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CSP Data: A Data Discovery Web Application of Commercial CSP Plants

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Abstract. CSP Data is a free web application for data discovery of all commercial Concentrating Solar Power (CSP) plants. CSP data is fed with CSP.guru data, an open source dataset of all Concentrating Solar Power (CSP) plants. This paper introduces and explains the tools and information provided by CSP Data to potential users so they can use it efficiently together with the ongoing work being performed to release new features. It also presents the CSP.guru dataset, how the original idea was developed, its key features and how this dataset is used by industry and academia.

Keywords: Commercial CSP Plants, Database, Data Discovery

1. CSP Data

This section introduces the CSP Data web application. A brief description of the tool is given first. Then, the main current supported features are presented. The last subsection outlines ongoing and future work to improve this tool.

1.1 Description

CSP Data (https://cspdata.com) is a free web application for data discovery of all commercial Concentrating Solar Power (CSP) plants. CSP data is fed with CSP.guru data, introduce in the next section, and presents an easy, fast, and convenient way of visualizing, filtering, and exporting all information of CSP plants directly in the browser. Researchers can use this application to study trends, identify patterns and highlight areas for improvement. Policymakers can use this application to monitor the growth of the CSP industry and make informed decisions about incentives and regulations. Investors can also use this application to get a general view of the field and identify promising projects.

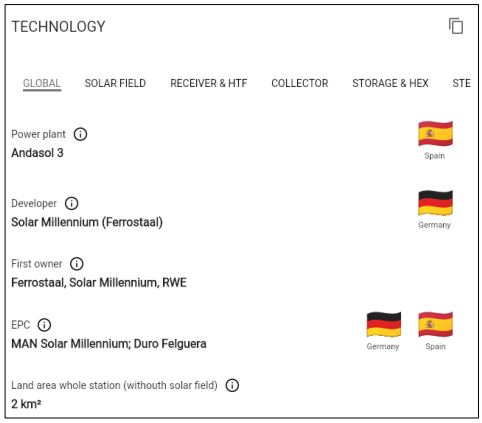
1.2 Features

The CSP Data website shows all commercial CSP power plants on a map and a table. The map can be moved, reset and zoomed in and out (see Figure 1).

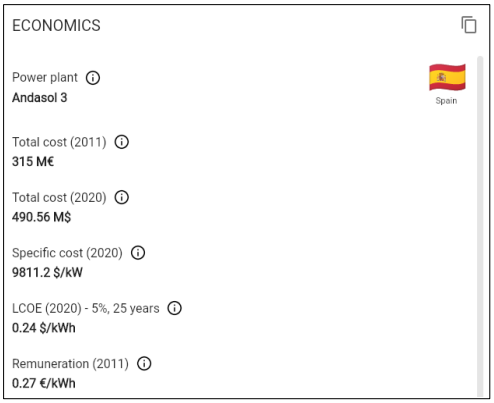
***Figure 1**. CSP Data map.*

Map pinpoints are interactive. Clicking on them will show a card with the summary of the selected power plant (see Figure 2.1) and links to detailed information about the technology, economics, and location of the power plant (see Fig 2.2 - 2.4). The map's pinpoint colors depend on the CSP technology as stated in the map legend. The table is also interactive and contains links to detailed information about each power plant previously mentioned (see Figure 2.2 - 24d). The columns displayed in the table are year of construction, year of operation, name, status, technology, capacity, expected production, kind of hybridization, total cost (deflated to 2020 dollars) and country of location.

1. Summary card



2. Technology

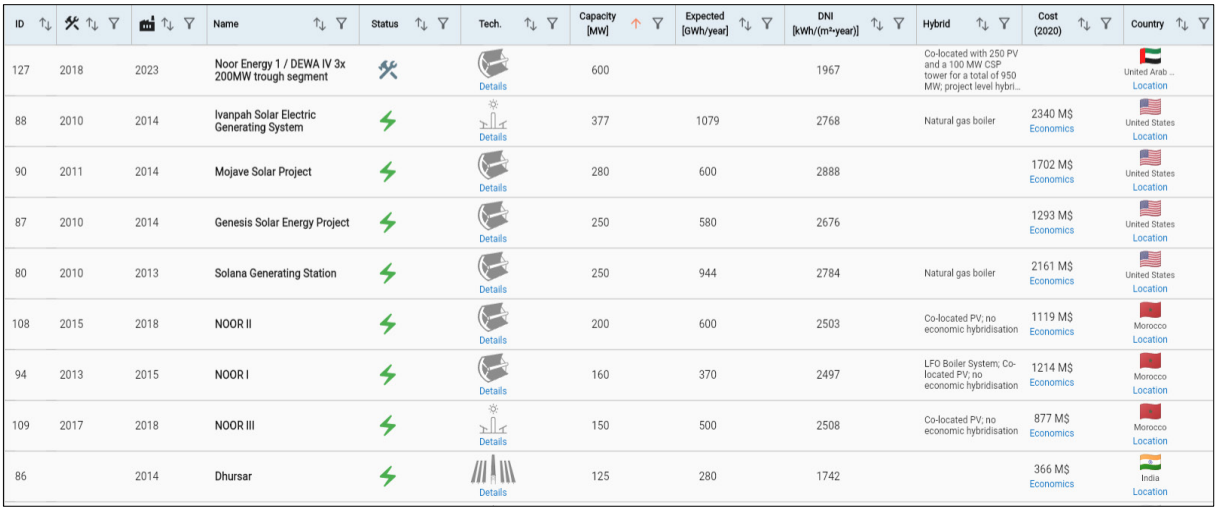


3. Economics

4. Location

***Figure 2**. Power plant summary and details about technology, economics, and location.*

When a row is selected, the map is zoomed in to the location of the power plant. The table can be sorted by any column by clicking on the arrow's icon in the column header. It also has filtering capabilities. The data can be filtered by one or several columns with Excel-like filters: search, text, and number filters. Filtered data in the table can be downloaded as a Microsoft Excel XLSX file.



ID			Name	Status	Tech.	Capacity [MW]	Expected [GWh/year]	DNI [kWh/(m²·year)]	Hybrid	Cost (2020)	Country
127	2018	2023	Noor Energy 1 / DEWA IV 3x 200MW trough segment		Details	600		1967	Co-located with 250 PV and a 100 MW CSP tower for a total of 950 MW; project level hybri...		United Arab ... Location
88	2010	2014	Ivanpah Solar Electric Generating System		Details	377	1079	2768	Natural gas boiler	2340 M$ Economics	United States Location
90	2011	2014	Mojave Solar Project		Details	280	600	2888		1702 M$ Economics	United States Location
87	2010	2014	Genesis Solar Energy Project		Details	250	580	2676		1293 M$ Economics	United States Location
80	2010	2013	Solana Generating Station		Details	250	944	2784	Natural gas boiler	2161 M$ Economics	United States Location
108	2015	2018	NOOR II		Details	200	600	2503	Co-located PV; no economic hybridisation	1119 M$ Economics	Morocco Location
94	2013	2015	NOOR I		Details	160	370	2497	LFO Boiler System; Co-located PV; no economic hybridisation	1214 M$ Economics	Morocco Location
109	2017	2018	NOOR III		Details	150	500	2508	Co-located PV; no economic hybridisation	877 M$ Economics	Morocco Location
86		2014	Dhursar		Details	125	280	1742		366 M$ Economics	India Location

***Figure 3**. CSP Data table.*

1.3 Future work

CSP Data is at an early development stage. The website usage will be analyzed to improve the graphical user interface and data accessibility. Such improvements will consider changes in the design, functionality and adding new features.

Ongoing work includes developing new sections for our website. One of them will display various graphs, tables, and summaries that show an overview of the evolution of CSP over the years. Another section will focus on each country and provide details about the installed power, production, and technology of CSP plants, along with yearly information in graphs and tables. Our future work includes exploring the feasibility and availability of incorporating real production data from CSP plants and the development of a conversational Artificial Intelligence (AI) powered chatbot designed to provide information about CSP plants.

2. CSP.guru

CSP.guru is introduced in this section. The first subsection provides a description of this dataset. The following subsections present how the original idea was developed, its main current features and how this dataset is used by the industry and academia.

2.1 Description

CSP.guru [1] (https://csp.guru) is an open dataset of CSP plants of the world for energy modelers and analysts. This dataset holds technical, economic, financial, and industrial data on all commercial CSP plants. CSP.guru is periodically updated and the latest update dates to July 2023 [2]. For a detailed description of the data collection procedure, please check [3]. Data is provided in different standard formats: Comma Separated Value (CSV) and Microsoft Excel extensible markup language format (XLSX). The dataset also includes a JavaScript Object Notation (JSON) file holding the metadata information. The license of this dataset allows

 CSP data web application is fed with CSP.guru data, and presents an easy, fast, and convenient way of visualizing, filtering, and exporting all information of CSP plants directly in the browser.

2.2 Idea

The aim of CSP.guru is providing the research and policy community with a detailed and high-quality overview of the available data on CSP plants around the world. The first version of CSP.guru was released in the scope of a research project on the learning rate of CSP power plants [3] and was continuously improved over the last decade. A major step was the open CSP project aimed to merge the dormant NREL/SolarPACES database into a unified high-quality open-access database of existing CSP plants to improve the accessibility of CSP for researchers and analysts. Making this data available increases the likelihood that CSP will be realistically represented in models and scenarios and considered again as a policy option. The project's core focus was the compilation and publication of detailed and verified data covering all CSP plants worldwide from 1984 through to today as well as up-to-date information on all power plants under construction. These findings will help to put CSP back on research and policy agendas and encourage the ongoing development and application of this potentially important technology.

In the first phase of the Open-CSP project, the research team merged the two largest scientific CSP project databases: the SolarPACES database, administered by the National Renewable Energy Laboratory (NREL) in the United States, and CSP.guru, administered by the Research Institute for Sustainability. The resulting database is updated twice annually to supply the scientific community and the public with up-to-date and verified data. These data, which are published under a Creative Commons license, enable researchers to analyze market, industry, and technology trends and to support the further development of CSP.

2.3 Features

The CSP.guru dataset holds technical, economic, financial, and industrial data on all operating concentrating solar power plants, including the ones under construction, and many demonstration plants. The latest version has 87 data categories and 154 power plants. The dataset is versioned and citable, and it is hosted by Zenodo [2].

We distinguish four main data categories that are relevant to different stakeholders. First, is geographic information such as the region, country and GPS location of the plant. Second, are technical parameters of the CSP plant such as turbine pressure, heat transfer fluid composition, or the number of heat collecting elements per solar collector assembly. Third, we collect data on the industry. That means, project developers, EPC services but also the delivery of main components such as steam turbine, solar collectors and receivers, to be able to understand the geographic connection of the industry. Fourth, it is also included information on policy and financing such as feed-in-tariffs and provides bases for economic comparison by discounting and converting all currency information into USD.

2.4 Data usage

The CSP.guru dataset accounts for over 5,000 unique views and 3,000 unique downloads. Downloads increased when CPS.guru was linked directly on the National Renewable Energy Laboratory (NREL) SolarPACES landing page.

CSP.guru use has been featured in more than 30 academic papers from different communities. First, in technical or engineering-oriented papers from the SolarPACES community [4, 5]. Second, in CSP policy and market analysis [6, 7]. Third, transition and innovation studies [8]. Finally, from practitioners working to consult or inform government

decisions-making. Especially notable is the usage in high-impact documents such as NREL's publications, the IPCC AR6 [9], IRENA [10], or REN21 [11, 12]. Also several book chapters on CSP have taken up the data [13-15]. A comprehensive list of examples can be found at https://csp.guru/paper.

3. Call for contributions

Both CSP data and csp.guru are work in progress and look for collaborators. Both projects profit from feedback of users on current and needed features. This is also especially true for data collection. If you find mistakes, or if you can and want to contribute data or time to either project please get in touch with the authors.

Data availability statement

The dataset is openly accessible at https://csp.guru under a CC-BY license, which means that anyone can use, share, and modify the data as long as they give appropriate credit to the original source. The dataset is versioned and citable, and it is hosted by Zenodo [2], a platform that enables researchers to archive and publish their research outputs.

Underlying and related material

The data set includes a separate column that lists all the data sources for CSP.guru, which enables independent verification of the data. All previous versions of CSP.guru are archived at http://doi.org/10.5281/zenodo.1318151.

Author contributions

Javier Bonilla: Conceptualization, Software, Visualization, Writing – original draft.
Richard Thonig: Conceptualization, Data curation, Methodology, Writing – original draft.
José A. Carballo: Software, Visualization, Writing – original draft.
Johan Lilliestam: Conceptualization, Data curation, Methodology, Funding acquisition, Resources, Supervision, Writing – review & editing.
Diego C. Alarcón-Padilla: Resources, Supervision, Writing – review & editing.
Eduardo Zarza: Resources, Supervision, Writing – review & editing.

Competing interests

The authors declare no competing interests.

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