government has shown strong leadership and proactivity in using the government estate to promote rooftop solar. This is an important contribution to driving the market[40].

Figure 9.5: Projected split of rooftop solar installed capacity by market segment



40. In the graphs here, Public Sector Undertakings (PSUs) appear as part of the industrial sector.

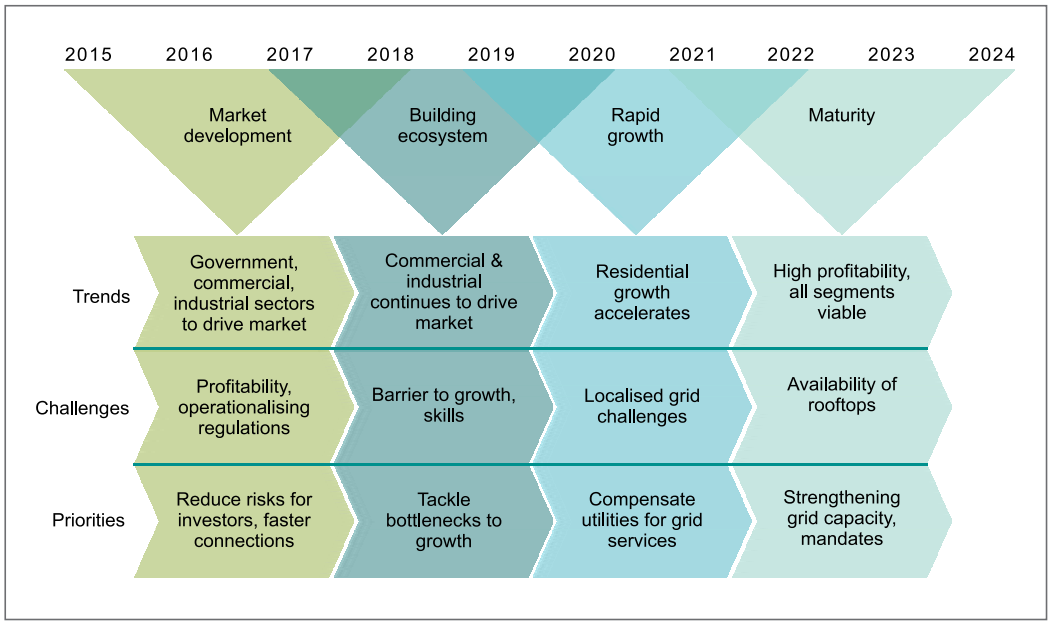
This analysis offers some points for decision-makers.

No	Recommendation	Cost/ Difficulty	Impact	Authority
R 57	Pilot new approaches and models in states with greatest solar rooftop potential (Maharashtra, Tamil Nadu, Andhra Pradesh/Telangana, Uttar Pradesh and Karnataka) that other states can draw upon	L	H	MNRE, State policy makers
R 58	Ensure that rooftop solar policies are appropriately focused on high growth segments. The current priority should be supporting adoption in commercial and industrial and government segments	L	M	MNRE, State policy makers
R 59	Government should continue to drive adoption across its own estate as a way of driving the market and building the ecosystem	M	M	MNRE

9.3 Phases of development of rooftop solar

On the way to 2022, it is clear that the rooftop solar market is going to go through several phases, with the priority problems evolving as the market develops. Figure 9.6 provides an overview of these phases for India as a whole. The pattern is likely for individual states is likely to be similar, albeit with variation in timings due to the different starting positions of states.

Figure 9.6: Phases of growth in the rooftop solar market



9.4 The cost of implementing these recommendations

We have made nearly 60 recommendations in this report (see section 9.5 for the complete list). We have scored each recommendation for cost/difficulty as high, medium or low. The costs of implementing the recommendations in this report will need to be assessed in more detail. However, we can give a rough estimate of the costs to government.

We have estimated costs for the seven priorities set out in the Executive Summary. This aims to give an understanding of the relative costs so subsequent work can focus on estimating the higher cost elements more precisely. These estimates also allow us to estimate an upper limit on the total costs of implementing these recommendations[41].

We have not disaggregated the costs into those for central government and those for state governments because, in many cases, where they fall will be policy decisions.

Priority	Costs to government (Rs crore)	Examples of type of costs
Operationalising net metering	20	Policy development, training, staff time, public engagement
A fair deal for utilities	500	Rs 500 crore fund for utility investments in infrastructure, systems and training specific to rooftop solar
Reducing investor risk and providing a level playing field for investors	50	Policy development, training, staff time, public engagement
Aggressive consumer awareness	50	Costs for funding organisations to undertake consumer awareness
Maximising available rooftop space	30	Policy development, staff time, public engagement
Skills in industry, regulators and utilities	100	A training programme for regulators, utilities and private sector with an average unit cost of Rs 10,000 a head, could reach 100,000 people
Use mandates once viability and ecosystem in place	50	Policy development, training, staff time, public engagement
Grid upgradation	200	Applied research, exceptional investments not covered by Rs 500 crore fund for utilities
Total	1000	

41. We have estimated on the high side and assumed significant costs fall to government. This need not necessarily be the case and this should not be taken as policy recommendations.

Whilst this list totals to Rs 1,000 crores, these are generous costings and our judgement is that the actual costs to government would be considerably less. This estimate shows that the costs of measures to support market-led growth are much more cost-effective than subsidy (for example when compared to Rs 5,000 crores that the government has allocated for 30% capital subsidy).

MEASURES TO SUPPORT MARKET-LED GROWTH ARE MUCH MORE COST-EFFECTIVE THAN SUBSIDY

9.5 Complete list of recommendations

These recommendations are listed in the order that they appear in the report. The sub-headings correspond to the seven priorities set out in the Executive Summary plus other recommendations under their own sub-headings.

The cost/difficulty and impact markings are relative (lower/medium/high). The high and medium impact recommendations are most important. But even the lower impact recommendations are significant so should not be ignored.

No	Recommendation	Cost/ Difficulty	Impact	Authority
a) Operationalising net metering – easy, quick connections				
R 1	Regulators should set and monitor target timescales for new connections, and should sanction non-compliance	L	H	State regulators
R 2	Transparent data is needed on interconnections. Regulators should require utilities to publish data on applications, interconnection times, refusals and transformer loading	M	H	State regulators
R 3	Utilities should urgently develop interconnection guidance for staff and ensure adequate staff are trained	M	H	Utilities
R 4	Online, single window clearance processes should be the norm	L	M	State Nodal Agencies
R 5	Regularly update Forum of Regulators Draft Model Regulation to develop consistency and best practice across states. States should draw on draft model regulations when updating state regulations	M	M	Forum of Regulators, State regulators
R 6	Future regulation could allow group net metering projects and multiple location benefits to allow more consumers to undertake rooftop solar	L	L	State regulators
R 7	Utilities should make easy-to-understand maps and databases available on their websites showing connected capacity against the threshold limit of transformers	L	M	State regulators, Utilities
R 8	Regulators should make clear that new rooftop solar systems should be connected unless the utility can show serious harm to the grid	L	M	State regulators, Utilities

R 9	In case of refusal to connect, the utilities should quickly provide reasons in writing copied to the regulator and State Nodal Agency	L	L	Utilities, State regulators, SNA
R 10	If transformer thresholds are approached or reached, utilities should consider ways to continue to connect consumers, such as sanctioning a higher allowable load (where safe to do so) or upgrading the transformer	M	L	Utilities
R 11	State net metering regulations should allow energy banking of 100% of consumption calculated over a year	L	L	Utilities, State regulators
R 12	Restrictions on export of power should be phased out, with surplus saleable at a price that reflects the avoided cost of energy	M	M	State regulators, utilities
R 13	Harmonise metering regulations across states	L	L	CEA, State regulators
R 14	Develop bi-directional meter standards and encourage research into low cost manufacturing	M	L	CEA
R 15	Additional inverter features that could inculcate better grid discipline should be made mandatory by CEA	L	L	CEA
R 16	Develop systems that can safely allow deliberate islanding and specify necessary standards	M	M	CEA, State regulators
b) A fair deal for utilities				
R 17	Government should put in place a package of incentives for utilities addressing short term and medium term issues along with clear regulatory and political signals	M	H	MNRE, Ministry of Power, State Governments
R 18	Introduce medium term grid services charge on new net metered rooftop consumers to compensate utilities for grid services	M	H	MNRE, Ministry of Power
R 19	Adjust RPO rules so generation from rooftop counts as 1.3 times that from ground mounted towards RPO compliance to boost the sector	M	H	MNRE
R 20	Set up fund to support early-adopting utilities to make investments in infrastructure, training and systems for rooftop solar	M	M	MNRE, Ministry of Power
R 21	Send firm political and regulatory signals to utilities that active support for rooftop solar is mandatory	H	H	Central & State Governments

c) Reducing investor risk and providing a level playing field for investors				
R 22	Empower a local level quasi-judicial authority to resolve disputes related to denial of access to roof by the roof owner to the project developer	M	H	MNRE, Ministry of Law and Justice
R 23	Government should undertake or commission consultations on a contract default insurance mechanism to boost investment	H	H	MNRE
R 24	Grant automatic consent for creation of sub-lease over rooftops from government, quasi-government and private bodies such as industrial development organisations	L	M	Relevant central and State Government departments
R 25	Provide waiver of stamp duty charges for registration of roof lease agreements (as the rooftop value is otherwise nil, this will not result in loss of significant revenues for the exchequer)	L	H	Respective State Governments
R 26	Utilities to act as buyer of last resort (at discounted price) in case of disputed private PPAs	M	H	State regulators
R 27	Provide complete certainty over applicability of taxes, duties and other charges (cross subsidy surcharge, electricity duty, transmission and distribution charges and losses) for rooftop installations for a minimum period of 15 years	L	L	State regulators
R 28	Devise all rooftop policies including any financial support measures so as to create a level playing field between different classes of investors including consumers-owners of rooftop systems	M	M	Central and State Governments, State regulators
R 29	Phase out accelerated depreciation or make the benefit available to all investors, and generation-based, when the current provision ends in 2017	M	H	Ministry of Finance
R 30	Assist lenders and educate them on technical and operational robustness of rooftop solar projects to encourage them to improve debt availability and terms for the sector	M	M	MNRE, Ministry of Finance, RBI
R 31	Government should support the development of standard contracts to facilitating refinancing markets and growth of rooftop solar	M	H	MNRE, Ministry of Finance
d) Aggressive consumer awareness				
R 32	State Nodal Agencies should support independent consumer bodies to provide high quality consumer information	L	M	SNAs

R 33	Encourage set up of voluntary databases of system performance to build up consumer performance data (wiki-type databases)	M	L	SNAs/MNRE
R 34	Encourage development of solar maps, system ratings and other tools to support consumers consider adopting solar rooftop	L	M	MNRE
e) Skills in industry, regulators and utilities				
R 35	Ensure that rooftop solar is a priority for the Sector Skill Council for Green Jobs	M	M	MNRE
R 36	Through the Sector Skill Council, support accreditation, certification and expansion of solar training institutes	M	M	MNRE
R 37	Urgently roll out skill development in rooftop solar for regulators	L	M	MNRE/FOR/ CERC
R 38	Work with utilities to identify their urgent skills requirements and ensure supply of skilled staff can meet demand	M	M	MNRE
f) Maximising suitable rooftop space				
R 39	Amend planning rules to make new buildings more 'rooftop ready'	L	M	MNRE
R 40	Allow mounting of solar panels on unused ground space within premises under rooftop solar rules	L	L	State regulators
R 41	State Nodal Agencies should work with urban local bodies to put in place 'deemed permissions' with local authorities to facilitate rooftop solar approvals	L	M	
R 42	Rooftop solar mounting structures should not result in violation of Floor Space Index norms	L	M	
g) Use mandates once viability and ecosystem in place				
R 43	Prepare and publish long term strategy for using mandates to support rooftop solar	L	M	MNRE
R 44	Introduce mandates requiring rooftop solar for new buildings of all types over 500 sq yards across India	M	H	MNRE
R 45	Prepare model rooftop solar mandate with good practice for (state) retrofit mandates for commercial, industrial, government and institutional buildings	M	M	MNRE, MoUD
R 46	States to adopt retrofit mandates once viability established and ecosystem in place to support additional adoption	H	H	MNRE, MoUD
Fiscal incentives (chapter seven)				
R 47	Marginal benefits of additional subsidy are diminishing, so further national direct fiscal subsidy to reach the 40 GW target would not be good value for money	L	H	MNRE, Ministry of Finance

R 48	Non-subsidy measures offer better value for money and should be the first priority for the funds available to MNRE for rooftop solar (ahead of the 30% subsidy)	M	H	MNRE, Ministry of Finance
R 49	The government should review the capital subsidy and consider whether it is value for money and if so, maximise the targeting and ensure funds are available	L	M	MNRE
R 50	If states are considering subsidies, they should assess carefully the value for money and model the additional capacity that can be expected before going ahead	M	M	MNRE
Can a rooftop solar revolution benefit energy access (chapter eight)				
R 51	Encourage research into the technology spillovers between grid-connected and off-grid distributed solar systems	L	M	MNRE, DST
R 52	Develop inverter technologies adapted to rural contexts that can be mass produced cheaply	L	M	MNRE, DST
R 53	Utilities should develop business models for rural, grid-connected distributed solar to reduce costs of serving rural communities	L	M	MNRE/State nodal agencies
R 54	Explore how a separate solar tariff for rural communities could boost distributed solar, support energy access and work for utilities	L	M	State regulators
R 55	Develop practical systems and standards for supporting end-of-grid voltage with rooftop solar	L	M	MNRE, CEA
R 56	Integrate skill development approaches for the grid-connected and off-grid sectors to maximise the benefit of each	L	L	MNRE
Scenarios, conclusions and recommendations (chapter nine)				
R 57	Pilot new approaches and models in states with greatest solar rooftop potential (Maharashtra, Tamil Nadu, Andhra Pradesh/ Telengana, Uttar Pradesh and Karnataka) that other states can draw upon	L	H	MNRE, State policy makers
R 58	Ensure that rooftop solar policies are appropriately focused on high growth segments. The current priority should be supporting adoption in commercial and industrial and government, segments	L	M	MNRE, State policy makers
R 59	Government should continue to drive adoption across its own estate as a way of driving the market and building the ecosystem	M	M	MNRE

ANNEX 1:

MARKET MODEL AND ITS ASSUMPTIONS

Introduction

This annex sets out the assumptions we used in the modelling of India's rooftop solar market. As we set out to understand the impact of various policy measures on the rooftop solar market, it was essential to create a model that could help answer questions such as: How will adoption vary with the changing viability of solar? What is the impact of various regulations and policies on rooftop solar adoption? How much rooftop solar will be installed in India without any government support? What will be the impact of proposed incentives, obligations, regulations and policy measures on rooftop solar adoption?

This model is used to estimate rooftop solar market growth on a state-by-state basis as each state has a different mix of customer segments, different grid tariffs, grid tariff escalation and regulations.

Process for modelling the solar rooftop market

Owing to the different drivers and consumer behaviour for the market segments, two sub- models were created - one for commercial, industrial, government and railway customers and second for residential customers.

Commercial, industrial, government and railway customers: Adoption of rooftop solar for these customers depends primarily on commercial viability of the installations. This commercial viability is calculated by comparing the status quo power costs with power costs after opting for rooftop solar. We considered three system types which have different viabilities:

- Grid tied solar installations
- Solar system synchronized with diesel gen-set
- Battery based solar installations

For the three system types mentioned, we calculated commercial viability (defined as the difference between rooftop solar power cost and grid tariff) for the consumers and accordingly assumed different adoption rates for rooftop solar (as explained later below). As commercial viability improves, consumer adoption rates of rooftop solar increase.

Residential consumers: For residential consumers, two different types of solar installations were considered:

- Grid tied solar installation
- Hybrid systems backed by storage solutions

Based on power demand-supply situation in each state, shares for grid connected and hybrid systems were calculated. In view of the various power sector reforms underway, we assumed gradual reduction in power cuts over the years.

The availability of 30% capital subsidy until 2019 was assumed for the residential, government and railways segments.

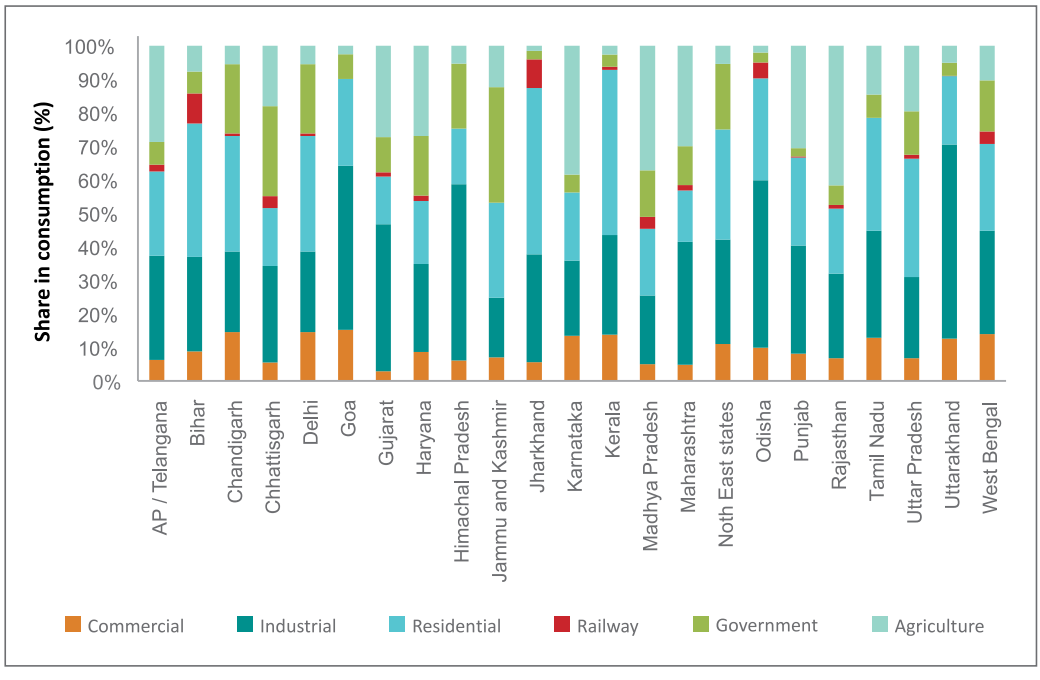
Key inputs to the market model

Power demand in India

Power consumption for the states was taken from the CEA Load Generation Balance Report. The growth in power demand has been estimated based on past trends.

State wise power consumption for each segment was sourced from the Planning Commission (excluding captive generation). The share of power consumption for consumer types in the country was sourced from Ministry or Power, Planning Commission (erstwhile) and assumed to be constant until 2022.

Figure 1: Share of consumption by segment[42]

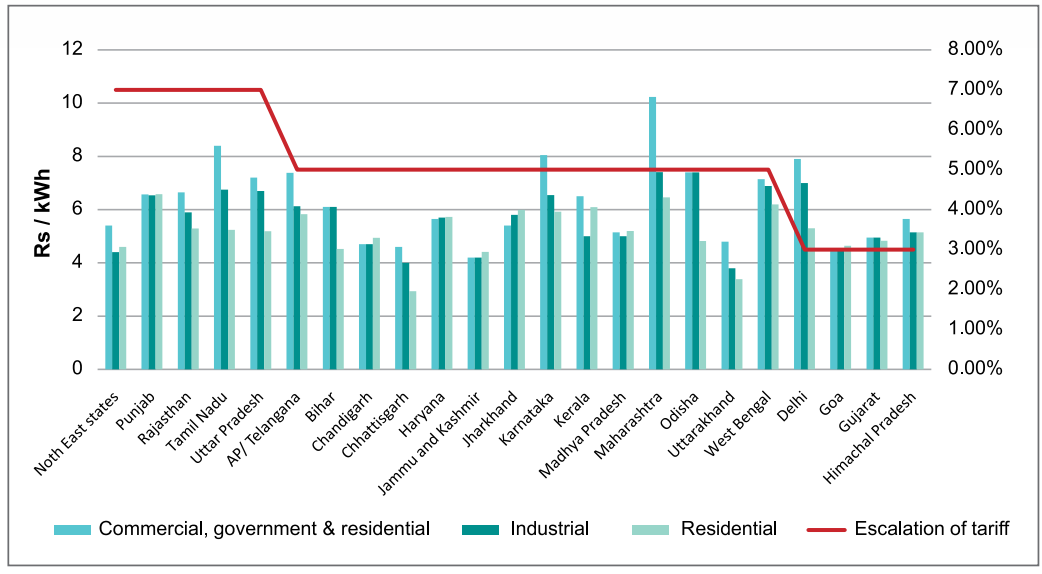


42. 'Annual Report 2013-14 on the working of State Power Utilities & Electricity Departments', Planning Commission

Grid tariffs

Based on factors such as power deficit across the states and the financial position of respective utilities, we estimated grid tariff escalation up to 2022.

Figure 2: Grid tariffs and escalation



Rooftop solar power cost

For the purposes of calculating the solar tariff, it has been assumed that projects would be structured with an escalation of 3% per annum for the solar tariff to compare with grid tariffs. This is in line with most rooftop solar projects executed by project developers for third party model projects. The other assumptions used are given in table 1.

Table 1: Assumptions for rooftop solar power cost calculation

	Commercial, Government & Railways	Industrial	Residential
Capital cost	Rs 62,000/kW	Rs 60,000/kW	Rs 80,000/kW
O&M cost per annum	Rs 800/kW	Rs 800/kW	Rs 1,000/kW
O&M cost escalation	5.72%	5.72%	5.72%
Annual degradation	0.8%	0.8%	0.8%
Debt:equity	70:30	70:30	70:30
Interest rate	11%	11%	11.5%
Equity return expectation	16%	16%	12%

For each individual state, the Capacity Utilisation Factor was calculated based on local radiation data. Capital costs for rooftop solar systems are assumed to fall at 5.2% per

annum in view of ongoing technology advancement and innovation.

Net metering policy status

Based on studies from the US which found that after accounting for otherwise anticipated growth, implementation of net-metering increased the adoption rate by over 60%, we assumed that effective implementation of net-metering in India will result in a 50% increase in adoption rates.

Most Indian states have already approved a net-metering policy. However, progress on the ground is very limited and there are various challenges to policy implementation. Based on current experience, we assumed a time delay between policy approval and effective on-the-ground implementation, as shown below.

Table 2: Net-metering implementation schedule

State	2015	2016	2017	2018	2019	2020	2021	2022
Andhra Pradesh	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bihar	No	No	No	No	No	No	No	Yes
Chandigarh	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Chhattisgarh	No	No	No	Yes	Yes	Yes	Yes	Yes
Delhi	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Goa	No	No	No	No	No	No	No	Yes
Gujarat	No	No	No	Yes	Yes	Yes	Yes	Yes
Haryana	No	No	No	Yes	Yes	Yes	Yes	Yes
Himachal Pradesh	No	No	No	No	No	No	Yes	Yes
Jammu and Kashmir	No	No	No	No	No	No	No	No
Jharkhand	No	No	No	No	No	No	No	Yes
Karnataka	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kerala	No	No	No	No	Yes	Yes	Yes	Yes
Madhya Pradesh	No	No	No	Yes	Yes	Yes	Yes	Yes
Maharashtra	No	No	No	Yes	Yes	Yes	Yes	Yes
North Eastern states	No	No	No	No	No	No	Yes	Yes
Odisha	No	No	No	No	No	Yes	Yes	Yes
Punjab	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Rajasthan	No	No	No	No	Yes	Yes	Yes	Yes
Tamil Nadu	No	No	No	No	Yes	Yes	Yes	Yes
Uttar Pradesh	No	No	No	No	No	Yes	Yes	Yes
Uttarakhand	No	No	No	Yes	Yes	Yes	Yes	Yes
West Bengal	No	No	No	No	Yes	Yes	Yes	Yes

Accelerated depreciation

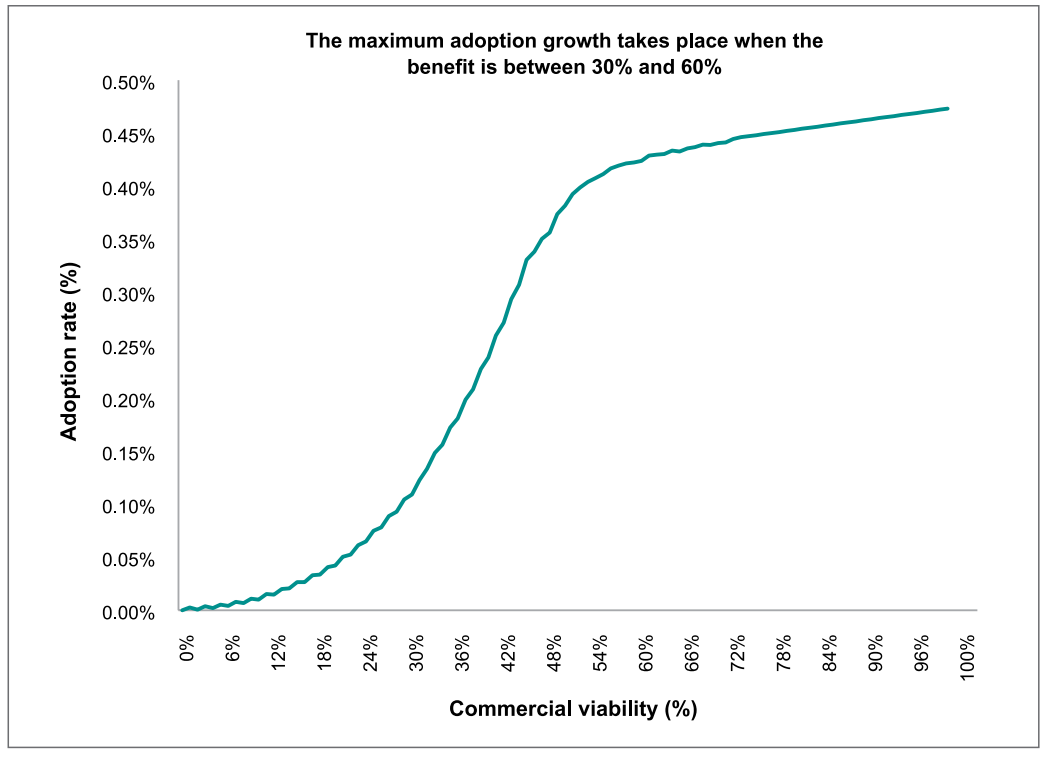
As per the current government plans, accelerated depreciation is available until March 2017. For this analysis, it was assumed that the accelerated depreciation benefit will not be extended beyond this date. We assumed that 25% of all investors will be able to claim this benefit.

Adoption curve

As explained above, we modelled future rooftop capacity addition based on assumptions of increased adoption rates as commercial viability strengthens over time. We assumed that the adoption rate curve for rooftop solar will resemble that of other technology products. We studied adoption curves for refrigerators, colour televisions, microwaves, cell phones and digital cameras in US, all of which take the shape of an S-Curve[43].

In our model, we derived an adoption rate S-curve separately for each customer segment for each state based on improving commercial viability. The adoption rate in this case has been defined as the demand for overall power consumption that can be replaced by solar in a particular year, based on the commercial viability.

Figure 3: Estimated adoption curve for rooftop solar plants

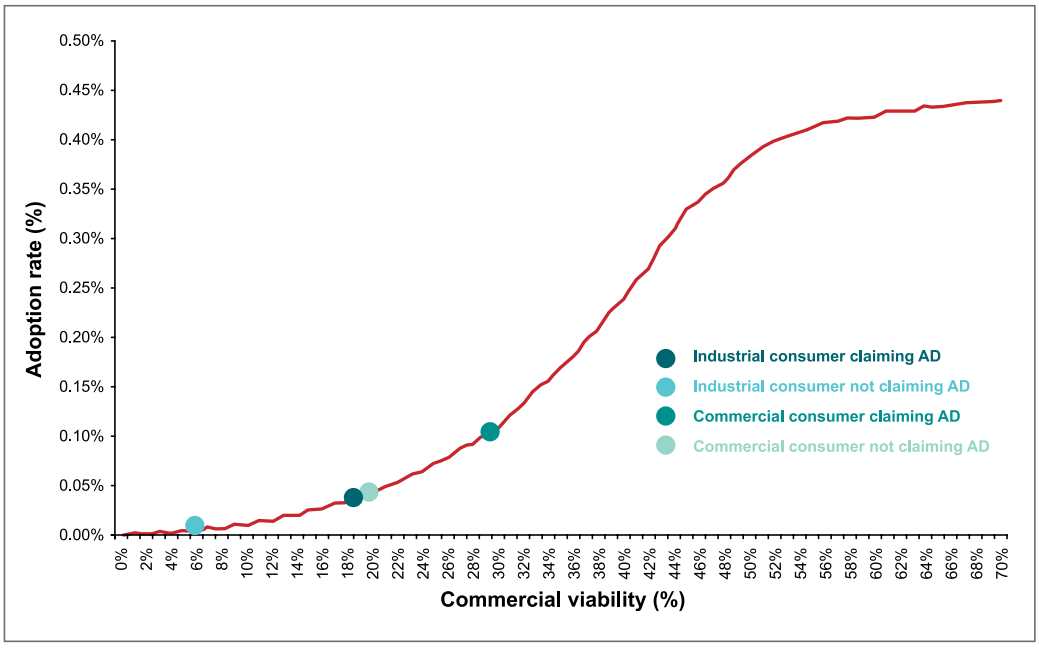


43. O'Neil Centre for Global Markets and Freedom, US Census Bureau

In status quo, we have capped the cumulative adoption to 4% of the power consumption by 2022. This 4% signifies that India will install 40 GW by 2022. We have back tracked the adoption curve to year-on-year basis.

As an example, we have shown the placement of industrial and commercial users for the year 2016.

Figure 4: Adoption curve for industrial and commercial users



ANNEX 2:

ACRONYMS

AC	Alternating current
ADB	Asian Development Bank
APPC	Average Power Purchase Cost
CAPEX	Capital expenditure
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CSR	Corporate Social Responsibility
DST	Department of Science and Technology
DC	Direct current
ECBC	Energy Conservation Building Code
EPC	Energy, Procurement, Construction
FOR	Forum of Regulators
GBI	Generation Based Incentives
GW	Giga Watt
HSIDC	Haryana State Industrial Development Corporation Limited
IEA	International Energy Agency
IREDA	Indian Renewable Energy Development Agency
kWh	Kilowatt Hour
MIDC	Maharashtra Industrial Development Corporation
MNRE	Ministry of New and Renewable Energy
MoUD	Ministry of Urban Development
MSEDCL	Maharashtra State Electricity Distribution Company Limited
MW	Mega Watt
MWp	Megawatt Peak
NABARD	National Bank for Agriculture and Rural Development
NREL	National Renewable Energy Laboratory
OPEX	Operational expenditure
PPA	Power Purchase Agreement
RBI	Reserve Bank of India
RESCO	Renewable Energy Service Company
RIICO	Rajasthan State Industrial Development and Investment Corporation
RPO	Renewable Purchase Obligation
SECI	Solar Energy Corporation of India
SERC	State Electricity Regulatory Commission
SNA	State Nodal Agency
UPCL	Uttarakhand Power Corporation Limited

ANNEX 3:

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MORE ABOUT THE FUNDING PARTNERS OF THE ROOFTOP SOLAR POLICY COALITION

The Nand & Jeet Khemka Foundation was established in 2005 as a foundation focused on strategic philanthropy in India. Since that time it has sought to build innovative cross-sectoral collaborations and to establish and enable development infrastructure within India and internationally. The foundation's focus areas comprise major development themes including education, health, climate change and the environment, social entrepreneurship and the welfare state. The Foundation's Leadership Development arm, The Global Education & Leadership Foundation is dedicated to build a community of ethical, altruistic leaders on the planet who work together to improve the state of the world.

The Department for International Development (DFID) leads the UK's work to end extreme poverty. We're ending the need for aid by creating jobs, unlocking the potential of girls and women and helping to save lives when humanitarian emergencies hit.

We are responsible for:

- honouring the UK's international commitments and taking action to achieve the Millennium Development Goals
- making British aid more effective by improving transparency, openness and value for money
- targeting British international development policy on economic growth and wealth creation
- improving the coherence and performance of British international development policy in fragile and conflict-affected countries
- improving the lives of girls and women through better education and a greater choice on family planning
- preventing violence against girls and women in the developing world
- helping to prevent climate change and encouraging adaptation and low-carbon growth in developing countries

The Climate Group is an award-winning, international not for profit organization. Our goal is a prosperous, low carbon future. We believe this will be achieved through a 'clean revolution': the rapid scale-up of low carbon energy and technology. We work with corporate and government partners to develop climate finance mechanisms, business models which promote innovation, and supportive policy frameworks. We share successful low carbon growth and pilot practical solutions, which can be replicated worldwide.

Our offices are in New Delhi, London, New York and Greater China.
Our vision is a prosperous low carbon future for all.
Our mission is to inspire and convince leaders at the top of government, business and society to reduce carbon emissions now and accelerate the transition to a vibrant low carbon economy.

Shakti Sustainable Energy Foundation (www.shaktifoundation.in) works to strengthen the energy security of India by aiding the design and implementation of policies that encourage energy efficiency, renewable energy and the adoption of sustainable transport solutions. We convene industry, academia, law, finance, civil society, and think tanks to drive this change. Our work focuses on sectors with the maximum potential for energy and carbon savings: Power, Transport, Energy Efficiency and Climate Policy. A Section 25 non-profit organization under the Companies Act, Shakti is governed by a national board of directors, and supported by both Indian and international philanthropies.

ABOUT THE CONSULTANTS

BRIDGE TO INDIA is the leading consultancy and knowledge services provider in the Indian renewable market. We work with all industry stakeholders including technology companies and contractors, project developers and investors, government agencies and developmental institutions. We have a unique vantage point on the market dynamics, combining the 360 degree view from our market intelligence capability with the in-depth analysis performed as part of our consulting and transaction advisory businesses. Our goal is to enable innovative cleantech solutions in India. We also produce regular market leading research and have published several thought leadership pieces shaping the growth of the renewables sector in India. - See more at: http://www.bridgetoindia.com/

MEGHRAJ

Meghraj Capital Advisors is Meghraj Group's Indian infrastructure consulting and investment banking business. We are headquartered in Mumbai and also have offices in Delhi and Ahmedabad. We offer advisory services for:

- Power sector, including conventional power, renewable energy and energy efficiency
- Urban infrastructure
- Transportation infrastructure

MCA clients include private sector companies, public sector institutions, development aid agencies, and state and central government agencies. In addition to South Asia, we offer services to clients in Africa and Middle East. MCA team includes experts in engineering, management and economics. We work closely with Meghraj Group's investment banking teams, and are able to provide a seamless end-to-end solution for our infrastructure-related clients. See more at: http://www.meghraj.com/"

Disclaimer

About the report

This report was supported by the Solar Rooftop Policy Coalition (The Nand and Jeet Khemka Foundation, the UK Department for International Development, The Climate Group and The Shakti Sustainable Energy Foundation).

The Solar Rooftop Policy Coalition was formed in January 2015 to identify policy solutions that would support the Government of India's ambitions for scaling up the rooftop solar sector.

For further information, please contact

The Climate Group
Suite No.1203, 12th Floor, Chiranjiv Tower
43, Nehru Place, New Delhi -110019, India

T : +91 (0) 11 4200 3342
F : +91 (0) 11 4200 3343
E : info@theclimategroup.org
W : www.TheClimateGroup.org
www.TheCleanRevolution.org

The Nand & Jeet Khemka Foundation
The Nand & Jeet Khemka Foundation
1st Floor, Khemka House, 11 Community Centre,
Saket, New Delhi - 110017, India

T : +91 (0) 11 46034800
F : +91 (0) 11 46034823
E : info@khemkafoundation.net
W : http://www.khemkafoundation.net