Techno-economic analysis of concentrated solar power plants in terms of levelized cost of electricity

Techno-Economic Analysis of Concentrated Solar Power Plants in Terms of Levelized Cost of Electricity

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Abstract. Levelized Cost of Electricity (LCOE) is an important metric which provides one way to compare the economic competitiveness of different electricity generation systems, calculated simply by dividing lifetime costs by lifetime production. Hidden behind the simplicity of this formula are various assumptions which may significantly alter results. Different LCOE studies exist in the literature, although their assumptions are rarely explicitly stated. This analysis gives all formulas and assumptions which allow for inter-study comparisons. The results of this analysis indicate that CSP LCOE is reducing markedly over time and that given the right location and market conditions, the *SunShot* 6¢/kWh 2020 target can be reached. Increased industrial cooperation is needed to advance the CSP market and continue to drive down LCOE. The results also indicate that there exist a country and technology level learning effect, either when installing an existing CSP technology in a new country or when using a new technology in an existing CSP country, which seems to impact market progress.

INTRODUCTION

Levelized Cost of Electricity (LCOE) is an important metric which can be used to compare the economic competitiveness of different electricity generation systems. LCOE is calculated simply by dividing the sum of the total lifetime costs of an installation (notably CAPEX and OPEX) by the total lifetime production of the installation. The resulting benchmark, typically expressed in USD¢/kWh, provides one way to assess the competitiveness of a technology and can be used to determine required governmental financial support, for example in the forms of a carbon tax or a feed-in tariff (FiT), or as a basis for comparing bids in response to competitive tenders.

High LCOE is a common criticism for concentrated solar power (CSP) plants. The USA's *Department of Energy* (*DOE*) through its *SunShot* initiative [1] aims at an aggressive LCOE of 6¢/kWh for CSP plants by 2020. To determine whether industry is on target to reach this *SunShot* goal and in general to look at progression over time, the authors have carried out a complete study of the CSP market. All 74 worldwide operational and stand-alone CSP plants1 have been analyzed based on different techno-economic metrics.

[1] Excluding combined cycle plants.

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The results obtained in this paper have been used to observe trends over time, find correlations, for example between LCOE and tower height for central receiver systems or between LCOE and CSP technology type, and also to assess their evolution in the future.

METHODOLOGY

Whilst different studies looking into CSP LCOE exist [2-4], their methodological assumptions are not well defined and thus inter-study comparisons are difficult. In addition, despite the apparent simplicity shown in Eq. (1), LCOE calculations are sensitive to numerous variables. Discount, interest and inflation rates can significantly impact capital intensive projects. The debt and equity structure can vary across projects as can governmental incentive schemes. Accounting or not for costs of grid connection [5], R&D, project management and impact assessment [4] can alter results. Carbon prices and external mitigation may or may not be included in revenue streams. Fundamental assumptions on the lifetime of the project, the financing period and the operating expenditures are also important. Projects that use natural gas for pre-heating the heat transfer fluid (HTF) and/or super-heating the steam can also influence the economics.

$$LCOE = \frac{CAPEX_0 + \sum_{t=1}^{N} \frac{OPEX_t}{(1+i)^t}}{\sum_{t=1}^{N} \frac{Production_t}{(1+i)^t}} \tag{1}$$

As described in Eq. (1), LCOE is calculated by summing the CAPEX (capital expenditure) in year 0 and the discounted OPEX (operating expenditure) from years 1 to 30, and then dividing the total by Production from years 1 to 30. In order to structure the LCOE calculation in a way that makes it comparable and which allows for the separation of inter-project differences and advances, each project's input parameters are standardized as shown in Table 1.

TABLE 1. Standardized assumptions for LCOE normalization.

➢ **Technical inputs**
- Project lifetime i.e. the production period (N): 30 years
- Production degradation factor: 0.4 %/year [2]
- Gas consumption: 800 Btu/kWh
- Water consumption: 80 gallons/MWh (dry cooling), 800 gallons/MWh (wet cooling)

➢ **Economic inputs**
- Euro € to Dollar $ conversion: 1:1.15
- Interest Rate: 5 %/year
- Equity Rate: 13 %/year
- Debt/Equity Split: 70 %/30 %
- WACC (i): 7.4 %/year
- Residual Value: 12 % of total CAPEX
- Gas cost: 5 $/MMBtu
- Water cost: 0,005 $/gallon
- Loan lifetime: 25 years
- O&M OPEX costs: 90 $/kW$_e$/year
- Insurance cost: 0,4 % of total CAPEX
- Land rental: 2 % of total CAPEX
- Contingency and Miscellaneous (Project Development, Project Management, Grid Access) costs: 15 % of total CAPEX
- Miscellaneous OPEX (Unexpected Corrective Maintenance, Additional Taxes): 3 % of total CAPEX
- PPA Escalation: 1 %/year

This LCOE normalization relies on common values for all key technical and economic parameters that may vary on a project-by-project basis. Also, all capital costs are inflation-adjusted using the OECD consumer price index (CPI) from 1984 to 2015 [6].

The use of a common set of parameters (project lifetime, annual OPEX, etc.) for calculating LCOE is important in order to make a fair comparison between CSP projects in the same country or same local area. These comparisons can be used to derive learning curves to indicate progress over time by technology or country. The authors are aware that whilst this methodology harmonizes OPEX allowing for more relevant cross country project comparison, a future study on this subject should additionally attempt to balance out CAPEX. For example, a project built in a country with low labor and/or fuel costs would unfairly penalize a like-for-like comparison of a similar project in a country with higher labor or fuel costs.

Whilst LCOE is the main metric being analyzed in this study, the collected information allows for the calculation of additional techno-economic indicators such as project efficiency (%), capacity factor (%), NPV (M$), ROI (%), project IRR (%) and PP (years).

The formulas used to calculate each indicator along with a description of all the required inputs are shown in Tables 2 and 3. All necessary input data: installed cost ($), local solar resource (kWh/m²/year), collector surface area (m²), type of cooling (dry or wet), tower height (m) feed in tariff price ($/kWh), first operational year, electrical power output (MW_e) and annual production (MWh) was taken from the *NREL/SolarPACES* or *CSP World CSP* databases [7-8]. The Weighted Average Cost of Capital (WACC) is calculated by multiplying the proportionate interest and equity rates by the debt/equity split and summing the products.

TABLE 2. Description of the inputs used in the various techno-economic formulas

Installed Cost	Cost paid to build the CSP plant, with the value of the dollar based on the first operating year.
Real Installed Cost	Cost paid to build the CSP plant (Installed Cost) brought forward to 2016 to be in real dollar terms. Consumer Price Index data from 1984-2015 was used to calculate the real dollar value of the project [6].
Financing Cost	Cost required to finance the construction of the project (interest and dividends).
Total Real Installed Cost	Total cost of the installation in 2016 dollar terms (Real Installed Cost plus Financing Cost).
Lifetime Production	Annual plant production multiplied by project lifetime, taking into account an annual degradation factor (%).
Real Feed in Tariff	Feed in Tariff price based on first operating year converted to 2016 real dollar terms using Consumer Price Index data from 1984-2015 [6].
Annual OPEX	Includes all operating expenditures: O&M, insurance, land rental, gas consumption, water consumption and miscellaneous OPEX.
Lifetime Revenue	Lifetime Production multiplied by the Real Feed in Tariff.
Discounted Cash Flow	Future cash flows are calculated to include an annual Power Purchase Agreement escalation factor and are then discounted to reach a present value.

TABLE 3. Formulas used to calculate the different techno-economic metrics.

Project Efficiency

$$\frac{Annual\ Production\ (MWh)}{Collector\ Surface\ (m^2) * DNI\left(\frac{kWh}{\frac{m^2}{year}}\right)}$$

Capacity Factor

$$\frac{Annual\ Production\ (MWh)}{Nameplate\ MWe\ * 24\ (h)\ * 365\ (d)}$$

Net Present Value

$$Discounted\ Residual\ Value + Discounted\ Cash\ Flow - Discounted\ OPEX - Real\ Installed\ Cost$$

Discounted Residual Value

$$\frac{Real\ Installed\ Cost\ *\ Residual\ Value\ \%}{(1+WACC)^{Project\ Lifetime}}$$

Discounted Cash flow (assumes all production arrives at the end of the period)

$$\frac{Real\ Feed\ in\ Tariff * Annual\ Production}{WACC} * \left(1 - \frac{1}{(1+WACC)^{Project\ Lifetime}}\right)$$

Discounted OPEX

$$\frac{Annual\ OPEX}{WACC} * \left(1 - \frac{1}{(1+WACC)^{Project\ Lifetime}}\right)$$

Total Real Installed Cost

$$Real\ Installed\ Cost + Financing\ Cost$$

Non-Discounted Payback Period

$$\frac{Total\ Real\ Installed\ Cost}{Annualized\ Cash\ Flow - Annualized\ OPEX}$$

LCOE

$$\frac{Total\ Real\ Installed\ Cost + Discounted\ OPEX}{Lifetime\ Production}$$

ROI

$$\frac{Net\ Present\ Value}{Real\ Installed\ Cost}$$

IRR

$$\sum_{t=0}^{n} \frac{Revenue - Costs}{(1+IRR)^{Project\ Lifetime}} = 0$$

RESULTS

An overview by technology type, region and overall trends of the 74 stand-alone plants comprising the current CSP market is first presented, followed by an analysis of the technical differences influencing the standardized project LCOE.

Market Observations

PT (parabolic trough) technology is dominant with 84.4 % of the current CSP market (Fig. 1). Figs. 1, 2 and 3 respectively display installed CSP capacity by technology type, installed capacity by country and annually installed and cumulative installed capacity.

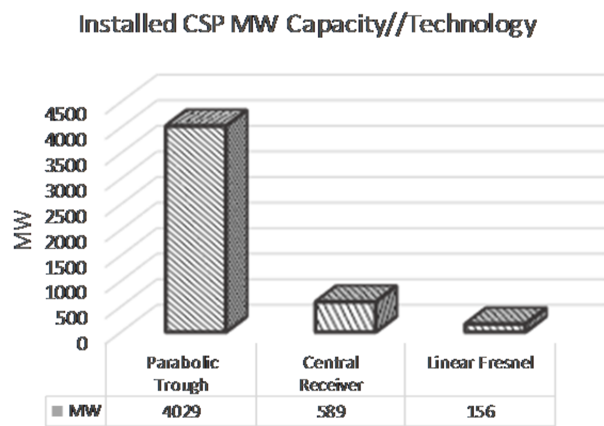

FIGURE 1. Installed CSP capacity (MW) by technology type.

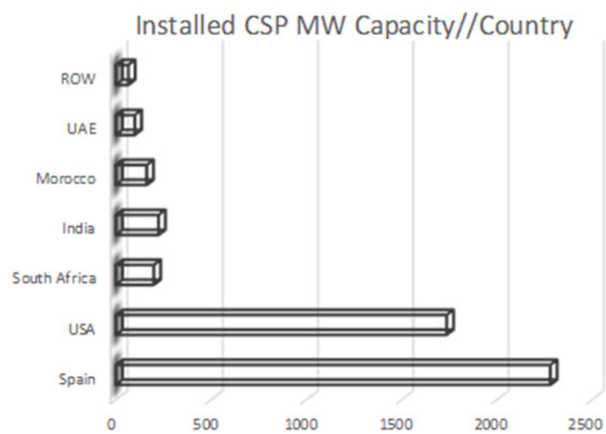

FIGURE 2. Installed CSP capacity (MW) by country.

Spain still leads total CSP installed capacity although new installations in the country have ceased. New market growth is expected to come from emerging markets such as Chile, China, Morocco, Saudi Arabia, South Africa, and the UAE.

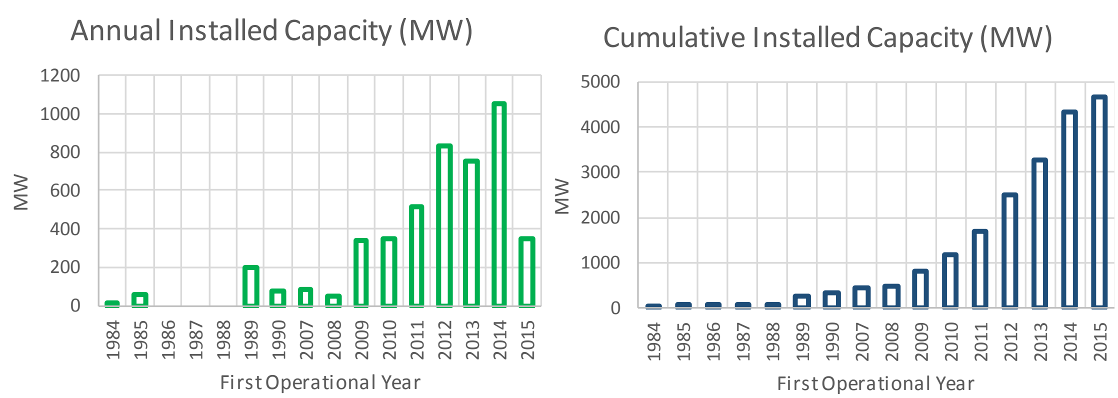

FIGURE 3. Annual & Cumulative Installed Capacity (MW) worldwide. Calculated using plant's first year of operation. Years 1991-2006 are omitted due to no new plants being commissioned during this period.

Levelized Cost of Energy (LCOE)

The standardized LCOE can depend on direct normal irradiance (DNI), aperture area, land area, plant latitude, TES (thermal energy storage) capacity, receiver outlet temperature, CSP technology type, concentration factor, overall plant efficiency, power output and so on. The authors proceed with the study using statistical correlations and trends resulting from the corresponding analyses.

LCOE Trend over Time

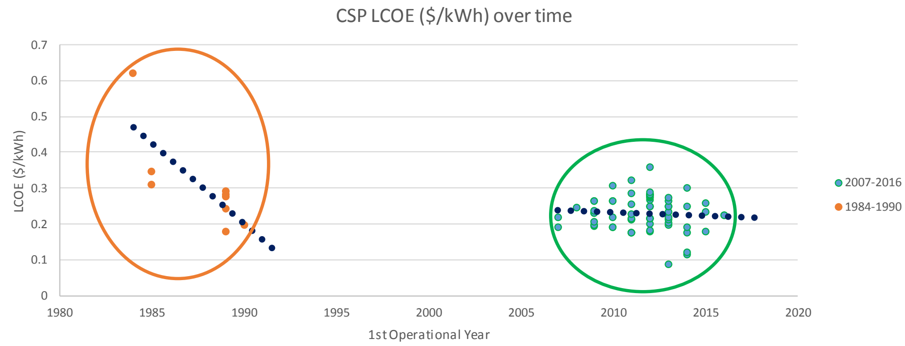

FIGURE 4. CSP LCOE ($/kWh) over time worldwide (real dollars).

Two main groups can clearly be defined in Fig. 4, indicated by the orange and green circles. The initial CSP learning curve through the SEGS plants was extremely quick and LCOE dropped rapidly over a period of 6 years.

Following the market restart in 2007, LCOE initially resumed around the same 1990 level and subsequent progress has been slower, although market diversification has increased. The trending lines for the two periods can be seen in dark blue. In order to achieve the *SunShot* 2020 target of 6¢/kWh, extra market impetus is needed to drive costs down.

Levelized Cost of Energy by Country Over Time

By zooming to country level, it can be seen in Fig. 5 that progress in the USA has been limited since the commissioning of the last SEGS plant. As the US market subsequently diversified into the CR (central receiver) technology, with one plant making 24-hour production possible, this result is not necessarily unusual. For example, Crescent Dunes provides the lowest cost per kWh, just below that of SEGS 8 which had the lowest LCOE of the 1984-1990 installations, and new CR plants of this type should continue the downward LCOE trend.

Unusually the opposite trend can be seen in Spain (Fig. 6) where LCOE increases over time. The lowest LCOE values belong to Valle 1, Valle 2 and Andasol 3, with all three plants being commissioned in 2011. When comparing the ratio of total cost to annual production over time the trend is for the ratio to increase, indicating that plants are getting more expensive per unit production over time in Spain. To note that there is little correlation of DNI and 1st operational year, indicating that this result cannot be explained by the earliest projects having acquired the best DNI locations.

As the Spanish FiT regime required a particular type of CSP plant (50 MW_e PT – the "Andasol configuration"), it would be expected to see LCOE reducing over time as developers gained experience with this type of configuration. The results in Fig. 6 indicate that the FiT did little to stimulate cost reductions in Spain as developers rushed to build plants to obtain the high tariff. With hindsight whilst the FiT served to increase CSP market penetration in Spain, an auction-based system may have been more effective in promoting cost reductions over time.

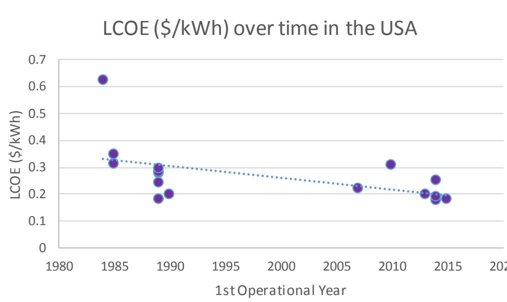

FIGURE 5. LCOE ($/kWh) over time in the USA (real dollars).

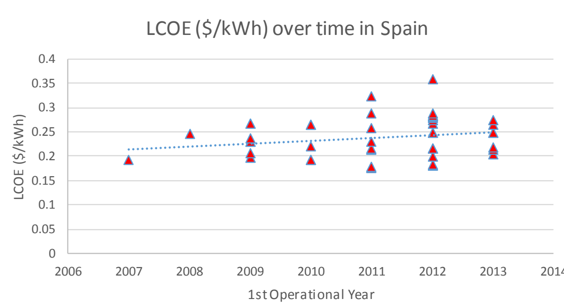

FIGURE 6. LCOE ($/kWh) over time in Spain (real dollars).

Levelized Cost of Energy Versus Technology Type

Cross-technology comparisons are difficult given PT's dominance (Fig. 1) and conclusions at this stage of market evolution are unlikely to be definitive.

TABLE 4. CSP LCOE ($/kWh) broken down by technology type.

	LF	CR	PT
LCOE 1984-2016 ($/kWh)	0.252	0.224	0.240
LCOE 1984-1990 ($/kWh)	//	//	0.291
LCOE 2007-2016 ($/kWh)	0.252	0.224	0.233
Weighted Average LCOE 1984-2016 ($/kWh)	0.168	0.196	0.237
Number of Plants	3	7	64

Table 4 breaks LCOE down based on technology type and first operational year. The first three rows look at a simple LCOE average in real dollar terms over different periods, relating to the two CSP installation "phases" of 1984 to 1990 and 2007 to present. LF (linear Fresnel) performs best out of the three technologies when doing a weighted average using power output as a pondering factor, although this is mainly because of one large plant with relatively low LCOE.

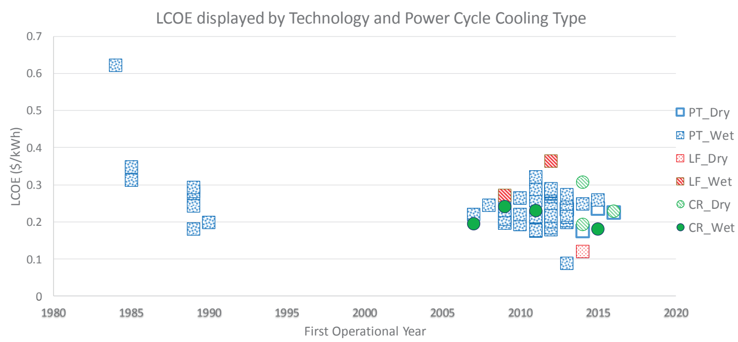

FIGURE 7. CSP LCOE ($/kWh) broken down by technology and power cycle cooling type.

Fig. 7 presents the overview of LCOE by technology power block cooling type. Initial PT progress in the 1980s with the SEGS plants was rapid although not subsequently built on after the CSP market restart. Based on Table 4 and Fig. 7, LF is a promising CSP technology from an economic viewpoint as it provides one of the lowest LCOEs rivalled by a single PT plant, although more data would be needed as more plants come online to back up this point. However, the LF technology has no industrial experience with thermal energy storage and without that is in direct competition with solar photovoltaic, which currently has a lower average LCOE.

CSP plants such as Shams 1 in the UAE, Ivanpah in the US, and the three currently commissioned plants in South Africa (Bokpoort, Khi Solar One, and KaXu Solar One) use dry cooling in the power cycle as a way of reducing water consumption. When correlating cooling type with LCOE (Fig. 7) it can be seen that this has surprisingly little overall impact on LCOE (there is in fact a tradeoff between lower efficiency, higher CAPEX and lower OPEX with dry cooled systems which as a whole correlate to a similar LCOE), favoring the financial case of choosing dry-cooled plants which provide a better environmental option.

Levelized Cost of Energy Versus DNI

A plausible hypothesis for the relationship between LCOE and DNI is that they would be inversely proportional, i.e. LCOE would decrease with increasing DNI, as with all other things being equal higher DNI would lead to higher production and therefore lower LCOE. Figure 8 does not confirm this hypothesis for the existing CSP plant fleet. The results are slightly skewed by the SEGS plants which all have excellent solar resource (2725 kWh/m²/year), although the initial projects have higher LCOE as they were built at the start of the CSP learning curve. The authors also note that there is a lack of projects built with a DNI of between 2300-2600 kWh/m²/year.

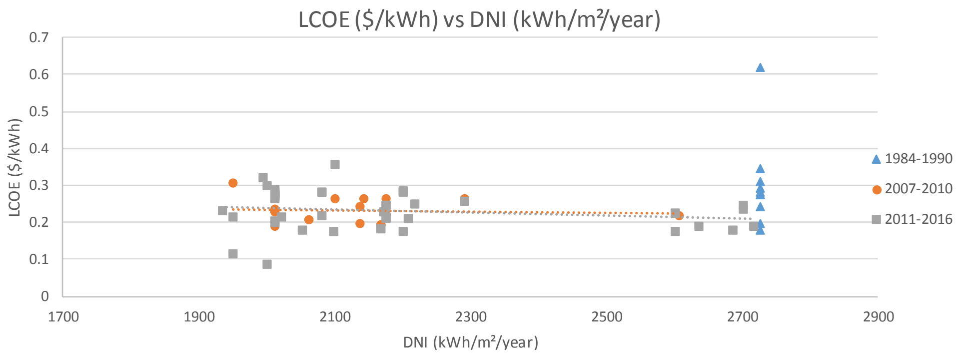

FIGURE 8. CSP LCOE versus DNI.

In addition, the CSP plants with the lowest LCOE have the lowest DNI indicating that construction consortiums are able to push costs down when the resource is not exceptional. For developers, this implies that it is not critical to have an excellent DNI to achieve a respectable LCOE.

To look more closely into the impact of DNI, the ratio of annual production and solar field area is plotted against irradiation (Fig. 9). Two main groups, one with a DNI range from 1900-2300 kWh/m²/year and another between 2600-2750 can be seen. Whilst the lower DNI group tends to cluster, the higher DNI projects are more spread out, indicating that for the same DNI value different levels of production per unit area are reached.

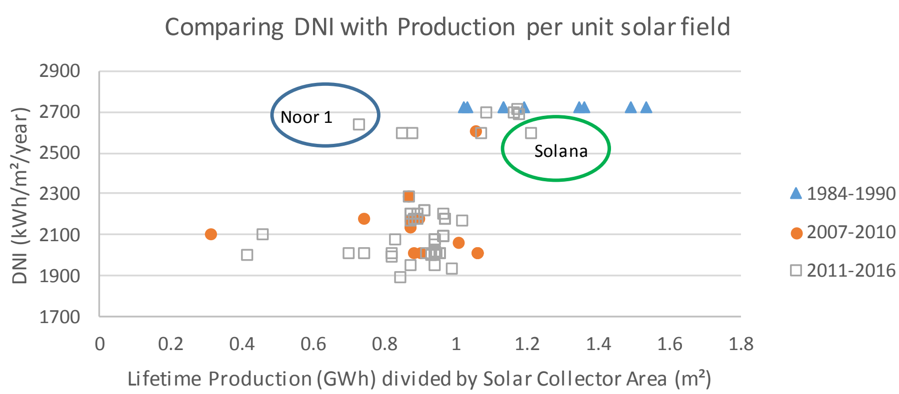

FIGURE 9. DNI correlated against production per solar field unit area.

The blue triangles correspond to the SEGS plants with SEGS1 being the furthest on the left and SEGS9 on the extreme right, indicating coherent progress over time. The grey-bordered squares indicate plants commissioned over the last five years, so it would not be unexpected to see the majority of these symbols to the right of the graph, although this is not the case. Two plants have been highlighted with the blue and green circles. In spite of similar DNI and comparable technology (both are PTs with molten salt thermal energy storage), Solana extracts 66.5 % more production per unit area than Noor 1.

As Noor 1 is the first CSP plant in Morocco, one explanation of this result would be through a "country effect", whereby new plants in a new country need time to move down the learning curve. As the infrastructure in a country develops, costs and LCOE should subsequently reduce. As the CSP market is currently expanding into new countries, industry players should foster learning between each other internationally to minimize such country effects as much as possible.

Levelized Cost of Energy Versus Tower Height for CR Plants

As can be seen in Fig. 10, a bigger tower does not necessarily lead to a lower LCOE despite the economies of scale that a larger project could engender. Larger projects require more project financing and therefore greater market confidence, so as the market matures projects should become larger which would theoretically, in turn, reduce LCOE.

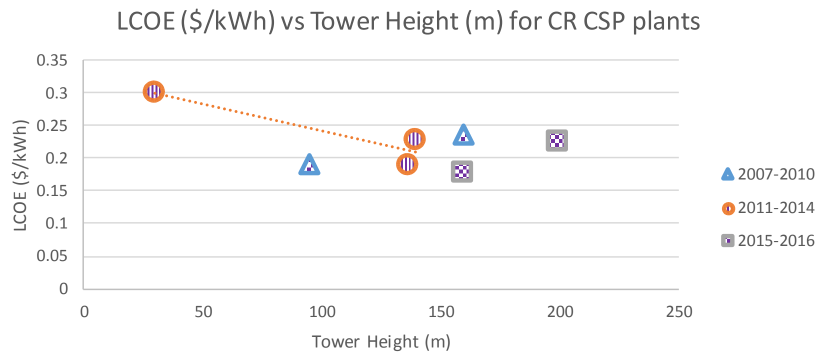

FIGURE 10. CSP LCOE versus tower height for central receiver plants.

Whilst little data is available for this particular analysis, it can be seen that the projects with the biggest towers are the most recent ones. However, it must be noted that tower height may be restricted either by market conditions (for example in South Africa where a maximum tower height is set) or by the available land provided in the tender, leading to a tower height which might be different from the optimal choice. Theoretically, a larger tower with a larger solar field will lead to higher optical efficiency and higher production per unit area, which in turn would engender a lower LCOE.

Table 5 presents tower height against lifetime production, as a way of seeing if over time CSP plants are “squeezing” more production out of the tower. The red cells indicate the lowest production to tower height ratio whilst the green values indicate the highest ratio. It is interesting to note that two plants have towers that are the same height (160 m), whilst lifetime production between the two differs by a factor of 10, indicating that the plant with the higher production makes more efficient use of the cost paid to construct the tower.

TABLE 5. Tower height and solar field vs lifetime production.

Tower Height (m)	First Operational Year	Lifetime Production (GWh)	Solar Field (m²)	Project Location	Production to Tower Height Ratio	Production to Solar Field Ratio	LCOE ($/kWh)
95	2007	660	74 880	Spain	6.95	0.88	0.191
160	2009	1 354	150 000	Spain	8.47	0.90	0.237
140	2011	3 104	304 750	Spain	22.17	1.02	0.228
30	2014	62	15 000	Australia	2.07	0.41	0.301
137	2014	10 151	866 667	USA	74.09	1.17	0.190
160	2015	14 108	1 197 148	USA	88.18	1.18	0.178
200	2016	5 079	576 800	South Africa	25.40	0.88	0.225

This, of course, can be due to the size of the solar field and therefore a supplementary comparison of lifetime production to solar field size is considered. Once again the red cells indicate the lowest ratio and the green values the best. From Table 5 it can be seen in general that the highest production to solar field ratios are those of the most recent CR plants, indicating greater efficiency for newer installations.

Seeing as the solar field is one of the main target areas for CSP cost reduction [2], the trend towards attaining more production out of each unit collector area is encouraging in terms of achieving a lower LCOE.

Levelized Cost of Energy Versus Power Output

Results based on power output (Fig. 11) are not as conclusive as might be expected, as although LCOE tends to decrease with increasing size, there are many outliers which attempt to disprove the trend. The authors are aware that developers may be restricted to a certain power output based on tender or financing requirements, and that in certain cases a different power output could lead to a lower project LCOE.

LCOE would be expected to decrease with increasing plant power output as even though relative production (per unit power output) is likely to be similar, cost decreases per MW installed due to more efficient O&M practices and larger quantities leading to lower fixed costs per unit. Larger projects require more project financing, and as market confidence grows perceived risk should decrease leading to more favorable financing conditions and increasingly lower LCOE for larger projects.

Fig. 11 shows that building bigger projects is only slightly more economically attractive in terms of LCOE, and developers should, therefore, look to convince investors to support projects above a threshold, but there appears to be little advantage in building truly big projects. It can also be noted that the biggest projects have all been built since 2011, indicating that market is tending towards larger and larger plants.

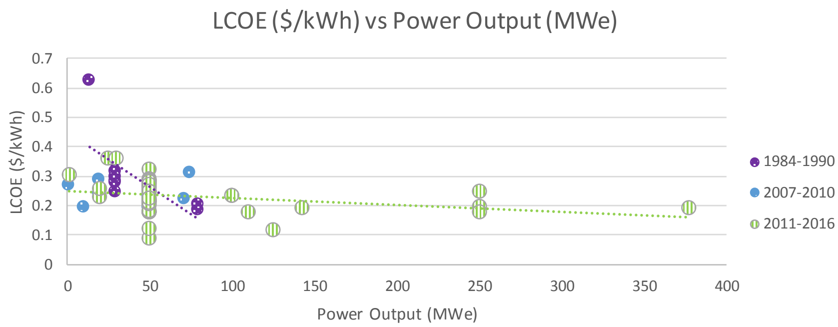

FIGURE 11. CSP LCOE versus Power Output.

Levelized Cost of Energy Versus Capacity Factor

CSP plants with high capacity factor are those with integrated TES, such as Gemasolar, Crescent Dunes or Bokpoort, making 24-hour continuous operation possible. The plants with lower LCOEs are generally those with the highest capacity factor (Fig. 12), indicating that the extra cost incurred investing in thermal energy storage makes economic sense. Therefore, in order to facilitate integration into the energy mix, CSP should incorporate high levels of thermal energy storage. In reality, thermal storage is dictated by market requirements, and very high capacity factors are not a standard requirement in current CSP tenders.

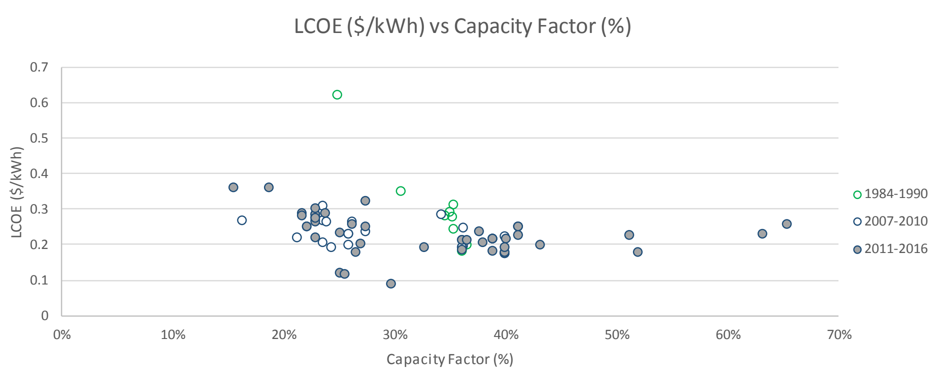

FIGURE 12. CSP LCOE versus Capacity Factor.

From Fig. 12 it can be observed that the plants with the highest capacity factor have all been built since 2011, which demonstrates the trend towards larger thermal energy storage over time.

Levelized Cost of Energy Versus IRR, NPV and ROI

Investors typically use LCOE combined with additional metrics such as ROI, NPV, project IRR and PP (payback period) to characterize and define their optimum investment choice.

By comparing among different economic metrics, the relative importance of using different criteria to evaluate a project becomes evident.

Comparing LCOE and IRR (Fig. 13) demonstrates that there is an inverse relationship between the two; a higher IRR (better project) has a lower LCOE and vice versa. In general, newer projects have higher IRR, however some recent projects have low IRR which may be as a result of governmental grants or low-cost loans not disclosed in the literature.

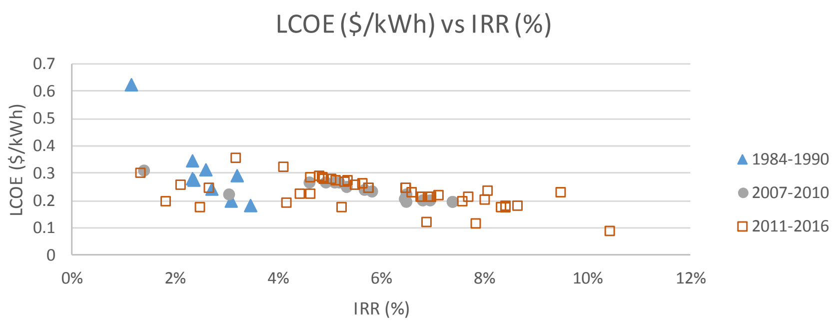

FIGURE 13. CSP LCOE versus IRR.

When comparing LCOE and NPV the results are less clear. A project can have a low LCOE and a negative NPV (results not shown). The authors at the outset had assumed that no tax breaks, grants or any government assistance are provided when financing the CSP projects, which may explain why some projects have received project financing in spite of the negative NPV found in the analysis.

A similar story can be seen with ROI, whereby low LCOE does not always lead to positive return on investment, which highlights how it is important not to rely on one sole metric when comparing projects, as is outlined in [9].

The projects with the lowest ROI are not necessarily the oldest ones. An explanation for this would be the effect of starting CSP operations in a new technology or country, where developers tend not to learn from experience gained in other countries or technologies. The CSP learning curve seems almost to start from zero when developers have to adapt to a new country or technology.

For example, the cluster of negative ROI projects indicated by the red circle on Fig. 14 includes two of the first three South Africa projects, the first Moroccan project, and the two first CR projects in the USA.

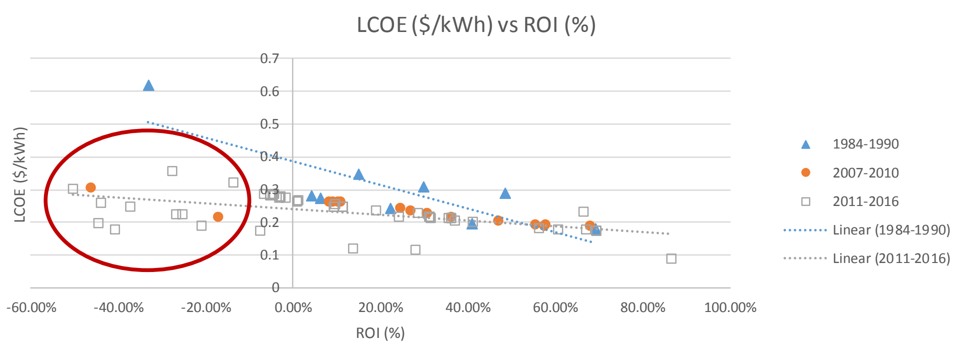

FIGURE 14. CSP LCOE versus ROI.

CONCLUSIONS

Based on this analysis, *SunShot*'s 6¢/kWh LCOE CSP target can be reached given the right solar resource and market conditions, although it is not likely to be a market standard for all new plants by 2020 under the current trends. LCOE is nevertheless reducing over time, with different areas of progress being highlighted:

- Plants with the highest capacity factor and therefore the largest thermal energy storage are those with the lowest LCOE (Fig. 12). This allows CSP the opportunity to exploit its main advantage as a complement to other forms of Renewable Energy: its dispatchability;
- Developers should look to optimize solar field costs, whereby the plants with the lowest total cost to solar collector area are those with the lowest LCOE (see Fig. 15 below). This conclusion was also outlined in a recent *IRENA* study [2];
- Little difference exists with cooling type (dry or wet), favoring the installation of a dry cooling cycle which reduces water consumption;
- Linear Fresnel provides the lowest weighted average LCOE of the three industrial CSP technology types. However industrial examples with thermal energy storage are needed to make this technology commercially competitive.

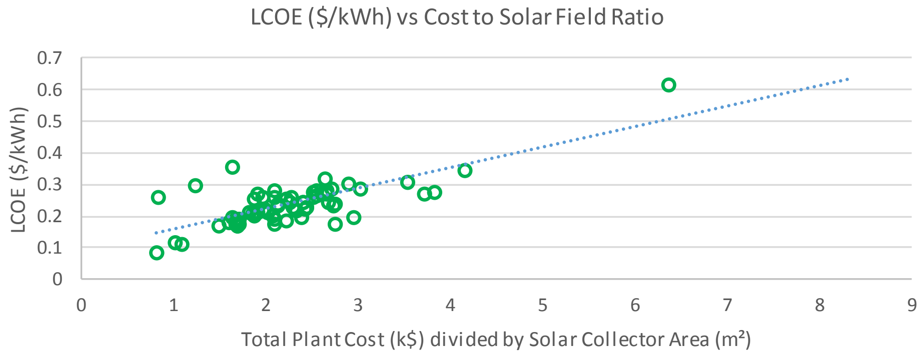

FIGURE 15. LCOE compared to a ratio of Total Cost and Solar Collector Area.

Up to a certain threshold, bigger is better for the CSP market. LCOE reductions are generally positively correlated to larger thermal energy storage, a larger capacity factor and to a certain extent power output.

However, some unexpected results have been derived from this analysis:

- Building "large" CSP plants (e.g. >250 MW_e) does not currently bring LCOE reductions;
- On a global level, there exists little correlation between LCOE and DNI (however, if presented with two identical CSP plants differing only by DNI, clearly the higher DNI project would have a lower LCOE);
- Learning is slow when using a new technology or when starting operations in a new country.

The initial CSP learning curve initiated in the 1980s was rapid and LCOE dropped sharply. Following market restart in 2007 LCOE has since dropped, although a "country and technology effect" have slowed progress. Progress made in one country or in one technology does not seem to be shared when using an existing technology in a new area or when using a new technology in the same country. This may be caused by a lack of communication between industrial players, a lack of one main market leader or simply due to the different conditions in different countries.

As new countries integrate CSP into their energy mix, internal learning curves will drive LCOE down. The challenge will be in sharing this progress with other industry players to promote ongoing competition and lowest LCOE throughout the CSP market.

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