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Upscaling Concentrating Solar Power: Economics, Technology and Competitiveness

Economics of PV versus CSP:

Solar photovoltaic (PV) has reached generation parity with most conventional and renewable power technologies. A case in point is Mexico, where in the last of a series of international competitive auctions, PV developers have on average bid tariffs in the area of USD 45 per MWh. For the coming years, all indicators point at the continuous further decrease in PV energy cost, such that the game-changing character of solar PV seems hardly stoppable for global electricity markets. That is, on a purely MWh or kWh tariff basis.

Grid operators, however may take a slightly different view. In many countries in the global sunbelt, the main peak demand is in late afternoon or evening hours, at times when PV cannot deliver. Hence, PV power needs a backup with additional power generation capacities that typically provide mid-load or peak power to cover non-solar hours. These additional facilities signify additional capital and/or fuel costs that need to be taken into account to get the full picture of the impact of PV power to the grid and, eventually, to the customer.

In this area, concentrating solar power (CSP) can provide valuable complementary solutions. Most CSP technologies offer economic storage and co-firing options, enabling CSP to be used typically as a mid-load or even base load plant. Average tariffs quoted in recent auctions have come down to range between USD 140 and USD 120 per MWh (Morocco, South Africa). This is still a long way from the USD 60 to USD 40 per MWh where PV is today, but nonetheless, an often neglected, important aspect: CSP does not require additional backup capacity in the grid. CSP tariffs reflect the overall cost to the grid without any additional backup or storage capacities needed to balance out the intermittency of supply, as is the case for PV or wind power generation. This has been acknowledged in situations where grid operators have a say in auctions. In South Africa, for instance, CSP's dispatchable power gets almost triple the base tariff during the peak hours in the grid, between 5 pm and 9 pm.

But even with a higher value of its power being dispatchable, CSP tariffs need to decrease substantially further in order to compete. CSP needs to achieve electricity tariffs in the range of USD 40 to USD 60 per MWh to compete with conventionally generated power, and also in order to significantly scale up. How can this be achieved?

What can be done to further drive costs of CSP down?

The main factors to drive competitiveness of CSP power and scale up deployment are the so-called learning curve, low cost of capital and competitive environments for long-term offtake contracts. In principle, the aforementioned factors are all closely interrelated: the lower the tariffs offered by CSP plants, the more would be deployed, production capacities grow and the learning curve process is on, further contributing to higher efficiency and cost savings. To enter this process chain, the technology risk is the key.

Technological risk and the cost of capital

In the solar PV industry, project financing structures have not only mobilized large amounts of inexpensive, long-term debt, but also brought up new types of equity investors in addition to "usual suspects" like utilities, IPPs or EPC's: a new landscape of financial investors such as asset managers, infrastructure and pension funds as well as private individuals of all types have been massively investing into solar PV as a major renewable asset class. They all appreciate low technology risk with long-term highly predictable cashflows. With massive global appetite for clean tech assets and high comfort with PV technology risk, equity returns have been under pressure: today, investors in PV projects accept equity returns that are significantly below the middle to high teens that international IPPs asked for over the last decades. As emerging markets are taking over the larger part of global solar activity, the same applies to these higher risk environments: PV auctions in countries such as South Africa, Brazil or Mexico amazingly result in tariffs that are going to yield merely single-digit or low teen returns.

Proven technology?

One of the essential success criteria for the high technology comfort of investors and bankers is the "proven technology" status. In the PV sector, many equipment suppliers have reached this status today. With over 150 GW solar PV capacity in operation, many suppliers and EPCs find it easy to show evidence. For CSP, this cannot be claimed in a similar dimension. Parabolic trough projects have successfully operated in over 3 GW amounts for many years today. As a result, the trough is the technology most relied upon, considered as most trustworthy. Yet, most of CSP projects presented for financing have significant technological improvements and design innovations that cause lenders to raise eyebrows about reliability and performance predictability. Missing standards for energy yield forecasts cause uncertainties, such as the right method for solar irradiation assessments and energy yield evaluations. Such uncertainties have a multiple effect on the cost of capital: leverages are lower as banks take heavy discounts on project cash flows to reach their comfort zone, margins are higher than with comparable solar PV projects and, eventually, extensive guarantees for construction and performance risks put an additional burden on sponsor's balance sheets and increase financing cost.

On the equity side, as long as a technology does not qualify as proven, the investor landscape remains sparsely populated: only strategic investors such as utilities, IPP's, developers or EPCs would be willing to look at accepting risks resulting from innovations. In project finance, they do not only have to assess the risks for their own equity invested, but also need to provide comfort to lenders, mainly in form of additional guarantees. Most financial investors shy away completely from getting involved into CSP for this reason.

Throughout the phases of project development and financing, the yield calculation is the key issue for CSP. However, until today, no standardized methodology for yield calculation of CSP plants exists. Developers, investors and lenders spend a lot of efforts in each project discussing the right approach for solar resource assessment and its translation into energy yield under the chosen technology design of the plant, just to arrive at the conclusion that the uncertainty is high until eventually operative performance provides evidence. This uncertainty results in high risk premiums such as higher spreads, lower leverages and shorter tenors, needless to mention the efforts and negotiations between banks, sponsors and their respective advisors to cast the risk into bankable agreements.

Reducing technology risk by standardization: the CSP bankability project

In 2014, a consortium of research institutions and industrial partners initiated the project *CSP Bankability.* Funded by the German Ministry of Economic Affairs and Energy (BMWi), the project aims at establishing a guideline and a handbook as an input to the international CSP community of developers, investors, banks and other stakeholders. The guideline will contain concepts for CSP yield analysis, different energy yield modelling approaches, operational strategies and recommendations to handle uncertainties in yield analysis. Further, standards shall be proposed for modelling all sub-systems in a CSP plant, such as solar field, power block, thermal energy storage and auxiliary heaters. Besides a description of technical system features, a yield model also requires a precise assessment of the expected amount of solar irradiation, including the influence of varying irradiation levels. In PPA and tariff regimes with a time-of-delivery function, the timely energy yield and capacity available play a decisive role to project economics.

The initial guideline version provides a generic framework for modelling all types of CSP technologies. Depending on the maturity of the technology (e.g. parabolic troughs today are more mature than solar towers), the level of detail in the models and parameters differs. Since this guideline document serves for both, development of projects and support of research & development, setting up principles for modelling new technologies is considered an essential part, as well as their quick inclusion into the overall standardization.

A comprehensive draft of this guideline is currently under review and will be presented in 2016 to the international CSP community at the SolarPACES event, an international conference of scientists and professionals of the global CSP industry.

The way forward: which factors can drive CSP deployment further?

a. **Valuing dispatchability** - In the South African Renewable Independent Power (REIPPP) auctions, CSP power in the evening peak hours achieves a 170% premium on the base tariff, still in line with other, more expensive peak power. This values the dispatchable power capacity of CSP with storage to deliver firm power in the evening peak hours. This is a good example how to acknowledge CSP’s cost to the grid, which is lower than intermittent renewable power supply from PV or wind with backup and storage capacities.

b. **Reduction of Capital Cost by Standardization -** Once the CSP community agrees on energy yield modelling standards, lenders´ and investors´ comfort with energy yield forecasts will lead to reducing risk premiums. New investor segments such as pension or infrastructure funds could get attracted to CSP assets.

c. **Concessional finance -** The Moroccan Solar Energy Agency MASEN has mobilized concessional funding for its Ouarzazate CSP investments at favourable

d. concessional financing terms. Some development banks exclusively lend to national utilities or national banks. A blend of public and private sector financing instruments instead might catalyse crowding-in effects. With some specific risk-mitigating instruments like first-loss pieces or mezzanine tranches in project financing schemes, commercial banks may be incentivised to familiarize themselves with the CSP technology and appraisal procedures. Such processes could help facilitate to spread technology risk comfort among private sector lenders and trigger further private sector financing activities.

e. **Supporting project development -** Compared with PV, CSP takes longer to develop and is more costly, with more complex issues to be addressed. Returns, however are not necessarily higher, due to competitive bidding even in emerging markets. Concessional funding support of development risk, together with technical and capacity building, would balance market inadequacy in this area and provide suitable projects for investors to join in.

f. **Growing penetration rate of PV -** The dynamically growing penetration rate of PV and other intermittent renewables in international electricity markets increases the need for grid-stabilizing, dispatchable clean power. CSP can offer high value to smooth out load curves and provide ulitity-scale power with many full load hours after sunset. Chances are, the PV tide also lifts many CSP boats.

g. **Competitive solutions -** Already today, CSP already offers very competitive solutions in some previously disregarded market segments. Industrial process heat is one of these. CSP can supply temperatures well above 100°C to 200°C to many industrial processes, many of which have load curves highly matching those of CSP’s energy supply. Solar-generated high temperature saturated steam can be used in industries from leather and textile production, to diary production and mining. In the Gulf region, Kuwait Oil Corporation is currently implementing a project of enhanced oil recovery with solar CSP. As an example, CSP is delivering steam at much lower cost than the conventional supply fuelled by oil or gas. An entirely untapped market segment, solar process heat could help scaling up CSP significantly on a competitive basis from the start.

Suntrace GmbH is an independent expert for developing solar energy projects in emerging solar markets in Asia, Africa, the Middle East and Northern Africa (MENA) as well as in Latin America. The company covers all major technologies from photovoltaics to solar thermal power, advising customers from industry, finance and institutions. The company’s focus is on solar resource, technical performance, bankability and investment structures. In total, the company has provided support to more than 50 solar power projects with over 3000 MW capacity in over 21 different countries.