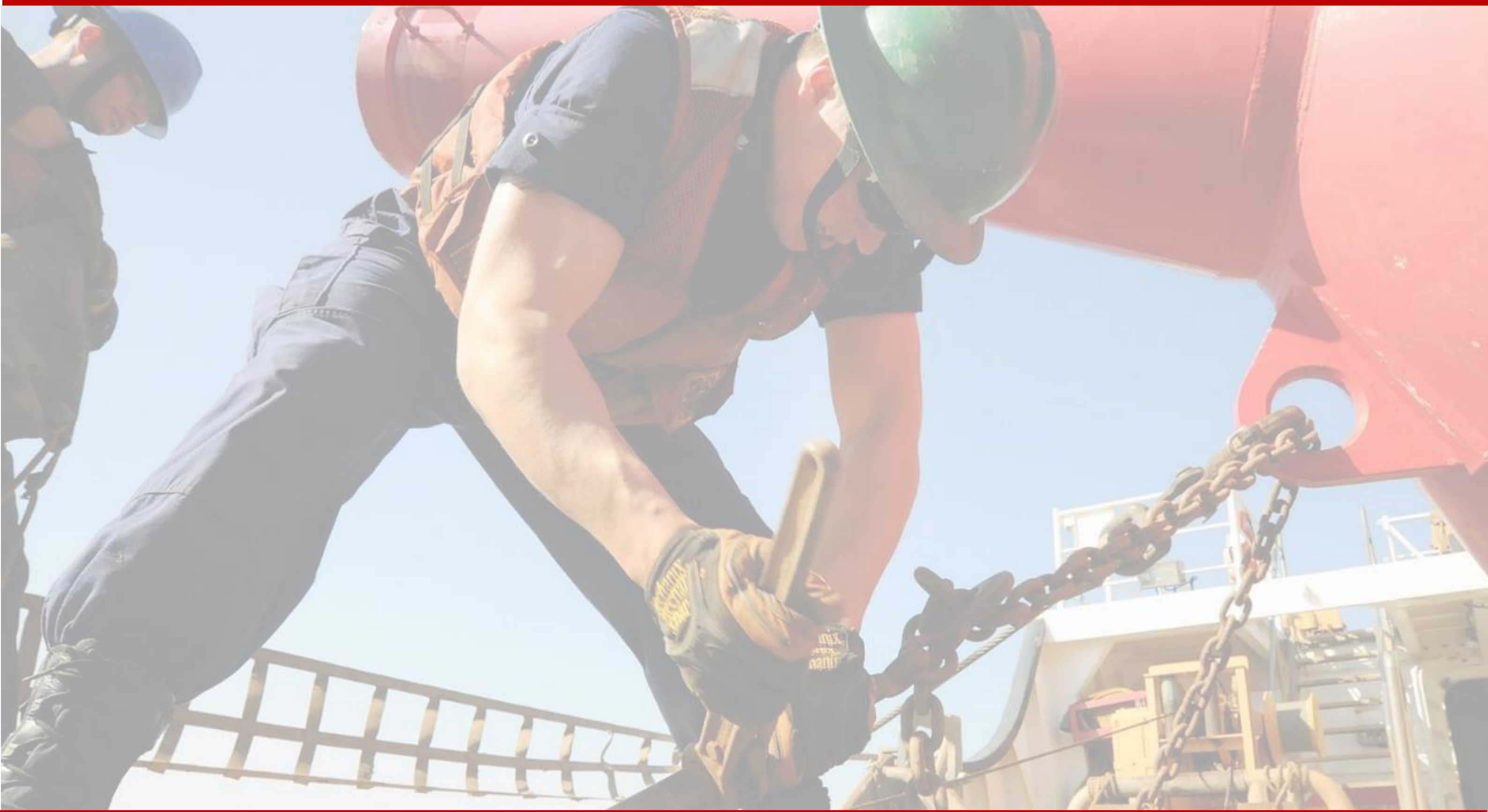

Job creation potential for Portugal due to deployment of Concentrated Solar Power plants

Technical report

July 2020

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LNEG Technical report

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Resource Economics Unit

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LNEG's **Resource Economics Unit** (UER) is crosscutting the Energy and Geology areas of LNEG. It develops I&D&D activities and decision-support for both public policymakers and the private sector on energy and geology resource economics, towards carbon neutrality and sustainable resource exploitation and use. The unit applies **techno-economic & social analytical approaches** in the fields of: (1) Sustainable energy systems, (2) Resource use for energy production and consumption, (3) Classification of national geological deposits and energy resources in a global economy, (4) Economic and social impact of the energy transition, (5) Circular economy, including design of products, services, systems and business models, and (6) Sustainable public procurement.

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Job creation potential for Portugal due to deployment of Concentrated Solar Power plants

Key points

- Concentrated Solar Power (CSP) employs circa 34 000 persons worldwide and approximately 5 000 persons in Europe, mainly in Spain which has 99% of the 2 323.3 MWe CSP capacity in Europe in 2019;
- There is no detailed study for Portugal regarding job creation due to future CSP deployment although there is previous work on jobs created with renewable power;
- By assuming the same employment factors as for Spain and considering that 300 MW of CSP will be installed in Portugal until 2030, it is estimated that installing and operating these plants could create a total number of direct and indirect jobs of 3840 in 2030 only;
- There is substantial uncertainty in the assessment of potential jobs created with CSP deployment in Portugal since there is uncertainty both on foreseen deployment and on the value chain configuration.

1 Context

This document summarises a short exploratory assessment from LNEG on the potential for job creation due deployment of Concentrated Solar Power (CSP) plants in Portugal. Currently, in Portugal, a 3.6 MWth research and demonstration platform for specific CSP equipment (such as heat transfer fluids, receivers, joints, others) at the EMSP - Évora Molten Salt Platform[1], is being finalized. In the existing prospective studies for the Portuguese energy system, NECP 2030 - National Energy and Climate Plan 2030[2] and RNC2050 – Portuguese Carbon Neutrality Roadmap 2050, only the first refers to a planned deployment of 100 MWe and 300 MWe of CSP in Portugal by 2025 and 2030. Since the Portuguese renewable energy sources (RES) arena is very dynamic more CSP could be deployed in the coming years.

Therefore, currently there is no available statistical data on historic job creation for CSP technologies in Portugal and for this exploratory assessment a review of available scientific literature and market data was made.

[1] http://www.newsol.uevora.pt/demonstration-site/

[2] Resolução do Conselho de Ministros n.º 53/2020 of July 10th 2020

1.1 CSP deployment

Within this document is used the term Concentrated Solar Power (CSP) covering all the technologies that aim to transform solar radiation energy into very high temperature heat to convert it into electricity and currently this includes the following types of technologies (EurObserv'ER, 2020):

- **Solar tower plants**, whose heliostat fields (2-axis solar tracking systems fitted with reflectors) concentrate the sunlight onto a receiver at the top of a tower;
- **Parabolic trough plants** comprising parallel line-ups of long half-cylindrical reflectors that revolve around a horizontal or slightly titled axis to track the sun and concentrate its rays on a horizontal tube;
- **Linear Fresnel type plants** comprising rows of flat reflectors that pivot tracking the sun to redirect and concentrate the sun's rays permanently on an absorbing tube;
- **Parabolic dish plants also known as dish-stirling** (less widespread) where a parabolic reflector reflects the sun's rays onto a convergence point, as the reflector's base is automatically orientated opposite the sun to track it.

Most of the current CSP development is taking place in countries and regions that offer adequate sunlight conditions and an attractive economic opportunity to invest, such as **China, India, Australia, South Africa, the Middle East and North Africa**. At the end of 2019 there was a global deployment of 6 055 MWe CSP capacity and circa 2 323 MWe CSP in the European Union (EU) (EurObserv'ER, 2020).

The EU's new CSP plant installation has taken place mostly in **Spain between 2007 and 2014** and has somewhat slowed down after that (Figure 1). In 2019, the EU increased this capacity slightly to 2 323 MWe due to the eLLO project in the Pyrénées-Orientales.

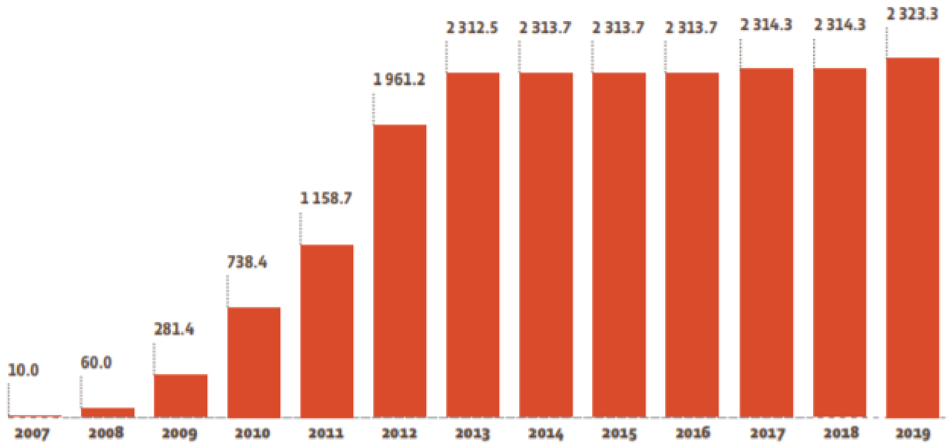


Figure 1 – CSP deployment in Europe from 2007 until 2019 (EurObserv'ER, 2020)

1.2 Job creation with RES technologies deployment

The following factors are identified as affecting how and where jobs are created with Renewable Energy Sources (RES) technologies deployment along the supply chain (IRENA, 2019):

- governmental policies;
- diversification of supply chains;
- trade patterns;
- industry reorganization and consolidation trends.

Additionally, the evolution of labor productivity also affects the number of jobs created in this field (as in other) since the increasing maturity of RES leads to gains in economies of scale, moving along learning curves and automatization which in turns results in a smaller number of employees for a given task (IRENA, 2019).

There are mainly two approaches to assess job creation (Cameron & van der Zwaan, 2015): (i) input–output (IO) or computable general equilibrium (CGE) models of the economy; and (ii) simpler largely spreadsheet-based analytical models making use of employment factors i.e. the number of jobs per unit of installed capacity as also presented previously. In most cases, only a small number of studies makes use of surveys to RES industry (Cameron & van der Zwaan, 2015).

Two main types of employment can be accounted for: direct and indirect jobs created. The first, measures the number of jobs created by an impulse (or an expenditure that generates an economic effect) within the industry in which this employment is created. Indirect employment measures the jobs created in upstream industries from where the impulse originates (e.g. expenditure in intermediate inputs like steel, synthetics, software, etc. for plants construction). The sum of direct and indirect employment results in the variation of total employment in a given industry. In some economic studies, also the *induced employment* may be accounted for. This is the employment created or retained elsewhere in the economy by the re-spending of a worker's income within the local community or new spending due to energy bill savings.

Academic work has been made to evolve to a combination of the approaches such as for instance (Henriques et al., 2016), by methodologies that not only take into account direct and indirect impacts of renewables industries value chains, but also identify the different life cycle stages of RES power plants, namely, installation, construction, manufacturing, O&M and fuel handling phases.

2 Available information on job creation due to RES technology deployment

Several business and governmental associations have also compiled information on job creation due to several RES technologies deployment, notably the International Renewable Energy Agency or IRENA (IRENA, 2019).

According to IRENA, the RES sector employed directly and indirectly circa 11 million people in 2018 (IRENA, 2019). In terms of job creation with RES technologies the **solar photovoltaics (PV) industry is the largest employer**, with circa 33% of the total RES workforce (Figure 2). RES energy employment has continued to grow since the first annual assessment by IRENA in 2012.

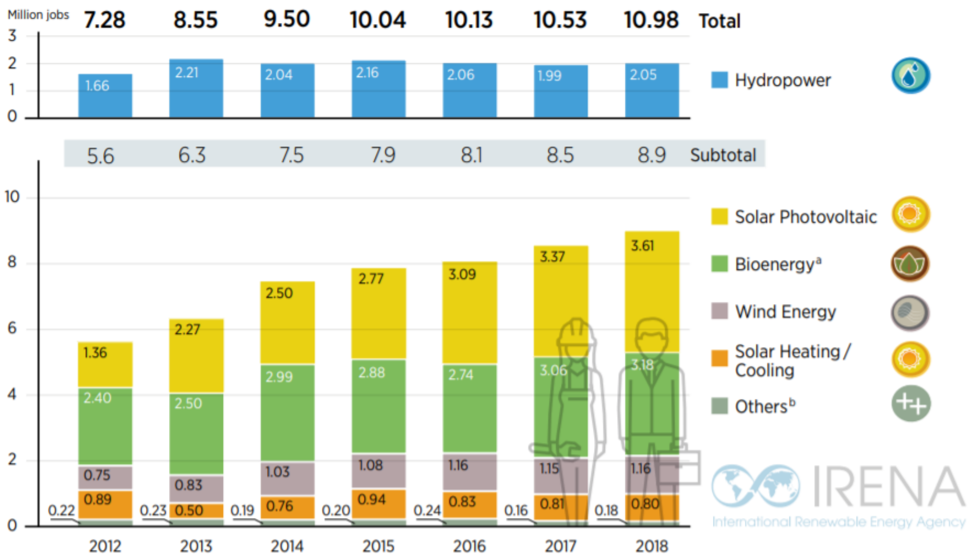


Figure 2 – Global renewable energy employment in million jobs by technology 2012-2018 (IRENA, 2019). **Notes: [a] Bioenergy includes liquid biofuels, solid biomass and biogas. [b] Other technologies include geothermal energy, concentrated solar power, heat pumps (ground-based), municipal and industrial waste, and ocean energy.**

Solar PV, bioenergy, hydro, and wind power industries have been the biggest employers. The remaining RES technologies —geothermal energy and ground-based heat pumps, CSP, waste-to-energy, and ocean or wave energy — employ far fewer people, with less information available for them. In 2018 **CSP employed approximately 34 000 people worldwide** (Figure 3), whereas solar PV employed 3.61 million people, liquid biofuels 2.01 million, hydropower 2.05 million and wind energy 1.16 million (IRENA, 2019)

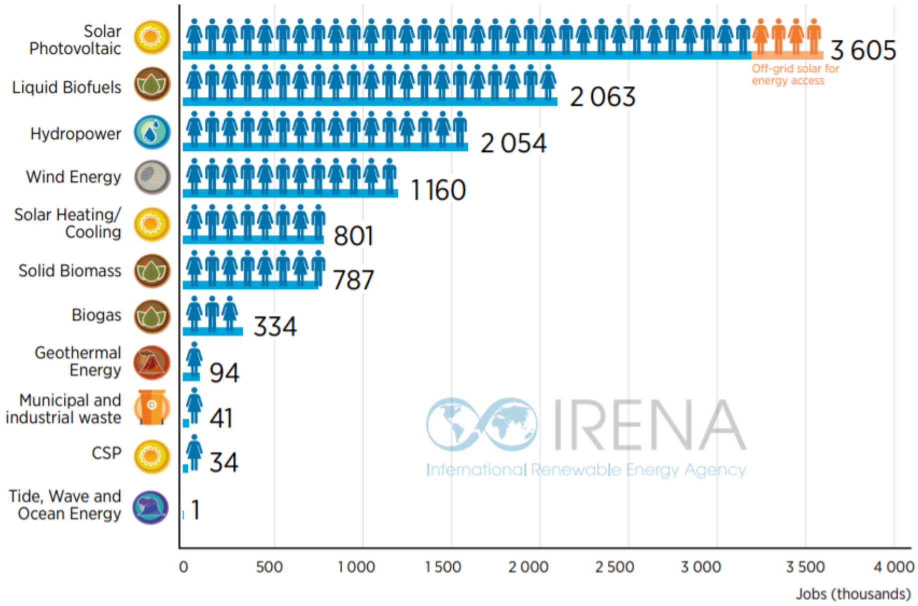


Figure 3 – Renewable energy employment per technology (IRENA, 2019)

In geographical terms employment is concentrated in a relatively small number countries (Table 1), mainly in China (with 39 % of all renewable energy jobs), Brazil, the United States, India and members of the European Union (EU) (IRENA, 2019). This is a changing arena since the "footprint" of energy-generation capacities (and, to a lesser degree, its assembly and manufacturing plants) is becoming more geographically diverse creating jobs in a gradually increasing number of countries.

Table 1 – Thousand's jobs in RES technologies per technology and country

RES technology	World	China	Brazil	USA	India	EU
Solar PV	3,605	2,194	16	225	115	96
Liquid biofuels	2,063	51	832	311	35	208
Hydropower	2,054	308	203	67	347	74
Wind power	1,160	510	34	114	58	314
Solar heating/cooling	801	670	41	12	21	24
Solid biomass for power and heat	787	186		79	58	387
Biogas	334	145		7	85	67
Geothermal energy	94	3		35		23
CSP	34	11		5		5
TOTAL	**10,932**	**4,078**	**1,125**	**855**	**719**	**1,198**

Source: (IRENA, 2019)

The 34 thousand jobs worldwide on CSP represent ~0.9% of all jobs in solar technology industry used to generate electricity, thus excluding thermal heating/cooling (~0.7% including thermal heating/cooling sector). 32% of CSP jobs are in China; 15% in USA and likewise 15% in the EU (mainly in Spain), while most created jobs, 38%, are in South Africa[3].

Specifically for tracking jobs within CSP projects it is relevant to highlight the **Technology Collaboration Programme Solar PACES**[4] of the International Energy Agency (IEA) which is an “international network of researchers and industry experts for the development and marketing of concentrating solar thermal power systems and solar chemistry technologies” and has compiled data on CSP projects around the globe including “Construction Job-Years” and “Annual O&M Jobs”[5]. The programme hosts information on CSP projects for 23 countries including Spain and has been cited as the main data source for other studies.

Likewise the study developed by Deloitte Consulting in 2011 on the **macroeconomic impact of the Solar Thermal electricity industry in Spain** (Deloitte, 2011) commissioned by PROTERMA Solar provides key-information on job creation in sector in that country during 2008-2010. The information was obtained from varied sources as follows (Deloitte, 2011):

(i) **Data on jobs for installation and construction data was obtained via surveys with construction companies** that were later verified with records of plant income for specific plant construction, assembly and commissioning activities for creation of coefficients of employment per unit of added value specific to each industry;

(ii) **Data on jobs for plant operation and maintenance activities** (O&M) **was obtained via contacting plant owners** on employment not only by the company itself, but also on employment via the subcontractors in charge of O&M. The impact on other economic industries (power supply, water, gas, insurance, etc.) from the bandwagon effect was also assessed using employment multipliers.

The obtained results are presented in the following table. (Deloitte, 2011) considered a wider scope in their assessment than in other cases, namely by considering within “plant contracting, construction and assembly” all people employed by the plant and also in other construction work or professional activities (technical and economic studies, consulting and advisory services, etc.)”. These were considered here as corresponding to direct jobs in installation and construction, although other studies consider a narrower definition. “Components and equipment” included jobs on “manufacture of machinery specific to the solar industry and the rest of the equipment (manufacture of glass and glass products, metallurgy, manufacture of metal products, machinery and mechanical equipment, office machinery and IT equipment, manufacture of electric machinery and material”, which were here considered as manufacturing jobs[6]. Finally, Deloitte

[3] South Africa with the help of domestic content legislation, has generated an estimated 15 000 jobs in solar PV and close to 8 900 in the concentrated solar power (CSP) industry (IRENA, 2019)

[4] https://www.solarpaces.org/

[5] The individual CSP project information is hosted at the USA NREL website: https://solarpaces.nrel.gov/

[6] It is unclear to what extent these jobs are direct or indirect employment. It appears that Deloitte considered these jobs as direct when other studies/definitions would consider them as indirect employment since they are from upstream industries to solar industry.

also considered “jobs in the rest of the economy” that account for the jobs created by upstream effect in other economic sectors. These are here considered as “indirect jobs”.

Also, worth noting is that the period analysed in this study, from 2008 to 2010, coincides with the construction and installation phase of commercial CSP projects in Spain. In this sense, the yearly calculated indicators show a decreasing annual evolution, meaning that the impact in job creation is most important during this phase of the life cycle of the CSP project and that this has a short/temporary duration, while O&M jobs are more enduring and stable along time in the economy.

Table 2 – Employment created due to CSP in Spain during 2008-2013

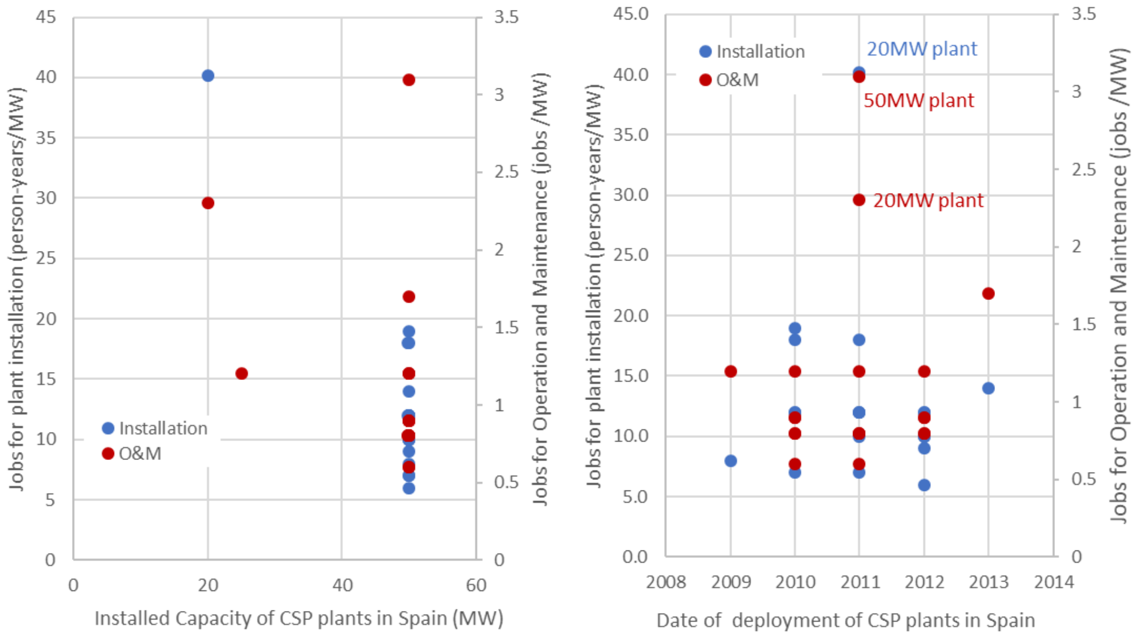
Jobs	2008	2009	2010	Average '08-'10
Construction	**11713**	**18522**	**23398**	**17878**
Plan contracting, construction and assembly	4399	6477	8049	6308
Components and equipment (manufacturing)	4515	7442	9542	7166
Jobs in the rest of the economy (Indirect)	2799	4603	5807	4403
Power production - O&M	**13**	**123**	**446**	**194**
Plant operation and maintenance	11	108	344	154
Jobs in the rest of the economy (Indirect)	2	15	102	40
TOTAL JOBS	**11726**	**18645**	**23844**	**18072**
Installed CSP capacity (MW)	60.9	231.7	531.5	275
Annual increase in CSP capacity (MW)	49.9	170.8	299.9	174
Jobs per installed capacity (jobs/MW)	**2008**	**2009**	**2010**	**Average '08-'10**
Construction	**192.3**	**79.9**	**44.0**	**105.4**
Plan contracting, construction and assembly	*72.2*	*28.0*	*15.1*	*38.4*
Components and equipment (manufacturing)	*74.1*	*32.1*	*18.0*	*41.4*
Jobs in the rest of the economy (Indirect)	*46.0*	*19.9*	*10.9*	*25.6*
Power production - O&M	**0.2**	**0.5**	**0.8**	**0.5**
Plant operation and maintenance	*0.2*	*0.5*	*0.6*	*0.4*
Jobs in the rest of the economy (Indirect)	*0.0*	*0.1*	*0.2*	*0.1*
TOTAL JOBS	**192.5**	**80.5**	**44.9**	**106.0**

Source: elaborated by the authors based on (Deloitte, 2011)

Within the **scientific literature** several pieces of work use “employment factors”, i.e. the number of jobs per unit of installed capacity as also presented previously[7]. These are sometimes disaggregated into direct / indirect jobs or into jobs created for manufacturing, construction and installation, operation and maintenance, and decommissioning as summarised in Table 3.

[7] Other ways to measure jobs creation are: i) jobs per cumulative MW installed; ii) manufacturing jobs per MW; iii) person-year per MW; iv) one-year jobs. Jobs in person-year per MW can be converted to jobs per MW by dividing by the lifetime of the system.

Table 4 presents the reviewed employment factors from both scientific literature and market data. Most of the values in the table are from a total of 31 Spanish CSP plants deployed between 2009 and 2013 with an installed capacity mostly of circa 50 MW (although a couple of smaller CSP plants were also included). From an economic point of view, Spanish CSP plants are of special relevance for Portugal since the economic structure and labour market of Portugal and Spain have some similarities, despite that from the technical point of view, nowadays, plants tend to be larger (the 50MW value of the Spanish plants is due to the feed-in tariff existing at the time) and will have storage capacity (in Spain most of the plants were not equipped with storage capacity. Figure 4 summarizes the obtained employment factors per CSP plant listed in Table 4. Although there is some dispersion in the values, especially for smaller CSP plants, most plants employ between 5-20 person.years/MW for construction and 0.5-2.0 persons/MW for O&M. The median values for CSP in Spain are of 12.0 person.years/MW for construction and 0.9 persons/MW for O&M.



Source: authors elaboration based on IEA Solar Pace Programme and (Rutovitz et al., 2015)

Figure 4 – Jobs created with CSP in Spain per plant per size of plant (left) and per date of deployment (right)

The values obtained also for Spain by from the APPA (Spanish Association of RES companies) are slightly higher for construction and point to circa 29.86 indirect jobs/MW during construction between 2011-2013 and 1.37 direct jobs/MW for O&M, to which extra 0.90 indirect jobs/MW for O&M can be added (APPA, 2018). The higher value for construction is probably due to different consideration of direct and indirect jobs.

Table 3 – Overview of main sources on job from RES technologies within scientific literature

Reference	Publication year	Geographical scope	Covered RES technologies	Types of jobs considered	Main data sources
(Ram et al., 2020)	2020	Europe, MENA, Sub-Saharan Africa, South Asian Association for Regional Cooperation, Northeast Asia, Southeast Asia, North America and South America using regional employment multipliers based on labour productivity factors derived from the ILO-International Labour Organisation and the IMF-International Monetary Fund	Bioenergy, solar PV (utility scale and rooftop), CSP (referred to as solar thermal power), wind (on shore and offshore), hydropower (dam and run-of-river), geothermal, biogas, waste to energy, methanation, adiabatic compressed air storage, battery storage and pumped hydro[8]	- Manufacturing (job-years/MW) - Construction and installation (job-years/MW) - O&M (jobs/MW) - Fuel jobs (associated to fuel supply to power plants in jobs/PJ) - Decommissioning jobs (job-years/MW) - Power transmission jobs (jobs/b€)	Mainly adaptation from (Rutovitz et al., 2015) except for transmission and storage. Note: CSP data is the same from 2015 and was not adapted
(Jacobson et al., 2017)	2017	Global (139 countries)	Onshore wind, offshore wind, wave power, geothermal, hydropower, tidal, residential PV, commercial PV, utility PV, CSP, CSP for storage, solar thermal storage, geothermal heat plants, additional conventional transmission, extra conventional distribution, and long-distance HVDC line	- Construction and installation (job-years / MW) - O&M (jobs/MW)	Jobs and Economic Development Impact (JEDI) models from NREL (2013)
(Rutovitz et al., 2015)	2015	Global	Bioenergy, Solar PV, CSP (referred to as solar thermal power), wind (on shore and offshore), hydropower (small and large), geothermal and ocean[9]	- Construction (person-years / MW) - O&M (jobs / MW)	IEA Solar Paces Programme

[8] Employment factors are also provided for coal and gas power plants, as well as nuclear power.

[9] Employment factors are also provided for coal power plants; gas, oil and diesel and nuclear power.

Reference	Publication year	Geographical scope	Covered RES technologies	Types of jobs considered	Main data sources
(Cameron & van der Zwaan, 2015)	2015	Global	Wind, solar PV and CSP	- Manufacturing (person-years/MW) - Installation (person-years/MW) - O&M (jobs/MW)	Review of 16 studies using I-O and CGE models and 20 more using employment factors. Only 6 data points for CSP
(Jacobson et al., 2014)	2014	USA – California	Wave, tidal, solar PV (utility scale and rooftop), CSP, wind (on shore and offshore), hydropower (dam and run-of-river), geothermal	- Construction and installation (job-years) - O&M (jobs)	Jobs and Economic Development Impact (JEDI) models from DOE (Department of Energy) (2012) [accessed 10.6.2012][10]
(Wei et al., 2010)	2010	USA	Biomass, geothermal, landfill gas, solar PV, small hydro, CSP (referred as solar thermal) and wind[11]	- Construction, installation, and manufacturing (CIM) in jobs/MWa and jobs/MWp - Operations, maintenance, and fuel processing in jobs/MWa and jobs/MWp	For CSP: NREL[12] and EPRI (for CSP)[13]

[10] http://www.windpoweringamerica.gov/filter_detail.asp?itemid=707

[11] Employment factors are also provided for CCS, coal, gas and energy efficiency.

[12] L. Stoddard, J. Abiecunas, R. O'Connell—National Renewable Energy Laboratory (NREL)

[13] Electric Power Research Institute (EPRI) and California Energy Commission (CEC), 2001. California Renewable Technology Market and Benefits Assessment. EPRI 100119, Palo Alto, CA and Sacramento, CA.

Table 4 – Overview of employment factors for CSP in the literature

Data Source	Manufacturing (person-years/MW)	Installation & construction (person-years/MW)	Installation & construction (person/MW)[14]	O&M (jobs/MW)	Geographical scope	Date of data	CSP plant capacity (MW)	Notes
(APPA, 2018)	n.a.	29.86	1.19	1.37	Spain	2011-2013	n.a.	Data from Spanish Association of RES companies published in 2019
(Ram et al., 2020)	4.0	8.00	0.32	0.60	Global	before 2015	n.a.	Data from Ruvikovitz with some adaptations mostly for non CSP
(Cameron & van der Zwaan, 2015) Mininum	4.0	4.00	0.16	0.2	Global		n.a.	data from only two plants for manufacturing and installation and for 6 plants for O&M
(Cameron & van der Zwaan, 2015) Median	**12.80**	12.80	0.51	**0.5**	Global		n.a.	data from only two plants for manufacturing and installation and for 6 plants for O&M
(Cameron & van der Zwaan, 2015) Maximum	21.6	6.00	0.24	1.0	Global		n.a.	data from only two plants for manufacturing and installation and for 6 plants for O&M
(Wei et al., 2010)	n.a.	10.20	0.41	1	USA - California	2009	n.a.	SkyFuels and National Renewable Energy Laboratory, 2009. Solar thermal jobs data. Personal communication, 21 March 2009.
	n.a.	14.40	0.58	0.38	USA - California	2006	n.a.	L. Stoddard, J. Abiecunas, R. O'Connell (2006).Economic, Energy,and Environmental Benefits of Concentrating SolarPower in California. USA National Renewable Energy Laboratory (NREL)
	n.a.	5.71	0.23	0.22	USA - California	2001	n.a.	Electric Power Research Institute (EPRI) and California Energy Commission (CEC), 2001. California Renewable Technology Market and Benefits Assessment. EPRI 100119, Palo Alto, CA and Sacramento, CA.
(Deloitte, 2011)	41.4	38.44	1.54	0.4	Spain	2008-2010	10, 22, 30 and 50	Data from surveys to Spanish companies including people employed by the plant and in other construction work/professional activities (technical and economic studies, consulting and advisory services, etc.).
IEA Solar PACES Programme	n.a.	8.00	0.32	1.2	Spain	2009	50	EL REBOSO II 50-MW Solar Thermal Power Plant (El Reboso II), Sevilla (La Puebla del Río) www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=49

[14] For converting person-years/MW to person/MW it was assumed a project lifetime of 25 years

Data Source	Manufacturing (person-years/MW)	Installation & construction (person-years/MW)	Installation & construction (person/MW)[14]	O&M (jobs/MW)	Geographical scope	Date of data	CSP plant capacity (MW)	Notes
	n.a.	12.00	0.48	0.8	Spain	2010	49.9	Helios I (Helios I), Arenas de San Juan, Villarta de San Juan, Puerto Lápice (Ciudad Real) www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=47
	n.a.	15.10	0.60	0.6	Spain	2010	50	Alvarado I, (Badajoz) www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=5
	n.a.	7.00	0.28	0.9	Spain	2010	50	Arcosol 50 (Valle 1), San José del Valle (Cádiz) www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=12
	n.a.	18.00	0.72	0.9	Spain	2010	50	Central Solar Termoelectrica La Florida (La Florida), Badajoz (Badajoz) www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=27
	n.a.	19.00	0.76	1.2	Spain	2010	50	Ibersol Ciudad Real (Puertollano) www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=18
IEA Solar PACES Programme	n.a.		0.00	0.8	Spain	2010	50	Aldiere (Granada) www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=3
	n.a.	12.00	0.48	0.8	Spain	2011	50	Extresol-1 (EX-1) www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=10
	n.a.	12.00	0.48	2.3	Spain	2011	20	Gemasolar Thermosolar Plant (Gemasolar), Fuentes de Andalucía (Andalucía (Sevilla)) www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=40
	n.a.	40.20	1.61	1.2	Spain	2011	50	Helioenergy 1, Écija (Sevilla) http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=210
	n.a.	12.00	0.48	3.1	Spain	2011	50	Lebrija 1, Lebrija, (Sevilla) http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=17
	n.a.	10.00	0.40	0.8	Spain	2011	50	Manchasol-1, Alcazar de San Juan (Ciudad Real) http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=7
	n.a.	12.00	0.48	0.6	Spain	2011	50	Palma del Río I, Palma del Río (Córdoba) http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=16
	n.a.	7.00	0.28	0.8	Spain	2011	49.9	Termesol 50, San José del Valle (Cádiz) http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=13
	n.a.	18.00	0.72	-	Spain	2012	50	Aste 1A, Alcázar de San Juan (Ciudad Real) http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=215
	n.a.	10.00	0.40	-	Spain	2012	50	Astexol II, Olivenza (Badajoz) http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=229

Data Source	Manufacturing (person-years/MW)	Installation & construction (person-years/MW)	Installation & construction (person/MW)[14]	O&M (jobs/MW)	Geographical scope	Date of data	CSP plant capacity (MW)	Notes
	n.a.	10.00	0.40	1.2	Spain	2012	25	Borges Termosolar, Les Borges Blanques (Lleida) http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=242
	n.a.		0.00	0.8	Spain	2012	50	La Africana, Posadas (Córdoba) http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=236
	n.a.	6.00	0.24	0.9	Spain	2012	50	Morón, Morón de la Frontera (Seville) http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=227
	n.a.	12.00	0.48	0.9	Spain	2012	50	Olivenza 1, Olivenza (Badajoz) http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=228
	n.a.	12.00	0.48	0.8	Spain	2012	50	Solacor 1, El Carpio (Córdoba) http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=223
	n.a.	9.00	0.36	1.7	Spain	2013	50	Solaben 1, Logrosán (Cáceres) http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=230
	n.a.	14.00	0.56	1	France	2015	12	Alba Nova 1, Ghisonaccia (Corsica Island) http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=221
IEA Solar PACES Programme	n.a.	12.50	0.50	1.4	USA	2009	5	Kimberlina Solar Thermal Power Plant (Kimberlina) www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=37
	n.a.		0.00	0.3	USA	2010	280	Solana Generating Station (Solana) www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=23
	n.a.	5.40	0.22	1.8	USA	2011	110	Crescent Dunes Solar Energy Project, Tonopah, Nevada. www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=60
	n.a.	13.60	0.54	0.3	USA	2011	250	Abengoa Mojave Solar Project, Harper Dry Lake, California www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=57
	n.a.	4.80	0.19	0.2	USA	2011	250	Genesis Solar Energy Project, Blythe, California www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=54
	n.a.	4.30	0.17	0.2	USA	2011	392	Ivanpah Solar Electric Generating Station (ISEGS) www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=62
	n.a.	4.80	0.19	0.4	USA	2011	75	Nevada Solar One (NSO), Boulder City, Nevada www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=20
	n.a.	4.70	0.19	0.3	USA	2011	150	www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=61
(Jacobson et al., 2014)	n.a.	5.50	0.22	1.5	USA - California	Future - 2050	n.a.	Using Jobs and Economic Development Impact (JEDI) models developed at US DOE (2012)
(Jacobson et al., 2017)	n.a.	11.13	0.45	0.9	Global	Future - 2050	n.a.	Using Jobs and Economic Development Impact (JEDI) models NREL (2013)

Data Source	Manufacturing (person-years/MW)	Installation & construction (person-years/MW)	Installation & construction (person/MW)[14]	O&M (jobs/MW)	Geographical scope	Date of data	CSP plant capacity (MW)	Notes
(Stitou, 2019)	n.a.	16.35	0.65	-	Morocco	2013-2019	160, 150, 200	Data for Ouarzazate Noor I, II and III CSP plant, employment data not disaggregated and thus unclear what is construction or O&M

n.a. – not available

The median values for CSP in all the values in Table 4 are of 10.7 person.years / MW for construction and 0.8 persons/MW for O&M, which are slightly lower than those encountered for only the Spanish plants (12.0 person.years /MW for construction and 0.8 persons/MW for O&M).

The median values for only the several CSP plants in Spain of 12.0 persons.years / MW for construction and installation (i.e. equivalent to 0.40 jobs /MW for 25 years lifetime of project) and of 0.8 jobs / MW for O&M will be used as assumption for the employment factors for Portugal in the calculations in section 3.2.. This assumption is considered since APPA's values are also higher than the median of all values in the Table 4 and since the values from (Deloitte, 2011) for Spain (Table 2) are also higher (38.4 person.years / MW for construction and 0.5 persons/MW for O&M).

It is clear that across the several sources there is substantial variety in employment factors, which is due to several factors as in (Cameron & van der Zwaan, 2015):

- differences in the approach used for calculating impacts in employment;
- different consideration of types of jobs within the concept "direct" job;
- variable country context regarding the share of local jobs and overall employment intensity;
- different assumptions on the types of RES technologies deployed, and
- differences in representing RES job creation potential possibly due to "vested commercial or ideological interests of the institutions behind the respective publications – especially for those studies in which no methodological description is provided".

3 Assessing potential job creation with possible CSP deployment in Portugal

3.1 Job creation in the RES power sector in Portugal

3.1.1 Deloitte/APREN study

In Portugal, APREN, the Portuguese Association of Renewable Energy Companies[15] regularly publishes an assessment of the socioeconomic impacts due to RES power technologies deployment in Portugal (Deloitte/APREN, 2014, 2019). Within these assessments it is estimated the number of created jobs in the past, as well as an assessment of future potential job creation.

(Deloitte/APREN, 2019) present the impacts that the RES power production has on the market daily electricity consumption, as well as the economic and social impacts for the country. Information was collected from main national and international bodies/organizations responsible for policy and regulation in the energy sector - in particular, electricity and RES energy, as well as via surveys to companies that operate in the renewable electricity sector in Portugal.

Historical data for 2014-2018 was analyzed, and some projections made until 2030. The projections for 2030 use two scenarios: one, that of the NECP, which derives mainly from the “Platoon” scenario of the Roadmap for Carbon Neutrality 2050 (RNC); the other, maintaining the current trends, which derive from the “Out of Track” scenario, also from RNC.

3.1.1.1 Period between 2014 and 2018 (historic)

Between 2014 and 2018, according to (Deloitte/APREN, 2019) RES power created more than 41 thousand jobs (annual average), with an added value per employee much higher than the national average, as is displayed in Figure 5, Figure 6 and Figure 7 below taken from this study (Deloitte/APREN, 2019).

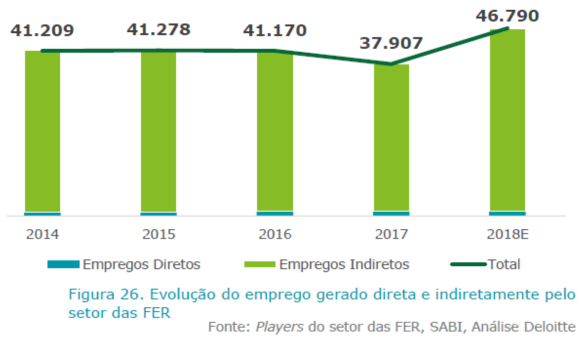
Wind and hydropower are the RES technologies that generated the largest volumes of employment (82%, on average of total RES) between 2014 and 2018.

However, it is solar that generates more jobs per installed MW (10 employees per MW installed, approximately 5-times the employment factor of the hydropower sector). Hydropower has registered a decrease of employees per installed MW (2.4 in 2014 and 2.2 in 2018E), the result of a stabilization of employment in view of the increase in installed capacity. Wind (and bioenergy) have an employment ratio per installed MW similar to each other, close to the 4 employees (Figure 7). In the previous study in 2014,

[15] https://www.apren.pt/

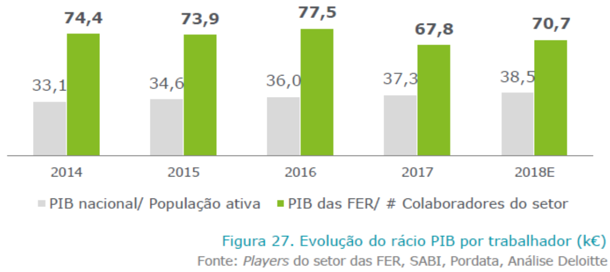
solar was also identified as the source with the highest number of employees per installed MW (10.7 in 2013), with hydropower maintaining the downward trend already seen since 2010 (3.8 in 2010; 2.7 in 2013).

Overall, between 2014 and 2018, it is estimated that the contribution to the GDP of each employee in the RES sector recorded an average annual value of ~ 73 thousand euros, more than twice the national average that represented ~36 thousand euros in this period (Figure 6).



Source: (Deloitte/APREN, 2019)

Figure 5 – Evolution of direct and indirect employment created by RES sector in Portugal between 2014 and 2018



Source: (Deloitte/APREN, 2019)

Figure 6 – Evolution of GDP per worker (k€) in Portugal between 2014 and 2018

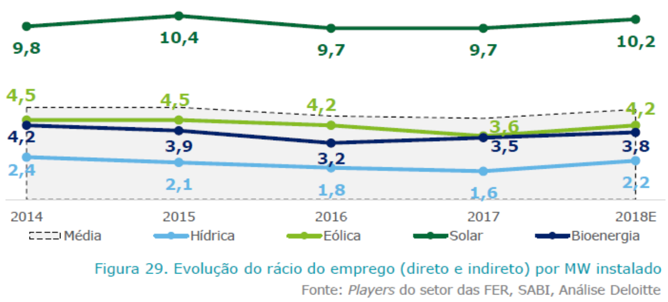
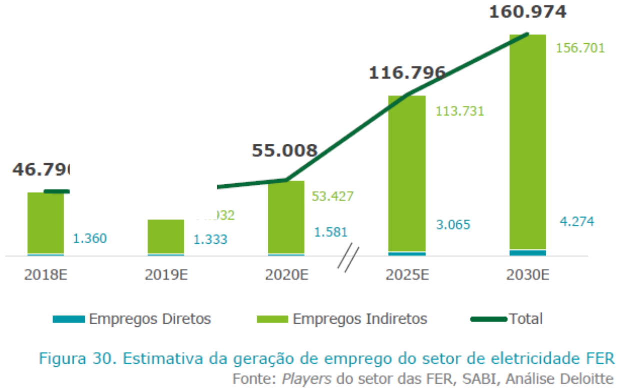


Figure 7- Evolution of employment (direct and indirect) factors (Jobs/MW) for each RES power technology in Portugal between 2014 and 2018

Source: (Deloitte/APREN, 2019)

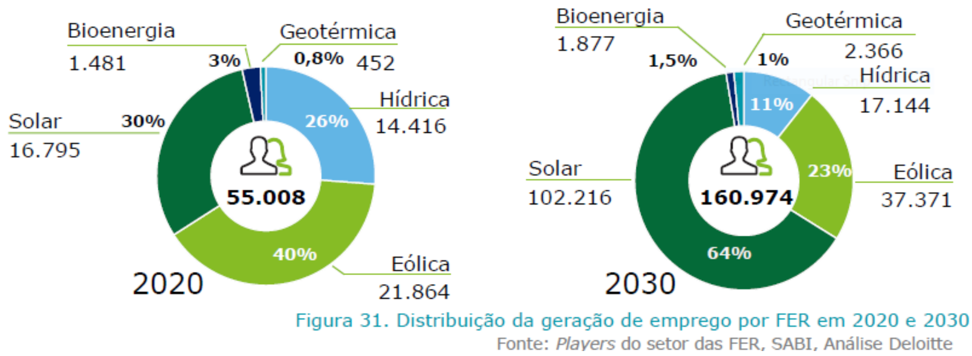
3.1.1.2 Period between 2019-2030 (prospective)

Figure 8 and Figure 9 illustrate the expected evolution between 2018 and 2030 of jobs figures according to what is planned in a combination of scenarios from RNC and analyzed in (Deloitte/APREN, 2019).



Source: (Deloitte/APREN, 2014, 2019)

Figure 8 – Evolution of jobs to be created in the future with RES power technologies in Portugal



Source: (Deloitte/APREN, 2014, 2019)

Figure 9 – Evolution of jobs to be created in the future for the different RES power technologies in Portugal

Between 2018E and 2030, the impact of RES on employment will more than triple, generating **an additional of** approximately 114 thousand employees in the RES sector (Figure 8). These values are due to the expected growth of the RES sector, particularly, solar PV. It is estimated that PV will be responsible for about **63% of the employees directly and indirectly associated with the sector in 2030**. Employment will grow across all energy sources, although at different rhythms. Due to the high growth of **solar PV (5x, between 2020 and 2030)**, the relative share of hydro and wind power for job creation will be reduced to 23% and 11% respectively in 2030. Nonetheless, both hydro and wind will increase their number of employees, between 2020 and 2030 (2.7 thousand and 15.5 thousand, respectively) (Deloitte/APREN, 2019).

3.1.2 Academic publications

(Oliveira et al., 2013) and (Henriques et al., 2016) take Portugal as a case study of an assessment of the impact of renewable energy by means of the Input-Output (IO) approach (quantity and price models). In the second paper, targets for electricity generation on employment for the years 2008–2020 are assessed for both RES and non-RES, while considering the different life cycle stages of power plants.

Table 5 shows a comparison of employment indicators for Portugal NREAP pathway to 2020 subdividing CIM and O&M jobs and a series of studies including several technologies listed by (Wei et al., 2010).

Table 5 – Comparison of employment indicators (jobs/MW) in Portugal and other projects

Technology	Installation of new facilities (person-year/MW)		O&M (Job/MW)	
	(Wei et al., 2010)	Portuguese case-study (Henriques et al., 2016)	(Wei et al., 2010)	Portuguese case-study (Henriques et al., 2016)
Geothermal electricity	4 - 17.5	n.a.	1.67 - 1.79	0.05
Hydropower large	n.a.	10.50	n.a.	0.20
Hydropower small	5.71	17.22	1.14	0.18
PV	7.14 – 37.00	25.17	0.12 - 1.0	0.10
Wind	2.57 - 10.96	5.04	0.14 - 0.4	0.14
Biogas	3.71 - 21.3	15.71	2.28 - 7.8	0.25
Biomass	4.29 - 8.50	17.67	0.24 - 1.53	0.20
Biowaste	-	-	-	0.41
Coal	8.50	-	0.18	0.16
Natural gas	1.02	4.10	0.10	0.10
CSP	**4.50-10.31**	**-**	**0.22 – 1.00**	**-**

3.2 Exploratory assessment of potential job creation with possible CSP deployment in Portugal

As previously mentioned, NECP 2030 the National Energy and Climate Plan for 2030, foresees in its RES electricity sector trajectory to 2030 the deployment of include CSP pilot projects, namely 100 MW in 2025 and 300MW in 2030, where the technology would include hours of storage. By considering the values previously mentioned of 12.0 persons.years / MW for construction and installation (i.e. equivalent to 0.40 jobs /MW for 25 years lifetime of project) and of 0.8 jobs / MW for O&M a total of 3 840 jobs could potentially be estimated for Portugal by deploying the foreseen 300 MW by 2030 as in the following table.

Table 6 – Estimate of potential job creation in Portugal with CSP deployment

Potential created direct jobs in Portugal with CSP	2025	2030
Installed foreseen capacity of CSP as in NECP 2030 (MW)	*100*	*300*
Installation & construction jobs	1200	3600
O&M jobs	80	240
TOTAL jobs	**1280**	**3840**
Jobs / MW	*12.8*	*12.8*

The assessments of job creation in renewable energy projects in a comprehensive form should appraise its contribution to the sustainability of the economy and integrate environmental, social and economic dimensions. The employment created by a renewable project is undoubtedly one of the dimensions to consider.

The choice of certain indicators or the consideration of a certain period of analysis in the analysis of the jobs created in an economy by any project (including a project within RES industry) may overweight certain stakeholders' perspectives over others. For instance, the results may be shown as a snapshot of a certain given year of additional jobs or as the cumulative jobs per unit of installed capacity. Also, results can be shown as the full time equivalent for a job over the lifetime of the project as opposed to jobs created for one single year period. An example are those jobs associated to construction of a plant which are temporary as they will last only about 2.5 years, while the O&M jobs are more stable along the whole project lifetime. In the case of the indicator being "Jobs in person-year per MW", which represents the jobs created in a certain year by the additional installed capacity, this value can be converted to "jobs per MW" by dividing by the lifetime of the plant. Moreover, Job ratios can be misleading where there is lack of clarity over whether jobs are local or have an export component.

It is very important for understanding various studies within the green jobs literature to use a normalized methodology and common taxonomy for comparing employment impacts from these studies. Data aggregation in the analyzed reports should focus on uniform methodology of job metrics and definitions and analysts need to be careful when comparing technologies and to be specific on the timing and duration of employment.

In this exploratory work, we have done our best to use the data in the correct format, although this is not always a straightforward task. Given the lack of available information and/or clarity on assumptions used in some of the reviewed literature it could be that some of the available data and figures could have been misinterpreted. For instance, in some works direct and indirect jobs are quantified with no mention at all on the life-cycle stage of the investment project these refer to or with an unclear/incomplete mention of this, while other studies only refer to life-cycle activity and no specific mention if these are direct/indirect.

In the calculation presented in **Table 6** we show the number of new jobs that will be created in the year 2030, and not specifically the number of jobs that one MW of installed capacity of CSP may generate in the economy during the whole duration of the project in average terms, i.e, equivalent full time employment.

Some figures within CSP projects of jobs.year/MW are much higher than the remaining because of specificities of the projects, such as, the existence of hours of energy storage opportunity with the use of molten salt within the thermal circuit, that will have an impact in a relatively higher amounts of both CIM (construction, installation and manufacturing) as well as O&M jobs (eg. Gemasolar Thermosolar Plant in Spain).

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