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De-risking concentrated solar power in emerging markets: The role of policies and international finance institutions

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HIGHLIGHTS

- We analyze the financial model of two large-scale concentrated solar power (CSP) plants in two emerging markets (India and Morocco).
- We focus on the role of policies and public finance in reducing investment risks and generation costs.
- Development banks' concessional loans can reduce the weight of CSP support on public budgets.
- Even when non-concessional, development banks' loans can reduce investment costs by extending debt maturities.
- Competitive tariff setting mechanisms can ensure cost-effectiveness of public financial support.

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ABSTRACT

Concentrated solar power (CSP) is a promising technology for low-carbon energy systems, as combined with thermal storage it can store solar energy as heat, and deliver power more flexibly and when most needed by the grid. However, its high cost prevents its rapid deployment and affects its affordability in emerging economies. International financial institutions (IFIs) have emerged as key players to enable CSP in emerging economies, especially when cooperating with national policymakers. Through the analysis of two CSP plants in India and Morocco where IFIs provided the lion's share of finance, this paper aims to assess the effectiveness of their support and estimate the impact of IFIs financing on electricity production costs and mobilization of private investments. The two case studies show that public financial institutions can play a leading role in reducing the cost of CSP support on public budgets by providing concessional loans in countries where public and/or private finance would be too expensive, or extending maturities where commercial investors are present but poorly suited for project finance. Finally, we show that, combined with competitive tariff setting mechanism (tenders and auctions), public financial support can also be a cost-effective tool to engage private investors in CSP.

1. Introduction

Concentrated solar power (CSP) is a promising energy technology for low-carbon energy systems, as, in combination with thermal storage; it can store solar energy in the form of heat and therefore deliver clean power as peak or base load while increasing energy security and grid stability. This is especially valuable in energy systems with a high penetration of fluctuating power from solar photovoltaic and wind technologies (IEA, 2010, 2014; Jorgenson et al., 2014).

CSP has particular potential in some emerging markets that are planning to use their high solar irradiation for power production: in a carbon-constrained energy scenario, the IEA expects CSP to supply approximately 11% of global electricity by 2050, with more than 65% of CSP capacity installed in countries such as Africa, China, India, and MENA (IEA, 2014). Many countries in these regions are building or planning to build CSP plants. China is currently planning its first CSP plants (BNEF, 2014), India plans to deploy 20 GW of solar power by 2020 (MNRE, 2013), South Africa has ambitious plans to deploy 30 GW of renewable energy by 2030, including 3.3 GW of CSP (DoE, 2013), and several countries in the Middle East and Northern Africa (MENA) have plans to deploy CSP, Morocco is advancing towards 2 GW of CSP before 2020 (Norton Rose, 2010), and Saudi Arabia announced a target of 20 GW of CSP by 2030 (KACARE, 2013).

Massetti and Ricci (2013) model that up to 2500 GW of CSP could be installed in China and 1500 GW of CSP in the MENA region by 2100, requiring around USD 250 billion of annual

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investment in CSP in the latter region. In case of stringent climate policies, the MENA region may even export CSP electricity to Europe (Bauer et al., 2008), up to 750–800 GW[1] by 2100 (Massetti and Ricci, 2013).

However, the high cost of CSP is the main barrier to rapid deployment. The difference between the cost of generating power from CSP plants (around 0.2–0.3 USD/kWh, see IRENA, 2013) and the revenues that project developers can make in the electricity market –the financial viability gap – is substantial: 98% of investments in CSP so far have needed some form of public support in both developed and developing countries (Stadelmann et al., 2014a). Further deployment is expected to reduce costs. 5–15 GW of new CSP capacity in addition to the existing 3 GW may enable enough economies of scale and learning to bring CSP costs down to a level where the technology could compete with other sources of power in several markets (Stadelmann et al., 2014c).[2] Currently, each GW installed demands up to USD 10 billion of investment (IRENA, 2013); however these costs are projected to fall below 2 billion/GW from 2050 on (Massetti and Ricci, 2013).

While CSP's investment costs are higher than many low-carbon alternatives, so is its value to the grid given the technology's potential to deliver power flexibly when it is most needed (e.g. at peak load times) and more reliably than fluctuating renewable energy sources such as wind and solar photovoltaic (PV). Although estimating CSP's value to a particular power system requires granular data of local power generation settings and demand patterns, Jorgenson et al. (2014) suggest that CSP's added value, measured as *operational value* (the value of avoided cost due to conventional generation with fossil fuels) and *capacity value* (the value of avoided new capacity built to meet current demand), can be significantly higher than solar PV (given an equal solar resource available) and increases when renewable energy penetration is higher. Policymakers drafting support measures for CSP should keep in mind that most of this added value is due to CSP's potential for storage.

Beside technology costs, in emerging and developing economies in particular, investors face acute technology, regulatory and financing barriers (Stadelmann et al., 2014c).The limited experience with CSP in many of these countries increases technology risks, including the risk of solar resources being lower than predicted. Komendantova et al. (2011, 2012) identified regulatory and political factors as the main risks increasing the financing costs of solar power investments in North Africa. In addition, CSP projects face further financing risks in these countries as their financial markets are often not fully developed or well suited for project financing, offering high interest rates and short maturities on debt (Nelson et al., 2012; Stadelmann et al., 2014b). Despite this literature on risk perception and investment challenges, little has been written about the nature of de-risking tools for CSP investments and the impact they could have on the cost of CSP power, by reducing investors' required returns and lenders' interest charges. Komendantova et al. (2011) suggest that policies can mitigate these risks, thereby reducing required rate of returns on investment and saving up to an estimated USD 200 billion of subsidies in the North Africa region. Trieb et al. (2011) suggest long-term power purchase agreements (PPA) based on peak power prices as way to reduce risks and bring CSP closer to the market.

International financial institutions (IFIs) have emerged as key public players to enable CSP in emerging economies: they have invested more than 2 USD billions of low-cost and long-term loans in CSP plants in Chile, India, Morocco and South Africa (Boyd et al., 2014; Falconer and Frisari, 2012; Stadelmann et al., 2014b); and their low-cost and long-term loans have proven their potential to substantially reduce the required subsidies for renewable energies (Nelson and Shrimali, 2014; Shrimali et al., 2014). However, the literature has not yet answered the following two questions: (1) how effective are IFIs in reducing risks and costs of CSP in emerging economies? and (2) how can these IFIs' efforts be combined with national policies to enable effective deployment of CSP and relieve some of the financial burden on developing countries' budgets?

This paper addresses these questions by analyzing the financial structures and risk profiles of two CSP plants in India and Morocco where IFIs provided the majority of investment capital. We assess the effectiveness of IFIs' and national policy makers' de-risking in reducing the plants' electricity production costs and their ability to mobilize private investments, that will need to provide most of the capital needed for future CSP plants (Komendantova et al., 2012; Stadelmann et al., 2014b). For this purpose, we employ project finance models based on discounted cash flow analysis, and a stakeholder-centered approach for valuing investments' drivers, risk perception and mitigation, based on both direct interviews and discussions of our findings.

2. Methodology and data: the case study approach

We carried out our research through systematic analysis of two large-scale CSP case studies: the 100 MW Noor 1 project in Morocco, and the 100 MW Rajasthan Sun Technique project in India, both involving national and international public actors that successfully drove private investments. Both these projects offer interesting insights in shaping support policies for a still immature technology like CSP in developing markets with significant solar resources and the need for a more stable and dispatchable source of low-carbon power. The case of Noor 1 in Morocco provides a testing ground for a public-private partnership (PPP) model applied to a renewable technology with a significant viability gap and upfront investment needs that neither the domestic financial sector nor foreign private investors can manage alone. In the India project, the private sector played a more proactive role under an Independent Power Producer model (IPP), while still leaving to public policymakers and public financial institutions the crucial role of mitigating market and revenues risks and of overcoming the specific limitations of the domestic private financial sector. Finally, both case studies provide interesting evidence on the amount of cost reduction achievable for CSP energy when projects are allocated through competitive auctions and tenders.

The case-specific approach allows an in-depth analysis of the drivers of investment decisions and the challenges that determine the outcome of actual policies and the effectiveness of IFIs investment programs implemented in emerging countries. Eliciting investors' preferences and behaviors through questionnaires and interviews (Waissbein et al., 2013) allows us to compare them with analysis of the financial results of their decisions and their direct impact on the costs of policies for public budgets. However, the focus on individual cases means the findings are less applicable beyond the specific context of the single projects.

When publicly available, we performed the analysis on projects' documentation and financial data, and complemented it with information provided directly through interviews with 7 private (developers and lenders) and 12 public (government officials and IFIs officers) project stakeholders and industry representatives (producers, consultants, trade associations).[3] Finally, we used

[1] 750–800 GW is the capacity corresponding to 3000–3200 TWh of CSP power exported to Europe per year.

[2] As comparison, already 90 GW solar photovoltaic and 270 GW wind power plants are on the grid (Stadelmann et al., 2014a).

[3] In the case of the Noor 1 CSP case study, we interviewed 3 private sector representatives (AcwaPower, Archimede Solar Energy and Enel Green Power), 4 representatives from public lenders (African Development Bank, KfW and World Bank) and 2 representatives from the national solar energy agency (MASEN). In case of the Indian case study, we interviewed four private sector representatives