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The Role of Public Finance in CSP: Lessons Learned

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Related CPI Reports	San Giorgio Group Case Study: Ouarzazate I	
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	The Role of Public Finance in CSP - Case Study: Rajasthan Sun Technique	

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About CPI

Climate Policy Initiative is a team of analysts and advisors that works to improve the most important energy and land use policies around the world, with a particular focus on finance. An independent organization supported in part by a grant from the Open Society Foundations, CPI works in places that provide the most potential for policy impact including Brazil, China, Europe, India, Indonesia, and the United States.

Summary

Concentrated solar power (CSP) is a promising technology for low-carbon power generation. Thanks to abundant solar resources in the world's sun belt and its ability to provide flexible and reliable power supply when combined with thermal storage, CSP could play an important role in maintaining a steady power supply in future low-carbon energy systems with high penetrations of fluctuating renewable power from solar photovoltaic and wind.

The barrier preventing further CSP deployment is cost. Currently, due to a lack of deployment it is a higher risk, higher cost investment than available alternatives. However, our analysis shows that **if international finance institutions (IFIs) and committed national governments joined forces to deploy 5-15GW of CSP, it could reduce its electricity production costs by around 14-44% and make CSP competitive in countries like Morocco and South Africa**, providing increased energy security and affordable power to drive their growing economies and positioning them as market leaders in a promising technology.

National policymakers choosing to support the deployment of CSP can ensure they achieve their policy objectives more effectively and at lower cost by considering the following lessons learned from our analysis of the CSP markets and projects in key countries:

- Provide sufficient financial support to drive deployment
- Ensure that support can be sustained over time to avoid boom and bust
- Design policy to ensure the cost of support falls to reflect decreasing technology costs over time
- Align public and private actors' financial interests to reduce the perception of policy risk and the cost of renewable energy support
- Make reliable on-site solar irradiation data available
- Consider low-cost and/or long-term debt as one of the cheapest ways for national governments to support renewable energy deployment
- Move away from flat power tariffs to remunerate the flexible power supply provided by CSP to more accurately reflect its benefit to the energy system
- Longer-term more private and local debt is needed to secure long-term financing and reduce currency risks

CSP needs international financial resources that can be concentrated on specific technologies. This international public finance is best used:

- In countries committed to harnessing their solar resources that are unable to bear the full cost due to weak capital markets and no CSP experience
- For early stage CSP technologies with high investment risks but great potential for cost reductions or energy system benefits to mitigate those risks the private sector is unwilling to bear.
- To provide knowledge on policy tools and technology to local policymakers

IFIs can improve the effectiveness of this support in the following ways:

- Consider adjusting loan requirements according to the technology maturity
- Harmonize loan and regulatory requirements when groups of institutions lend to large CSP projects
- Reduce foreign exchange hedging costs of IFI loans for developers

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 to deliver clean power when it is most needed. The abundance of solar energy resources at the global level distinguishes CSP from other renewable technologies that can store energy and mean it has the potential to play an important role in a future energy system by providing reliable and flexible source of power to complement high penetrations of fluctuating output from cheaper but non-dispatchable wind and solar photovoltaic technologies.

The high cost of CSP is the main barrier to rapid deployment. Currently, all CSP plants worldwide total just 3GW in capacity[1] and the difference between the cost of generating power from CSP plants and the revenues that project developers can make in the electricity market is substantial. To support the scale-up of CSP and thereby drive down its cost, policy makers have to allocate significant shares of public budgets or rate payer's money to fill this 'viability gap'.[2] The reliance of projects' profitability on public resources increases the risk that policy changes might hit project returns resulting in the perception of high policy risk by investors. Furthermore, CSP costs are heavily concentrated at the beginning of the investment phase. The high initial investment makes it more difficult to access enough capital at an affordable cost.

In emerging and developing economies in particular, investors face challenging technology, regulatory and financing barriers. The limited experience with CSP in many of these countries increases technology risks, including the risk of solar resources being lower than predicted. In emerging and developing economies, regulatory risks are also high, increasing the financing costs. Finally, CSP projects face additional financing risks in these countries as financial markets are often not fully developed, and compared to more developed financial markets interest rates on debt can be high and debt maturities short.

1 Compared to 90 GW of solar photovoltaic and 270 GW of wind (Stadelmann et al, 2014a).

2 By viability gap we mean the difference between costs and market revenues. This is a private company perspective of a viability gap. For public entities, the viability gap can refer instead to the difference between CSP and other electricity generation costs. From this perspective, the public viability gap may be lower, particularly in countries where, due to regulation, current electricity prices are lower than marginal electricity generation costs. Unless stated otherwise, in this brief viability gap refers to the private sector's perspective.

To improve knowledge on how to address these barriers, the Climate Investment Funds (CIF) asked Climate Policy Initiative (CPI) to answer the following research questions:

- When is public support needed for CSP?
- How effective and cost-effective are different policy tools in deploying CSP?
- How can international public finance best support national policy efforts in emerging economies?
- How can public support drive cost reductions and ensure scale up?

This policy brief summarizes the main lessons learned on effective public support for CSP. They are based on comparative analysis of financing and policy models across the globe, three case studies of projects in Morocco (Ouarzazate I), India (Rajasthan Sun Technique), South Africa (Eskom) and one of Spain's CSP market, and three expert workshops ('dialogues') to share findings and promote discussions among key public and private CSP stakeholders.

When is public support needed for CSP?

Across the world, all CSP technologies[3] need some form of public support to close the viability gap. Our case studies show that different policymakers have employed different instruments to do this[4] but the need is global. More than 98% of all the CSP plants built by 2012 required public support. Current carbon market prices reduce but do not eliminate the viability gap for CSP.

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In addition to closing the viability gap, public support is particularly warranted where specific risks or knowledge gaps hinder investments as in the following cases:

3 The main CSP technologies to concentrate sunlight in order to generate electricity are parabolic trough, linear Fresnel, and power tower.

4 These include fixed feed-in tariffs or premiums in Spain, subsidized power purchase agreements (PPAs) in India, Morocco and South Africa, or grants, tax credits and public guarantees and low-cost loans in the US.

- **Early stage CSP technologies with high investment risks but great potential for cost reductions or energy system benefits.** Closing the viability gap is the main role for public CSP support in countries with fully developed financial markets, and for widely deployed CSP technologies (e.g. parabolic trough). Instead, additional interventions are needed to mitigate risks of or provide knowledge on early stage technologies. Some early-stage CSP technologies have great potential for cost reductions and substantial energy system benefits (e.g. power tower combined with substantial thermal energy storage)[5] but investors are hesitant to provide them with debt due to their lack of deployment history and additional technology risks. By supporting deployment in these cases, public lenders can reduce technology risks which make private banks hesitant to lend even when the viability gap is closed. Both the Indian and the South African CSP markets provide evidence that the most innovative technologies with the most promise over the long-term are not deployed without special incentives.
- **In countries that have made clear commitments to harnessing their solar resources but have weak capital markets and no CSP experience**. Countries like Morocco and India have made clear commitments to harnessing their solar resources through CSP deployment but their capital markets are not well suited for infrastructure finance,[6] meaning that developers face the risk of not securing sufficient debt at low enough cost and long enough maturities to make investment attractive. Additionally, some of these countries have limited knowledge on how to best finance CSP and design policy tools. Public interventions, including debt, can address these risks and provide knowledge, as shown in our case studies in India, Morocco and South Africa.

5 Power tower has the highest cost reduction potential of all CSP technologies (21-33% by 2020 according to ESMAP (2013)). For the system benefits of storage, see Mills and Wiser (2012) and Jorgenson et al. (2013).

6 These markets are short-term oriented, mostly based on relationships between large corporations and have limited liquidity for interest rate and currency hedging.

National public support: How to make policy tools effective and cost-effective?

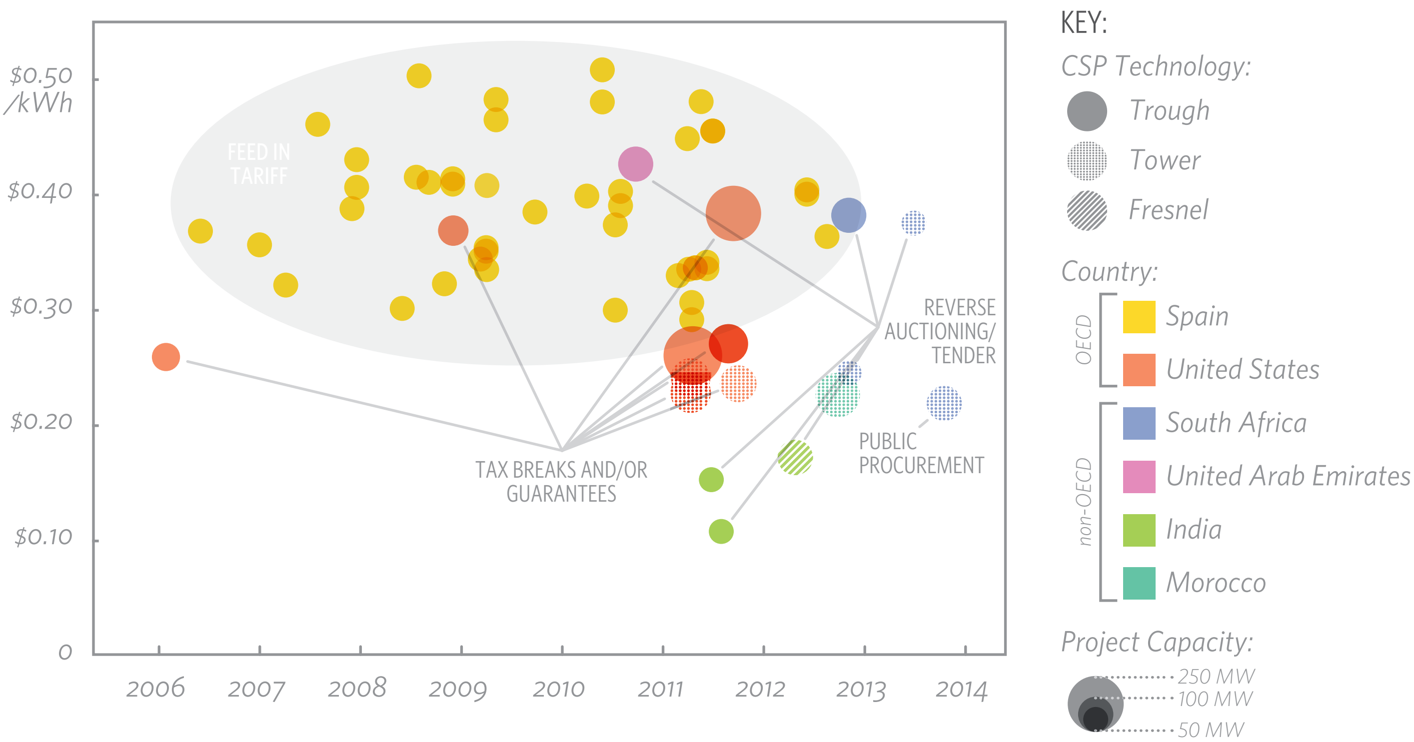
National governments have been the key driver for CSP development both in developed countries and emerging economies particularly in closing the viability gap for private investors in their local power markets, and in influencing project developers' and investors' perception of investment risks.

However, evidence from projects around the world (see Figure 1 on the next page) shows that the policy tools governments have employed differ widely as do their results in terms of capacity installed and cost reductions. In some contexts, policies drove significant installations but led to higher costs than had been budgeted for; in others they helped reduce costs but the capacity deployed did not meet governments' deployment targets. Based on our research, **policy-makers could make national policies more *effective* in encouraging deployment of CSP if they followed these recommendations:**

- **Provide sufficient financial support to close the viability gap**. Under Morocco's two-stage tendering process, the project developer bid a power purchase agreement (PPA) tariff that was cheap in global terms but that provided them an acceptable return considering the risk for this specific project and policy framework. Spain's fixed feed-in tariff also brought CSP plants' returns to a high enough level to mobilize private investment to deploy 2.3 GW of capacity in less than five years. In the process, it built a world-leading CSP industry that exports to all continents – however at a cost to the public that proved significant. In contrast, competition in India's reverse auction prompted inexperienced CSP developers to bid very low tariffs leading to financially weak projects whose predicted returns are below usual investment return expectations for comparable projects. In combination with the weak balance sheets of some developers, the result is that none of the supported projects commissioned on the original deadline[7] and India's CSP program is likely to fall 300 MW short of its 500 MW CSP deployment target.
- **Make support sustainable and stable over time.** The Spanish CSP market experience with a sudden decrease of installations from 2012

7 The initial timeline was very ambitious but, even after a nine-month extension of the timeline, only one plant commissioned before the deadline.

Figure 1: Levelized investment costs per financing year



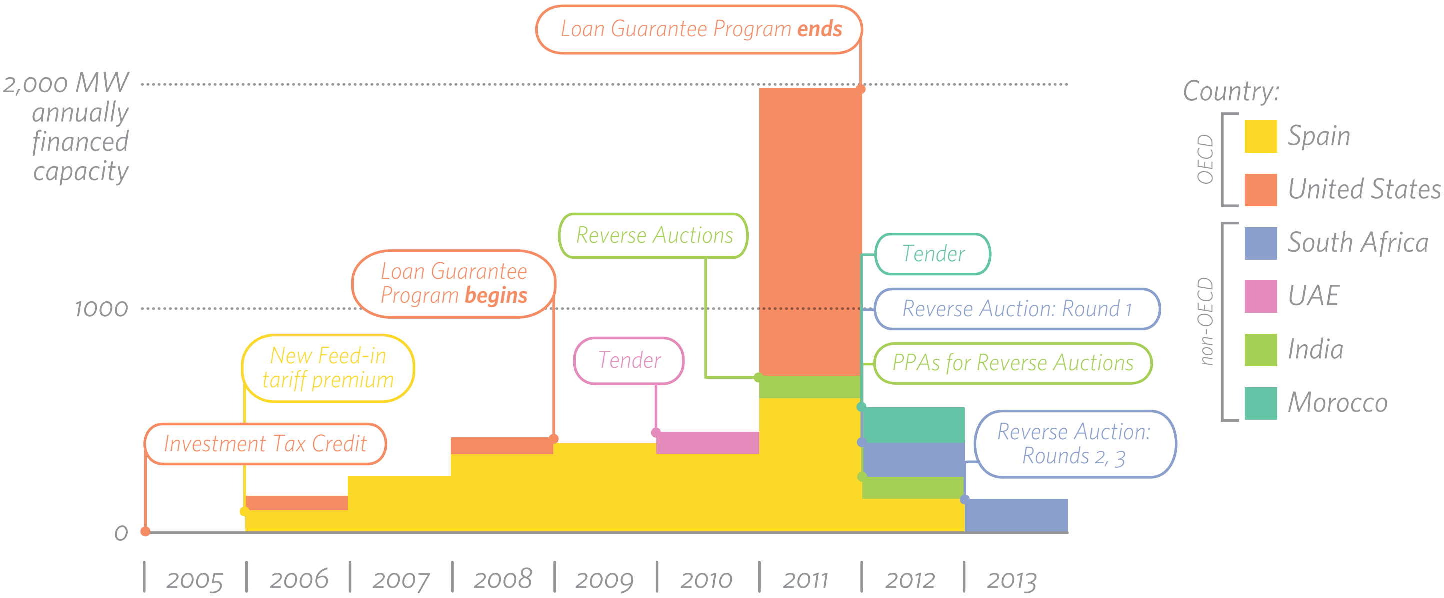
Source: CPI elaborations

onwards (see Figure 2 on next page) highlights not only the importance of an adequate level of support but also of its stability. In 2007, Spanish regulators introduced a support framework that successfully drove CSP deployment. However, the framework neither drove down the cost of power from CSP on the market nor allowed policymakers to control the total amount of subsidies that electricity ratepayers had to finance. From 2012 on, Spain dramatically changed its CSP support to address these weaknesses in the initial policy design both by abolishing the feed-in-tariff /premium that had previously driven deployment and by retroactively reducing support for existing plants. These changes have so badly damaged investor confidence that no CSP plant has been built in Spain since 2012 (Frisari and Feás, 2014) and the local industry has only survived because of exports.

- **Ensure that low-cost and long-maturity debt is available to address financing risk.** The Indian case study showed that even when stable viability gap funding is in place specific barriers in a country's capital markets may prevent project developers from finding the long-term capital they need.[8] In this case, public debt at low-cost and/or long maturities is needed to support CSP's high upfront investment and make projects happen. The winning bidders in the first phase of the Indian National Solar Mission had to source loans with longer maturity (12-18 years) from publicly owned national or international banks as the local, private financial market would not provide capital for more than five to seven years.
- **Promote the involvement of local actors with long-term policy signals rather than with local content requirements.** Our Indian case study shows that government plans for the deployment of CSP until 2020 helped local project developer, Reliance Power, to invest as an early mover because they expected to recover some of their initial investment in later projects. The same study also highlighted that long-term policy certainty may increase local manufacturing of components (e.g. mirrors). Long-term policy signals may, therefore, be a preferable way to incentivize local content than

8 Apart from reducing financing risks, low-cost and long-term debt may also reduce the overall level of public support needed. A recent CPI report estimated that in case of renewable energy technologies in India, low-cost and long-term debt could reduce the needed level of public support by up to 78%. See Shrimali et al. (2014)

Figure 2: Financed CSP capacity per year with policy timeline



Source: CPI elaborations based on BNEF (2014)

politically determined minimum requirements. Local content requirements can increase costs if local suppliers are more expensive, and can hinder the participation of IFIs in funding CSP, as the latter generally ask for full competition between local and international suppliers.

- **Make reliable on-site solar irradiation data available to reduce solar resource risks**. In India, overestimations of the available solar resource led to serious financing and construction delays and lowered plants' profitability, while in South Africa the availability of long-term, on-site data helped private investors to better estimate system performance.[9] One way to address solar resource risk is to bundle plants in solar parks where reliable on-site data is available. This also speeds up deployment as gathering reliable data takes at least one year.

Policymakers can ensure *not only high effectiveness but also low cost of policy support*, if they do the following:

- **Tailor the level of support to the real technology costs**. Morocco's competitive bidding process provides an example of how to deploy CSP at relatively low cost to the public.[10]

The combination of competitive bidding and strict quality requirements for bidders helped to reveal the real technology costs. In contrast, Spanish policy failed to incentivize cost reductions and, as a result, despite creating the world's largest CSP market, the cost of CSP electricity in Spain did not fall over time. The Spanish case shows that high feed-in tariffs can not only be costly for the public but also risky for investors, as they tempt policymakers to retroactively reduce or even cancel support.

On the other hand, India's experience with reverse auctions provides an example of how overly aggressive competitive bidding can lead to project developers bidding very low. While this reduced the cost of support below initial government expectations and will result in some of the cheapest CSP power available worldwide, it also meant the government offered a level of support that falls below projects' real costs and many plants are unlikely to be built. One way to improve the deployment effectiveness of the reverse auctioning approach in India is to better screen the experience and financial strength of bidders, e.g. through a two-stage process where only experienced and financially strong bidders from the first phase can bid again in phase 2 (see our Morocco case study).

9 Resource investigations carried out by state-owned electricity utility, Eskom, since 1998 reduced uncertainty about solar irradiation and determined South Africa's best locations for CSP by recording solar data over years.

10 The process implemented by Moroccan policymakers led to CSP deployment within budget and in the timeframe initially expected. However, high transaction costs and length of procedures meant that more than two years were necessary to award a single project and negotiate its financial package.

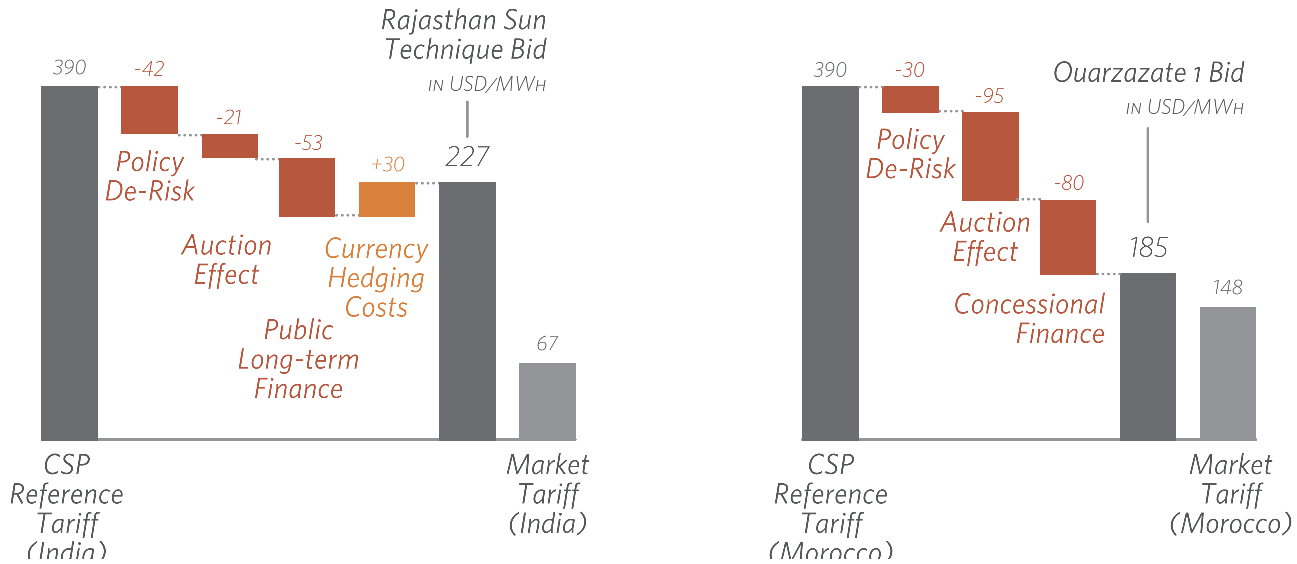
Measuring cost effectiveness of policy frameworks

For two of our case studies (Morocco and India) we estimated how much the general policy setting and the auctioning reduced tariffs compared to a hypothetical reference tariff that would have resulted from benchmark values for technology costs and investment return rates prevailing in each country (Kulichenko and Wirth, 2011).

We estimate that the policy settings in the two countries (the public-private partnership with government guarantee in Morocco, and the government backing of the power off-taker in India) reduced risk perceived by the average investor ("Policy De-Risk" in Figure 3) and translated into a lower rate of return required by equity investors (13% instead of 15% for Morocco,[1] and 11.5% instead of 15% for India). In both cases, the auction process helped to reduce final bids much further than the median bidding tariff, showing the **ability of competitive tenders to push developers to reduce their costs and/or required returns as much as possible and below the perceived average values in the market** ("Auction Effect" in Figure 3).

Finally, we estimate the effect of public finance to arrive at the actual tariffs bid ("Concessional Finance" and "Public Long-Term Finance" in Figure 3), highlighting how, in the Indian case, currency-hedging costs cancel out most of the positive effects of public finance on the final tariff.

Figure 3: Policy and public finance impact on tariff for Rajasthan Sun Technique, India (left) and Ouarzazate 1, Morocco (right).



Source: CPI elaboration

1 In Morocco, this reduction is corroborated by project developer ACWA Power's statement that the partnership led them to reduce their required rate of return by 2%.

- **Reduce the cost of renewable energy support by aligning public and private actors' financial interests to reduce the perception of policy risk.** Developers of the Noor 1 CSP plant in Ouarzazate (Morocco) have publicly stated that having a governmental agency as equity partner in the project company significantly reduced their perception of policy risk and prompted them to reduce their required rate of return by 200 basis points. We estimated that such a de-risking measure alone translated into a 7.5% reduction in the cost of CSP electricity produced by the plant in Morocco.

- **Low-cost and/or long-term debt may be one of the cheapest ways for national governments to support renewable energy deployment.** The long maturities of foreign public loans (15 years)[11] allowed the developers of the Rajasthan Sun Technique CSP plant to achieve their required rate of return and to bid a tariff roughly 4-5% lower than would have been

11 Longer 15-year maturities allowed the project developer to reach their required rate of return. 10 years is the longest maturity of reference for long-term debt in the Indian banking sector (Nelson et al, 2012), which more commonly offers 5-7 years.

affordable with debt of seven years maturity. The developers could have achieved the same return if Indian public banks provided domestic debt for the same length of time.[12]

International public support: how is finance best deployed to support national policy efforts?

International public finance has been essential to support the efforts of emerging economies like Chile, India, Morocco and South Africa to scale up CSP. **It is supporting CSP deployment in the following ways: by closing risk gaps, viability gaps and knowledge gaps:**

- **International public debt, even when not subsidized, can mitigate those risks that the private sector is not yet willing to bear.** The India case study shows that even non-subsidized, market-rate debt can effectively reduce financing risks in a country with little experience with CSP and a capital market where only short-term debt is available. As noted above, despite the government providing a subsidized PPA to close the viability gap, developers struggled to secure enough local private debt with long tenors, which increased financing risks. In this situation, USD 280 million in international public debt with long tenors reduced the financing risks[13] and was a key factor in getting the 100 MW Rajasthan Sun Technique plant built.
- **Subsidized international finance can help to close the viability gap where single countries are unable to bear the full cost.** In the case of Morocco's 160MW Noor 1 CSP plant, concessional debt brought CSP tariffs to an acceptable level for national policy makers. International Finance Institutions (IFI) committed USD 1 billion of highly subsidized finance for the construction of the 160 MW CSP plant in Morocco. We estimate that the international donors and concessional lenders including the Clean Technology Fund (CTF) reduced the project's electricity production costs by 0.08 USD/kWh (see Figure 3).[14] In South Africa, IFIs provided USD 995 million in highly subsidized debt, which lowered Eskom CSP's financing costs and thus helped to reduce the project's electricity production costs by 0.03-0.11 USD/kWh. Low cost finance was essential for Eskom CSP. IFI finance enabled Eskom to proceed with the highly innovative technology configuration chosen for Eskom CSP(100 MW power tower plant with 9-12 hours of thermal energy storage and a dry-cooled steam cycle to minimize water usage) that costs more than alternative options including conventional and renewable energy sources. If successful, this project will help to reduce all stakeholders' perception of technology risk associated with power tower CSP plants with long thermal storage capacity – a technology configuration with great potential for cost reductions and energy system benefits.
- **Providing knowledge on policy tools and technology to local decision makers is an effective use of international subsidized finance**. In India and Morocco, national policymakers benefited from IFI capacity building and knowledge transfer. In Morocco, IFIs provided necessary institutional and specialized technical support to assist the national solar energy agency MASEN with the project design and the structure and implementation of the tender process. Their engagement helped to further mitigate private investors' perceived risks. In India, the Asian Development Bank is supporting the national government in designing the CSP auctioning for the second phase of the Indian National Solar Mission.[15] IFI finance also kick-started the national knowledge generation process in South Africa and reduced costs by supporting the recording of solar resource data over years to determine the best locations for CSP in the country, and undertaking studies of the most suitable CSP technologies and components for South Africa (Boyd et al. 2014).[16] All case studies show that policy design has a significant impact on CSP scale up, so future international interventions – from

12 A recent CPI report estimates that long-term debt in India could reduce the public subsidies needed for solar PV by 17% and low-cost debt could reduce it by 11% (Shrimali et al. 2014).

13 Despite currency hedging costs, IFI long-term debt also slightly lowered electricity production costs. See Figure 3.

14 This corresponds to 25-30 percent of initial electricity costs (Falconer and Frisari 2012).

15 Our Indian case study identified significant room to improve the policy design of Phase 1 through, for example, qualification requirements for bidders, solar resource data availability, and incentives for storage.

16 In India, the lack of reliable solar resource data increased the risk of CSP plants underperforming and lead to delays in securing financing (Stadelmann et al. 2014b).

CTF and others – should continue to build policy design capacities.[17]

International public finance could drive CSP investments more effectively if the following lessons are taken into account:

- **Costs for hedging foreign currency have to be reduced. In the case of the Indian and South African projects we studied, costs for hedging currency risks almost completely offset the benefits of low-cost foreign debt.** While in South Africa foreign public debt offers lower interest rates (less than 2%) than local lenders (around 12%), the cost for hedging the related currency risk, can increase the cost of debt by up to 8% at current rates (Boyd et al. 2014). For India's Rajasthan Sun Technique CSP plant, the cost of hedging risks from debt in foreign currency almost completely offsets the benefits of the longer maturity offered by foreign public lending (Stadelmann et al. 2014b, see also Figure 3).[18] **As well as taking on exchange risks themselves, IFIs may also try to convince host governments to partially denominate tariffs in foreign currency, thereby reducing or even eliminating foreign currency risks for investors.**[19] In Morocco, CSP tariffs were partially denominated in foreign currencies, so foreign exchange rate risks of IFI debt for the developer were largely transferred to the government. In case of Morocco the additional currency risks for the government are partially mitigated by the fact that CSP mainly replaces electricity generated from dollar-denominated fossil fuel imports.
- **International financial institutions (IFIs) can speed up deployment of CSP by adjusting their requirements according to a technology's stage of development and the country context.** The two-step World Bank procurement process Eskom had to apply for procuring engineering services and technology provides an example. Bidders had to meet certain eligibility criteria including demonstrated expertise and experience in the field and a certain degree of financial health. Generally, these requirements encourage competition, and make the bidding process as transparent and nondiscriminatory as possible. However, in this case they also proved to be time-consuming and challenging to meet because, for technologies under early market conditions such as CSP power tower, there is a limited number of experienced technology and service providers. Eskom and the IFI lenders have agreed to discussions with prospective bidders to ensure that risks associated with the early stage of technology development are adequately addressed in the structuring of the project and that the most suitable, experienced and cost competitive provider is awarded the contract. If successful, this process could show how IFIs can improve bidding results and reduce project delays and costs by adapting procedures to a technology's stage of development and country context.

By partially denominating tariffs in foreign currency, governments can significantly reduce currency risks of foreign public debt for private investors

- **When multiple IFIs lend to large projects they can speed deployment by taking a harmonized approach.** In the Moroccan case, strong coordination between stakeholders was essential to get this large and complex project off the ground. Rather than providing a complex portfolio of loans with different interest charges, loan tenders and collateral guarantees, European donors (EIB, KfW and AFD) chose a joint financing package with synchronized loans. In the future, syndication of loans could help project developers in countries beyond Morocco by easing the administrative burden of dealing with multiple lenders and their separate loan rates, conditions, and procedures (Falconer and Frisari, 2012).

17 Reducing knowledge gaps can also reduce investment costs as investors perceive additional risks if they become aware of their knowledge gaps.

18 Project sponsors with a strong balance sheet and existing expertise or capacity can more easily manage or internalize risks such as those resulting from the foreign exchange of currency. Both Reliance and Eskom handle the sensitivity of project returns to currency exchange rates using in-house hedging capacity.

19 For further discussion of this see Nelson D, Shrimali G. 2014. Finance Mechanisms for Lowering the Cost of Renewable Energy in Rapidly Developing Countries. San Francisco: Climate Policy Initiative.

A roadmap to drive cost reductions and ensure scale up of CSP

Key governments and IFIs could boost CSP development by agreeing on a road map that provides policy certainty for investors and ensures economies of scale. National experience clearly shows that stability and long-term predictability are essential policy elements to attract private investors, support local supply chains and develop a CSP industry. The latter is a priority for many emerging economies including India. Technology providers in particular would benefit from long-term plans when investing in local production facilities.[20]

To make CSP competitive in some markets, national and international policymakers have to join forces to cover the viability gap for at least 5-15 GW of CSP capacity

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In order to make CSP competitive, national and international policymakers have to join forces to cover the viability gap for at least 5-15 GW,[21] according to expert estimates. If policymakers use tools that incentivize competition and cost-reductions, the experience gained through building new plants and cost reductions arising from economies of scale could make CSP competitive in specific markets, such as Morocco and South Africa. CPI estimates that this scale of additional capacity could reduce CSP electricity production costs by 14-44%.[22] In optimistic scenarios, this would make CSP cost competitive in Morocco and South Africa but not in India where electricity prices are lower (see Annex 2)[23] Competitiveness in some markets is likely to drive more deployment and further cost reductions making CSP competitive in other markets. To this end, international actors that can concentrate concessional resources on a few technologies (e.g. the CTF) could play a crucial role. Under such a plan, we advise policymakers to consider the following lessons for driving CSP scale up and cost-reductions:

- **International public finance should focus on countries with high political willingness to deploy CSP and a need for external support.** This means that IFI finance should not necessarily be focused on countries with the highest solar resource potential; indeed we found situations where solar-rich countries either do not advance their CSP plans (several North African countries)[24] or are anyway able to pay for CSP on their own (United Arab Emirates); in both cases IFI finance would not be effective. IFI finance has most successfully driven CSP deployment where national policymakers committed financial resources early on, such as in India and Morocco. There are advantages to focusing funding.
- **CSP needs international financial sources that can be concentrated on specific technologies.** With its commitment to provide a large amount of highly subsidized finance to one single technology,[25] the CTF helped to generate knowledge and reduce costs among all players in South Africa. The same applies to Morocco.
- **Public support has to be attractive enough to promote deployment but must decrease as technology costs fall over time**. Support that is too low slows deployment (as seen in India), while support that is too high and doesn't decrease over time increases costs to the public, policy risks for investors, and fails to incentivize technology cost reductions (see Spain).
- **While IFI debt is an effective tool to implement first plants, policymakers should also initiate the transition towards more private and local debt to secure long-term financing and reduce currency risks.** International public resources will only be able to cover a small part of the finance needed to scale up CSP by an additional

20 The mirror manufacturer for linear Fresnel plants in India wanted 400 MW firm capacity before setting up a local production facility.

21 This is in addition to the 3 GW already deployed worldwide. The figure is based on expert views from project developers and multilateral development banks in our Third CSP dialogue.

22 This cost reduction estimation is based on past learning rates for CSP and renewable energy technologies. Renewable energy technology costs have fallen by 10-20% with each doubling of installed capacity and 10-15% in case of CSP (Stadelmann et al. 2014a). We used the upper 20% bound for our estimates because till now CSP has mainly been promoted in Spain where few incentives for reducing costs existed. See Annex 2 for more.

23 The low electricity price in India is, however, partly due to regulated fuel prices, so CSP is closer to being competitive than Annex 2's estimates suggest. E.g. the average tariff for Indian gas power was 0.06 USD/kWh in 2012, similar to our benchmark power price in Annex 2, but a planned increase in the regulated gas price may increase costs to around 0.1 USD/kWh (Bloomberg 2014).

24 Some of these countries went through serious political or economic crises in the last few years, which may explain why plans did not move forward.

25 Currently, almost 60% of South Africa's USD 500 million CTF financing is allocated to CSP.

5-15GW. Our Indian case study shows that IFI finance is unlikely to provide enough loans for the country's ambitious CSP plans in the next years.[26] Policymakers have to mobilize private debt to secure the financial capital needed for the transition to a low-carbon energy system. In the medium term, policymakers will also have to deploy local public lending in countries with capital markets that are ill-suited to infrastructure finance where developers face the risk of not securing enough debt at low-cost and long maturities. In such cases local public (long-term and/or low-cost) debt reduce financing risks (see Stadelmann et al 2014b) and can even reduce direct cost of public support (see Nelson and Shrimali, 2014).

- **National policymakers should move away from flat power tariffs and remunerate the system benefits of the stable and flexible power supply provided by CSP.** This approach could reduce the volume of subsidies needed to maximize the value of CSP for the electric system as project developers would receive a higher price on the market for the power they produce. By stimulating investments in those CSP configurations that offer most benefits to the local energy system, it could also support a deeper penetration of wind and solar PV in future low-carbon energy systems, by managing gaps in power supply and demand arising from fluctuations in their output. Simulations show for US states that the value of fluctuating renewable energy supply rapidly drops with deeper penetration, while the value of CSP with storage only decreases slightly (Mills and Wiser, 2012). Remunerating peak power could drive substantial CSP deployment, as its electricity production costs are competitive with most storage technologies.[27] If power pricing according to system benefits is politically unviable, policymakers should directly incentivize energy storage, as CSP plants can only offer system benefits with sufficient storage (see Jorgenson et al. 2013).
- **Consider the social costs of carbon[28] when comparing CSP costs with fossil technologies.** Current carbon prices have a negligible impact on the economics of CSP plants. See, for instance, our Indian case study where carbon credits help reduce the required tariff by only 2%.[29] However, should the viability gap for CSP decrease, the social cost of carbon emissions will become more relevant when deciding whether to invest in CSP or fossil fuels, in particular gas power plants that offer similar reliability and flexibility in power output.

The following questions on scaling up CSP remain open:

- How best to combine cost reductions driven by tenders with the effective deployment of feed-in tariffs?
- How best to stimulate local private financing for CSP: capacity building, credit enhancement or demonstration projects?
- How best to address foreign exchange risks: through low-cost local debt or denominating tariffs in foreign currency?
- How best to measure the system benefits of CSP and best remunerate them?
- Which specific business models are most appropriate for CSP?

26 To provide all debt needed for CSP under phase two of the Indian National Solar Mission, the Asian Development Bank and the World Bank Group, the most important development banks for India, would have to commit all their funding for the South Asian energy sector as a whole to CSP in India for 4-7 years in a row.

27 Electricity production from CSP with storage ($0.2-0.25/kWh) is cheaper than most storage technologies examined by Steward et al. (2009). While pumped hydro and compressed air ($0.1-0.13/kWh) tend to be cheaper, hydrogen, fuel cell and battery storage ($0.19-0.83 /kWh) tend to be equally or more expensive than CSP. It has to be noted that pumped hydro is not available in many countries with substantial CSP potential (desert regions).

28 The social cost of carbon is the economic damages per unit of carbon dioxide (CO2) emitted. The US EPA (2014) estimates the social cost of carbon as USD 61 per tonne of CO2 in 2015, rising to USD 104 in 2050 (average estimates).

29 This would be the tariff that would ensure the same level of project returns if the value of carbon credits were zero.

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