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The Role of Public Finance in CSP
Case Study: Rajasthan Sun Technique, India

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San Giorgio Group Overview

This paper is one of a series prepared by Climate Policy Initiative for the San Giorgio Group, a working group of key financial intermediaries and institutions engaged in green, low-emissions, and climate-resilient finance. San Giorgio Group case studies seek to provide real-world examples of how public resources can spur low-carbon and climate-resilient growth, what approaches work, and which do not. Through these case studies, which share a systematic analytical framework, CPI describes and analyzes the types of mechanisms employed by the public sector to catalyze and incentivize private investment, deal with the risks and barriers that impede investment, establish supporting policy and institutional development, and address capacity constraints.

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Executive Summary

Among the technologies capable of harnessing renewable energy to meet growing world energy demand, concentrated solar power (CSP) is of particular interest. Its potential to store the sun's energy as heat allows it to deliver power when it is needed to balance out gaps in supply and demand arising from the fluctuating supply provided by other renewables, helping to maintain a stable energy supply. Energy systems with high levels of fluctuating supply from renewables like wind and solar PV will increasingly need technologies that can play this balancing role. While other renewable technologies like hydropower or geothermal power can also deliver power on demand, the renewable sources they harness are limited. The power CSP could potentially generate dwarfs theirs:[1] solar is by far the most abundant form of renewable energy worldwide.

Financing challenges for CSP in emerging economies like India

CSP has particular promise in emerging economies with abundant solar resources, such as India and South Africa. However, after more than 20 years of limited deployment experience, CSP investment and production costs are still high compared to other more established conventional and renewable energy technologies. For now, the technology requires deployment experience in order to reduce costs and risks and so CSP projects still need public interventions to be financially viable. This implies particular risks for project developers, such as regulatory change, the high sensitivity of project economics to debt costs, and difficulties in securing enough investments. The public sector, on the other hand, faces the twin challenges of keeping costs for CSP deployment low and encouraging scale-up and replication.

Rajasthan Sun Technique CSP plant

Our analysis of the 100 Megawatt (MW) Rajasthan Sun Technique CSP plant in India indicates that, in this project, the public and private sector have addressed the financing challenges outlined above. As a result, the project developer is nearing completion of one of the most technologically innovative CSP plants worldwide. As well as being the world's largest CSP plant using linear Fresnel technology, the plant will also be one of the first completed under India's National Solar Mission (NSM). However, despite its ultimate success, construction of the plant was delayed. This was true of many plants tendered in phase one of the NSM, which did not meet its deployment goals in the expected time. In addition, neither the Rajasthan plant nor the other large CSP plants in India planned to date include heat storage technology that would allow them to deliver power more reliably and on demand even after the sun has gone down. By outlining what worked and what did not this case study can inform the design of future policies and the investment of both domestic and international public finance programs to deploy CSP, such as the Climate Investment Funds (CIFs), one of the key public investors in CSP in emerging economies.

A combination of national policy, public co-financing, and private risk management enabled investment in the Rajasthan Sun Technique CSP plant

The Rajasthan Sun Technique CSP project has involved a range of key stakeholders: the Government of India set the policy framework, foreign development banks and an export credit agency provided debt, Reliance Power developed the project and provided equity, and finally Areva Solar provided the technology. Our analysis suggests that **each project stakeholder played a particular role in addressing the major financing issues and thereby enabling the project:**

- **The Government of India's subsidized power purchase agreement (PPA) and payment security scheme were essential to ensuring the project's financial viability.** By awarding a subsidized Power Purchase Agreement (PPA) through a reverse auctioning scheme, the government covered the cost gap between conventional power and CSP technology. The government is backing this PPA in two ways: first, through public-ownership of the power off-taker, and second, by establishing a payment security scheme that insures developers against the default of the sub-national distribution companies that will buy the CSP plant's electricity from the PPA off-taker. In this way, the government also reduces off-taker risks.
- **Foreign development banks and an export credit agency provided debt with substantially longer maturities than local financial institutions, making the project appealing to the local developer even at a very competitive power tariff for CSP. This was true even**

1 See e.g. Intergovernmental Panel on Climate Change (IPCC). 2011. "Special report on renewable energy sources and climate change mitigation (SRREN)". Cambridge and New York: Cambridge University Press.

though the costs of hedging foreign exchange risks cancelled out a large part of the benefits of foreign debt. The USD 280 million in long maturity foreign debt provided by the Asian Development Bank, FMO (Dutch development bank) and the US Export-Import Bank (US Ex-Im bank) won't need to be paid back for up to 18 years - much longer than the 7-10 year maturities of local debt. It reduced financing risks and increased the internal rate of return of project equity by around 250 basis points (2.5%), helping the developer to implement the project at a very competitive tariff for CSP. While the foreign public debt has lower interest rates than local lenders, they did not lower the high costs of debt because of the cost of hedging currency risks. However, they did improve the project economics through the longer maturity of debt.

- **After the public sector PPA reduced the revenue risks and foreign public debt the financing risks, the private sector was able to manage the remaining risks, but not always at low costs. We find that the amount of risk taken by the private sector (developer and technology supplier) in this case is much higher than standard practice for similar projects in other countries.** The project developer Reliance Power covered development and non-hedgeable foreign exchange risks, while the technology provider Areva offered comprehensive warranties. These and other companies involved in projects under the NSM took on technology and foreign exchange risks among others, partly in order to establish themselves in a highly promising CSP market.

The following table summarizes how the project addresses the major issues of different stakeholders.

ACTOR	BARRIER TO INVESTMENT	PROJECT RESPONSES AND EFFECT
Government of India	High cost of CSP	Subsidized PPAs allocated through a reverse auctioning scheme promote cost reductions; bundling of CSP with cheap publicly-owned coal power finances subsidized PPA
Government of India	CSP developers and investors do not trust PPAs with sub-national electricity distribution companies, as the latter are financially weak	The PPA counterpart under the NSM is financially stronger public entity at the national level than sub-national electricity distribution companies and an additional payment security scheme addresses the risk that the sub-national distribution companies buying the electricity may default
Developer (Reliance Power)	High investment costs and short-term orientation of Indian capital market	Debt with long maturity from development finance institutions and US Ex-Im bank; choice of Areva Solar as U.S. technology provider enables debt from US Ex-Im bank (the latter only lends to U.S. companies)
All investors	Debt from foreign institutions in USD-terms implies high foreign exchange (FX) risks as PPA and most investment costs are in local currency	Dynamic FX hedging for 60-80% of risks, remaining risks are taken by Reliance Power with its strong balance sheet
All investors (Areva)	Perceived high technology risks due to the innovative nature of Areva's linear Fresnel in the country and the large scale of the plant	Developer secures comprehensive technology warrantee from Areva that mitigates perception and impact of technology risk

While Indian national CSP policy resulted in low costs for the government, it has not deployed CSP at the planned scale and time horizon

In analyzing the broader aims of Indian national CSP policy, we find that, among the projects awarded, only those few with financially strong developers that were able to source public investment are on track to be completed. As a result we find that Indian CSP policy did not deliver fully on its objectives for installing CSP capacity, creating jobs, and increasing learning on CSP technology:

- **The Government of India awarded a subsidized PPA through a reverse auctioning system. Strong competition among project developers resulted in several bids submitted at prices much lower than the initial reference tariff and also lower than most CSP tariffs worldwide.** Thus, the program met one important objective by delivering CSP power at lower costs for the government. The average tariff resulting from the auction process is 25% lower than the reference CSP tariff for the phase one of the NSM and also lower than tariffs in other major CSP markets such as Spain and South Africa.
- **Project delays, possible cancellations, and difficulties in sourcing technologies and financing indicate that the subsidized tariff alone was not sufficient to deploy CSP at the desired scale.** There were several reasons for the delays: the low quality of the solar resource data made available before the closing of the auction resulted in winning bidders overestimating potential plants' performance and returns. Additionally, the novelty of CSP within the country may have – in combination with the tight timeline for placing bids – led project developers to underestimate some of the costs and risks of CSP, particularly the sourcing of technology abroad and the establishment of a local supply chain. Lower-than-expected solar resource and higher costs, in turn, reduced margins so far that some winning bidders that have faced major financial and technological issues are now unlikely to build their plants. In fact, the case of CSP in India may be an example of the 'winner's curse' phenomenon under auctioning schemes.[2] This 'winner's curse' can partly explain the very low bids, but strategic first-mover behavior might have also been a reason for the low bids.
- **The only winning bidders able to build CSP plants at the low tariffs that resulted from the competitive bidding process were those that were financially strong and able to source public debt.** The three (nearly) completed out of the seven CSP projects under the NSM (Godawari, Megha, and Rajasthan Sun Technique) are all backed by financially strong parent companies able to strategically invest in high risk projects with relatively low margins. These projects also all managed to source debt with relatively long tenors from public-owned banks, thereby improving their projects' economics.
- **Implemented projects enabled learning on CSP, establishment of local supply chains and investment in basic infrastructure.** This led to local benefits, such as job creation, and may reduce CSP technology costs both in India and abroad. In the case of the Rajasthan Sun Technique plant, both the technology provider and the local developer have learnt substantially from building their first CSP plant of this scale. The project developer also made longer term investments. The local content of the project's investment value is estimated at 61-71% and included the establishment of a local supply chain, and the construction of water and electricity infrastructure. These investments created hundreds of local jobs many of which were high-paying, and should enable future plants to be built more quickly and cheaply. However, these learning and cost reductions benefits would have been higher had the original plan of 500 MW CSP power installed by mid-2013 been achieved. Now only 150-200 MW are projected to be completed by mid-2014.

2 If a technology has not yet been deployed at scale in a country (as with CSP in India), costs and risks are uncertain. Winning bidders can substantially underestimate costs and risks and be unable to build the plants.

Many elements of this project could be replicated and scaled up in India and elsewhere, but there is substantial room for improving the policy design and mobilizing local finance

Our findings suggest that this project offers valuable lessons to policymakers, international donors, and development finance institutions looking to scale up CSP in India and abroad. They are:

- **If a reverse auctioning scheme is used in India for future CSP programs, the design could be substantially improved.** Given that this program led to some project implementation and that reverse auctions have been used successfully for CSP in other countries, we see no evidence to indicate that a reverse auction scheme for CSP could not be successful in India. However, improvements in the auctioning scheme can substantially increase the likelihood of project implementation. Our conversations with stakeholders identify potential improvements including stricter qualification requirements for bidders, setting out more realistic timelines for bidding, making better solar irradiation data available, and allowing sufficient time for construction and then enforcing penalties more strongly for delayed projects. Furthermore, in order to promote learning and future cost reductions in energy storage - a key advantage of CSP over other renewable energy technologies - future bidding rounds may need to provide incentives or separate windows for plants using energy storage. Incentives for storage are planned under phase two of the NSM.
- **The Rajasthan Sun Technique financing model combines debt from foreign public institutions with local private investment.** This model could be replicated for other innovative projects, but, for scaling up CSP in India, more local financing has to be secured. International debt providers limit their exposure to specific sectors and countries, so local banks are needed for scaling up.[3] More local debt financing could theoretically become available after local finance institutions become acquainted with the technology. However, policy makers have to address financing issues specific to the Indian context, such as short tenors and high costs of debt, which could be addressed with low-cost public loans. As long as foreign debt remains important for CSP in India, partial denomination of tariffs in foreign currency would reduce exchange rate risks.[4]

International donors and development banks can accelerate national efforts to scale up CSP technology and reduce its costs by mobilizing local private investment, supporting the design of relevant policies, and covering part of the subsidies. Credit enhancement and building capacity at local banks would help them to increase financing to CSP. International expertise may improve the design of reverse auctioning schemes while the provision of financing with long tenors or at subsidized terms[5] makes it more likely that CSP project developers can bid low and still implement their projects, thereby minimizing the cost to the public.

3 For instance, we estimate that the most important development banks for India ADB and the World Bank Group would have to commit all their loans to the south Asian energy sector to India for 4-7 years in a row were they to provide all the debt needed for CSP under phase two of the solar mission (see section 6.3. for further information on how this was calculated).

4 For more on challenges and solutions for financing renewable energies in India, see Nelson D, Shrimali G, Goel S, Konda C, Kumar R. 2012. "Meeting India's Renewable Energy Targets: The Financing Challenge", and Nelson D. Shrimali G. 2014. "Finance Mechanisms for Lowering the Cost of Renewable Energy in Rapidly Developing Countries". San Francisco: Climate Policy Initiative.

5 By subsidized terms, we mean that public capital is lent at more favorable than the standard terms and interest rates of public finance institutions.

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1. Introduction

Among the technologies capable of harnessing renewable energy to meet growing world energy demand, concentrated solar power (CSP) is of particular interest. Its ability to store the sun's energy as heat allows it to deliver power when it is needed to balance out gaps in supply and demand arising from the fluctuating supply provided by other renewables, helping to maintain a stable energy supply. **CSP has particular promise in emerging economies with abundant solar resources, such as India and South Africa.**

However, CSP investment and production costs are high compared to other more established conventional and renewable energy technologies. For now, the technology requires deployment experience in order to reduce costs and risks and so CSP projects still require public interventions to be financially viable.

Investing in CSP, therefore, involves significant risks and challenges, both for project developers and the public sector. Private developers, on one side, have to consider potential technology failure, regulatory change, the sensitivity of project economics to debt costs and exchange rates. The public sector, on the other hand, faces the twin challenges of keeping costs low and finding the right tools for encouraging private investment in CSP deployment.

With this in mind, **the Climate Investment Funds, one of the major public institutions investing in CSP, has charged Climate Policy Initiative with analyzing the effectiveness of different public financing approaches to promote CSP deployment and future scale-up.**

In the background paper published as the first in the resulting series of Climate Policy Initiative reports on 'The Role of Public Finance in CSP' (Stadelmann et al. 2014), we identified key questions on the effectiveness of public finance in enabling CSP. They are:

- Is public support needed in all cases? If not, in which cases is it needed?
- How effective or cost-effective are different policy and public investment tools?
- Can public policy and support drive technology cost reductions simply by enabling additional capacity, or are more specific interventions needed?
- How can international public finance best support national policy efforts in emerging economies?

To answer these questions we will use a background paper, two case studies, and three stakeholder dialogues. A lessons learned paper and a policy brief will then distil the lessons.

This case study analyzes the Government of India's policy of reverse auctioning subsidized power purchase agreements (PPAs), the international non-subsidized[1] public financing, and private risk arrangements that stand behind the 100 Megawatt (MW) Rajasthan Sun Technique Concentrated Solar Power (CSP) plant. We selected this project as it is the largest CSP project worldwide using the promising Linear Fresnel technology, and one of the most advanced and cost-effective plants under India's ambitious National Solar Mission (NSM).

This report follows the methodology of San Giorgio Group case studies to systematically explore the role of project stakeholders, the investments and sources of return for the various stakeholders, the risks involved and arrangements to deal with them, and lessons on how to replicate and scale up best practice.

Section 2 provides an overview of the Rajasthan Sun Technique project, its main stakeholders and investors, and the policy environment in which it was developed.

Section 3 examines the investment costs and returns of the project as a whole.

Section 4 discusses the risk management framework, including risk allocation of the various technical, economic and financial risks associated with the project.

Section 5 explores the effectiveness of the project in the short- and long-term, and also compared its costs, implementation speed, and potential for learning to similar CSP projects.

Section 6 examines the replication and scale-up potential of the project's financing structure and likely routes to unblocking such potential.

Section 7 summarizes our key findings.

1 By non-subsidized terms, we mean that public capital is lent at the standard terms and interest rate of public finance institutions. In other words, no government grants are used to make the interest rate or tenor more favorable for the borrower.

2. Overview of project and policy context

Concentrated Solar Power (CSP) has the potential to provide India with a clean domestic energy source that can improve energy security in a country with scarce fossil fuel resources, while also avoiding greenhouse gas emissions.

The 100 MW Rajasthan Sun Technique CSP plant is highly innovative. It is the largest linear Fresnel CSP plant in the world, the first in India, and the largest CSP plant under construction in India.

2.1 Project background

Project context: India's power sector

India's power generation capacity increased from just 1.7 Gigawatts (GW) in 1950 to 186 GW by end of 2011 driven by sustained economic development during the period (CEA, 2012). However, the country still has a power-deficit as power demand outstrips supply. Even though India added 55 GW of new power generation capacity during the 11th Five Year Plan (2007-12), the country experienced an overall power deficit of 8.7% during the period (Ministry of Finance, 2013) and is struggling to source more local coal and gas (Economic Times, 2011).

The Planning Commission of India estimates that the country needs to add as much as 75.7 GW of new power generation capacity during the 12th Plan (2012-17) to achieve an annual GDP growth of 9% (Ministry of Finance, 2012). If this electricity were generated using the same share of coal as in the existing coal-dominated power mix in India, the additional capacity would generate additional emissions of 300 Million tonnes of CO_2 per year, representing a 17% increase of India's total CO_2 emissions from fuel combustion in 2011 (IEA, 2014).

Enabling environment of the project: National solar power policies

The Government of India announced the **National Action Plan on Climate Change (NAPCC)** in 2008 to sustain its rapid economic growth while dealing with the threat of climate change. **The NAPCC contains eight national missions that include solar power**, energy efficiency, sustainable habitat, water, sustaining the Himalayan ecosystem, green India, sustainable agriculture, and knowledge for climate change (Government of India, 2008).

The National Solar Mission (NSM)[2] under the NAPCC was announced by the government in 2010 with a target to install 20 GW of grid-connected solar power capacity (including rooftop) by 2022 (MNRE, 2013). The primary objective of the NSM is to create a policy framework for promoting the diffusion of solar power technology across the country as quickly as possible.

The National Solar Mission is not only helping India to meet its international pledge to reduce CO_2-intensity of its economy by 20-25% by 2020 compared with 2005 levels (Ministry of Environment & Forests, 2010)**, it is also improving energy security and diversifying the energy supply of a country with limited fossil resources and rapidly growing electricity demand.** India currently struggles to produce as much power from fossil fuels as planned: extraction of coal and gas in India is lower than expected, and the capacity of coal plants has been increasing more than domestic coal production in the last few years, leading to the need for more and costly coal imports (Economic Times, 2011, Sreenivas and Bhosale, 2013, Live Mint, 2014). Lower domestic coal production than expected, together with the high number of coal supply allocation to power stations (see Sreenivas and Bhosale, 2013), has led to the shelving and delay of many planned coal power plants (Economic Times, 2012, Financial Express, 2012, expert interviews).

The solar power capacity installation target under the NSM is divided into three phases with specific target ranges for each phase (MNRE, 2009):

- Phase 1: 1,000-2,000 MW by March 2013; 500 MW awarded to CSP[3]
- Phase 2: 4,000-10,000 MW by March 2017
- Phase 3: 20,000 MW by March 2022

The targeted capacity in phase one of the NSM was split 50/50 between solar PV and CSP technologies. The main feature of its CSP policy was the reverse

2 Originally named Jawaharlal Nehru National Solar Mission (JNNSM)

3 Only 470 of the 500 planned MW were awarded, as the winning bidders capacity totaled 470 MW, and adding another plant would have meant exceeding the 500 MW.

auctioning of subsidized PPAs (for all features of the NSM CSP policy, see Appendix A). However, the targeted capacity in phase two favors solar PV more with a ratio of 70:30 (MNRE, 2012). The proposed preference of solar PV technology over CSP in phase two of the NSM is due to delays in the construction of CSP plants in phase one.[4]

While solar PV in India has also flourished under state level policies (particularly in Gujarat[5]), **CSP in India has primarily been driven by the National Solar Mission.** No plant with a capacity of more than 25 MW is under construction or has been commissioned outside the NSM framework (CSP World, 2013a) and recent state-level auctioning of PPAs for CSP plants were unsuccessful because of the specific design of the auctioning.6 We list all Indian CSP projects tendered under phase one of NSM in Table 1.[7]

products from 14% to 4% and exempted solar project equipment from the entry tax (Makhija, 2012). The project also benefitted from leasing earmarked land at subsidized rates under the RSEP. The other measures under the RSEP – 33kV transmission lines for plants within 15 kilometers from the next substation – did not benefit the project, as developers built a dedicated 220 kV transmission line for the plant.

Linear Fresnel: innovative CSP technology with high potential for local manufacturing

The Rajasthan Sun Technique plant is particularly interesting because it is one of the most advanced CSP plants under the NSM despite using a technology that has never been deployed at this scale. Not only is it among the largest projects under the National Solar Mission and the second most advanced in terms of planned commissioning, it is also the only one that uses the more innovative linear Fresnel instead of the more common parabolic trough technology (see Table 1 for technologies used).[8]

Table 1: Concentrated solar power projects sanctioned in phase one (2010-2013) of the National Solar Mission in India

PROJECT DEVELOPER	SIZE (MW)	TECHNOLOGY	STATE/ LOCATION	STATUS
Lanco Solar	100	Parabolic trough	Rajasthan	Under construction, delayed
Rajasthan Sun Technique	100	Linear Fresnel	Rajasthan	Under construction, to be commissioned in March 2014
KSK Energy	100	Parabolic trough	Rajasthan	Under construction, delayed
Godawari	50	Parabolic trough	Rajasthan	Commissioned in June 2013
Aurum Renewables	20	Parabolic trough	Gujarat	Under construction, delayed
Corporate Ispat	50	Parabolic trough	Rajasthan	Under construction, delayed
Megha Engineering	50	Parabolic trough	Andhra Pradesh	Under construction, likely to be commissioned in 2014

Enabling environment of the project: Solar energy policy at the state level (Rajasthan)

In addition to the subsidized PPAs offered by the NSM, the Rajasthan Sun Technique project also benefited from the Rajasthan Solar Energy Policy (RSEP) from 2011, which reduced Value Added Tax (VAT) for solar

The choice of linear Fresnel enabled a high share of local content (61-71%) compared to other solar plants (see Appendix C for details): steel and concrete can be sourced in India, and the used linear Fresnel technology uses water and not imported synthetic oil or a specific salt as heat transfer fluid (as in the case of parabolic trough technology).[9]

4 The delays suggest there is a lack of data on implementation and operational issues, and make it more difficult for policy makers to set realistic conditions for a next auctioning round, when compared to solar PV.

5 According to ReSolve (2013), Gujarat state policy enabled 70% of the 1000+ MW of Indian PV deployed between 2010 and 2012

6 The auctioning in Karnataka did not attract CSP bids as CSP competed with the cheaper solar PV, while the one in Rajasthan (for 100 MW) has probably not attracted bids due to a combination of a low reference tariff, off-taker risks, and site restrictions.

7 In addition to the projects in Table 1, three concentrated solar power projects with a total capacity of 30 MW that were started under various state policies became part of the National Solar Mission (MNRE, 2012)

8 According to stakeholder interviews, technology provider Areva Solar's comprehensive warrantee was the main reason for selecting linear Fresnel.

9 The flat mirrors for linear Fresnel are easier to manufacture in India than parabolic mirrors but the mirror supplier decided to only open a manufacturing plant in India, if demand further increases. Therefore, only the assembly of mirrors took place in the country (on site).

2.2 Project timeline

According to information at the end of January 2014, **the Rajasthan Sun Technique plant will commission in early March 2014, around two years after financial closure. The implementation time of the plant is actually very short when compared with other CSP plants internationally** (see chapter 5).

None of the seven CSP projects granted a PPA under phase one in early 2011 (see Table 1) met the initial commission deadline of May 2013, mainly due to lower than expected levels of solar irradiation at the project sites, financing and technology-sourcing challenges, and very ambitious timelines set by the government (NRDC/CEEW, 2012; stakeholder interviews). As a result, the NSM extended the deadline for commissioning by almost one year to March 2014. Even so, **the studied Rajasthan Sun Technique project is one of only two to three CSP projects that expect to meet this extended deadline.**

The project is planned to generate electricity for at least 25 years (see Figure 1).

2.3 Project stakeholders

The project involves a series of public and private stakeholders, each having a specific role in financing the CSP plant (see Table 2). Reliance ADA, a large Indian conglomerate, developed the project through its subsidiary Reliance Power, holds the full equity in the Special Purpose Vehicle and is responsible for engineering, procurement and construction (EPC) through Reliance Infrastructure, another Reliance ADA subsidiary (see Figure 2). A US-based subsidiary of a large French energy company (Areva) provides the Linear Fresnel technology and ensures operation and maintenance through an India subsidiary. The other key stakeholders are two national public bodies (MNRE and NVVN) responsible for policies and power purchase, and a consortium of domestic private and international public investors, including FMO (Dutch Development Bank), Asian Development Bank and Export-Import Bank of the United States.

Figure 2: Project stakeholders for Rajasthan Sun Technique plant

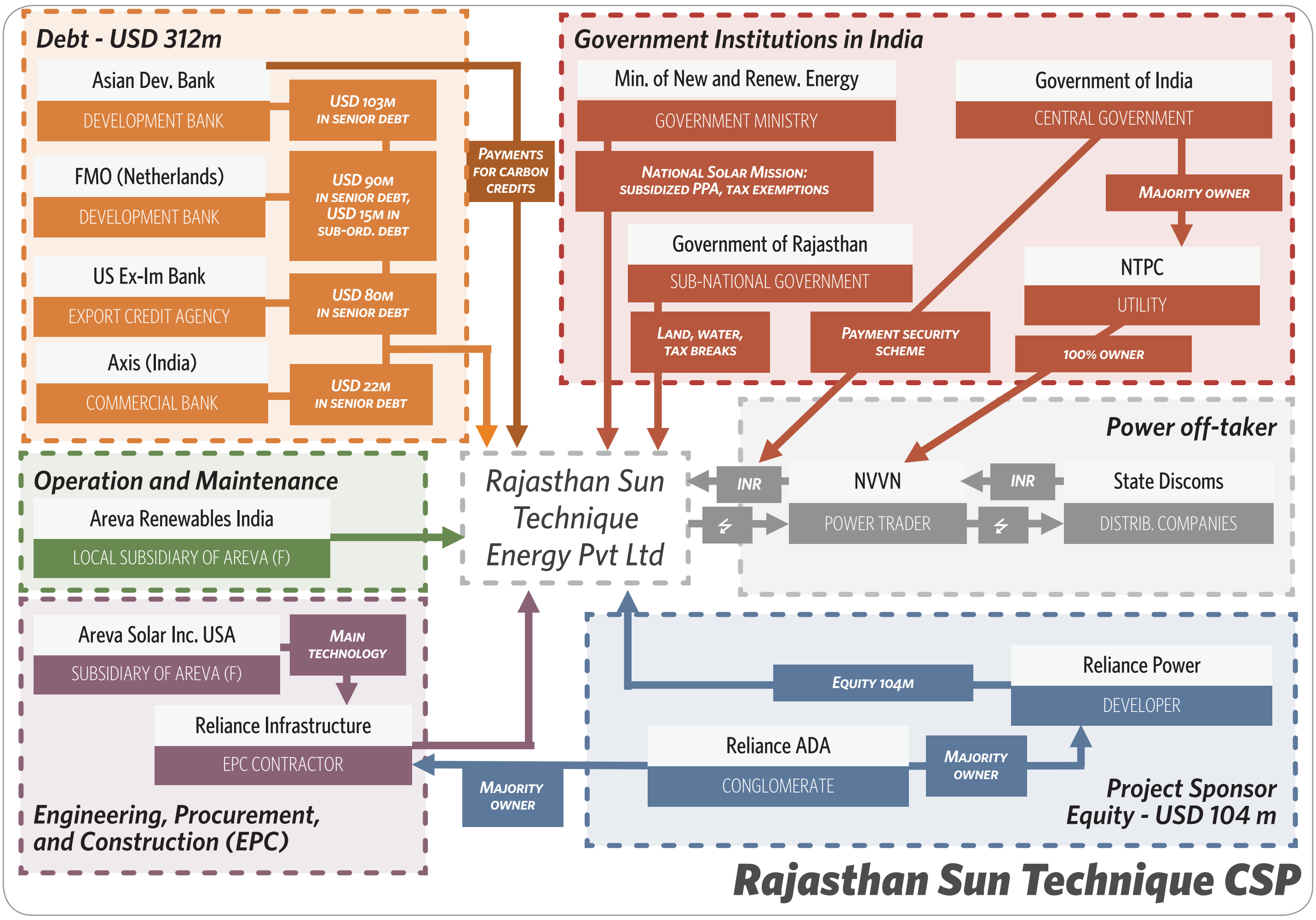


Figure 1: Timeline for Reliance Power CSP highlighting major stakeholders involved and key project milestones

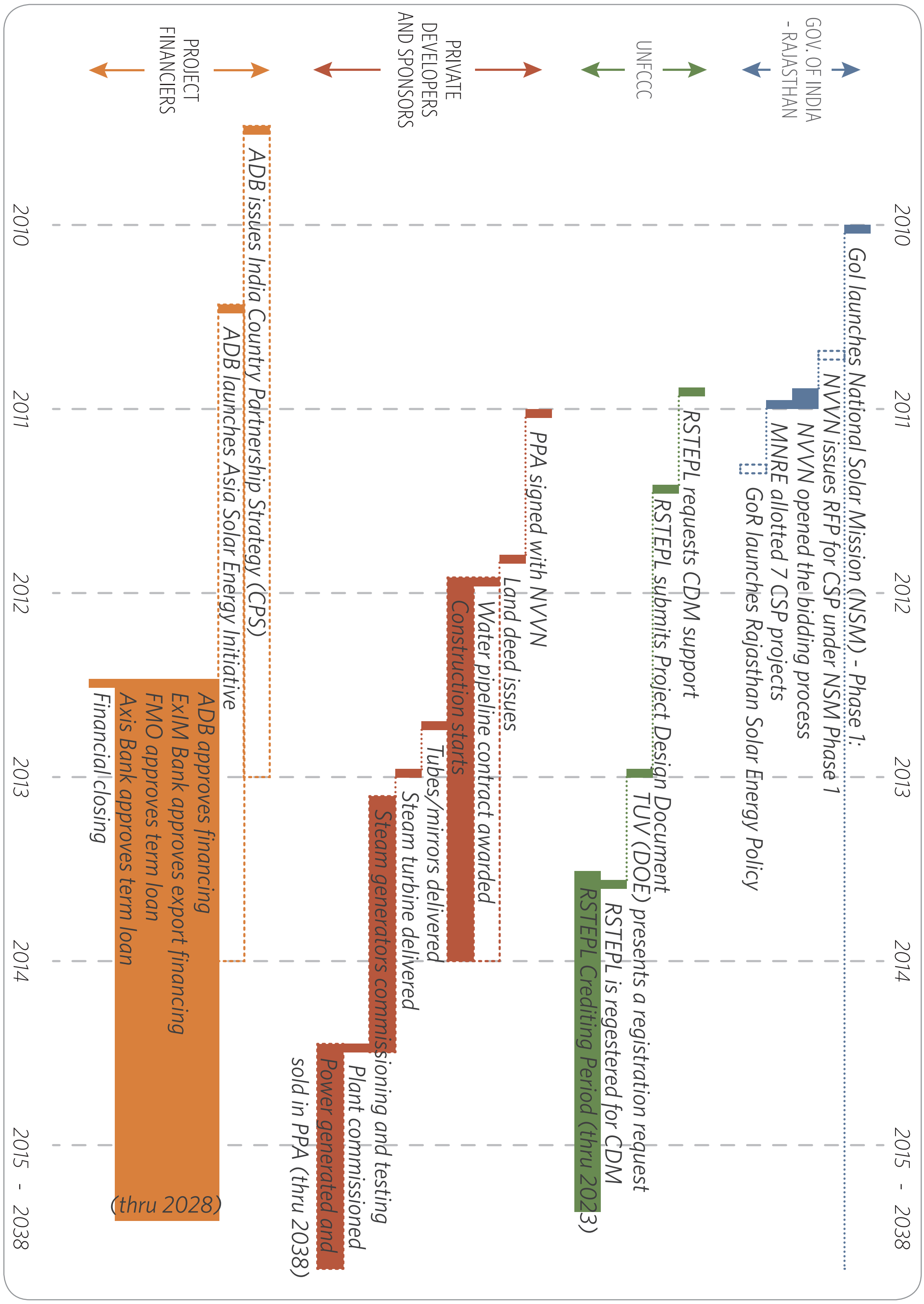


Table 2: Rajasthan Sun Technique CSP project stakeholders' description and financing role

STAKEHOLDER DESCRIPTION		PROJECT ROLE	FINANCING ROLE
Government of India and public bodies	**Government of India: the Ministry of New and Renewable Energy** (MNRE) manages the National Solar Mission, under which 470 MW of CSP power plants received subsidized power purchase agreements (PPAs)	• Issued guidelines for the project allocation and bidding process • Devised the blended power scheme, drafted the template power purchase agreement	• Charges NVVN with awarding favorable PPAs to CSP plants
	NTPC Vidyut Vyapar Nigam Ltd. (NVVN) is a power trader, owned by NTPC Ltd (NTPC), one of the largest utilities in India (75% government owned)	• Invited bids for the development of 470 MW of CSP under the National Solar Mission • Power off-taker in the project	• Pays favorable tariff to project, recovers cost by blending CSP with cheap coal power when selling it
Project developer	**Reliance Power Ltd.** Is a developer in the Indian, electricity sector, founded in 2007, has more than 30,000 MW of thermal power plants under development Majority owned by Reliance ADA, one of the largest Indian conglomerates	• Develops project and provides 100% of equity for the Special Purpose Vehicle (SPV). • Reliance Infrastructure (subsidiary of Reliance ADA) is the EPC contractor	• Provided INR 5500 (around USD 105) million in equity • 100% owner of project Special Purpose Vehicle (SPV)
Public debt providers	**Asian Development Bank (ADB)** is as regional development bank, owned by 67 governments (16% each by USA and Japan, 6% each Australia, China and India)	• Provides non-subsidized debt	• Contributed USD 103 million in senior debt to SPV
	FMO is the Dutch development bank, 51% owned by Dutch government, 49% by Dutch commercial banks, trade unions and other private-sector representatives	• Provides non-subsidized debt	• Contributed USD 90 million in senior debt, 15 million in subordi-nated debt to SPV
	Export Import bank of the United States (US Ex-Im Bank) is the official US export credit agency, part of the US government	• Provides debt at a pre-defined rate • Involvement made possible as Areva Solar is US-based technology provider	• Contributed USD 80 million in senior debt to SPV.
Commercial lender	**Axis Bank** is a major Indian Bank, publicly listed, minority owned by the government via the Specified Undertaking of the Unit Trust of India	• Provides debt. Only private lender involved	• Contributed INR 1140 (around USD 22) million in senior debt to SPV
Technology provider	**Areva Solar**, is a US-based provider of Linear Fresnel CSP technology; subsidiary of Areva France S.A., a French publicly-owned multinational company, specializing in nuclear energy	• Provides technology to project • Parent company Areva France is responsible for Operation & Maintenance, through its subsidiary Areva Renewable Energies India	• Comprehensive tech-nology warrantees

3. Investment, return, and profitability

Public support provided through a competitively awarded power purchase agreement (PPA) was essential to ensure the financial viability of the plant

International development banks provided most of the financing at rates close to their cost of capital, without grants or subsidized terms used. The long maturity of their debt increased equity returns by 120 basis points (1.2%) making the project appealing to local developers even at a very competitive tariff

Project returns seem below comparable projects in India suggesting the developer might be accepting lower profitability on the first project to acquire market share and a leading position for future projects

Hedging costs in particular almost double the financial charges of foreign debt, strongly reducing the appeal of the longer maturity debt it offers for the local borrower

This section addresses two main San Giorgio Group methodological questions: what are the public and private financial inputs, and what are the main financial outcomes of the Rajasthan Sun Technique CSP plant? To assess the return profile of the project, we first consider the total project costs broken down across equity and debt contributors. Then, we estimate returns and profitability at the overall project level and those accruing to each project contributor.[10]

3.1 Investments: who pays for what

The 100 MW Rajasthan Sun Technique CSP plant gathered total financing of approximately USD 414 million. Foreign investors provided for 70% of financing, a local Indian bank 5%, and the project developer 25% in equity contributions. Table 3 lists all investors and details the amounts provided by each.

Financing from foreign investors is denominated in USD and mostly in the form of senior debt with long-term maturities of 18 years.[11] The Export-Import Bank of the United States (Ex-Im Bank of the U.S.) provided a loan tied to U.S. Treasury pricing, provided that the project purchase goods from U.S. exporters, in this case Areva Solar Inc. Conversely, the debt provided by the ADB and the FMO contained no subsidies. They provided loans

Table 3: Rajasthan Sun Technique capital structure

SOURCE	FINANCING TYPE	AMOUNT	AMOUNT IN USD	SHARE
Debt				
US Ex-Im Bank	Export Credit Loan	USD 80	80	19%
ADB	Senior Loan	USD 103	103	25%
FMO	Senior Loan	USD 90	90	22%
FMO	Subordinated Loan	USD 15	15	4%
Axis Bank	Senior Loan	INR 1,140	22	5%
Equity				
Reliance Power	Equity	INR 5,500	104	25%
Total Project Cost			414	

Source: ADB, 2012; US Ex-Im Bank, 2012; FMO, 2012; RPL, 2011.

Figures in INR are converted using the exchange rate at the time of the project financial closing, April 2012 (oanda.com)

10 We attempt to quantify cost inputs, returns, and impacts that will derive from the investment to the extent possible using information about project specifics if it is publically available, or industry standard assumptions if it is not.

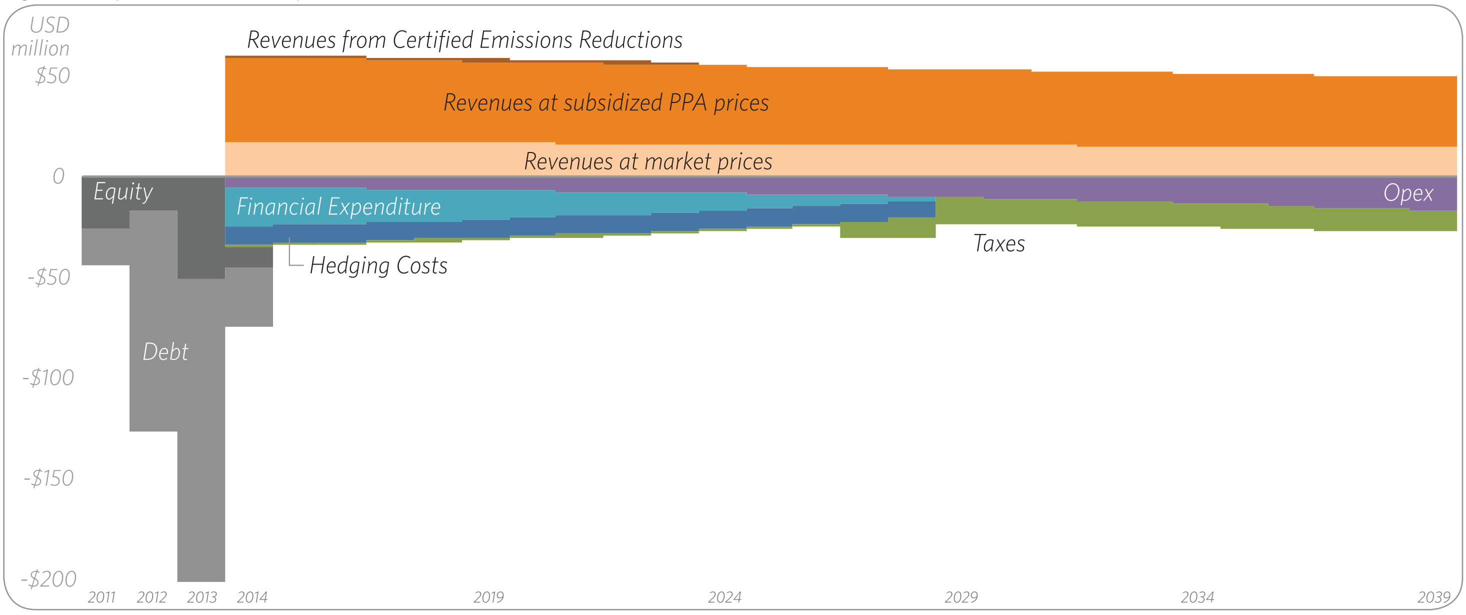
11 The only exception is a subordinated loan provided by FMO when channeling funds from the Interactive Climate Change Fund ("ICCF"), whose funds are provided by a group of 11 European Development Finance Institutions (FMO, 2012b).

at rates consistent with the cost of capital for these Development Finance Institutions (DFIs).[12]

3.2 Project costs and sources of return

Using a discounted cash flow analysis (Varadarajan, 2011) we model the project's financial profile, in order to estimate revenues and liabilities, its profitability metrics and financial strength, and ultimately the levelized cost of the electricity generated (LCOE).[13] Table 4 reports in detail the main results from the financial model while Figure 3 shows the composition of the project cash flows.

Figure 3: Rajasthan Sun Technique cash flows



Cost breakdown

The overall project costs are comprised of capital expenditures, operation and maintenance costs, and financial charges.

- **Capital expenditures (CAPEX):**[14] The project's capital costs amounted to USD 410 million. As with most CSP plants built in other regions, construction costs accounted for the vast majority (85%); while pre-development expenses, land acquisition, contingencies and financing during construction, accounted for the balance. Within construction costs, the solar field (collectors, receivers, tracking systems and support structures) accounts for 70%, while the power block accounted for the balance (Areva, 2013a).[15] At the plant's name-plate capacity (100 MW), the project unit capital costs are approximately USD 4,100/kW – one of the lowest amongst the CSP projects built in the last few years (IRENA, 2012; Stadelmann et al. 2014).[16]

- **Operating expenditures (OPEX):**[17] We estimate operating expenditures are USD 26 per kW installed, with an annual escalation factor of 5.72% (CERC, 2010). On an annual basis, we estimate that the operation expenditures amount to approximately USD 5 million and represent less than 10% of the overall project's LCOE.

- **Financial expenditures (FINEX):**[18] Overall, total

12 Interest rates have not been disclosed but we estimate that those applied by foreign investors are consistently lower than rates available in the Indian market.

13 By levelized cost, we mean the (present value of) total project costs for each kWh of energy generated by the solar plant. The levelized cost of energy actualizes all cash flows related to a specific energy source. Consistent with previous CPI reports, the calculation has been based on the expected after-tax internal rate of return of the project, based on anticipated cost and revenue estimates.

14 A detailed breakdown of CAPEX is not yet available; estimates are then based on information reported by project stakeholders.

15 The high impact of the solar field on CAPEX is also due to the decision to install a reserve capacity of 25 MW in order to increase the probability that the plant produces enough electricity to comply with the signed PPA, with the upside potential of selling excess power to a 3rd party off-taker.

16 Interestingly, if we consider the actual size of the solar field (125MW), technology unit costs are even lower at approximately USD 3,315/kW.

17 Operating expenditures are not yet available. The Central Electricity Regulatory Commission has provided some guidance to project developers in the request for proposals.

18 The remaining financing charges are confidential. Interest on the onshore

Table 4: Rajasthan Sun Technique financial metrics

ESTIMATED VALUES AT THE TIME OF BIDDING	VALUE	COMMENT
Annual Energy Generated	265 GWh	Annual power generated is estimated on the available capacity of 125 MW in the solar field, a capacity utilization factor of 24% and an annual degradation factor of 0.72% p.a.
Total Annual Revenues	USD 60.5 million	Annual revenues are almost entirely generated through the sale of power to NVVN at the tariff bid in phase one of the NSM. The tariff benefits from revenue support policy of the solar mission (roughly USD 40 million p.a.).
- Power sold through PPA	USD 59 million	
- Sale of carbon credits	USD 1.5 million	
Investment Costs	USD 410 million	Investment costs are considerably lower than in the case of most CSP plants developed in both developed and emerging countries (IRENA, 2012; Stadelmann et al. 2014).
	USD 4,100 /kW	
Levelized Cost of Electricity (LCOE)	INR 12.5/kWh	LCOE is computed with the project IRR as the discount factor. CAPEX is the largest component, with the cost of financial charges and hedging also representing a significant portion of the value.
	USD 0.24/kWh	
- CAPEX	70%	
- OPEX	9%	
- FINEX	21%	
Internal Rate of Return (IRR)	Project 11-12%	Rate of returns are at the lower end of the spectrum reported by literature and below those expected by the Central Electricity Regulatory Commission (CERC, 2010).
	Equity 11-14%	

kWh = kilowatt hours, GWh = Gigawatt hours

financial expenditures (FINEX) and hedging costs (net of tax rebates) on the debt facility should amount approximately to USD 200 million over 18 years, and represent more than 20% of the project's levelized cost of electricity. Hedging costs, in particular, almost double the financial charges of the foreign debt, strongly reducing the appeal of its longer maturities for the local borrower (see Figure 3).

Expected generation and levelized cost of energy (LCOE) calculations

We compute the LCOE of the plant using current estimates for costs and power generation levels[19] and apply the project's rate of return (after tax) as its discount rate[20] (see Table 4 for details). This methodology allows us to link the LCOE to the tariff ultimately quoted in the tender process – to assess the impact of the project financial structure on the cost of the electricity produced and, consequently, its price for the end user.

We estimate an LCOE of INR 12.5/kWh (USD 0.24/kWh21) for the Rajasthan Sun Technique plant. This is roughly in line with the tariff awarded to the project, and confirms the plant as one of cheapest CSP projects built so far in the world (Frisari and Falconer 2013; Stadelmann et al. 2014).

Breaking down levelized costs, CAPEX represents two thirds of the total (70%), financing expenditures and hedging costs (FINEX) slightly less than one quarter (21%), and operation and maintenance costs (OPEX) close to 10% of the total value.

LCOE computations allow two very interesting insights:

- **Longer maturities of 10 years have allowed the project developers to reach their required rate**

loan is estimated using the India Prime Lending Rate for the last quarter of 2010 at 12.5% (CDM, 2012b). The interest on the foreign debt is derived through interviews with project stakeholders. Despite being much lower when quoted in dollar terms (ADB, 2013), it comes very close to the domestic debt when the cost of hedging is considered. Hedging costs are derived from the difference between the two countries interest rate curves and computed with Bloomberg Data Swap Manager.

19 An average equipment degradation of 0.72% per annum is taken into account (CDM, 2011a).

20 The discount rate in the LCOE calculations represents the "adequate" remuneration of the financial resources committed to the project.

21 The LCOE value in USD is derived used the exchange rate at the time of project's financial closing (INR/USD 52.6); however, as there's no direct pass-through of foreign exchange in the tariff, the LCOE in today USD should reflect the devaluation of the Indian Rupee and be valued at less than USD 20/kWh.

of return bidding a tariff roughly 4-5% lower than what would have been affordable with debt of 7 years maturity.[22]

- Very high hedging costs due to the low liquidity in the currency swap market for long maturity debt weigh heavily on the LCOE (almost 10% of the total). **We estimate that, if policymakers could lower these hedging costs to half,23 the project developers could achieve the same rate of return with a 7% lower tariff.** In turn, such a lower tariff would reduce the plant's viability gap[24] from USD 42 million to roughly USD 37 million per year.

Project's sources of return

The main source of return for the project is the sale of power through the PPA signed with the government-backed agency NVVN at the agreed tariff of 11.97 INR/kWh (USD 0.23 per kWh). Assuming an average plant load factor of 24% (for 125 MW gross capacity), annual revenues from sales of electricity amount to USD 60.5 million. This value is more than three times the amount that a plant could realize on the market and ultimately makes the project financially viable. Consequently, we estimate the value of the revenue support policy at around USD 40 million per year. **Without any revenue support, the developer would not achieve a positive IRR nor be able to repay debt by selling the power at the prevailing market prices for industrial usage** (around INR 3.5/kWh).

Of much smaller relevance are the revenues expected to result from the sale of carbon credits, approximately USD 1.5 million per year and USD 14 million over the life of the project.[25] Their impact on the project's financial metrics is, therefore, negligible.

3.3 Costs and benefits for project stakeholders

The project generates several financial and non-financial benefits that accrue to different stakeholders and, ultimately, justify their involvement. In fact, in order to be viable, the project needed substantial inputs from all stakeholders: support to revenues provided by the country's national government, long term financing from DFIs that plugged a gap in the local capital market, and the equity and management resources that project developers made available.

Public Sector stakeholders

National and local government

Within the framework of the NSM, the Government of India's support for the 470 MW of CSP projects seeks to achieve two main outcomes. First, to increase security of energy supply by exploiting a domestic clean energy source while displacing fossil fuel sources whose domestic production is not keeping up with the increase in power plant capacity, leading to below capacity production and necessitating more expensive imports.[26] Second, to kick start the development of a local concentrated solar power industry in a similar way that it managed to do with the PV industry.

Once commissioned, the 100 MW project will generate 265 GWh of grid-based electricity per year, which equals the annual consumption of 400,000 Indian inhabitants in 2010. This clean electricity will replace coal, gas, and other fossil-based technologies, equaling approximately 266,000 tCO_2e per year (CDM, 2011a),[27] or around 0.03% of Indian power sector emissions in 2011 (IEA, 2013).

The local content requirements in the tender were designed to ensure that at least part (a minimum of 30%) of the project value would be sourced in the country. We estimate that more than 60% of Rajasthan Sun Technique's value has been sourced within the country (see Appendix C for details): infrastructure and project management work have been completely localized (also thanks to the already established operations of Reliance Infra as Engineering Procurement Construction (EPC) contractor), infrastructure material

22 10 years is the longest maturity of reference for long-term debt in the Indian banking sector (Nelson et al, 2012), with more common values being 5-7 years.

23 For example, by offering a portion of the debt in local currency, by offering a portion of the revenues in hard currency (Nelson and Shrimali, 2014), or by a broader increase of liquidity in the currency swap market.

24 The plant's viability gap is estimated as the difference between the tariff required by the developer to operate the plant and the average market price, multiplied by the power produced.

25 The CDM Executive Board approved the project in July 2013 awarding it approximately 250,000 carbon credits each year for the next ten years. We have valued carbon credits at EUR 4.8/tCO2 using a transaction that occurred in November 2012 between a wind farm in Rajasthan and the Swedish Energy Agency as a benchmark (The Times of India, 2012).

26 Issues concerning lack of coal and gas to run the country's power plants started to surface in 2011 (Singh, 2011) and have worsened over the years as the cost of imports in local currency has skyrocketed (The Financial Express, 2013), helped by rupee's weakness.

27 Based on total electricity consumption and number of inhabitants according to the EIA (2013).

(cement and steel) has been sourced locally, and the assembly of the solar receivers on site has prompted the training of a highly skilled workforce employed in tasks such as high precision construction and welding. In total, several hundred jobs have been created during construction and fewer are created during operation

The local content is one reason why the project will help the government to meet its goal to build up a competitive solar industry in India: critical CSP knowledge and technology are transferred from US and European countries to India, local supply chains are established (e.g. for the steel support structure and parts of the receiver), basic land, water and electricity infrastructure for further CSP plants are established, and the involved local stakeholders learn on how to source, install, finance and operate CSP technology in India.

From a financial perspective, the national government allowed the project developers to enjoy the benefit of a much higher tariff than available on the market. It then combined this expensive solar power with a portion of the country's coal power produced by public entities at very low costs. The resulting bundle was offered to state power distribution companies at the same price they would have paid in the market for their power needs.[28] This policy creates an incentive for distribution companies to purchase the solar power without it costing them anything more.

However, the policy has an opportunity cost due to the multi-year commitment of this publicly-owned coal power to support solar power. The estimation of this public cost proves very hard as the value of the publicly-owned coal power is highly dependent on the political decisions over its use.[29]

Finally, the project will generate, on average, approximately INR 8,810 million (around USD 170 million) in tax revenues over the project's life.

Foreign public lenders: Development Finance Institutions and export credit agency

The ADB, FMO, and US Ex-Im provided long-dated debt to the project, extending available maturities from 10 to 18 years.[30] We have estimated that the availability of this longer-term debt ultimately increases the rate of return for equity holders by roughly 100 basis points, improving the risk-return profile of the project developer. The debt was not provided at subsidized levels, and charged interest rates that represent the cost of funding for these international investors.

We estimate these international investors will collect approximately USD 148 million in interest rates payments over the project's life. ADB and FMO financed the project in order to support the demonstration of the linear Fresnel CSP technology at utility scale, to help India exploit its indigenous renewable resources, to promote local manufacturing, and to reduce technology costs over time (ADB, 2012; FMO, 2012b). U.S. Ex-Im instead provided financing to the project in order to support the export of US technologies (Areva Solar Inc USA) (US Ex-Im, 2012).

The DFIs share the government's goal of clean energy, local job creation and establishment of a local CSP industry. In addition, they are also interested in cost reductions and competitiveness of CSP technology worldwide. Such cost reductions can, indeed, be expected due to three reasons: first, as the project is the first of this size, all key stakeholders report substantial learning during the project development and construction, and the same should happen in the operation phase. Second, the establishment of a local supply chain reduces costs, and third, there are clear economies of scale, as future CSP plants in India will benefit from the water and electricity infrastructure built for this plant.

Private Sector stakeholders

Project Developer: Reliance Power Limited

Reliance Power Limited (RPL) is the sole owner of the project company Rajasthan Sun Technique Energy Private Limited (RSTEPL) and funded it with USD 105 million of equity. The project will generate net earnings (after tax and debt payments) of USD 12 million per annum, on average, and USD 280 million over the project's life. We estimate a rate of return for the equity holders of approximately 11-14%. This sits at the lower end of the range cited by the regulator (CERC, 2010) and during stakeholders' interviews, but seems to suggest a first mover strategy, in which the developer accepts a lower profitability for the first project to make sure to acquire market share, to increase learning on developing and constructing CSP plants, and to establish a leading position for successive projects. RPL has already prepared a follow-up to this project by acquiring more land than needed for the first plant, and by introducing in the project design certain features that will be shared with the second phase of this project (mainly

28 The purchase of CSP power also helps utilities to comply with their Renewable Power Obligations (RPOs).

29 This "reserve" coal power is often provided to states or municipalities almost free of charge if they are facing fuel shortages, or used to prevent outages and excessive load shedding.

30 This includes a one year moratorium.

civil constructions). At the same time, the commercial agreement between RPL and Areva included the possibility of building two 125 MW Fresnel plants for the site (Areva, 2012b) from the beginning provided that the developer secures another PPA for the second plant on the site.

Technology Supplier: Areva Solar

Areva has supplied, delivered and installed the technology for the solar field through a sub-EPC contract with the project main contractor Reliance Infrastructure.

the long-term interest of the supplier for the Indian market.

Private Lender: Axis Bank

Axis Bank provided a small tranche of the debt facility but, interestingly, at 18 years maturity, indeed much longer than the one prevalent in the Indian banking market. This was likely due to the small size of the debt relative to the value of the project, and their existing business relationships with the project developer. We estimate that the bank will receive (in local currency)

Table 5: Summary of stakeholders' inputs to and benefits from the Rajasthan Sun Technique plant

INPUT	OUTPUT	INTERIM BENEFITS	OUTCOME
Private capital: USD 126 million, of which USD 104 million equity (**project developer**) and 22 million from **private lender**	**Installed CSP capacity:** 100 MW (constructed in less than 2 years), benefit for public stakeholders	**Clean energy:** 265 GWh per year of solar energy generation, benefit for public stakeholders	Support for meeting **India's solar, renewable energy and emission targets**, benefit for national government
Public capital: USD 288 million (debt) from **foreign public lenders**	**Several hundred jobs** in manufacturing and construction created, benefit for public stakeholders	**Greenhouse gas emission reduction:** around 266,000 tonnes of CO2 per year, benefit for public stakeholders	**Taxes:** INR 8,810 million corporate taxes over project life, benefit for national government
Public revenue support: >6 INR/kWh from **national government**	US **exports and technology transfer** to India benefit for all stakeholders	**Jobs for operation & maintenance** created, benefit for public stakeholders	**Return on investment:** 11-14% return on equity (project developer), and USD 148 million in interest rates payments for public and private lenders
Technology: warranties by **technology supplier**	**Learning** during installation, benefit for all stakeholders Established local supply chain & infrastructure for further CSP plants, benefit for developer and technology supplier	**Learning** during operation, benefit for all stakeholders	**Cost reduction** in linear Fresnel CSP technology, benefit for all stakeholders

Areva assumed a significant amount of risk through this EPC as this was the first time their technology has been scaled up to such size.[31] Furthermore, as one of the first concentrated solar power projects in the country, it faced a non-existent local supply chain for high precision infrastructure. Despite the high first-mover costs, the project was an interesting venture for Areva as it provided opportunities to learn, improve its technology, and prove to developers that its technology can be deployed at utility scale. The agreement with Reliance for a second 125 MW solar plant (Areva 2012b) proves

USD 26 million in interest payments over the lifetime of the debt.

Table 5 summarizes the key inputs and benefits for different stakeholders. Inputs are the ingredients to make the project happen. Benefits are classified as outputs (benefits during construction, which can already be measures), interim benefits (in the first years of operation) and outcomes (long-term or ultimate benefits during the lifetime of the plant).

31 The largest plant developed by Areva before this project was of only 4 MW capacity.

4. Risk allocation

Central government backing for the subsidized PPA and foreign public investment was essential to reduce off-taker and financing risks

The private sector was able to manage the remaining risks, including technology and foreign exchange risks, but not always at low costs

The financial strength and appetite for risk of the private sector players involved may be very specific to this project. The public sector cannot expect that the private sector will always cover the risks of deploying immature technologies in countries like India and may need to step up its support.

4.1 Risk identification and assessment

To ensure we capture all significant sources of project risk (non-material and very low probability risks are excluded from the analysis), we collected an exhaustive list of categorized risks that could affect the Rajasthan Sun Technique project before systematically assessing those risks according to two criteria: their probability of occurrence or frequency (from very low to very high) and their impact on the project's financial and non-financial objectives (again from very low to very high):

Low-risk events

Risk events with low probability of occurrence and low to medium impact:

Project failure to meet government and Development Financial Institutions (DFI) standards. The project's development had to comply with two sets of standards: those set by the Government as a condition to eligibility for the tender process (mainly local content); and those set by DFIs for the operation of the plant. The risk of non-compliance was, however, rather low given the amount of local content expected to materialize for the technology (around 61-71% against a requirement of 30%), the relatively low risks of negative social and environmental impact in a CSP project and the due diligence on social and environmental impacts performed by the DFIs prior to approving the loans.

Moderate-risk events

Risk events with moderate-probability of occurrence, but medium-high impact:

Regulatory Change / Public budget overburden: the project's financial viability rests on several government interventions, mainly an above-market tariff but also several tax exemptions. A retroactive change or recall of the subsidized power tariff or the non-exemption from customs' duties would significantly hurt project's profitability and its ability to meet debt repayments (see Appendix B for details on project sensitivity on tariff's changes). This risk (perceived by the developer) has a low or moderate probability of occurrence, as the government does not provide direct subsidies.

Off-taker default: revenues depend almost entirely on the PPA signed with the government-owned power trading company, NVVN. As such, its default would have a significant impact on the project's financial viability. However, the probability of this default is very low given the government's ownership of the company

Infrastructure risk / water availability: the significant water demand for steam generation and cooling makes the availability of water a critical risk. Water is sourced from a canal, approximately 140 km from the project site, through a pipeline built for three quarters by the Public Health and Engineering Department (PHED) of Rajasthan and for one quarter by the project company. The pipeline will serve both the plant (with 5% of its overall capacity) and the villages nearby. Provisions for temporary water shortages (storage ponds) are also in place. Given the delays in the construction of the pipeline (for the section under PHED responsibility), the need for maintenance, and the severe impact of a prolonged water shortage, this risk is categorized as moderate.

Failure to secure financing at reasonable costs: the risk of failing to source the capital needed, at a cost and maturity that allows the project developers to achieve their required rate of return, is a moderate to high, as the Indian capital market is short-term-oriented and not familiar with CSP technology. Furthermore, there is some evidence that, despite increasing in the more recent past, non-recourse project finance[32] is still a relatively uncommon practice in the Indian banking sector (Nelson et al, 2012).

High-risk events

Risk events with high to very high impact whatever the probability of occurrence:

Cost overruns / delayed commissioning: the project is the first of its kind in the country and the first at this scale for the technology supplier, hence making timing and cost estimates highly uncertain. Construction and permission delays already prevented the plant from being delivered within the original expected 28 months commissioning period, and the project is now expected to be completed only slightly before the expiration of the 10 month extension granted by the Government.[33] The potential impact is very high as, provided the delay is not due to NVVN or to force majeure, the project developer can lose a portion or the full amount of the USD 6 million performance guarantees (NVVN, 2010b) and more importantly, can lose the right to sell the power at the tendered tariff.[34]

Technology risk: on commissioning the project will be the largest installation of linear Fresnel operating anywhere in the world.[35] It is three times larger than the next largest installation and the first linear Fresnel plant in India. The risk of equipment malfunctioning, achieving lower than expected performance or higher system degradation, is high and would have a significant impact. We note here, however, that most the components of the linear Fresnel modules are simpler to manufacture and easier to acquire than those for parabolic trough and power tower, hence presenting a lower risk in terms of equipment acquisition and input cost variability.

Solar resource risk: at the time of bidding, no detailed track record of irradiation levels on the project site was available, only interpolation from satellite data. On-site data was produced after the bidding closed. However, uncertain estimates of local weather events, soiling and dust may alter significantly the irradiation that actually hits the mirrors.[36]

Currency (FX) risk: As more than 90% of the project debt is in USD while revenues are denominated in INR, a deteriorating exchange rate would seriously affect the ability of the project to meets interest payments and repay its debt.[37]

Capacity shortfall (failure to reach expected clean power capacity): none of the developers awarded with projects in phase one of the solar mission had experience with developing CSP projects of this kind and scale, representing a significant risk that not all the 470MW of solar power will be delivered on time.

4.2 Risk analysis, allocation, and response strategies

In the risk matrix below, we categorize the medium and high risk events identified above according to which of the three major phases (development, operation, and outcome) of a project lifecycle they occur in, identify their bearer and, eventually, map any risk transfer or mitigation that is put in place in the project financing structure. Risks are thus regrouped into:

Development risks cover all the risks incurred before the project begins to operate, including procurement (equipment / technology), construction, and financing.

Operation risks cover all the risks related to project output (production and availability risks), operating costs (notably operation & maintenance risk), and revenues (power price but also all the regulatory and price risks relative to the associated benefits).

Outcome risks cover the risks more specific to overarching public policy objectives and strategic private investor objectives. They include the risk of not meeting renewable energy deployment and emissions reduction targets, the risk of overpaying for incentives, and the risk that growth and jobs co-benefits are not delivered.

The dynamic risk matrix in Figure 4 highlights two aspects of the risk management process: a) risk allocation, how risks are borne and by which stakeholder

32 In a non-recourse project finance loan, in case of default, the lender has recourse only to the assets of the project and not to those of the promoters. Conversely, the borrower can only lose as much equity has been pledged to the project company (Nelson et al, 2012).

33 The PPA document states a 28 months construction period for concentrated solar power projects, starting on the date the PPA is signed. The Government of India granted all CSP plants under the Solar Mission an extension of 10 months, as no plant was commissioned on time.

34 A delay greater than 36 months is considered a cause of default and the PPA is terminated.

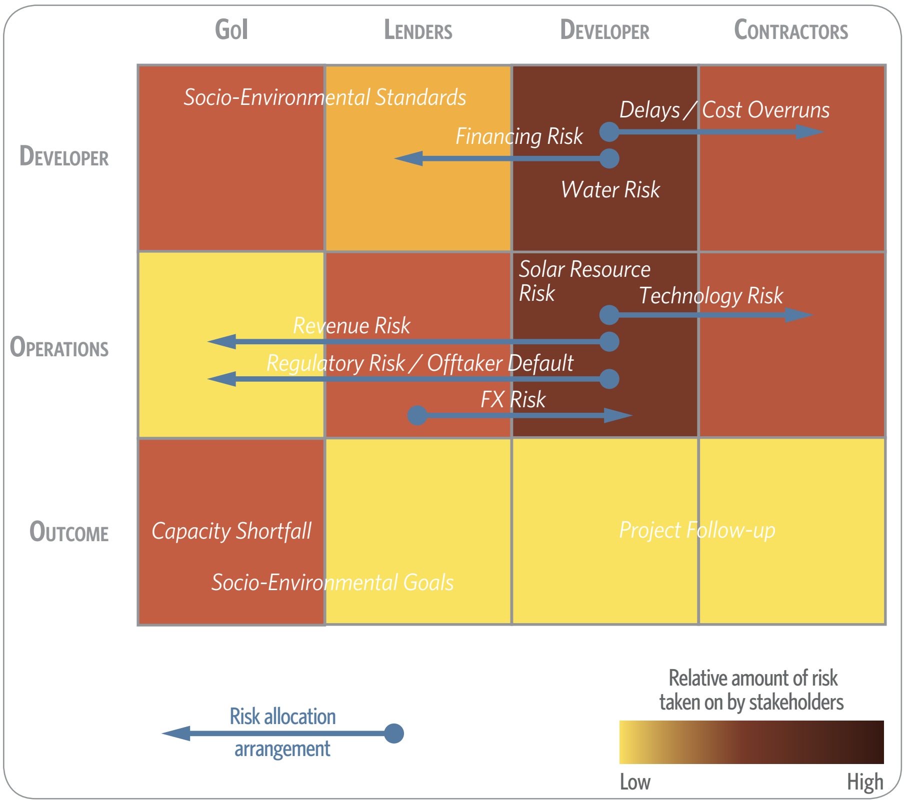
35 Before Rajasthan Sun Technique was commissioned, the largest utility-scale CSP plant using linear Fresnel technology was the 30MW Puerto Errado 2 in Spain, developed by Novatec Solar (http://www.novatecsolar.com/56-1-PE-2.html

36 At the time of writing, data collected on site following the PPA signing date have proved that initial estimates were approximately 10% too high.

37 The Indian Rupee has indeed significantly depreciated since the signing of the PPA: by 12.5% at the time of the financial closing, to more than 25% at the time of writing (December 2013).

at project initiation; b) risk response, how the overall risk profile shifts through the use of risk transfer instruments.

Figure 4: Rajasthan Sun Technique dynamic risk matrix



A close look to the risk allocation arrangements indicates that the private sector carries the majority of risks in the project. The Government of India mitigates the level and uncertainty of revenues through the PPA and carries the risk of building a policy framework (e.g. the National Solar Mission) capable of delivering its economic, social, and environmental goals. The foreign public lenders carry the majority of the financing risks by providing the majority of debt. Once this is done, the project developer and its contractors are able to manage all risks internal to the project.

We focus here on the moderate and high-risk events identified earlier, deemed the most important for the project's viability and its stakeholders' decisions.

Construction delays, cost overruns, and technology failures: these are all risks internal to the project and better managed by the actor with the best information on their probability of occurrence and the best control over their impact. The transfer of all cost overruns and construction delay risks to the sub-contractors seems an effective risk allocation arrangement and is common in this type of project financing. Unique to this project is the willingness of the technology supplier to provide a comprehensive warrantee on the performance of the solar field. The warranty obliges Areva Solar[38] to ensure the expected performance for the plant during the first five years, and, if this is not possible, to compensate the developer for the net present value of the revenue losses for the whole duration of the PPA.

Revenue risk, off-taker and regulatory risk: revenue uncertainty for the investors has been completely mitigated by the fixed, above-market tariff stated in the PPA signed with NVVN. This risk has, however, been transformed into an off-taker default risk and, being tariff supported by a policy decision, into a regulatory risk. The off-taker default is mitigated implicitly by its government backing (through NTPC ownership) and contractually by a letter of credit issued in favor of the project company, while a Collateral Agreement gives the project access to the receivables originated from the sale of power from NVVN to the states' power distribution companies (NVVN, 2010b). Regulatory risk is mitigated by the bundling of solar power with the coal power from the solar reserve that, in fact, eliminates the need a direct subsidy from the budget and aligns the price paid by the electricity distribution companies to the market price.

Solar resource risk: The project has 25 MW of reserve capacity installed that could compensate for irradiation shortfall from the estimated values. However, the financial performance of the plant would deteriorate significantly in case the power generated is lower than 90% of initial estimates[39] (see Appendix B for details).

Financing and currency risk: the risk of capital shortage (due to lack of long-term debt in the Indian financial market)[40] has been mitigated through foreign debt. However, this debt denominated in USD has created

38 There is no formal recourse to the parent company should Areva Solar default on its obligation but a bank guarantee has been pledged.*

39 The PPA also states financial penalties for any power shortfall below a minimum threshold.

40 This is also coupled with the tight sector lending limits for Indian banks that limit their lending capacity to the power sector (NRDC and CEEW, 2012).

a significant currency risk, further increased by the high volatility of the Indian rupee.[41] Neither the project company nor its parent (Reliance Power) appear to be in a good position to manage such risk as the cost of the necessary hedging instruments (cross-currency swap, currency forward) is quite significant and completely erodes the benefit of the cheaper debt. At the time of writing, the project developer has opted for a partial hedging of the currency exposure that, on one side contains the cost of protection, on the other leaves the project partly exposed to the risk.[42]

Capacity shortfall: to mitigate the risk of highly speculative bids or non-committed developers, the government required successful bidders (hence Reliance Power as well) to provide a USD 6 million performance guarantee that would have been lost in case of project's commissioning delayed for more than 3 months (NVVN, 2010b).

41 The currency has showed almost a 10% annualized volatility (measured with standard deviation) since the PPA was signed (CPI elaborations on data from oanda.com)

42 However, Reliance Power is backing the project if financial health deteriorates significantly as a consequence of large devaluation, which has not been very uncommon in the Indian Rupee past history

5. Effectiveness of Rajasthan Sun Technique in reaching policy goals

Indian CSP policy delivered well on price but less well on deployment. By awarding subsidized PPAs through a reverse auctioning system, the Government of India was able to stimulate competition among private bidders, and drive down costs of CSP power to the public relative to other countries and its own reference tariff. However, the deployment targets of the CSP policy were not met, as ambitious time-tables, overestimations of solar resources, and challenges of most developers to source financing and technology led to serious delays.

The subsidized PPAs were not enough on their own to achieve the desired level of deployment. Rajasthan Sun Technique and the only other projects under the NSM likely to be built needed both public financing with long tenors and financially strong private developers to move to completion.

Lessons learnt during this innovative project, the establishment of **a local supply chain** for linear Fresnel technology, and investment in basic **infrastructure** locally mean the project **should contribute to substantial cost reductions in this CSP technology both in India and abroad**.

This section moves from a project to a policy focus and compares the effectiveness of the project's financing and policy support model with other CSP plants in India and worldwide. We focus here on the effectiveness of the project in meeting the following policy goals:

- Quick deployment of clean energy at scale
- Low costs per MW installed and per electricity unit
- Technological innovation, learning and establishment of a local CSP industry, to make CSP competitive in the medium to long term

The effectiveness assessment is preliminary as the plant is not yet operational, so electricity production and operation costs may differ from current estimates.

Comparing the project with other CSP plants in India, with other plants of its size, and other linear Fresnel plants worldwide, the Rajasthan Sun Technique project has effectively delivered several public finance and policy goals: providing clean energy in a short time (goal of the national government) potential cost reductions in CSP technology through pioneering technology and establishing local supply chains (goals of the national government, as well as international public actors,), and keeping costs of deployment low (goal of all stakeholders).

5.1 Effectiveness in speedy deployment

When compared with others internationally, the Rajasthan plant has been very quickly developed and installed: commissioning is planned for March 2014, which would be less than three and a half years after its award in late 2010 and less than two years after financial closure. Other linear Fresnel plants with a size of at least 30 MW (two projects in Spain and Australia) needed at least 1 year more for construction, and no CSP plant with a capacity of 100 MW or more achieved commissioning quicker, see BNEF (2013). Only one plant under the Indian Solar Mission was developed half a year quicker, the Godawari plant, but this plant is half the size (50 MW) and uses a more standard technology (parabolic trough).

It will be only the second CSP plant under the National Solar Mission to be commissioned. When looking at the reasons for deployment, a comparison of the project with other plants under the Nation Solar Mission in India (see Table 6) suggests that the subsidized PPAs offered in phase one of the NSM were not sufficient to deploy the Rajasthan Sun Technique or other CSP plants in India on their own. Only projects with a financially strong developer and public debt with longer tenors have been implemented or are under construction. There is uncertainty about whether other CSP plants will get built at all.

This supports our findings in sections 3 and 4 that both the long maturity debt from foreign lenders and the first-mover strategy of the financially strong developer were essential ingredients for the project. Other plants under the NSM without these ingredients struggled more with the challenges faced by all plants: the sourcing of technology proved to be more difficult and solar irradiation was lower than expected. This may also be an indication that bidders may not have been screened adequately (in terms of experience and

Table 6: Status of large CSP plants in India (all under the National Solar Mission)

DEVELOPER	SIZE (MW)	TARIFF (INR/KWH)	TECH-NOLOGY*	DEVELOPER FINANCIAL STRENGTH / STABILITY	TECHNOLOGY WARRANTIES	DEBT (MAJORITY)	STATUS
Godawari	50	12.20	Parabolic trough	Income of INR 11 billion in 2010/2011	Normal	Domestic, public	Commissioned in June 2013
Reliance Power	100	11.97	Linear Fresnel	Income of INR 28 billion in 2011/2012*	Comprehensive	Foreign, public	Commissioning in March 2014
Megha En-gineering	50	11.31	Parabolic trough	Income of INR 29 billion in 2010/2011	Unknown, likely normal	Domestic, public	Under construction
Lanco Solar	100	10.49	Parabolic trough	Parent company under debt restructuring	Unknown, likely normal	Domestic, private	Delayed, may be cancelled
KVK Energy	100	11.20	Parabolic trough	Parent company under debt restructuring	Unknown, likely normal	Domestic, private	Delayed, may be cancelled
Corporate Ispat	50	12.24	Parabolic trough	Parent company under debt restructuring	Unknown, likely normal	Domestic, public	Delayed, may be cancelled
Aurum Re-newables	20	12.19	Parabolic trough**	Very small company	Unknown, likely normal	Domestic, public	Delayed, may be cancelled

Sources: Aurum Ventures, 2013, BNEF, 2013; D&B; 2011, Godawari, 2013; NRDC & CEEW, 2012; Times of India, 2013a, 2013b; expert interviews.

* None of the plants include technology to store heat for power production later on

** Strong parent company (Reliance ADA had USD 15.4 billion, or INR 950 billion of revenues in 2012).

*** NRDC and CEEW (2012) say 'Linear Fresnel', BNEF (2013), CSP World (2013b) and experts say 'parabolic trough'.

financial backing) before being allowed to participate in the reverse auctioning scheme under the first phase of the NSM.

5.2 Effectiveness in keeping costs low

Compared to other CSP plants internationally, the Rajasthan Sun Technique plant, and the other CSP plants constructed under the National Solar Mission, have been deployed at low cost to the public both in terms of investment costs and electricity production costs. Our estimated investment costs for the Rajasthan Sun Technique plant of around 4,100 USD / MW (100 MW name-plate capacity), or 3,315 USD / MW (125 MW actual solar field capacity), are much lower than the costs estimated by BNEF (2013) for other linear Fresnel plants (>5800 USD / MW) and other large CSP plants worldwide (6400-10000 USD / MW). Similarly low investment costs can be observed for all Indian CSP plants that(3400-5000 USD / MW; 3500 USD / MW in case of the already commissioned Godawari plant). There are three reasons that can explain the low cost if Indian plants: First, the competitive bidding scheme that forced developers to look for cost reductions. Second, the lower cost of labor and manufacturing in India when compared to industrial countries. Third, the exclusion of storage, a typically expensive part of a CSP plant

The low electricity production costs are even more impressive. Rajasthan Sun Technique offered the fourth lowest out of 67 bids under the Indian Solar Mission (Emerging Ventures International, 2011), and the lowest of all plants that will certainly be commissioned (see Table 6).[43] The 11.97 INR (or USD 0.23) per kWh it receives is also very low internationally; it is around one third lower than the past feed-in tariff of 0.27 EUR (or USD 0.36/kWh) per kWh in Spain (CSP Today, 2011) and also below the roughly 2.51 ZAR (or 0.31 USD/kWh) awarded to winning bidders in South Africa (Eberhard, 2013).[44]

At least two plants worldwide have slightly lower production costs according to our knowledge: the first is the 280 MW Solana plant in the USA that receives 0.14 USD/kWh (CSP World, 2013c), and has production costs of around 0.20 USD/kWh when considering the 30% tax credit or cash grant.[45] The second is the

43 It has to be noted that actual electricity production costs in India may be higher as the winning bids suggest; solar irradiation proved to be lower as expected, and the recently published electricity production of the commissioned Godawari plant shows a much lower capacity utilization factor (10%, see ReSolve, 2014) than planned under the NSM (16-25%, see NVVN, 2010b)

44 All USD values are based on the average midpoint exchange rates from Oanda.com for April 2012 date of financial closure, Rajasthan Sun Tech plant). The USD value for the ZAR 2.51 is taken from Eberhard (2013).

45 It is not fully clear whether the plant receives cash grant or tax credits but the developer Abengoa made clear early on that the plant is not viable

160 MW Ouarzazate plant in Morocco that receives USD 0.18 per kWh but this project is co-financed with substantial finance at subsidized terms, so actual production costs are higher, estimated at around 0.22 USD/kWh(see Frisari and Falconer, 2013). It must be noted that these two plants with lower production costs than the Rajasthan plant have a higher capacity (160 and 280 MW instead of 100 MW), so they benefit from economies of scale.

Why has the Rajasthan Sun Technique plant been comparatively cost-effective, particularly in terms of production costs? The use of reverse auctioning in India has led to competition among bidders, which may partly account for the lower cost for tax payers, particularly compared to the case of Spain which employed a fixed feed-in tariff.[46] In addition, the long maturity debt from DFIs can explain lower costs compared to other CSP plants in India. The high share of local manufactured components in the plant, Areva's interest in demonstrating its technology and the strategic, risk-taking behavior of Reliance, also help explain why such a low price was offered.

5.3 Effectiveness in technological innovation, learning, and establishing a local industry

The Rajasthan Sun Technique project may also be effective in making CSP technology more competitive over time for two main reasons: accelerated learning in the case of an innovative technology and local manufacturing.

The Rajasthan plant breaks new ground. It is the world's first linear Fresnel CSP plant with a capacity above 50 MW. It will also be the largest CSP plant in India. Linear Fresnel technology has never been deployed at this scale and had never been deployed in India before. Therefore, the potential for learning is much higher than when investing in more established technologies like parabolic trough or investing in more established CSP markets like Spain. Stakeholders confirmed that substantial learning has taken place in interviews.

Secondly, linear Fresnel is quite a simple technology. Using flat rather than parabolic mirrors and simple steel pipes instead of complex absorber tubes, it has a high potential for local content, and therefore cost reductions due to the low cost of qualified labor in the country. Indian content of the Reliance plant is 61-71% according to CPI estimates (see Appendix C), so considerably higher than the 30% required under the NSM, slightly higher than the 40-65% in the Ouarzazate plant (Muirhead, 2013, Frisari and Falconer, 2013), and probably also higher than local content of most PV plants in emerging economies (except China). [47] Local content could even rise to 71-81% if mirrors are produced locally, which is expected from a capacity of 500 MW onwards, so cost reductions due to local manufacturing could be even higher. **Local manufacturing is also an important goal for the Indian government, and it helps to improve competitiveness of the Indian solar industry.**

One drawback in terms of technological innovation is that neither the Rajasthan Sun Technique plant nor any of the other projects under the Indian NSM includes technology for storing heat and therefore cannot deliver power on demand, a key advantage of CSP over other renewable energy technologies. The lack of storage is not just due to a lack of incentives for energy storage in phase one of the NSM but also because the lack of peak pricing at the national level in the Indian power market makes it less attractive for project developers to include it.[48]

without this subsidy (Fehrenbacher, 2008).

46 The plant also benefit from a slightly higher solar irradtiation (DNI of 2200 kWh/m2/year) compared to CSP plants in Spain (DNI of 2000-2100 kWh/m2/year, see CSP Today, 2012)

47 In South Africa, local content of PV plants is assumed to be between 40-50% although this is projected to raise (EScience Associates et al. 2013, pp. 129). In India, thin-film plants were exempted from any local content rules under the National Solar Mission, and have dominated the second bidding round (Johnson, 2013). If cells are imported, PV plants in India will at best achieve a local content of 58%, according to norm costs (CERC, 2013)

48 In South Africa, reverse auctioning without storage incentives (windows 1 and 2) resulted in plants with storage but South Africa has a power market with an evening peak price.

6. Replicability and scalability

If reverse auctioning is used to scale-up CSP in India in future, some design changes could improve the likelihood that successful bidders build the plants.

The Rajasthan Sun Technique financing model that heavily relies on foreign public debt is replicable but more local private financing has to be secured for scaling up CSP in India.

International donors and development banks can accelerate scale up of CSP by supporting interested governments in policy design, taking on part of the costs, and demonstrating the feasibility of innovative technologies (including storage) to local investors.

As shown in the previous chapters, the Rajasthan Sun Technique project's quick and effective implementation relies on four elements in the financing structure: Subsidized PPAs with government-owned entity, awarded through a reverse auctioning scheme and backed by a government payment security scheme; international public finance with longer maturity than local debt, including debt from an export credit agency; experienced and financially strong private developers; and comprehensive technology warranties.

This section asks if this structure can be replicated in other geographies or used to scale up CSP in India where the government has advanced plans to support 1-3 GW of CSP in phase two of the NSM.[49] The next section discusses the potential for replication and scale-up, and how to overcome the main barriers.

6.1 Evidence for replication and scale-up potential

Use of the same project financing model in other contexts may be an indicator for replication and scale-up potential in emerging economies. At the time of writing, several elements of the Rajasthan Sun Technique project model have already been applied in other emerging economies and for other CSP technologies (see Table 7). Experience elsewhere suggests that the public foreign capital that dominates the Rajasthan financing model may be replaced by private capital in cases where a

Table 7: Large CSP project in emerging economies using a similar financing structure as the studied project

NAME OF PLANT	COUNTRY	TECHNOLOGY	FINANCING STRUCTURE	MAIN PUBLIC POLICY
Rajasthan Sun Tech.	India	Linear Fresnel	Foreign public non-subsidized debt (majority)	Reverse auctioning
Godawari Parewar	India	Parabolic trough	Local public, non-subsidized debt (100%)	Reverse auctioning
Megha Engineering	India	Parabolic trough	Local public, non-subsidized debt (100%)	Reverse auctioning
KaXu Solar One	South Africa	Parabolic trough	Public-private (50-50)non- subsidized debt	Reverse auctioning
Khi Solar One	South Africa	Power tower	Local and foreign public, non- subsidized debt	Reverse auctioning
Bokport	South Africa	Parabolic trough	Private non-concessional debt (majority or 100%, not fully clear)	Reverse auctioning
Ouarzazate 1	Morocco	Parabolic trough	Foreign public subsidized debt (100%)	Competitive bidding
Shams	United Arab Emirates	Parabolic trough	Private debt	Competitive bidding

Note: Plants under the NSM where completion is uncertain are not included.

49 According to interviews, the responsible ministry plans to allocate 30% of the 4-10 GW solar power target under phase 2 of the NSM to CSP. According to the website of the responsible ministry, 2.7 GW of CSP are planned in phase two.

technology is already well-known (parabolic trough) and the financial market provides debt with long-term tenors (South Africa, United Arab Emirates). A replacement of auctioning/bidding with feed-in tariffs is theoretically possible but has never been applied in emerging economies, probably due to fears of over-subsidization.

6.2 Overcoming barriers and realizing the scale-up potential in India

Three strategies may help to unlock the potential of the Rajasthan Sun Technique CSP financing structure in India, by overcoming the major political and financial barriers.

Well-designed and internationally supported national CSP policies

The scale up of CSP in India may be slowed by limited willingness to provide subsidies for renewable energies. Other countries' experience suggests that issuance of subsidized tariffs for high-cost solar energy forms is restrained by the fiscal situation of a country (see Spain) or resistance of the energy consumers to pay higher bills (see Germany). In this regard, it will be important to keep costs for the public per installed CSP unit low.

To keep subsidies low, it seems promising to use either reverse auctioning, as in phase one of the NSM (see our analysis of the NSM's low costs in section 5), or another competitive scheme to award subsidies, e.g. competitive bidding for single CSP plants, which has led to lower electricity tariffs than expected in Morocco (see Frisari and Falconer, 2013). However, our analysis of the Rajasthan Sun Technique plant also clearly shows the shortcomings of the auctioning scheme under the NSM in terms of deployment and missing energy storage, so policy makers are advised to undertake the following two improvements:

- **Re-designing auctioning to improve the likelihood of project implementation.** Under the first CSP bidding round in India, implementation of projects has been delayed. Only three out of seven plants are expected to be built (see section 5).The delays were linked to overestimation of solar resources and underestimation of technology risks by bidders. The less delayed projects, including Rajasthan Sun Technique, were able to handle these risks due to financially strong private actors and long-tenor public debt (see section 5), but they were delayed as well. A re-design of the auctioning scheme could increase the likelihood that bids come from project developers that are financially strong and have access to long-tenor debt increasing the likelihood of project implementation. Interviews with developers and investors suggest the following additional improvements: more time for bidding and arranging financing (to allow for better cost estimations), stricter requirements for bidders in terms of financing and experience with CSP, allowing sufficient time for construction and then enforcing penalties more strongly for delayed projects, and better availability of solar irradiation data, particularly on-site measurement of direct irradiation over at least one year.[50]
- **Incentivizing storage if there are benefits for the national power system.** In the first round of bidding in India, none of the plants included storage (see section 5). However, storage is the key advantage of CSP over other renewable energy technologies (particularly solar PV power which is often cheaper than CSP), as it can help to bridge gaps in a power system dependent on more reliable and peak power supply (see Stadelmann et al. 2014).[51] Therefore, it may be advisable to promote storage, either through a separate bidding window or incentives for storage in the standard auctioning process. Incentives for storage are planned under phase two of the NSM.
- **Bringing in international expertise to help improve the design of policies.** The first round of reverse auctioning has shown that substantial room for improvement exists and international expertise is now sought for the next round of CSP bidding in India (see ADB, 2013b).

In the short to medium term, development finance institutions should step up their support to cover part of the viability gap to enlarge programs. International debt at subsidized terms or direct grants may incentivize India to increase support for CSP or other countries to set up new CSP programs. DFIs may feel that such

50 In fact, the government has already invested in the construction of several weather stations scattered across the country's territory to produce on-site actual irradiation measurements, thereby mitigating the resource risk in phase two of the National Solar Mission.

51 India may both have an interest in both baseload and peak load power. In the case of baseload power, the country struggles to source enough domestic coal its main baseload power fuel (see introduction). In the case of peak load, there is a peak load demand-supply gap of up to 10% countrywide (CEA 2012).

support is warranted due to the global economic and environmental benefits of CSP technology development and the need for stronger policy signals to build up a local CSP industry (as interviews with developers and investors suggest).

Tools to hedge foreign exchange risks and stimulation of local private investment

From a financing perspective, a scale-up of CSP in India may face the problems of foreign exchange risks, limited availability of foreign debt from development finance institutions, and high costs / low availability of local commercial finance. The chances of financing similar plants will increase, if the following measures are undertaken:

- **Assist hedging of foreign exchange (FX) risks.** When using debt from international DFIs denominated in foreign currency, project developers face substantial foreign exchange risks that require hedging on the market which are costly, especially for long-term debt. Assistance for hedging FX risks will improve the likelihood of reaching financial closure and might also reduce the final tariff charged by the developer. National governments can address this risk by partially denominating power tariffs in hard currency (see Nelson and Shrimali, 2014), and DFIs can do the same by lending in local currency.
- **Stimulating the switch to local financing.** A similar share of foreign public debt would not be possible for all CSP projects in India, as DFIs limit their exposure to specific sectors and countries,[52] and debt from export credit agencies is limited to projects using technology from specific countries. Therefore, the sooner local banks increase their debt investment in CSP at acceptable terms the quicker CSP could be scaled up in India. However, local debt has high costs, compared to other countries (Nelson et al. 2012), and the appetite of local commercial banks to finance CSP in India is limited.[53] The national government could stimulate investments through low-cost debt (see Nelson and Shrimali, 2014). International actors can support the provision of local financing in several ways. For instance, by enabling the set-up of pilot projects to improve banks' confidence in innovative and promising technological configurations (e.g. storage),[54] building local banks' knowledge of CSP technology, and providing them with credit enhancement to make them more comfortable with CSP investments.

Ensure scale and local manufacturing to enable learning and cost reductions

A substantial cost decrease in CSP technology will reduce several risks for scale up of the Rajasthan Sun Technique model, such as the need for high subsidies or high risk-taking by developers and technology providers. Policy makers can support cost decrease through:

- **Increasing the scale of CSP deployment.** The more CSP plants are planned, installed and operated, the more technology providers, developers, and policy makers will learn and the costs of CSP will decrease. Increased scale also decreases costs through economies of scale related to infrastructure and local supply chains.[55] While such cost decreases in CSP technology have not been observed on a global level, they are seen on a sub-technology and a country level (Stadelmann et al. 2014), indicating that costs have already begun to come down as a consequence of larger deployment.
- **Promoting local manufacturing.** One of the reasons for the success of the Rajasthan Sun Technique plant is the high percentage of local content. This has directly reduced project costs but also enabled knowledge transfer and local learning, which may lead to higher efficiency in the future. According to expert interviews, a scale up of linear Fresnel to 500 MW in India may secure local production of mirrors in

52 The World Bank and the ADB, the most prominent international financial institutions in India, invest around USD 1.1 billion in the energy sector of South Asia (Afghanistan, Bangladesh, Bhutan, India, Pakistan, Sri Lanka), see World Bank (2013) and ADB (2013c) . This means they would need to invest six years' of all energy finance in South Asia in CSP in India, to finance the debt needs of the 2700 MW of CSP planned under phase two (2013-2017) of the National Solar Mission (SECI, 2014). Debt needs for the 2700 MW are around USD 6.6 billion, assuming 70% debt share in project finance and investment costs of 3500 USD/MW.

53 The involvement of Axis Bank as only local lender in the project seems to be more linked to existing institutional ties with Reliance Power than to appetite for the project; and the loan is also too limited in size to be decisive.

54 ADB's plan in India is capacity building and a combination of ADB and CTF debt finance to build two demonstration CSP plants with a capacity of 50 MW each until 2017, see ADB (2013b). Selection of technology remains underway in consultation with SECI and other stakeholders.

55 ESMAP (2013) projects a cost decrease of 8-14% for linear Fresnel from 2010 to 2020, 11-19% in case of parabolic trough and 21-33% in case of central receiver plants.

India, therefore, increasing certainty regarding long-term CSP policy support may be a promising way to promote more local manufacturing. The alternative solution – minimum local content requirements – has major drawbacks. It may lead to sub-optimal efficiency of plants, and contradicts the internal competition policies of DFIs which are important debt providers for CSP in the medium term.

7. Conclusion

This paper is part of a larger project for the Climate Investment Funds that analyzes which forms of public finance and policies can enable the scale up of CSP as a promising but high-cost clean energy technology. CSP has not been deployed at the scale of other renewables, and costs are still high. Therefore, more deployment experience is needed to increase learning and make the technology more competitive. The novelty and high cost of CSP implies a double challenge: the cost of public subsidies can be high, and private investors face substantial investment risks.

This case study focuses on the Rajasthan Sun Technique CSP project in India, as an example of an innovative CSP plant that enjoyed relatively quick and effective financing and construction at low cost to the public.

According to our analysis, four elements enabled the plant. First, the subsidized PPA with a government-owned entity closed most of the viability gap, and the government's payment security scheme reduced the risks that the PPA price will not be paid. Second, international public debt had longer maturity than local debt and, thereby, improved the project economics and made the project attractive to the developer even at the very low PPA tariff. Third, the comprehensive warranties of the technology provider, who has a vital interest in demonstrating linear Fresnel CSP plant at utility scale, reduced the technology risk for both the developer and the investors. Finally, the experienced and financially strong private developer was willing and able to cover the remaining risks even though the project's equity returns are not very attractive, because of its first-mover strategy to enter the Indian CSP market.

Under phase one of the National Solar Mission, costs for the public were comparatively low but the reverse auctioning scheme did not perform as expected in terms of deployment. None of the winning bidders implemented their plants on time, and only 2-3 plants with financially strong developers and public debt providers, including the analyzed Rajasthan Sun Technique plant, will meet the extended commissioning deadline. One potential explanation for this suboptimal deployment effectiveness is the 'winner's curse'. In the case of a technology like CSP that is not widely deployed, costs and risks are highly uncertain. Winning bidders may, therefore, be the ones that have substantially underestimated costs and/or overestimated returns, leaving them unable to build the plants. The underestimation of technology sourcing challenges and the overestimation of solar resources are indicators for such a winner's curse, but the case of the Rajasthan Sun Technique plant also shows that some winners may have simply bid very low due to a first-mover strategy.

If policymakers want to scale-up CSP in India or replicate the project model in other countries, our analysis suggests the following policy recommendations on revenue support schemes and financing models:

- If reverse auctioning is used for future scale-up of CSP in India, its design can be improved in order to increase the chances that winning bidders build plants. Better solar data at the time of bidding, increased time for submitting bids and construction plants, combined with enforcement of penalties if plants are not built on time, and strengthening of the requirements for participating in the bidding may help in this regard. National policymakers could consult international experts to help with the above.
- To stimulate innovation policy makers may need to provide incentives or special bidding windows for technological specifications that were not promoted under the first phase of the NSM. For example, if a country struggles to source evening (peak) and night-time (off-peak) power, it may be advisable to promote storage - a key advantage of CSP over other renewables.
- In the long-term, scale up of CSP in the country will require a shift to domestic investments, as development bank and export credit financing is limited. Policy makers can stimulate this transition by providing low-cost local public debt (see Nelson et al. 2012), building capacity at private banks, using credit enhancement tools and setting up pilot projects for innovative technologies to improve investor confidence.
- As long as local financial resources with long tenors are not yet sufficiently available and foreign capital, including DFI debt, remains important for technology development, policy makers should consider how to address foreign exchange risks. Policy makers can, for example, reduce foreign exchange risks by providing revenues partially in hard currency (see Nelson and Shrimali, 2014).

An upcoming SGG case study on a South African CSP plant will help analyze whether these policy recommendations are valid beyond the Indian context. We will distill the lessons from this case study, the one in South Africa and a previous one in Morocco (Falconer and Frisari, 2012) in a lessons learned paper.

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9. Appendices

Appendix A: Key features of National Solar Mission's CSP policies

FEATURE	OBJECTIVE
Reverse auction/ competitive bidding	The auctions followed the pay-as-you-bid mechanism in allocating capacity to procure solar power in a cost-effective manner.
Long-term PPA	All projects commissioned under phase one could get a 25-year PPA to provide long-term revenue certainty to solar power generators..
Guaranteed offtake	Phase one projects were guaranteed offtake from NVVN to provide offtake guarantee for the solar power generated. NVVN will act as an agent of Ministry of Power,.
Payment Security Scheme (PSS)	The PSS ensured financial closure of projects sanctioned under phase one to provide partial payment security for solar project developers in the case of default by state distribution utilities
Bundling of power	NVVN will re-sell the solar power procured to distribution utilities at a lower cost after bundling it with the available cheaper coal power to make the relatively expensive solar power affordable to distribution utilities.

Note: Under the bundling mechanism, the designated agency for phase 1 projects – NVVN, will purchase solar power from developers (projects connected to the grid at 33kV and above) and sell it to distribution utilities after bundling with power from unallocated quota of NTPC coal stations at the rates notified by the CERC

Appendix B: Risk Analysis Sensitivity Tables

We measure the impact of moderate and high risks events by measuring the sensitivity of the project's key financial metrics to the variation of certain projects inputs. We calculate here the impact of these uncertain inputs on the equity internal rate of return (EIRR), as a measure of the project's attractiveness for the equity holder, and the debt service coverage ratio (DSCR)1 as a measure of the project's ability to meet its debt payments. We compare the resulting "tilted" metrics with the yield of the 10 year Indian Government bond as a measure of risk-free investment (8% in January 2011 when PPA was signed) (TradingEconomics, 2013), and with the minimum threshold of 1 for the DSRC (below that value the project would fail to meet its payments).

Revenues risk: The PPA with NVVN locks the tariff at INR 11.97/kWh for the entire life of the project (25 years). However, significant delays on the commissioning of the plant can trigger a renegotiation of the tariff (NVVN, 2010), reducing the price advantage of the solar thermal plants.

Table B1: Sensitivity test of project's financial performance to different levels of revenues

TARIFF CHANGES	REFERENCE	-10%	-20%
Equity IRR	12.1%	8.1%	4.3%
DSCR	1.20	1.06	0.93

Source: CPI elaborations

Solar irradiation risk: Data has already proven to be very uncertain compared to initial satellite estimates. Though the 25MW of reserve solar capacity installed should compensate this uncertainty, we here model the impact of further reductions, possibly due to "exceptional" weather regimes.

Table B2: Sensitivity test of project's financial performance to different levels of power generation

GENERATION SHORTFALL	REFERENCE	-10%	-20%
Equity IRR	12.14%	8.20%	4.43%
DSCR	1.20	1.06	0.93

Source: CPI elaborations

Our simulations show that with a 10% reduction of the tariff or of the power generated the attractiveness of the project for the developer is greatly reduced but interest payments are still met. At 20% reduction of the tariff (INR 9.5 /kWh) or of the power generated, the project has no longer any investment appeal (being much lower than the risk free rate), and just meets its debt repayments.

FX Risk: Scenario analysis applied to different possible currency devaluation levels yields an interesting observation: the cost of the currency hedging on project's profitability is so significant that the hedging strategy (partial or full) is the one with the highest payoff only if a currency devaluation greater than 50% is expected.

EQUITY IRR (BEFORE TAX)	NO HEDGING	60% HEDGING	FULL HEDGING
no change	18.2%	12.1%	8.7%
10%	16.1%	11.4%	8.7%
20%	14.1%	10.7%	8.7%
30%	12.2%	10.0%	8.7%
50%	8.8%	8.8%	8.7%
100%	2.7%	5.9%	8.7%

1 Debt service coverage ratio measures the ability of a project to meet its periodic debt repayments with the free cash flows generated during the regular operation of the asset.

Appendix C: Estimation of local content of Rajasthan Sun Technique CSP plant

ELEMENT	% OF PROJECT VALUE	SOURCING	% OF LOCAL VALUE
Solar field	70%	India/Import	46-56%
Solar collection system	52%	India/Import	39%
Support structures	23%	India	23%
Assembly & facility	9%	India	9%
Foundations	3%	India	3%
Land leveling	5%	India	5%
Drive Mechanisms	3%	Import	0%
Mirrors	10%	Import	0%
Thermal Conversion System	19%	Import/India	7-17%
Receiver Tubes	14%	Import/India	2-12%
Piping, valves, spare parts	3%	India	3%
Natural gas boilers	2%	India	2%
Thermal storage	0%	n/a	0%
Electrical Conversion System	30%	Import/India	15%
Steam turbine	15%	Import	0%
Civil work	4%	India	4%
Balance of Plant	10%	India	10%
Total	100%	India / import	61-71%

Source: ESMAP, 2013; expert interviews

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