THE ROLE OF BIOMASS IN THE FUTURE DEVELOPMENT OF CSP IN SOUTHERN EUROPE: THE CASE OF SPAIN

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ABSTRACT: For 2030, Spain has set ambitious targets for increasing intermittent renewable electricity generation. Concentrated Solar Power (CSP) plants have the capability of store solar energy during operation allowing a reduction of the external support to renewable generation to cover the demand. A model has been developed for the estimation of the impact of a CSP deployment by substituting the targeted solar photovoltaic generation in the country. The results indicate that biomass can play a role in the extension of energy storage in CSP plants and providing the residual external support needed to balance the demand.
Keywords: Concentrated Solar Power (CSP); grid model; energy storage; biomass

1 INTRODUCTION

The energy transition in the power grid has led to an increase of photovoltaic (PV) solar and wind penetration along Europe [1]. This increase is reaching a point where curtailment will play an important role unless energy storage is put in place. Energy storage for long-duration periods, long-duration storage, has been studied for grids with a high VRE penetration [2, 3]. Concentrated Solar Power (CSP) plants are an alternative to PV solar plants in regions with a high direct normalized solar irradiance (DNI) [4]. Three technologies are commercially available (Figure 1).

In Southern Europe, the solar irradiance is enough to include concentrated Solar Power (CSP) plants in the mix. However, CSP plants have not been considered in most countries, being the exception Spain where 50 commercial plants (ranging from 50 to 1 MW installed capacities). Typically, CSP plants have associated storage capacities of up to 6 hours using molten salts, oil or steam-based storage.

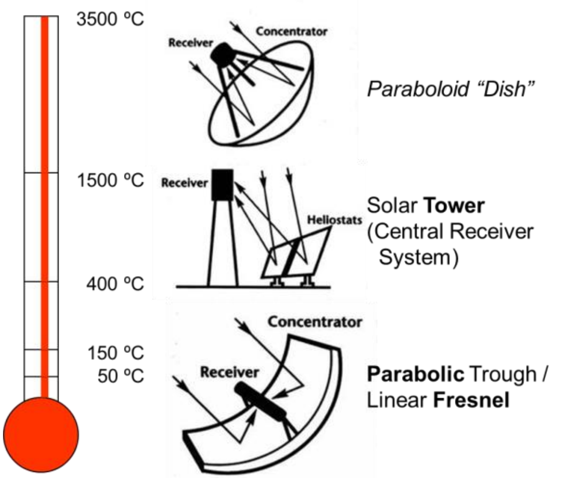

Figure 1: Technologies for CSP plants. Commercial technologies are in bold.

For 2030, Spain has set some preliminary targets for wind, solar PV generation [5]. These targets are shown in Table 1. For the expected deployment of intermittent renewable energy (i.e. wind and solar), more than10% curtailment can be expected. Regarding the targets, CSP generation is not a part of the future renewable electricity mix, which would remain as it is today (2.3 GW of installed capacity covering only 1.5% of annual electricity demand).

Table I: Targets for wind and solar PV generation in Spain for 2030 [6]

Technology	**Official Targets**	
	GW (%)	TWh (%)
Solar PV	47 (32)	88 (27)
Wind	31(21)	70(20)

The aim of this work is to provide a preliminary view of the potential role of biomass in scenarios where CSP would be included in the future renewable electricity mix. Therefore, two scenarios have been developed (Table 2).

Table II: Scenarios in the study

Technology	**Scenario 1**		**Scenario 2**	
	GW	TWh	GW	TWh
Solar PV	23	16	15	30
Wind	31	70	47	94
Solar CSP	Compensating the reduction of Solar PV			

2 METHODOLOGY

The analyzed grid is composed of all generating technologies in Spain. Data for 2016 is used for demand and the generation of all technologies but for wind, PV and CSP. A model for the balancing of renewable generation in each scenario. For the model, whereas the demand and other renewable technologies (i.e., hydro) remains unaltered for all analyzed systems (2016 data), the wind and PV generation profiles are scaled-up to meet the targets in Table II. The model considers that the net demand will be cover preferentially by the CSP plants (i.e., the model does not consider current or future rules for the Spanish's TSO). The intra-hour matching of demand (involving short-duration storage) is excluded from the study. VBA and spreadsheets have been used for the implementation of the model.

3 RESULTS

The results for each scenario are shown in Figures 2 and 3. The figures show that if negligible storage is used (< 2 hours) in CSP plants, the needs for external storage would be same as for the case of Table I, i.e., 53 TWh of external support. In both scenarios, the coverage of the net demand by fresh CPS, i.e., direct power production from solar irradiance without any intermediate storage, is limited (15-20 %). Energy storage is the key factor in the reduction of the external energy support. For scenario 1, a minimum external support of 19 TWh is achieved for 12 h storage). For Scenario 2, the external support can be reduced to 8 TWh thanks to the higher share of wind energy in the electricity mix.

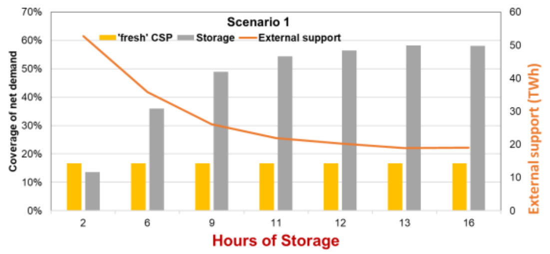

Figure 2: Results for Scenario 1.

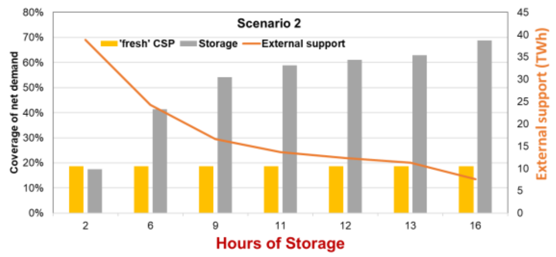

Figure 3: Results for Scenario 2.

The (very) high storage needed to reduce the external support (twice the current capacity in CSP plants) is not possible with current storage technologies (e.g. molten salts). Therefore, new storage technologies are needed.

Particularly we believe that the (partially) decoupling of energy storage from the solar irradiance, avoiding the storage to (completely) follow the day/night cycle, is a solution. Biomass can contribute for this decoupling allowing the extension from 6 to >12 hours of energy storage.

Even if the extension of the energy storage is solved, a minimum external support would be still needed. However, biomass is currently an option for external support in CSP plant in Spain (biomass boilers).

4 CONCLUSIONS

The preliminary study has shown the biomass a future development of CSP plants in Spain. Biomass can play a role in providing external support to CSP plants, e.g., avoiding the use of natural gas boilers, and also allowing the extension of energy storage periods in CSP plants.

5 REFERENCES

[1] Buttler, Alexander, et al. "Variability of wind and solar power–An assessment of the current situation in the European Union based on the year 2014." Energy 106 (2016): 147-161.
[2] Blanco H, Faaij A. A review at the role of storage in energy systems with a focus on Power to Gas and long-term storage. Renewable Sustainable Energy Rev 2018;81:1049-1086.
[3] Maroufmashat A, Fowler M. Transition of future energy system infrastructure; through power-to-gas pathways. Energies 2017;10(8).
[4] Zhang Y, Smith SJ, Kyle GP, Stackhouse Jr PW. Modeling the potential for thermal concentrating solar power technologies. Energy Policy. 2010 Dec 1;38(12):7884-97.
[5] Comisión de Expertos sobre Escenarios de Transición Energética. Análisis y propuestas para la descarbonización. http://www.minetad.gob.es/es-ES/GabinetePrensa/NotasPrensa/2018/Documents/Resumen%2020180402%20Veditado.pdf
[6] Data for demand and renewable generation inSpain 2106. www.ree.es

6 ACKNOWLEDGEMENTS

This work was supported by the Spanish National Plan I+D+I (project CTM2016-78089-R). P. Haro thanks the Universidad de Sevilla for the post-doctoral Grant Contrato de Acceso al Sistema Español de Ciencia, Tecnología e Innovación (VPPI-US) and the support of the Fulbright-Schuman Program for Visiting Scholars (E0585408).