CLIMATE POLICY INITIATIVE

The Role of Public Finance in CSP: Background and Approach to Measure its Effectiveness

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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

While concentrated solar power (CSP) currently contributes less than 0.1% of total electrical capacity worldwide, its potential is significant enough for many experts and international institutions to suggest it could supply up to 10% of global energy demand by 2050.

CSP's costs are coming down but, in most cases, they still remain above alternative sources of power and public finance is needed to bridge this gap. Indeed, our analysis estimates that over 98% of the total investment in CSP to date has needed some form of public support. Understanding how to structure effective public policies and investments is therefore crucial to further the development of the technology and to ensure that governments use their resources efficiently, particularly in a time of economic difficulties.

Over the next year, Climate Policy Initiative (CPI) will distill lessons on how effective the Climate Investment Funds (CIFs) and other public entities have been in financing CSP in emerging economies. This analysis will inform the extension and adjustment of these public entities' financing vehicles.

There are particular advantages to CSP as a technology to drive low-carbon growth. Not only is it potentially scalable, harnessing a relatively untapped and abundant renewable resource to generate low-carbon electricity, but its ability to store energy as heat also allows it to generate power on demand around the clock, even after the sun goes down. This enables CSP to provide peak power, and also base-load power to balance out fluctuations in supply from other renewables like wind and solar photovoltaic (PV). This combination of scalability and dispatchability gives CSP a key advantage over other renewables.

Nevertheless, its deployment has been limited to date as it is a relatively immature technology and is still expensive. In addition, as with many renewable technologies, although CSP power plants have no fuel costs during their lifetimes, they do require large sums of capital to be invested upfront.

Following almost two decades of standstill, the total capacity of installed CSP power plants has increased from 0.5 to 2.5 GW in the last five years. A further 3 GW is already financed and under construction. **This background paper will set the stage for further study on the effectiveness of CSP financing** in some of these CSP projects. It analyzes the current landscape of CSP (technologies, costs, financing and policies), details the approach we will use to analyze the effectiveness of different public interventions for financing CSP, and explains our next steps.

Key Insights from the Current Landscape of CSP

Our analysis of the current landscape of CSP yielded four key insights to be considered when analyzing the effectiveness of public interventions to finance CSP in emerging economies:

- **Some CSP plants are built without public financing, or only borrow part of the capital they need from public lenders at non-subsidized terms.**[1] This raises the question of why other plants need full public lending at highly concessional terms or full public financing, and whether and how this support can be phased out.

  Question for analysis: Is public support needed in all cases? If not, in which cases is it needed?

- **A range of policy and public investment tools have been used to support CSP financing with different results and levels of cost-effectiveness.** Governments in emerging markets are using competitive tenders and reverse auctioning rather than feed-in-tariffs to deliver revenue support policies, with the expectation that these will more effectively drive down costs. Early indications are that this approach can successfully drive down costs but that it increases the risk that winning bids are so low that developers are unable to build the plants.

  Question for analysis: How effective or cost-effective are different policy and public investment tools?

- **CSP costs are projected to fall as more plants are built but, despite public support for additional CSP deployment in the last five years, cost reductions can only be observed for some types of CSP technology and in specific regions.** CSP technology costs remain substantially above alternative energy sources (both conventional and renewable), although the additional benefits of CSP, such as energy storage and power-on-demand that support the

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.

energy system as a whole, reduce the viability gap to other technologies.

Question for analysis: Can public policy and support drive technology cost reductions simply by enabling additional capacity, or are more specific interventions needed?

- **CSP has not been deployed wherever solar irradiation is high but has instead emerged in specific niche markets where government policies support CSP in order to pursue specific national interests.** These interests include diversifying energy sources, building a local industry, or becoming more independent from fossil fuel imports. Spain and the U.S dominate the current CSP market, but emerging economies such as India, South Africa, China, and other countries in the Middle East - fueled by international public finance and national policy - play an increasingly important role among recent and planned installations, incentives. This means projects are moving towards countries where investment risks are high and the role of public finance is more crucial.

  Question for analysis: How can international public finance best support national policy efforts in emerging economies?

Approach to analyze the effectiveness of public interventions to finance CSP

We will base our analysis of the effectiveness of different policies and public investment tools in promoting deployment of CSP power plants using three main pillars:

1. **Two in-depth case studies** will analyze the effectiveness of policy, risk management, and public financing in two specific CSP projects, using the systematic analytical approach of the San Giorgio Group.[2]
2. **Three CSP expert dialogues** will provide a forum for experts from governments, development banks, and the private sector to discuss the case study insights and exchange ideas on effective policies and public finance to support CSP.
3. **A lessons learned paper and policy brief** will summarize the key findings of the dialogues, the two case studies, and an existing CPI San Giorgio Group Case Study on the Ouarzazate plant in Morocco .

The case studies will focus on the 100 MW Rajasthan Sun Technique project in India, and the 100 MW Upington power tower project in South Africa. The selected projects are the largest CSP projects utilizing public funding in two different developing markets, both of which have substantial CSP potential. The fact that the selected projects employ two different and innovative technologies (linear Fresnel and power tower) with substantial local manufacturing potential, and different financing models (public-private financing with non-concessional public loans, and public-only financing with concessional loans), will allow us to examine the effectiveness of very different approaches.

2 See the CPI website for additional information: http://climatepolicyinitiative.org/sgg/.

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1. Introduction

Concentrated solar power (CSP) is a promising renewable energy technology. Its storage capabilities allow it to fill gaps in supply arising from the fluctuating output of wind farms and photovoltaic panels, and reliably deliver power around the clock.

However, **CSP levelized electricity costs[3] are currently higher than average retail market prices, so public policies and finance are needed to encourage deployment** of CSP plants thereby promoting learning and potentially cost reductions in the future.[4]

Over the next year, CPI will distill lessons on the effectiveness of different public financing tools for CSP in order to help policymakers identify the most effective of these tools for reaching their goals. This San Giorgio Group[5] project 'Distilling lessons on the role of public finance in CSP' is carried out on behalf of the Climate Investment Funds (CIF) Administrative Unit. Therefore, the project will specifically focus on the role of CIF concessional finance in promoting CSP in sun-rich emerging economies such as Chile, India, South Africa, and Morocco, where CSP potential is substantial but high capital costs make its financing particularly challenging.

For this project, **we define effectiveness as the impact public investment and policies have on the deployment of CSP, and co-benefits associated to this deployment**.

We will measure the short-term deployment of CSP technology through indicators like investments in CSP projects or the capacity of installed CSP power plants, and assess which risk management and financing models have enabled this short-term deployment. We cannot directly measure long-term deployment. Instead, we will focus on intermediate indicators such as the transfer of knowledge, the establishment of local industries, and cost reductions that may enable long-term deployment of CSP at scale. As well as the low-carbon power generated by CSP plants, we also consider co-benefits, such as the creation of jobs, and improved energy security or grid stability.

This paper is the first step of the larger project on effective CSP financing, commissioned by the Administrative Unit of the CIFs. Its main purpose is to:

- Examine the **current landscape of CSP**, including geographical distribution, different technologies, their costs, and financing approaches used.
- Develop an **approach to analyze the effectiveness of different public interventions for financing CSP**.
- Outline the **next steps** for distilling lessons on effective CSP financing.

3 Levelized electricity costs (or levelized costs of electricity, LCOE) divide all of a power plant's costs over its lifetime by the total amount of power it produces to calculate the costs of generating electricity. The cost assessment considers initial investment costs, operation and maintenance costs, and capital cost and is often measured in USD per kilowatt-hour.

4 CSP with storage may eventually rival other forms of renewable energy for affordability: Mill and Wiser (2012) estimate that for California CSP production with storage has, in case of penetration rates above 2.5%, a higher economic value than photovoltaic and wind power.

5 The San Giorgio Group (SGG) is a working group of key financial intermediaries and institutions engaged in green, low-emissions finance. It was established by the Climate Policy Initiative and the World Bank Group, in collaboration with China Light & Power (CLP) and the Organization for Economic Co-operation and Development (OECD). See the CPI website for additional information: http://climatepolicyinitiative.org/sgg/

2. Overview of CSP financing landscape

Despite new growth in CSP installations, **at a global level technology costs have not fallen significantly and remain substantially above conventional and renewable alternatives**, contradicting studies projecting that CSP technology costs would fall with new installations.

The large upfront capital requirements and high production costs of CSP mean it is not competitive on a commercial basis so **public policies and investments are still crucial for the development of the technology**. While **feed-in-tariffs have been the main policy tool to promote CSP for years**, policy makers are now slowly shifting to competitive tenders/reverse auctioning and direct investment of public resources, with the expectation that these instruments will more effectively drive down costs.

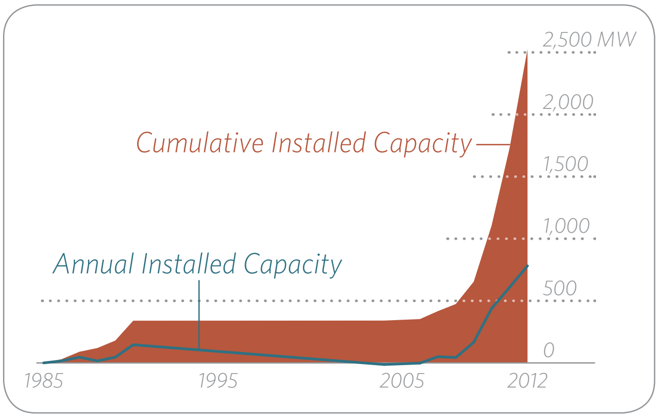
This chapter provides a snapshot of the current global landscape of CSP installations,[6] and identifies current and emerging trends in technological configurations, financing models, and policy support systems.

2.1 Global installed CSP capacity by geography and technology

CSP makes up less than 0.1% of total electrical capacity installed worldwide but several studies see an important role for CSP in the future energy mix with some suggesting it could supply up to 10% of global energy demand by 2050.

The International Energy Association (IEA) projects that in 20-40 years CSP will be among the main sources of power at a global level in scenarios consistent with an increase of average global temperatures lower than 2 degrees.[7] However, this would still require a drastic reduction in current costs that place CSP at a significant premium over other commercial alternatives.

Figure 1: Installed capacity by year in MW (BNEF database, 2012)



After the first modern CSP plants were built in the United States in the mid-80s, almost no new facilities were developed around the world for over two decades. This situation has changed in the past five years, with several large-scale CSP installations securing finance. Indeed, following almost 20 years of standstill, CSP power installations have picked up significantly in the last five years, mainly in Spain and the United States, and mostly using parabolic trough technology. Looking forward at plants already announced and soon to be commissioned, the future CSP landscape promises to be more diverse, both in geographical and technological terms.

In the years since 2008, overall CSP installed capacity has increased five times to 2.5 GW (figure 1). Despite this surge, CSP still represents a very small share of global renewable energy capacity, and less than 0.1% of the total 5,000 GW of total electrical power plants installed by the end of 2010 (EIA, 2013).

Geographies

Spain is currently the industry leader with 70% of global installed generation capacity, followed by the U.S. with about 21%. Despite concerns about renewable energy policy stability that have impacted CSP installations in

6 We base our analysis on single project-level data collected mainly from the Bloomberg New Energy Finance dataset and integrate, when needed, information from the NREL CSP project database and available media. Most of the analysis and considerations refer to utility-scale installations only (i.e. power plants with a capacity of 50MW or higher).

7 IEA Energy Technology Perspectives 2012 (IEA 2012) forecasts that CSP will produce a total of in 2050 between 3 and 4 million GWh of power in 2050 in a 2 degrees scenario (10% of total), around 1.2 million GWh in a 4 degrees one, and less than 500 thousand GWh in a 6 degrees one. A moderately optimistic projection of future market development suggests that CSP installations could still reach 830 GW by 2050, representing between 3.0 and 3.6% of global energy demand in 2030, and 8.5 and 11.8% in 2050. According to the IEA CSP Technology Roadmap (IEA 2010), CSP could meet up to 40% of electricity demand in some countries by 2050.

Figure 2: Installed capacity by area in MW (BNEF, 2012)

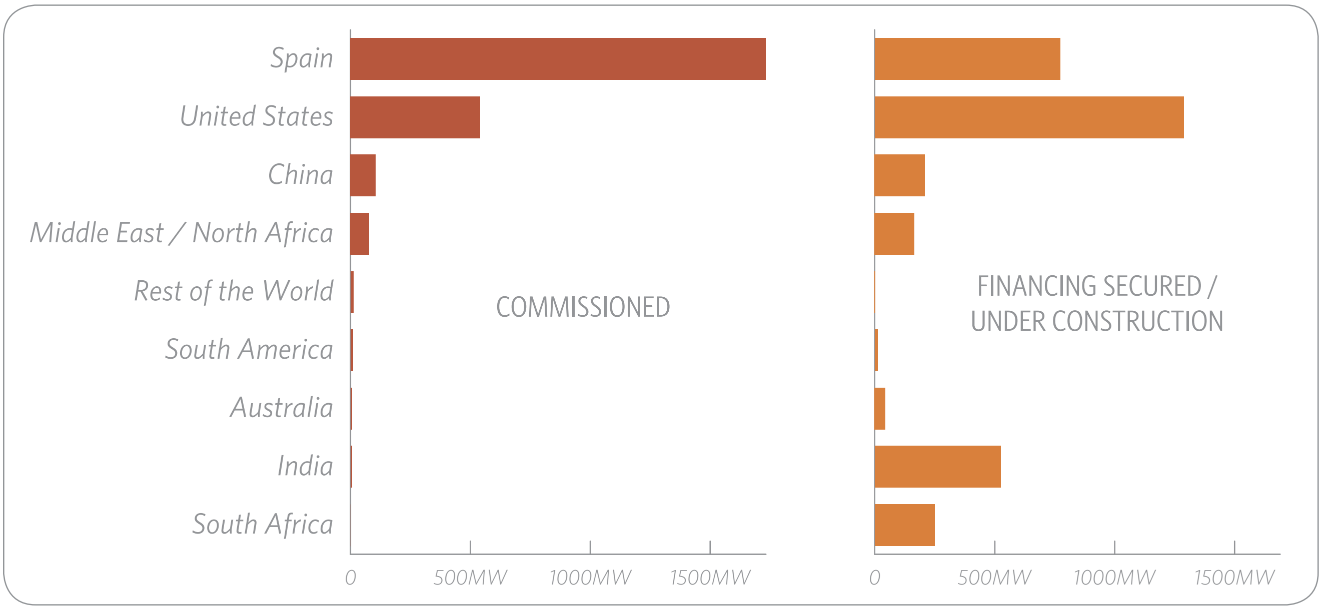
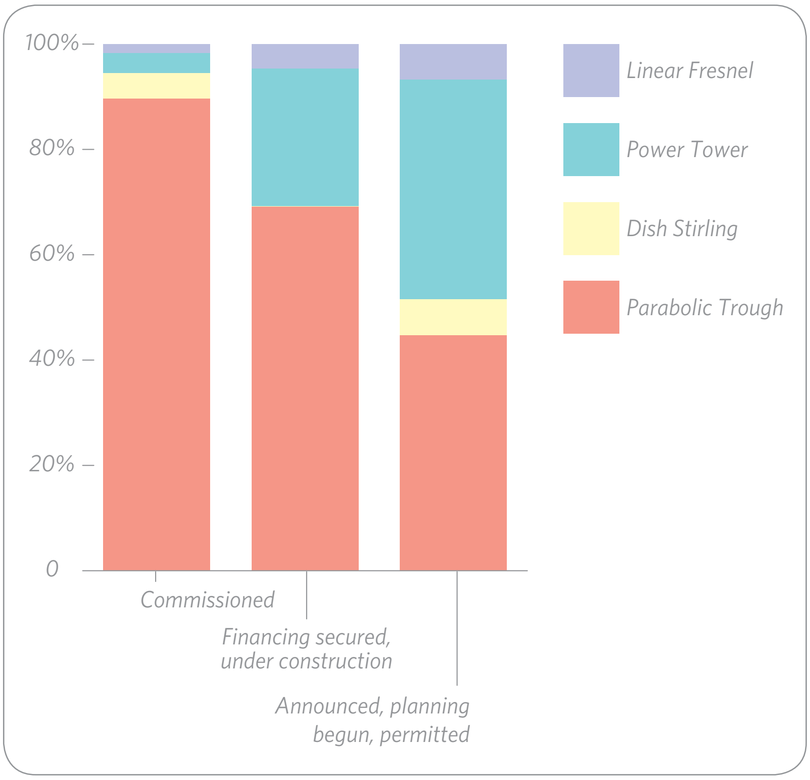


Figure 3: Installed and expected capacity by technology (BNEF, 2012)



these two countries, several projects that have secured financing or are under-construction will double their installed capacity in the near future: a further 773 MW of CSP is under construction in Spain, and a further 1,288 MW in the U.S..

Coming years will also see significant investment in CSP in emerging economies as approximately 1 GW in capacity is currently under construction in India, South Africa, and the Middle East and North Africa (MENA).

This shift of focus towards emerging markets is a result of these countries' desire to exploit fully their solar thermal resources, to diversify their energy generation portfolio away from fossil fuels, to increase their energy security, and to foster the development of a local industry.

Technologies

There are four types of concentrating solar thermal technologies currently available for commercial use: parabolic trough, dish Stirling, linear Fresnel, and power tower. Each of these technologies concentrate solar thermal energy by reflecting the sun's rays using mirrors, but differ in how they capture the solar resource, and in the ways they convey this energy to a turbine to generate power. These technical differences have significant impacts on cost, achievable electrical efficiency,[8] and water needs (see Box 1 for more details). In addition, there is more data on historical performance for some of the technologies that have been deployed than others. This has significant consequences for investors' perception of risks.

Of the four technologies, parabolic trough is currently the most widely-deployed, and until 2008, was practically the only technology used in CSP plants. At the

8 Electric power plant efficiency is typically defined as the ratio between the useful electricity output from the generating unit, in a specific time, and the energy value of the energy source supplied to the unit in the same time period.

Box 1: Overview of CSP technologies

All CSP technologies use mirrors and lenses to concentrate the sun's thermal power to heat a fluid (the heat transfer fluid, or HTF) and generate steam. The conversion of this steam into power then occurs through the same steam turbines you would find in any fossil-fuel or nuclear powered plant. CSP technologies differ mainly in the ways in which the sun's energy is concentrated. They can be grouped in:

Line-focusing systems: parabolic trough and linear Fresnel. Both systems track the sun along one dimension only and focus it onto a horizontal line. Parabolic trough uses a very accurate and efficient curved mirror. Linear Fresnel technology uses flat mirrors that concentrate the sun's heat on a receiver placed above the collectors. Their optical efficiency[1] is much lower than parabolic troughs but the simplicity of the mirrors' manufacture and installation and a lighter support structure (concrete and steel), has a significant impact on the overall costs of the plants and makes it easier to develop a local supply chain in emerging economies (IRENA, 2012). While parabolic trough can use oils or molten salts as the HTF and has been already combined with thermal storage, linear Fresnel has instead been developed so far with water/steam. This means storage would then require a further conversion to a different HTF, adding to costs and efficiency losses.[2]

Point-focusing systems: power tower and dish Stirling. They employ a double-axis tracking system that concentrates the sun's energy onto a single point, allowing much higher operating temperatures, and therefore higher operational efficiency levels. In the power tower, the focal point is on a tower at the center of a field of ground-mounted flat mirrors. In the dish Stirling, the heat is concentrated at the focal point of the parabolic dish, where a Stirling engine converts heat into power. For the power tower in particular, the higher temperatures make thermal storage more effective, allowing a more flexible generation strategy and the maximization of the value of the power sold (IRENA, 2012).

1 Optical efficiency is the ratio of the energy absorbed by the solar receiver over the solar energy received in the entire device. (IEA, 2010)
2 The two largest developers of linear Fresnel technology only recently announced testing of Fresnel collectors using molten salts as heat transfer fluid (CSP World, 2013).

end of 2012, parabolic trough technology represented 90% of the total installed capacity with about 2.3 GW. The remainder was made up of dish Stirling (5%), power tower (4%) and linear Fresnel (2%). Interestingly, the coming years will see large changes in the portfolio of CSP technologies, as project developers and investors aim to exploit the potential for CSP to store power and dispatch it with high flexibility: power towers account for 26% of the projects under construction, and almost 42% of those in planning phases.

2.2 Current costs and projections

The number of CSP power plants that are built will ultimately depend, among other factors,[9] on how CSP costs evolve relative to competing technologies. As of 2012, on a levelized-cost basis, both CSP parabolic trough and power tower were estimated, on average, to be the most expensive renewable energy technologies for utility-scale installations (IRENA, 2013). However, the current limited extent of CSP deployment, much smaller than that of other renewable technologies (see table 1 for details), provides necessary context for these figures. CSP's high costs are both a cause and an effect of its lower deployment rate.

In addition, levelized cost of electricity (LCOE) calculations do not reflect the true benefits of CSP. LCOE treats the value of each kWh produced as equal as it cannot assign any premium to electricity produced in peak times instead of off-peak ones. Neither does it ascribe any value to how beneficial each technology may be to the power system as a whole, even though CSP power is often of higher value than many other renewables, due to its potential for storage and dispatchability.

According to IRENA's comparative study, CSP's levelized costs[10] range between 0.2 and 0.38 USD/kWh,

9 Both national and international policy commitments to reduce carbon emissions and improve energy security / diversification remain a significant factor influencing CSP (as well as other renewables) deployment.

10 The figures provided in Table 2.1 derive from calculations in IRENA 2013 and assume a 10% discount rate for all technologies considered. We note that for some technologies and in some countries, this discount rate may be rather high – however, for ease of comparison, we maintain a uniform rate across the sample here.

Table 1: Cost comparisons between renewable technologies

TECHNOLOGY	LCOE RANGE USD/KWH	CAPITAL COSTS RANGE USD/KW	TOTAL INSTALLED CAPACITY GW
Wind onshore	0.05 - 0.15	1000 - 2500	270
Wind offshore	0.15 - 0.25	4000 - 4500	6.1
Solar PV	0.15 - 0.35	2000 - 5000	91.3
Biomass	0.05 - 0.25	1000 - 7000	77.4
Hydro large	0.03 - 0.15	1500 - 5000	1102
Geothermal	0.03 - 0.12	2000 - 6000	11.4
CSP parabolic trough	0.18 - 0.38	3500 - 8000	2.6
CSP parabolic trough with storage	0.15 - 0.35	7000 - 10000	
CSP power tower with storage	0.18 - 0.28	6000 - 10500	

Source: IRENA 2013; IEA, 2012b

while they average around the 0.05-0.25 mark for wind (both onshore and offshore), and 0.15-0.35 for solar PV; biomass, hydro, and geothermal are all also significantly cheaper. CSP cost projections for 2020 are lower but still reflect a premium for the technology. Interestingly, the inclusion of storage in CSP plants significantly increases the unit costs (cost for capacity installed) on the one hand, but enables much greater generation on the other, ultimately resulting in lower levelized costs and, if power prices vary significantly during the day, in higher project profitability.[11]

When looking at capital costs only, CSP compares even more unfavorably with other renewable technologies as its unit costs are two, three, or even four times higher (IRENA, 2013). Unit capital costs do not indicate how expensive the technology is[12] as, especially in presence of variable winds and solar irradiation the name-plate capacity of a plant might be much lower than the actual power generated. In case of thermal storage, CSP has a much higher capacity factor than wind and solar PV, so the technology is comparatively less expensive than the high capital costs would suggest. However, higher capital costs result in significantly higher investment needs, which reduce the number of developers and investors with the necessary resources available to finance the projects. They also increase the complexity and risks related to securing finance.

CSP costs are heavily skewed towards investment capital costs that, on average, represent more than four fifths of the total plant costs (IRENA, 2013).[13] Of these, the solar field and the receiver system can account for more than half while the thermal storage component (when present) can represent almost one fifth of total installation costs. More conventional components such as the power block, the balance of plant,[14] and civil and engineering works account for roughly a quarter of the total[15] (Fichtner, 2010). As it's unlikely that these conventional parts will experience major cost reductions, most of the competitiveness gap will have to be closed by innovation and cost reductions in the solar field and storage components.

Since the 1980s, CSP cost reductions have been limited and sometimes even reversed (Hinkley, 2011). This contrasts with other renewable energy (RE) technologies, where cost reductions have occurred due to learning when deploying new plants: solar PV has shown learning rates of 20%[16] and wind technologies of around 15% (Hayward et al., 2011). For CSP, learning rates of 10-15% have been estimated (IRENA, 2012). Even allowing for the much smaller overall installed capacity of CSP compared to solar PV and wind, CSP costs have not decreased with increased deployment over the last five years (see Figure 4): one reason could

11 If peak prices are sufficiently higher than base load ones, then the storage component can be used to dispatch power to the grid in order to take advantage of higher peak time prices, resulting in significantly higher project profitability.

12 When looking at capital costs, CSP is further penalized given that the solar field might be oversized to feed a storage system making the plant more expensive on the basis of the name plate capacity but, often, less expensive on the basis of the actual power generated.

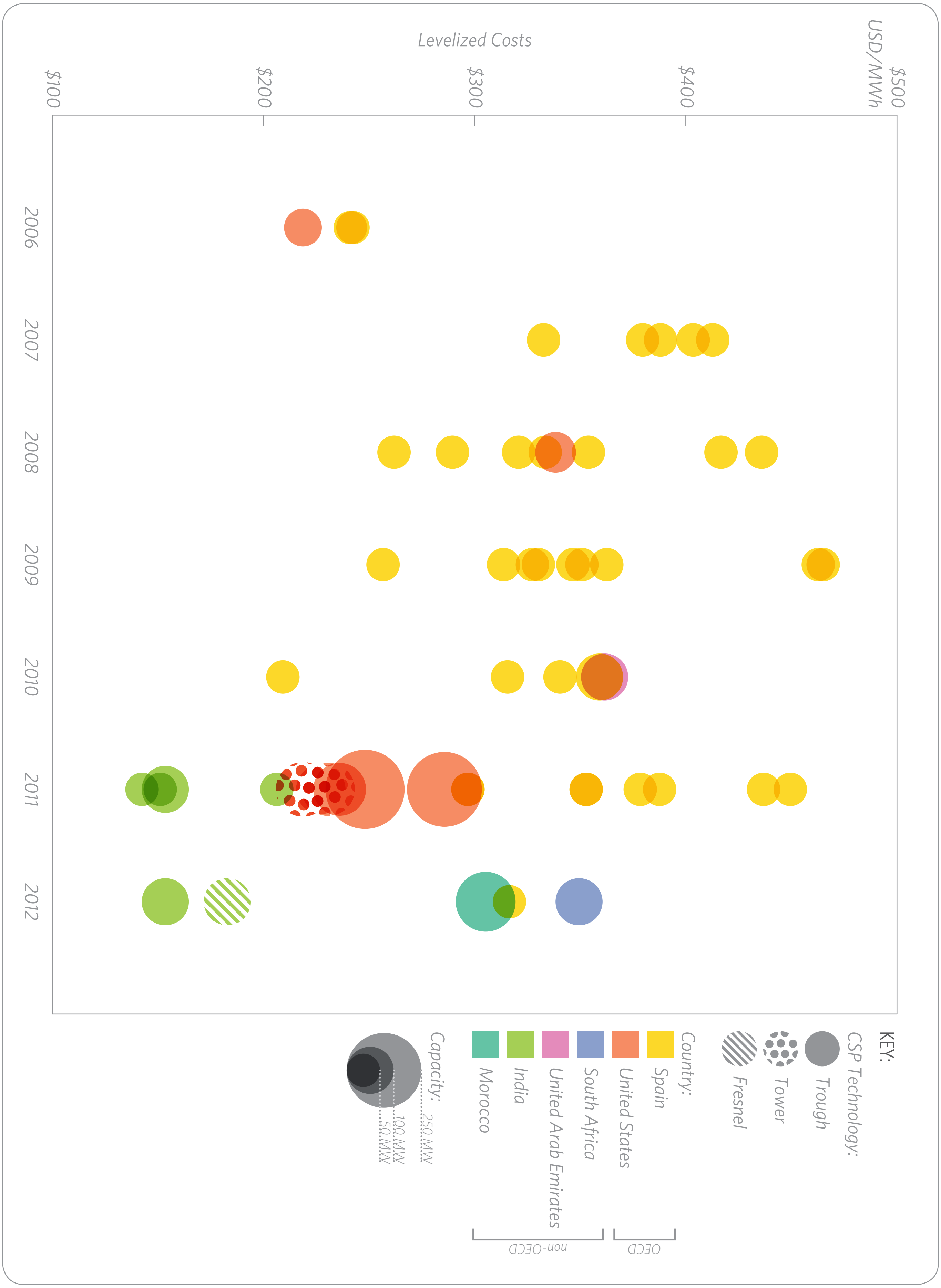
13 The remaining being operation and maintenance, financing and insurance costs.

14 Balance of plant indicates all parts of a power plant not included in the main driver of the plant; in this case the ones not specific to CSP (Rajpaul, 2012).

15 Cost estimates based on two CSP plants in South Africa adopting both parabolic trough and power tower technologies.

16 This means that unit costs for solar PV modules have decreased roughly 20% every time installed capacity has doubled.

Figure 4: CSP levelized costs since 2005 (CPI elaboration, based on BNEF, 2013)



be that market and regulatory design have not incentivized cost reductions with increasing deployment;[17] or that ongoing technology improvements have increased investment costs. We note, however, that in the last two years at least, projects in some countries (e.g. India) and for some technologies (e.g. tower) have shown levelized costs lower than the sector average, suggesting that different cost reduction dynamics might be at play in specific countries and for specific technologies.[18] The question to which extent future CSP deployment can generate further reductions, and how large this cost reduction potential is for each different CSP technology is central and remains open.

2.3 Financing, risk mitigation, and public support

In the last decade, developers of large-scale CSP plants have used public and private resources and a diverse range of financing models to reduce costs and mobilize total capital of USD 35.6 billion (Table 2).[19] The mitigation of risks is particularly relevant to the mobilization of this capital: risk (whether real or perceived) is the single most important factor preventing renewable energy projects from finding investors (Frisari et al. 2013). To determine how business risks (typically borne by equity owners) and financial/credit risks (borne mostly by lenders) are reallocated among public or private actors, we classify financing models according to the public or private nature of the equity and debt capital that supports them.

In our CSP projects database, covering projects commissioned or financed from 2006 to 2012,[20] we identified three broad equity financing project development models:

- **Private Producer model:** private investors (regulated utilities, independent private producers (IPP), or private developers) provide the risk capital for the construction of the project, operate the asset, and take the business risk of the venture.
- **Public-Private-Partnerships (PPP):** blending private and public equity capital for the construction and operation of the project, various forms of PPP are possible and they distribute business and operation risks between the public and the private actors differently.21
- **Public Procurement:** the public sector (government, municipalities, and state-owned utilities) commissions a private actor to build the project, but it retains ownership and the right to operate it. Typically, the private sector provides only services (construction, operations and management) but doesn't share any development or operational risk (Burger, Hawkesworth, 2008).

At the same time, we identified the following categories as the sources of debt investments:

- **Private Debt:** capital typically provided by debt investors (through bonds issued by the project company), or banks (through loans from their project finance desk), similar to common-place investments in conventional power infrastructures.
- **Private Debt with Public Support:** capital from private sources (again either loans or bonds) but with a portion of the financial risks transferred to public entities through credit guarantees or revenue support tools (e.g. feed-in-tariffs or tax credits).
- **Private-Public Blended:** the investment capital is provided by both private and public investors (either at concessional or market-based terms). The public sector investors not only provide a risk mitigation service, but also fill a capital shortage in the market.
- **Public Investment:** the full amount of investment capital is provided (either at concessional or commercial terms) by the public sector (state-owned utilities, state-owned banks, development banks, public investment funds).

While the private sector has so far been the main provider of equity capital to CSP projects with USD 31

17 The feed-in-tariff policy in Spain and its 50 MW size limit have been criticized for not being successful in driving down CSP installation costs (Nair, 2011).

18 These broad comparisons however do not take into account context and project specific issues, such as concessional loans, grants, and currency dynamics that might also influence investment costs beyond technology cost dynamics.

19 Values refer to global project values from 2007 onwards, in current dollar terms as converted by BNEF database.

20 In order to maximize data completeness and accuracy, we have limited the CSP projects database from BNEF to projects above a minimum size of 50 MW capacity installed that have already been commissioned (fully or partially), or for which financing has been already secured (the reader should note that the filters are slightly different from the previous section).

21 (Meaney, Hope, 2012) lists three different PPP models: 1) Build-Develop-Operate (BDO): private actor acquires and develop assets from the public agent, and operates it; 2) Build-Own-Operate (BOO): private actor builds and operates a new asset under the specification of the public agent, but it retains its ownership; 3) Build-Operate-Transfer (BOT): private actor builds and operates an asset but the ownership is transferred to the public agent at a later date.

Table 2: Development (equity) and investment (debt) capital profiles for CSP projects' value between 2006 and 2012. Values in USD million (share of total)

Debt / Equity	PRIVATE			PUBLIC & PRIVATE	PUBLIC	TOTAL
	WITHOUT PUBLIC SUPPORT	WITH PUBLIC GUARANTEES	WITH PUBLIC REVENUE SUPPORT			
PRIVATE	$476 (1%)	$6,906 (19%)	$21,955 (62%)	$1,61 (5%)	-	$30,952 (87%)
PUBLIC & PRIVATE	-	-	$722 (2%)	$1,450 (4%)	$1,163 (3%)	$3,335 (9%)
PUBLIC	-	-	-	-	$1,296 (4%)	$1,296 (4%)
TOTAL	$476 (1%)	$6,906 (19%)	$22,677 (64%)	$3,065 (9%)	$2,459 (7%)	$35,584 (100%)

billion in total, strikingly it has completely financed only a very limited number of projects.[22] In fact, **in almost all the projects in our database, developers have drawn upon some form of public resources**. As shown below in Table 2 this takes the form of revenue support for 62% of projects and guarantees for 20%.

In 2012 alone, public finance contributed around 36% of the total USD 5.6 billion mobilized by CSP investments, with state-owned entities, national, bilateral and multilateral development banks, and international public funds contributing an estimated USD 270 million in equity capital, and USD 1.7 billion in debt investments (Buchner et al., 2013). The shift of new CSP investments towards emerging markets and less proven technology specifications increases both real and perceived investment risks and will make public finance's role even more crucial in the next few years.

22 A 75MW project developed with utility balance sheet capital in the US (BNEF, 2013).

Public finance mechanisms to support CSP investments

Public finance mechanisms can be characterized as revenue support policies which aim to increase the value or the stability of the project's revenues; tools that reduce the financing costs of the investments by either agreeing to absorb potential losses (guarantees), providing finance at concessional terms (concessional loans and grants), or improving the functioning of financial markets; and fiscal support policies that reduce taxes to increase net revenues, reduce upfront investments or operating costs.

Revenue Support Policies typically take the form of an above-market-rate revenue stream provided by the public sector, directly or via a levy on electricity sales. They often ensure the financial viability of projects, while at the same time mitigating revenue risks. These subsidized revenues can be awarded via different delivery mechanisms, including:

- **Feed-in-tariffs** guarantee a level of revenue per amount of CSP electricity fed into the grid and have already been used in countries such as Spain, Portugal, Greece, Italy, Jordan, and Turkey. They have been quite effective in promoting private sector installations of CSP power plants but can put a significant burden on public budgets or on rate-payers' finances.
- **Competitive tenders** are a bidding process to build and run a CSP plant of a specific size at the electricity price fixed in the power purchase agreement between the winning bidder and the power distributor (e.g. Morocco, UAE, Saudi Arabia, Algeria, and Chile). It has the potential to foster competition and drive down costs but it results in a complex transaction for a single installation.
- **Reverse auctioning** is a hybrid between feed-in-tariff and competitive tenders. The reverse auctioning of the final tariffs obliges project developers to compete up to a fixed tariff ceiling for the right to provide electricity to utilities. Theoretically, reverse auctioning provides effective price discovery by ensuring that bidders bid low but request a tariff at which the project still yields their minimum acceptable rate of return. Used in India and South Africa, this approach can drive down costs by fostering competition and can spread procurement and transaction costs over a larger number of projects installed – on the other hand, it can attract speculative and excessively low bids that can result in projects failing to be built.

Tools to reduce the financing costs[23] are forms of public support that aim to reduce the costs of capital for the private sector, via transfer of certain investment risks, provision of concessional finance, or improvements of financial markets' functioning, including:

- **Public guarantees:** guarantees from the public sector in the form of full or partial debt repayment to investors (e.g. the U.S. Department of Energy Loan Guarantee Program) or in the form of insurance to equity investors (e.g. the Multilateral Investment Guarantee Agency's (MIGA) political risk insurance). They help mobilize private resources without requiring an immediate disbursement of financial resources from public budgets.
- **Public investment (concessional loans, grants):** subsidized equity and/or subsidized debt provided by public entities, typically necessary when the returns from the investment are not enough to compensate the risks perceived by private investors (international public investment in Morocco and Chile, national public investment in the U.S.).
- **Public support to financial markets:** direct interventions to create/increase liquidity in local financial markets and/or remove barriers to capital flows (e.g. facilitating/reducing costs of local currency hedging, supporting local currency financing, or the issuance of project bonds).

Fiscal support policies represent changes in fiscal regulation to increase net revenues, or reduce the upfront investments or operating costs of renewable energy investments They include:

- **Investment tax credits:**[24] tax credit for the investor equal to a specific percentage of the investment in CSP (U.S.). Its impact may be

23 It is important to note that whenever these tools simply transfer part of the costs from the private to the public actor, they reduce the cost "seen" by the private investor, but not a project's "economic" cost.

24 Further tax credits: reduced or alleviated taxes when investing in CSP and producing CSP electricity, including 1) Sales tax credit (USA), 2) Property tax credits (USA), 3) Tax credits for manufacturing plants (USA), and 4) Tax credit bonds (Clean RE Bond, USA): "tax credit bond, in which interest on the bonds is paid in the form of federal tax credits by the United States government in lieu of interest paid by the issuer (Oswald & Larsen, 2006)", actually only around 20% of USD 2.4 bn possible bonds have been used, see Kidney (2012).

limited to the extent that the applicant has enough revenues to benefit from tax credits.

- **Bonus depreciation:** higher depreciation of asset's value which, in the case of U.S., allowed project developers to expense 50% of the project capital costs for tax purposes in the first year of operations.

The different types of public support offered reflect different context-specific barriers to investment from the private sector. Direct injections of public capital (investment grants, concessional loans) are more relevant in markets where capital is constrained or perceived risks are so high that investors demand a return that makes capital "economically" unavailable. Revenue support policies (e.g. feed-in-tariffs) or credit-enhancement tools (e.g. public guarantees) are best used to address uncertainties arising because of a technology's lack of track record and innovative nature. Finally, public-private partnerships (PPPs) have the potential to align the interest of the public actor as service commissioner and the private investor as service provider (OECD, 2008), so PPPs seem particularly effective in contexts where regulatory risks are perceived as high (Frisari, Falconer 2013).

Why and when does CSP need public support for private investment?

Higher costs compared to other renewables and conventional fossil fuel technologies, and high real and perceived risks due to its innovative technological content, make the private sector unwilling to commit resources to CSP at scale without some form of support from the public sector.

Despite its current unfavorable financial profile, public sector policy and financial support to CSP can be justified by benefits of the technology that are not yet appropriately valued by the market. As one of the most promising technologies for harnessing scalable and dispatchable clean power, these benefits include:

- A very substantial potential to reduce carbon emissions by generating significant amounts of clean power and by displacing high emitting base-load fossil sources (e.g. coal);
- The possibility for this power to be stored and dispatched when it is most suitable for the grid (hence balancing the system and complementing fluctuating supply from other renewable sources) and when it is most profitable (e.g. during peak loads)
- The possibility of localizing manufacturing in emerging economies, fostering industrial development, while reducing further overall technology costs. The manufacturing potential is related to the simplicity of many components in some of its technical configurations.

However, the size of the financial resources needed to support the technology is often outside the capacity of many local governments. International public actors (such as the Climate Investment Funds) can then reduce the burden on national resources by sharing these early development and demonstration costs[25] and absorbing a portion of the risks involved. By providing knowledge and capacity to the development of local CSP policies and industries, international actors can also ensure greater knowledge transfer within regions, allowing cost reductions and technology improvements to be shared beyond the single projects and countries supported.

The upfront costs of CSP installations can have a significant impact on public budgets, so the benefits of CSP for countries with high solar irradiation may currently only outweigh the costs in specific situations, e.g. when cost-effective policy tools are chosen, when local benefits are high (e.g. due to high energy costs, need for reliable base-load power, or potential for local manufacturing) and when cost can be shared with the private sector. Involvement of the private sector not just as service provider but also as equity owner, may allow for a better alignment of interests in constructing and operating the plant (Burger, Hawkesworth, 2011).

25 Costs related to the early stages of technology development and linked to its low deployment. These should decrease as deployment rates increase and economies of scale are exploited.

Table 3: Principal CSP markets: technology choices, financing models, and policy frameworks

MAJOR CSP MARKET	INSTALLED / FINANCED CAPACITY	TECHNOLOGY USED	DEVELOPMENT / EQUITY CAPITAL	INVESTMENT / DEBT CAPITAL	MAIN PUBLIC SUPPORT	DETAILS OF PUBLIC SUPPORT
India	5.5 MW 525 MW	• Parabolic Trough 370 MW • Linear Fresnel 100 MW • Power Tower 52.5 MW	Private	Private	"Reverse auction"	India Solar Mission (Fixed subsidized tariff through a 25yr PPA with national authority).
MENA	80 MW 165 MW	• Parabolic Trough 220 MW • Dish Stirling 17 MW	PPP	Both Private or completely Public	Competitive tenders	Subsidized PPA in both the case of Morocco and UAE. In the case of Morocco, investment capital provided by public sector as well.
South Africa	0 MW 250 MW	• Parabolic Trough 100 MW • Power Tower 150 MW	Both Public and PPP	Public with some private sector participation	"Reverse auction"	CTF support and Regional Development Banks have provided most of the investment capital. The recently launched REIPPP Program will introduce private development capital for CSP.
Spain	1770 MW 770 MW	• Parabolic trough 2420 MW • Linear Fresnel 30 MW • Power Tower 50 MW	Private	Private	Feed-in-tariff	FIT set at national level through Royal Decrees, but currently undergoing drastic revisions.
United States	540 MW 1288 MW	• Parabolic Trough 1278 MW • Power Tower 540 MW	Private	Private	Loan guarantee + Investment Tax Credit	Investment tax credit of up to 30% of investment value; DOE Loan Guarantee supporting most of the projects (in most cases, the Federal Financing Bank has also provided the capital)

Source BNEF, NREL, CPI elaborations

2.4 Overview of public support in major CSP markets

Table 3 summarizes the main characteristics of both developed and emerging CSP markets in terms of the prevailing technologies, financing models, and types of public support of the projects that had been commissioned or financed up to the end of 2012.

The Spanish and U.S. markets have dominated the CSP landscape, with the highest number of installations and the largest overall installed capacity. Feed-in-tariff (FiT) policy supported the growth of the former. However, since the financial crisis, this has come under increasing criticism because of concerns about its cost to public budgets and many Spanish politicians have called for a drastic reduction in the tariff. This policy seems to have favored parabolic trough technology, while the capacity limit for receiving FiTs essentially led to installations of the same size (50 MW). On the other hand, U.S. projects appeared to have a more varied technology mix, with larger installations using power tower technology; here, a public debt guarantee program has mobilized the vast majority of the investments, with the exception of a 75 MW plant financed with the balance sheet capital of a large utility.

In developing economies with significant CSP activities (e.g. India, MENA, and South Africa), emerging financial structures include more active participation of private resources both as development capital through PPP models as in the case of MENA, or Independent Power Producer (IPP) models as in India or South Africa, and investment capital, alongside development banks and international climate funds. The most recently financed projects show a preference for competitive bidding (MENA) or reverse auctioning (India and South Africa). FiT systems still prevail in the European market, but are undergoing significant revisions.[26] For the installations in the U.S., the private-market negotiation of PPAs between project developers and utilities prevails, but the investment is often supported by debt guarantees issued by public entities.

26 Several countries are in the process of substantially revising feed-in-tariffs for solar (both photovoltaic and CSP). The most striking example of this is Spain which, in January 2012, suspended all economic incentives for all renewables until the government finds a solution for the widening tariff deficit due to support to renewables.

3. Methodological approach to distilling lessons on effective CSP financing

We will base our analysis off the effectiveness of different policies and public investment tools in promoting CSP installations at scale in emerging economies, on three main pillars:

- Two in-depth case studies will analyze the effectiveness of policy, risk management and financing, using the systematic analytical approach of the San Giorgio Group;
- CPI analysts will present and discuss case study insights and further lessons with experts at three 'CSP dialogues' to create a platform for exchange among researchers, private developers, investors, and policy makers.
- A lessons learned paper and policy brief will summarize the key findings from the case studies and the dialogues.

This section describes CPI's methodological approach to distilling lessons about the CIFs and other public investors financing of CSP.

3.1 Approach to case study analysis

CPI will use the San Giorgio Group case study approach to analyze the effectiveness of two specific projects that are supported by public finance. This approach has already been applied to assess four renewable energy projects to date: one CSP project (Ouarzazate I, Morocco), one solar thermal project (Prosol, Tunisia), one offshore wind energy project (Walney, UK), and one onshore wind energy project (Jädraås, Sweden).

We have adapted the San Giorgio Group (SGG) framework for assessing effectiveness to match the goals of the CSP project:

1. **Project overview.** This section describes the project background and policy context, its timeline, and presents key project stakeholders and their interactions;
2. **Investment, return and profitability analysis.** In this section, we quantify investment costs, returns and profitability for each stakeholder, relying on projects' financial information (cash flows, balance sheet) if publically available, or alternatively, industry standard assumptions. We look at:
   - **Project costs:** sources of finance (both public and private) across the different instruments used in its financing (equity, debt, guarantee)
   - **Project returns:** sources of returns to the project and to individual stakeholders.

   The cost-benefit analysis ultimately results in a detailed mapping of project cash flows, in the estimation of its levelized cost of energy (when applicable), and in an assessment of the benefits for different stakeholders.
3. **Risk allocation framework.** This section classifies and assesses risk in terms of severity of impact and probability of occurrence. We then analyze available risk management and response strategies (focusing on the high impact risks), to establish the project's sensitivity to unmanaged risks. Finally, we map the overall risk allocation framework resulting from those response strategies, in order to identify the ultimate bearer of each risk and how risk mitigation tools have reduced risks for investors.
4. **Effectiveness and costs.** This section tracks the project's effectiveness from its initial financial inputs, to short-term outputs and long-term outcomes. It also compares the projects' effectiveness with the initial assumptions,[27] and with similar projects (such as the CPI SGG case study on the Ouarzazate CSP project), while taking into account the differences in contexts (country, CSP experience, technology, and size of power plant). We specifically assess the project's technology and economic costs, and compare them with costs of other CSP projects. We will assess technology cost by tracking the supply chain of CSP plants and interviewing key stakeholders on cost reductions and the availability of technology suppliers.
5. **Replication and scale-up potential.** Here, we assess the potential to replicate or scale-up the project-specific financing structure by identifying and assessing the critical factors that contributed to a project's relative success or failure. Consider-

27 If CTF funding is involved, we consider the assumptions and expectations made at the time CTF investment plans were prepared.

ing the extent to which barriers are common to other investment structures and sources of finance (e.g. private and public sources), to projects in different geographies, with different stakeholders, or using different technologies, this section focuses particularly on the role of public loans (e.g. the CIFs' concessional funding) in getting projects built.

Applying the SGG approach will allow us to evaluate whether interventions (e.g. CIF loans) have had an effect (e.g. risk reduction, higher return for investors, and ultimately the installation of CSP plants). In theory, experimental or quasi-experimental approaches would be the best way to assess the impact of CIF funding on installations, but these approaches are not feasible for two reasons: either the required interventions for an experimental approach (e.g. random allocation of CIF funding) are not practically possible, or the required data for a quasi-experimental approach (e.g. a large sample of CSP projects) are not available. In this situation, the SGG approach has key advantages as the analyses of stakeholders, financing, policies, and risk allocation allow us to analyze the drivers of effectiveness of projects in depth.

As sources for the analysis, the project will use written documents, online resources, phone interviews, face-to-face interviews, and visits to the project sites.

3.2 Expert dialogues and distilling the key findings

CPI will share lessons from the case studies in three 'CSP dialogues' where key experts provide feedback and discuss challenges and solutions when financing CSP.

Finally, CPI plans to gather and review the relevant lessons on the effective scale-up of CSP technology, using insights from the case studies,[28] expert dialogues, and the literature.

Lessons learned cover three areas:

- **The effectiveness of policy and finance approaches** in driving deployment of new CSP plants by covering costs and mitigating risks.
- The **competitiveness of CSP** compared to fossil fuel power plants and other renewable energies in specific markets.
- The **role of CIF funding** in the past and future scale-up of CSP.

28 Including a past SGG case study on CSP - Ouarzazate, see Falconer and Frisari, 2013.

As we define **effectiveness** as the impact public investment and policies have on the deployment of CSP, and co-benefits related to CSP deployment, we have to, first, measure the deployment rates of CSP and other co-benefits and, secondly, evaluate the impact of public interventions. The short-term **deployment of clean energy** are measured through indicators like investments in and installation of new CSP plants, including the speed of deployment. **Co-benefits** considered include the creation of local jobs, the reduced dependence on energy imports, the transfer of technology and grid stability. There are no direct measures for long-term deployment so we look to indicators such as achieved cost reductions, learning on how to efficiently plan, finance, construct and operate CSP plants, and the creation of local manufacturing potential in emerging economies.

We conduct the assessment of the **relative impact of different finance and policy tools** on CSP deployment and cost reductions in two ways: firstly, through in-depth analysis of case studies, using financial modeling, risk assessment, and expert interviews, and secondly, by comparing similar projects to identify the key policy support and financing tools of the most successful CSP plants. Whenever possible, we compare the effectiveness of the policy with the cost to the public.

We analyze the **competitiveness of CSP** with other energy options by tracking the investment and production costs of CSP **in specific markets** (India, South Africa, and Morocco), while taking into consideration that storage implies both additional investment costs and benefits. If possible, we identify the rate of cost reduction as additional power plants are built (the so-called learning curve). Technology supply chain analysis within the case studies should deliver insights on where cost reductions have occurred or can occur in the future, including cost reductions due to local manufacturing. The impact of CSP's capacity for producing base-load power on its competitiveness is discussed with reference to the literature but not analyzed on its own.

We examine the use of **CIF funding in the past** and ask what role it could play in the future. We examine CIF's past role by using the tools to analyze effectiveness specified above. For the future role of CIF funding we look at different factors such as: the quantity of concessional financing required in different policy contexts, the aim of this funding (capacity building, cost coverage, or risk reduction for private investors), and the **type of instruments** (grants, concessional loans, non-concessional loans, and guarantees). We mainly base this second section on the outcome of interactions with key stakeholders.

4. Next steps: case studies on projects in India and South Africa

Based on the key emerging CSP markets we identified in the CSP landscape (India, MENA, South Africa), and our interest in the effectiveness of international public finance, we selected the Rajasthan Sun Technique project in India and the Eskom project in South Africa for our case studies. The next sub-sections outline the policy context in which they operate, and provide insights into their financing.

4.1 Rajasthan Sun Technique 100 MW linear Fresnel project in India

Studying the Rajasthan Sun Technique 100 MW power plant can provide valuable insights on the effectiveness of CSP financing for several reasons;

- **It is one of the nearest to completion of the CSP projects tendered under the 20 GW Indian Solar Mission**, which is among the largest renewable energy policies passed by an emerging economy in the last few years. The seven other CSP plants under the first phase of the Indian Solar Mission allow for comparative analysis across different technology specifications and financing solutions.
- By awarding subsidized Power Purchase Agreements through a **competitive reverse auction**, the Government of India **was able to deploy CSP plants in a very cost-effective way**. However, it may also have **reduced margins so far that some winning bidders will ultimately be unable to build** CSP plants.
- It is highly innovative. **It will be the largest ever plant using compact linear Fresnel**, a potentially lower cost CSP technology.
- The project is financed through a **combination of private sector resources and development bank funding on non-concessional terms**, which **is unique** for CSP.

Why study CSP in India?

The Indian government launched the Indian Solar Mission in 2010 (GoI, 2013). Targeting 20 GW in CSP and solar PV investments by 2022, it is one of the most ambitious expansion plans for renewable energy in any emerging economy. The government faces a significant challenge to bring it to completion on time while avoiding excessive burden on the public budget.

To support its development, India opted to reverse auction the final tariff: this can, potentially, support several projects at once, while minimizing overall transaction costs and encouraging competition and cost reductions. Reverse auctioning can also be risky, as some winning bidders may not ultimately be able to commission their plants. For instance, while the Rajasthan Sun Technique project is well advanced in construction, only one CSP project under the Solar Mission's phase one has been implemented on time. It will be interesting to explore whether a lack of data on solar irradiation or overly risky bidding has been responsible for the delay.

Reverse auctioning is a different approach from the feed-in tariff system that spurred CSP growth in Spain, or the competitive tender approach recently adopted for CSP installations in Morocco and UAE. For details on CSP policies, financing and CSP technologies used in India, see Table 4.

Why study the 100 MW Rajasthan Sun Technique plant?

The 100 MW Rajasthan Sun Technique CSP plant is currently under construction near the village of Dhursar, Rajasthan. It is one of the most advanced of the seven CSP plants (with a total capacity of 470 MW) to which the government has given permits in the first phase of the National Solar Mission in India, and it makes up for around half of the capacity likely to be installed.29

The Rajasthan Sun Technique plant will be the largest CSP installation in India when commissioned. It will also be the world's largest CSP plant using compact linear Fresnel technology (BNEF, 2013) and is projected by ADB (2012) to deliver utility-scale CSP power at lower costs than power tower and parabolic trough. The plant has been awarded a tariff of 11.97 Indian Rupees per kWh (around 0.19 USD/kWh) from the Indian government: lower than some parabolic trough plants, and interestingly lower than the other, smaller, linear Fresnel

29 At the time of writing, only one plant under the National Solar Mission (50 MW) has been commissioned, and only two other projects, including the Rajasthan Sun Technique plant, are likely to become operational, bringing the total installed CSP capacity under the mission to 200 MW.

plants also in the scheme, perhaps because of economies of scale (NRDC and CEEW, 2012).

Interestingly for India, despite the limited experience with CSP technology in the country, commercial banks have participated in the proposed limited recourse financing of CSP plants in the mission. For the Rajasthan Sun Technique project, the choice of a less-tested CSP technology than in other plants in the solar plan has required more public lending, including debt from ADB, the Dutch Development Bank (FMO), and the U.S. Export-Import Bank. All of this debt is provided at close to commercial terms.[30] However, while the interest rates of debt from international public lenders are below Indian market rates, the costs for hedging foreign currency risks means that it is only the longer maturity of loans that makes international public lending more attractive than local lending.

Reliance Power, a large Indian corporation, is developer and equity provider, and one private bank complements public with private lending. The case study will allow an analysis of how this multi-source financing model enabled the implementation of this first-of-a-kind project, and whether this approach can be replicated with other innovative CSP projects.

30 We define commercial terms as the market conditions for debt in similar projects. Conditions include capital costs (required interest and potential hedging costs), maturity, and grace period.

Table 4: Key features of CSP policies, financing, and promoted technologies in India

POLICY	• The Indian **National Solar Mission** plans 20 GW in solar investments by 2022 divided in three phases: 2 GW by 2013, 10 GW by 2017, and 20 GW by 2022. CSP is expected to make up almost 25% of the total installed capacity. In the first phase of the plan, seven CSP projects have been allocated a guaranteed tariff through a reverse bidding process for a total of 470 MW of CSP (NRDC and CEEW, 2012). • The **reverse auctioning** of the final tariffs obliges project developers to compete up to a fixed tariff ceiling for the right to provide electricity to utilities. This competitive process can result in an electricity rate that is higher than the market going rate, but still pushes costs down. Theoretically, reverse auctioning provides effective price discovery by ensuring that bidders request a tariff at which the project is commercially viable, while still yielding their minimum acceptable rate of return. • Dispatchable renewable energy sources can help India **replace high emitting coal** (42% of the energy mix, see WEF, 2012) and improve energy security. • **Synergies between national and state level policy can be explored.** Two states (Rajasthan and Gujarat) have launched their own state level solar missions whose interaction with the nationwide mission deserves analysis.
FINANCING	• **Cost of capital** is a barrier for clean energy development in India, especially with the high costs of debt (Nelson et al, 2012). This is driven partially by central bank rates aimed at controlling inflation. • Despite very **limited experience with project financing** and non-recourse lending, a significant number of both public and commercial banks both international and local are involved in the first phase of CSP financing for the solar mission (NRDC and CEEW, 2012). • **Potential interactions with CTF concessional lending:** the Clean Technology Fund (CTF) has two streams of concessional funding for solar power in India. Firstly, financing for solar parks (this does not include direct funding for CSP but it may benefit from the infrastructure, such as transmission lines), and secondly, a concessional pool of $50 million in funds to support several demonstration CSP projects, which is likely to be available for Phase II of the Indian Solar Mission (CIF, 2011).
TECHNOLOGY	• The Indian Solar Mission does not include **specific technology requirements** within the allocation for CSP, apart from minimum local content requirements, letting developers select their own preferred technology so as to optimize production efficiency at minimum cost. The tender process in Phase 1 has selected five parabolic trough CSP projects totaling 350 MW, and two linear Fresnel projects totaling 120 MW (NRDC and CEEW, 2012). • Phase 1 has already highlighted **the high resource dependence of CSP technology;** the tender was closed when data on the solar resource at each site were not complete and several bids were thus submitted based on interpolation of high level data[1] (NRDC and CEEW, 2012), leading to high uncertainty on actual generation costs.. In the end, solar irradiation proved to be lower than expected. Furthermore, construction times and issues seem to have been underestimated in several cases, with most of the plants experiencing significant delays.[2]

1 Developers took on a substantial resource risk that now is indeed affecting expected revenues (NRDC and CEEW, 2012).
2 Developers were originally facing financial penalties for not completing awarded projects by the end of May 2013 but the Government of India extended the deadline to the end of March 2014 (CSP Today, 2013a).

4.2 Upington 100 MW power tower project in South Africa

Studying the Upington 100 MW project can provide valuable insights on the effectiveness of CSP financing for several reasons;

- It will be the **largest CSP power tower project in South Africa** (and probably even in emerging economies) when completed in 2016-2017, and will be developed by Eskom, the state-owned utility.
- **The project lies outside of the national renewable energy support program**, which includes three CSP projects, so allows for comparative analysis across different scales, technologies, and financing structures.
- **Eskom's involvement could be crucial for the future development of CSP in the country** because of its important role in the national power sector (owning 95% of the generation capacity). For this project, it is receiving public financing from several bilateral and multilateral development institutions, in addition to providing project equity.
- The **state-owned/publically-funded project's financing arrangement differs from that of most other CSP plants**. It presents lessons for the future scale-up or replication of financing large-scale CSP projects in regions that have vast potential but lack private investor appetite for more suitable, but more immature CSP technologies.

Why CSP in South Africa?

South Africa has one of the greatest solar energy resources in the world, receiving irradiation levels up to 40-50% above Spain's.[31] However, despite the potential of its sun and wind, South Africa's renewable energy remains largely unexploited and the country has some of the lowest penetration rates among major economies. Domestically, CSP is expected to play a critical role in meeting the country's future electricity needs.

31 Specifically the Upington site: see GeoModel Solar Resource Assessment for the Upington site (GeoModel Solar, 2011)

Yet, South Africa relies largely on carbon-intensive coal generation, which, with fewer investment risks, is typically easier to finance than CSP, meaning the latter requires public resources to unlock investment.

The government mainly promotes CSP through the Renewable Energy Independent Power Producers' Procurement Programme (REIPPPP), which invites private developers to bid for allocated capacities of new build renewable energy power plants and receive a power purchase agreement with Eskom, set at a tariff (above market prices) that compensates them for their installation costs. In the first two bidding rounds, the government allocated 200MW of PPAs to three CSP plants, and in the third bidding round provisionally allocated a further 200 MW to two CSP plants.[32] For details on CSP policies, financing, and CSP technologies used in South Africa, see Table 5.

Why study the Upington 100 MW power tower project?

Upington will be the largest power tower CSP plant in South Africa (and probably even in all developing and emerging economies)[33] and can provide insight on the potential of a more suitable, yet more immature, technology's potential for increased deployment and cost reductions (AfDB, 2013). Since it is almost entirely publically financed (state-owned entity plus public funding) and includes 9-12 hours of thermal storage, Upington offers a unique technology and financing model among South African CSP projects. If Upington is a success, it will likely be the first in a long line of projects until 2025.

CSP financing risks means significant concessional finance or revenue support is required to get CSP plants built. While total project cost is not finalized, Upington is expected to cost approximately USD 1200 million. According to current plans, Eskom has secured approximately USD 1000 million in public debt: USD 250 million from the Clean Technology Fund (CTF) (part of the Climate Investment Funds), USD 220 million from the African Development Bank, USD 195 million from the World Bank, USD 140 million from the Agence Française de Développement (AFD), and around USD 200 million from Kreditanstalt für Wiederaufbau (KfW) and European Investment Bank (EIB). The remaining financing is assumed to be project equity on balance

32 The third bidding round was awarded in October 2013, and is subject to final checks, see DoE (2013).

33 According to BNEF (2013), only one other power tower plant of at least this size is financed and under construction in a non-industrialized country; the fate of the CPI Geermu Haixizhou 100 MW CSP plant in China is however unclear.

sheet, and/or alternative funding, from project developer Eskom (which will jointly develop the project with the 100 MW Sere Wind Farm). Eskom plays a critical role in South Africa's power sector, so its interest in CSP is important for its future development.

Table 5: Key features of CSP policies, financing, and promoted technologies in South Africa

POLICY	• In 2011, the government launched a 20-year **Integrated Resources Plan** (IRP) for electricity to expand generation capacity, and accelerate the use of renewable energy (see below). The plan aims to generate 10,000 GWh from renewable sources by 2013 (approximately 4% of total electricity generation), with 42% of new installed capacity to be renewable by 2030. It also aims to increase domestic energy security and electricity access to the population (GoSA, 2013). • **CSP plays a significant role in the IRP and the country's future energy plans.** The IRP plans almost 3,725 MW of new renewable capacity by 2017 and 20 GW by 2030, of which CSP represents 200 MW and 1.2GW,[1] respectively. This is small compared to the potential: state-owned utility Eskom estimates CSP potential of around 40 GW in the Northern and Western Cape regions alone. • The **Renewable Energy Independent Power Producers' Procurement Programme (REIPPPP)**[2] is in line with IRP targets, and invites private developers to bid/tender for allocated capacities of new build renewable energy and receive a power purchase agreement with Eskom, set at a tariff (above market prices) that compensates them for their installation costs. Three 'bidding windows' include 200 MW to CSP in the first two rounds,[3] and a provisional 200 MW in the third (CSP Today, 2013b).
FINANCING	• Eskom's 100 MW power tower project is planned with 9-12 hours of storage, and is fully publicly financed outside of the REIPPPP. **The REIPPPP projects are financed using a public-private model, so Upington will offer useful financial, technical, and cost comparisons to the following projects:** • Khi Solar One, a 50MW power tower project with two hours of storage, • KaXu Solar One, a 100 MW parabolic trough project with three hours of storage capacity, and; • Bokpoort, a 50 MW parabolic trough project with nine hours of storage. • A 2012 EPRI report found South African power tower CSP projects have lower capital costs and lower levelized costs of energy than parabolic trough projects (Rajpaul, 2012). Despite being technically more suitable, **there is difficulty in obtaining finance because of its innovative elements**. The Upington power tower is publically funded primarily from development banks, and partially by Eskom. Our case study analysis will include comparisons of costs and tariffs with other South African CSP projects in order to test this result. • South Africa faces similar CSP investment barriers (technical, experiential, or financial) to other countries. They reduce overall financing capacities/appetites and, in most cases, necessitate concessional lending. The CTF explain that public finance in Upington is to "**reduce high capital cost and/or to mitigate potential risks, such as cost overruns and/or performance risks.**" (CIF, 2013) • **All South African CSP projects have received some sort of public funding.** This is typically when public development financial institutions (e.g. African Development Bank, French Development Agency, European Investment Bank, German development bank KfW), or local community holdings and industrial bodies (Industrial Development Cooperation)[4] provide funding to privately developed projects (e.g. Spain's Abengoa Solar SA in two CSP projects, or South Africa's Emvelo). There are also plans for involving high-net worth foundations (Clinton Climate Initiative).
TECHNOLOGY	• REIPPP **does not specify support based on technology** other than the capacities available in the tendering process.[5] This resulted in the selection of the most mature technology (in this case parabolic trough). • **CSP in South Africa is still at a very immature stage**; but in 1999-2001, Eskom developed a CSP feasibility project in collaboration with the World Bank and the National Renewable Energy Laboratory, receiving funding from the Global Environment Facility. Presently, there are some 400 MW of CSP projects under 'firm' development which may come online byy 2017, and several more at earlier stages. Of the four projects currently in operation or being built, two opt for parabolic trough and two for power tower technology.

1 Equivalent to entire global CSP fleet as of 2010 (Fichtner, 2010)

2 Replaced the Renewable Energy Feed-in-Tariff in 2011. REIPPP is operated by the Department of Energy, and regulator NERSA (see DoE, 2013). See Energyblog (2013) for a list of projects.

3 For summary of REIPPPP CSP projects, see SASTELA (2013)

4 A community trust hold 20% of the CSP project in its area, with Abengoa owning 51% of the projects and the IDC 29% as part of its mandate to support development of the green economy (SASTELA 2013).

5 However, the recent bidding round included an increased tariff for peak supply of energy, somewhat incentivizing storage in CSP projects.

5. The role of public finance in CSP: key questions for policy makers

In reviewing the current CSP landscape, it is apparent that most projects have required some public support (either via policies or direct investments) but very different tools have been used. It is then necessary to consider how public support can be best delivered in a variety of economic and policy contexts, and whether the existing delivery mechanisms are being effective in making this technology more competitive with market alternatives over the longer term. The CSP landscape also identified emerging economies as new CSP markets with a particular role for international public finance to address investment risks.

The key questions raised by our research on the role of public finance in supporting CSP development in an effective and cost-effective way 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 development and 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?

These questions will inform the rest of our work in this series. We have already started work on the case studies. We plan to finish both the Indian and South African case studies in the first quarter of 2014.

The lessons learned paper and policy brief will be completed by May 2014 in order to inform policymakers at the last CSP dialogue and the Climate Investment Funds (CIF) Partnership Forum on the project's insights how to effectively use public finance to deploy CSP at scale. This schedule allows the CIFs to draw on lessons from different CSP markets around the world to improve their design, helping scale up investments in a promising technology that could make a significant contribution to the global transition to a low-carbon energy system.

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