THE NIGHT-TIME SOLAR POWER NICHE – CONCENTRATING SOLAR POWER VS. PHOTOVOLTAICS WITH STORAGE

Franziska Schöniger, Energy Economics Group, TU Wien, +43 1 58801 370378, schoeniger@eeg.tuwien.ac.at
Richard Thonig, Institute for Advanced Sustainability Studies, Potsdam, +49 331 28822 493, richard.thonig@iass-potsdam.de
Gustav Resch, Energy Economics Group, TU Wien, +43 1 58801 370354, resch@eeg.tuwien.ac.at
Johan Lilliestam, Institute for Advanced Sustainability Studies, Potsdam, +49 331 28822 393, johan.lilliestam@iass-potsdam.de

Overview

Sustainable energy systems being able to provide decarbonized and flexible electricity supply are in need of renewable as well as dispatchable electricity sources. Solar energy is an abundant source of renewable energy globally which is, though, by nature only available during the day, and especially at clear weather conditions. In power systems rich in solar generators, one of the main challenges is to be able to assure supply in a cost-efficient way when the sun is not shining.

There are two apparent technological solutions for providing solar electricity also during times when no sun is available: Photovoltaics (PV) with battery (BESS) and Concentrating Solar Power (CSP) with thermal energy storage (TES). In recent years, PV plus storage (PVS) has seen increasing adaptation in the residential and utility-scale sector. One reason for that is that the addition of battery storage significantly increases both the dispatchability and market value of PV installations (Denholm, Margolis, & Eichman, 2017). Also, the cost of PV and BESS have shown a strong downward trend. As another technology option, CSP has the well-proven capability to make its power output dispatchable and to supply solar power at night because it is usually complemented by a TES system. The CSP plants globally under construction (September 2019) have, on average, 9.5 hours of storage. Deployment policies have significantly reduced the cost of CSP in the last decade and further decreases are expected if further investments in new power plant capacities are undertaken (CSP.guru, 2019; Lilliestam et al., 2018). There are also most recent applications where PV is combined with TES. This leaves us with three different technology options being able to provide dispatchable solar power at night. The question is which technology combinations will provide the best solutions for this solar power niche in future electricity systems.[1]

Methods

We consequently undertake a systematic comparison of the three technology configurations PV + BESS, CSP + TES, and PV + TES. As previous analyses suggest (cf. e.g. Lovegrove et al. (2018)), one of the key parameters that determine competitiveness between both is the required storage time. We aim for providing clarification on that hypothesis from today's perspective, looking at the current cost. Additionally, we also perform a prospective assessment, investigating the space of potential future cost developments and show how the break-even between CSP + TES and PVS changes as technology cost shift. Complementing, we also look at the technology combination PV with TES for the medium cost scenario. We analyse storage times varying from 1 to 24 hours (delivery starting after sunset without any additional solar energy collection). We do a model-based investment and dispatch optimization within the open-source energy system model Balmorel in order to calculate the necessary electricity generation (solar field and power block for CSP, and PV modules) and storage capacities (TES and utility-scale BESS). As a result, the model informs on the specific cost for demand coverage under the given assumptions.

Results

We find that PV + BESS is more competitive for shorter storage durations and CSP + TES is more economic for longer storage periods. The tipping point of storage hours when PV + TES becomes more competitive than PV + BESS is highly dependent on the price development of all technology components. The corresponding tipping point lies between 2-3 hours under current cost assumptions. When technology costs develop as assumed in the medium cost scenario, the tipping point lies at around 4 hours. If the low cost trends assumed for the period up to 2050 can be achieved, the tipping point moves towards a storage duration of around 10 hours.

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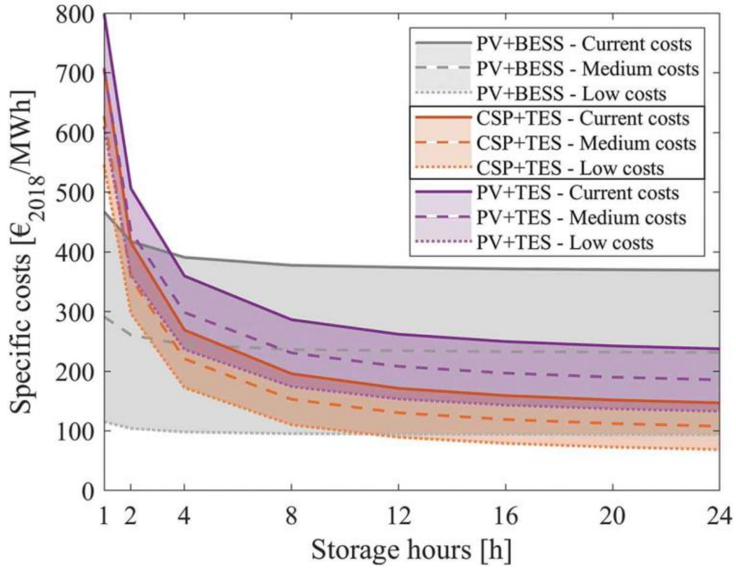

Figure 1: Specific cost for increasing hours of stored energy for CSP with TES and utility-scale PV with Li-Ion battery

(Source: Schöniger, Thonig, Resch, & Lilliestam, 2021)

The competitive advantage of CSP + TES for longer storage periods is driven by the fact that the CSP power block is decoupled from the other technology components, and that its size does not increase linearly with the storage hours in contrast to PV + BESS.

Conclusions

The results of our analysis show that the competitiveness of CSP + TES in comparison to PV + BESS is highly dependent on the required storage duration. We find that there are different niches for CSP + TES and PV + BESS in future electricity systems with a competitive advantage of CSP + TES for larger amounts of energy stored. Since both of them can cover different storage requirements, further development of both technology combinations should be enhanced in future years. That would allow us to take advantage of optimal solutions for different fields of applications. We see that even at current cost for CSP and medium cost reductions for PV + battery, CSP + TES is more competitive for more than five storage hours. However, CSP needs to keep up with the expected steep cost reductions expected for PV in a similar way. In terms of cost reductions, the advantage of CSP is that the globally installed capacity is much smaller than the PV capacity, meaning that, following the concept of technological learning, cost reductions can be achieved with relatively low capacity additions in absolute terms. Therefore, it needs targeted policy action in order to foster this technological learning also for CSP. In order to enable future electricity systems to cover short-term as well as long-term flexibility needs, it seems advisable to further develop PVS as well as CSP + TES and support deployment of both options in the electricity market. This way, the optimal technology combinations will be available for the different applications and time-scales and help to provide dispatchable renewable electricity for highly decarbonized energy systems.

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