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EU Solar Jobs Report 2021

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Foreword

Welcome to SolarPower Europe's EU Solar Jobs Report 2021.

The multiple advantages of solar power are increasingly known by decision makers in politics and industry: Foremost, solar energy is often the lowest-cost power generation source in the EU, with the cost structure continuing to improve further for many years to come. Solar PV is also the most flexible and easy to deploy power technology – from very small household applications to gigantic utility-scale power plants. One less well-known solar benefit is 'job friendliness.' No other power technology is as job intense as solar, which creates 2 to 6 times more jobs than any of its peers during the construction phase. At the same time, large-scale solar is also a leader when it comes to CO_2 abatement costs.

These are good reasons for an updated EU Solar Jobs Report 4 years after we published our last edition when solar was caught in its transition phase. And there are more reasons. In 2020, the EU solar sector installed over one third more power capacity than its closest follower, a lead it is unlikely to give away in the future. In fact, solar power will become our major energy provider in the long run, which makes it imperative to take a close look at the development of solar jobs in Europe at a time when policymakers are working on the details to enable the European Green Deal.

In 2020, the solar sector created around 357,000 direct and indirect jobs, compared to only 81,000 in 2016, estimated in our previous job report. In line with SolarPower Europe's latest Medium Scenario, which forecasts that the EU solar market will increase installations from nearly 20 GW in 2020 to over 40 GW in 2025, jobs will grow by 64% to 584,000 jobs in 2025.

Indeed, solar holds significantly more future job potential for Europeans. The 40% renewables by 2030 target proposed by the EU Commission already translates into doubling today's solar jobs to 742,000. However, our modeling has shown that a 45% renewables target is required to reach the agreed upon 55% GHG emissions reduction target by 2030, and set the EU on a cost-efficient track to reach 2050 climate neutrality, complying with a 1.5 °C Paris Agreement Scenario. For a 45% renewable share in 2030, we would need a solar power generation fleet of 870 GW, up from around 140 GW end of 2020. To match this effort over 70 GW of new solar per year would have to be installed throughout the decade – tripling EU clean solar jobs to more than 1.1 million in 2030.

While most solar jobs are, and will be, in the construction segment of installing PV systems, around 6% of jobs are employed in manufacturing. That's why, along with much higher ambition for solar deployment, our policy recommendations (see p. 6), call for urgent attention to the bottleneck of installers already being faced today, and an industrial strategy for domestic solar manufacturing. Although Europe has an exceptionally strong solar R&D landscape and a few leading manufacturers left along the value chain, not every product needed for a solar system can be made in Europe anymore.

EU solar jobs will not only be the key to Paris' climate goals, the overall ambition must be to improve European energy security by investing also in manufacturing jobs for the technology that already adds more power generation capacities than any other today and will shoulder the major responsibility of keeping European lights on in the long term.

A big thanks goes to Vlerick Business School, which supported us in accomplishing this report and was instrumental in creating a mathematical model for estimating solar jobs in Europe. To track EU solar developments, we will publish this report now yearly.

Enjoy reading our Jobs Report.

WALBURGA HEMETSBERGER
CEO, SolarPower Europe

MICHAEL SCHMELA
Executive Advisor, SolarPower Europe

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SolarPower Europe

Project Lead: Michael Schmela, SolarPower Europe.

Project Management: Raffaele Rossi, SolarPower Europe.

Authors: Christophe Lits, Raffaele Rossi & Michael Schmela (SolarPower Europe); Lowiek Buyens, Bart Lauwers & Harold-Jan Louwaege (Vlerick Business School).

Text editing: Bethany Meban, SolarPower Europe.

Contact: info@solarpowereurope.org.

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Executive summary

As the continent progresses towards its 2030 and 2050 climate ambitions, EU solar PV energy is steadily growing, with associated solar job-creation expanding rapidly. This study quantifies the number of jobs created directly and indirectly by the EU solar sector today and gives an outlook for 2025 and 2030. It employs a hybrid methodology that considers the different steps of the PV value chain – Manufacturing, Deployment, Operations & Maintenance, and Decommissioning & Recycling.

In 2020, 357,000 full-time equivalent jobs (FTEs) are employed in the EU solar sector. 150,000 FTEs, 42% of the total, are direct jobs, while 207,000 are indirect jobs. The great majority of jobs (80%) are associated with solar deployment activities. Operation & Maintenance jobs are 10% of the total, with the remaining share belonging to Manufacturing, at 6%, and Decommissioning & Recycling, at 4%.

Out of the total 23,000 jobs created by Manufacturing, inverter manufacturing provides nearly half, about 11,000 direct and indirect FTEs. Polysilicon production and module production provide 29% and 22% of total manufacturing jobs respectively. Due to the lack of production capacity for ingots/wafers and cells in the EU, less than 1,000 jobs are created by these activities.

This study provides a five-year outlook for solar job creation in the EU, based on the scenarios developed by SolarPower Europe's Global Market Outlook 2021-2025. Thanks to the strong growth of the annual market expected in 2021, solar jobs are also set to rise significantly, with a 30% increase year on year resulting in 463,000 FTEs. According to our Medium scenario, further growth could lead to 584,000 jobs in 2025 – that's a 64% growth compared to 2020 levels.

Job creation projections associated with manufacturing vary considerably depending on the ability to meet the European Solar Initiative 2025 goal to establish a production base equivalent to 20 GW production per annum across the whole value chain by 2025. Meeting this ambitious goal would result in 74,000 FTEs, while a low-ambition, business-as-usual, scenario expects only 32,000 FTEs. Partly meeting the ESI target – our central scenario – would signify 51,000 manufacturing jobs, a 121% growth compared to 2020 levels.

Further, the report assesses solar job creation potential with regard to the level of ambition in setting the new EU renewable energy target for 2030. With a 40% RES target, as proposed by the European Commission, solar jobs would double compared to today's levels, reaching 742,000 FTEs in 2030. However, with the 45% target put forward by SolarPower Europe, and an increased ambition for solar's contribution to enable a more cost-efficient EU energy transition, solar jobs would *triple*, totaling 1,100,000 FTEs by the same year.

1. **Raise EU ambition towards 45% renewable energy target by 2030.** The European Union needs at least a 45% renewables target by 2030 to be able to meet the 1.5°C Paris climate goal as it strives for carbon neutrality by 2050. The current proposal for a 40% renewable energy target by 2030 will not create the needed momentum to help transform Europe's economy as renewables would grow too slowly.

2. **Solar is the crucial key to Paris.** Solar energy is the only technology that can decarbonise the European economy quickly, due to its cost leadership and versatility, enabling both large-scale centralised power plants and distributed solutions for industrial, commercial, and residential solutions. Both the National Energy and Climate Plan (NECP) 2030 targets of the EU members states (335 GW) and the impact assessment figures of the European Commission (479 GW) are below the installed capacity forecasted in SolarPower Europe's Moderate scenario reaching a total operating solar capacity of 588 GW in 2030. As part of a 45% renewables target, installed solar capacities must reach 870 GW by 2030, which is 160% higher than the NECP goal, and would require on average 73 GW installations per year throughout the decade, a huge leap compared to the nearly 20 GW installed in 2020.

   Policymakers should strive to establish the right conditions to enable further solar growth, which would bring more jobs in the European Union while at the same time being the most affordable means to achieve the European Green Deal. That is why slow administrative and permitting procedures need to be streamlined for fast deployment of low-cost, utility-scale solar.

3. **Promote a solar industrial strategy for the EU to provide energy security in the long run.** With solar expected to take responsibility for the major share of energy generation in a decarbonised economy, it is imperative that the European Union establishes a substantial solar manufacturing industry along the entire value chain if it does not want to rely to a large extent on imports.

   The recent growth of the solar market opens a new chapter for solar PV manufacturing in the EU. Redeveloping a sizeable production in Europe is key to ensure a supply diversification and secure the resilience of the downstream industry, supporting the millions of jobs attached to it. A domestic manufacturing capacity is also critical to sustain high-quality jobs in the research ecosystems and create new engineering jobs in the manufacturing industry. Europe can count on unique strengths: a historical industrial ecosystem and know-how and leadership in many solar PV technologies. The European Solar Initiative, an industrial alliance launched by SolarPower Europe and EIT InnoEnergy together with other partners, aims to establish 20 GW of manufacturing capacity in Europe from polysilicon to modules, up from less than 1 GW on the solar cell level today. Yet, public support will be necessary to de-risk first projects and help them reach a critical scale allowing for global competitiveness.

4. **Address job bottlenecks.** There is an urgent need to train EU workers in order to have a skilled workforce to accompany the needed and expected growth of solar employment. Already today, there is a lack of skilled EU workers in clean energy technologies, which is quickly becoming a critical bottleneck that could hamper solar deployment – and in consequence the EU's climate targets. Thus, adequate training strategies need to be developed together with sufficient investments in up- and re-skilling programmes. One good example is Estonia's recovery plan, which allocates 15 million EUR to ensure high-quality expertise required to implement the green transition in enterprises is available. This includes the updating of upskilling and retraining programmes or the development of more flexible programmes, which integrate the future needs of the green economy. However, member states must do much more to direct recovery funds towards the "Reskill and upskill" flagship, which aims at ensuring Vocational and Educational Training graduates are employed and to improve access to "on the job" training.

5. **Develop comprehensive policy frameworks for the rooftop segment.** Residential, commercial and industrial rooftop PV systems not only hold a huge solar potential enabling prosumers, they also create more jobs than utility-scale systems, because of their higher labour intensity during the installation phase. Therefore, strategies must be rapidly developed to deploy rooftop PV to unlock this massive solar and job potential. Integrated renovation strategies must accelerate renovation rates of buildings and encourage the installation of solar PV in buildings. Individual and collective self-consumption must not only be allowed but incentivised by the development of national regulatory frameworks. Price signals and incentives should be granted to prosumers to unlock their flexibility.

6. **Promote diversity in the solar industry.** The renewable energy sector employs a significantly higher number of women compared to the energy sector overall.[1] Still, women cover only 32% of renewable energy jobs, and the percentage of women in the areas of science, technology, engineering, and mathematics (STEM jobs) is just 28%. Access to training and skills development programmes has been identified as the top priority to improving gender balance in the renewable energy sector. A more diverse EU workforce in terms of gender, social and ethnic background, sexual orientation would also allow to better utilise the talents and skills of EU workers.

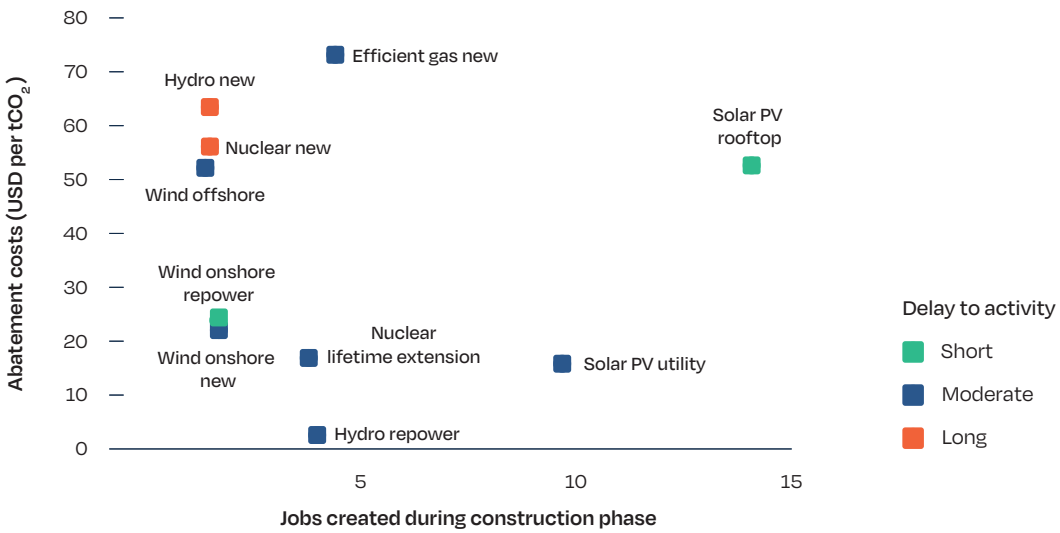
1 IRENA (2019): Renewable Energy: A Gender Perspective.

1 Introduction

The European Union is in a transition from fossil energy to green energy and wants to decrease emissions by 55% by 2030, as well as achieve carbon neutrality by 2050. Solar PV will be a key contributor to this transition. Solar is the largest growing renewable energy technology both at EU level and globally, and in recent years the sector surpassed expectations in terms of cost reduction and growth rate.

While solar tenders bids have been decreasing all around the world, the lowest winning bids were awarded in Europe, in Portugal. Despite the health crisis severely negatively impacting the global economy, last year solar reached a new annual record of 18% growth, with 138 GW installed in 2020. In the EU, where several countries were hit particularly hard, and stark lockdown measures were imposed, market demand grew by 17% to 19.8 GW of newly installed capacity. The years of disappointing solar market performance in Europe are gone, and the future outlook shows a stable two digit growth path. Such growth in the sector is reflected into job creation at all levels. As solar has turned into the primary force driving the EU energy transition – last year, solar installed about 35% more power than the second largest power generation source – its contribution to creating long-term employment in Europe is also quickly growing. This is no surprise, as solar is the most job-intensive among low carbon and renewable energy technologies (see Figure 1).

FIGURE 1 JOB CREATION PER MILLION DOLLARS OF CAPITAL INVESTMENT IN POWER GENERATION TECHNOLOGIES AND AVERAGE CO_2 ABATEMENT COSTS



NOTE: Avoided CO_2 emissions calculated based on displacing coal-fired generation, global averages shown. Delay to activity refers to the time required for capital to be invested into power generation technologies.
SOURCE: IEA.

Box 1. Coal versus solar jobs.

Today, coal employs half a million people in the EU, and about half of those jobs could be lost by 2030. In contrast, the PV industry is likely to increase employment from 357,000 in 2020 to 584,000 in 2025, and possibly up to 1.1 million in 2030. That means the solar sector could feasibly absorb all phased-out coal workers during this decade.

Sometimes a picture is drawn that demonstrates the transition to renewables dramatically worsens the socio-economic situation of coal-dependent workers, but studies show the exact opposite: regions that are coal intensive can benefit from the energy transition. These locations are a good fit to transition from black to clean power parks, where large-scale solar projects can be developed while creating local jobs.

In fact, after decommissioning of coal infrastructures, regions are left with land availability to develop gigawatt utility-scale projects. After years of intensive coal extraction, those vast areas cannot be used for agriculture anymore; instead these brownfield sites represent perfect locations for ground-mounted solar projects. In situations where groundwater levels increase again in open pit mines when pumping is stopped, the newly created 'lakes' can be used for floating solar power systems. Moreover, the electricity infrastructure is already present and ready for use; much needed workers are already present locally with knowledge and experience in the energy sector – making re-skilling easier and faster.

EU coal regions alone have the technical potential to install 1,516 GW of renewables, according to a European Commission Joint Research Centre (JRC)[2] report. Spain, Poland and Romania have the greatest potential when it comes for ground-mounted development while Germany and Spain share the highest potential for rooftop PV systems.

The coal-intensive regions of Brandenburg, Saxony and North Rhine-Westphalia in Germany are good showcases of successful transitions, according to the JRC. These new solar parks energise thousands of households while creating more jobs than offered by previous coal power plants. Thus, they are maintaining local energy generation – but now cleanly and safely – while creating new jobs, countering two major arguments sometimes still held against the development of renewable energy.

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2 Kapetaki *et al.* (2020): Clean energy technologies in coal regions: Opportunities for jobs and growth.

This study illustrates the current and future job creation associated with solar energy in the European Union, based on historical data and the market scenarios from SolarPower Europe's Global Market Outlook 2021-2025. Moreover, this report provides a long-term outlook for solar job creation in the EU, reflecting different levels of ambition in the setting of new 2030 renewable energy targets. The impact of a 45% RES target for 2030 is compared to the European Commission's 40% RES by 2030 proposal.

1.1. Methodology

The study uses a hybrid approach to calculate full-time equivalent (FTEs) jobs based on methodologies that have been previously employed in solar and renewable energy job creation studies.[3] The model estimates direct and indirect solar FTEs created on an annual basis for each EU member state, which are analysed individually at four different steps of the value chain: (i) Manufacturing; (ii) Deployment; (iii) Operation & Maintenance; (iv) Decommissioning & Recycling.[4] Direct jobs in Manufacturing and Decommissioning & Recycling are calculated through employment factors, while direct jobs in Deployment and Operation & Maintenance (O&M) are obtained through a CAPEX-OPEX model. Moreover, to quantify the indirect effects of solar PV investments, the report uses an Input/Output table that uses the 27 EU member states and 63 sectors that cover all economic activity. The Input/Output table that includes FTE multipliers that allows us to calculate indirect jobs based on direct jobs. An overview of the methodology is presented in Table 1. All results are annual, which implies that they show the FTEs that are required to fulfill the demand for the corresponding year.

TABLE 1 OVERVIEW OF METHODOLOGY

VALUE CHAIN STEP	METHODOLOGY FOR DIRECT JOBS		METHODOLOGY FOR TOTAL JOBS	
Manufacturing	Employment factors	Direct FTEs	Input/output (FTE multiplier)	Total FTEs
Deployment	CAPEX-OPEX model	Direct FTEs	Input/output (FTE multiplier)	Total FTEs
Operations & Maintenance	CAPEX-OPEX model	Direct FTEs	Input/output (FTE multiplier)	Total FTEs
Decommissioning & Recycling	Employment factors	Direct FTEs	Input/output (FTE multiplier)	Total FTEs

3 A full-time equivalent is a measure of employee workload and equals the number of hours of a typical full-time employee. A full-time staff member would have an FTE of 1.0.

4 Direct jobs are FTEs that are linked to core activities such as manufacturing, deployment, O&M and decommissioning & recycling. Direct effects are expenditures made by producers/consumers as a result of a final demand. By contrast, indirect jobs are a result of business-to-business purchases in the supply chain that are considered intermediate transactions. The spending of direct FTEs in intermediate sectors creates indirect FTEs in the corresponding sectors. Induced jobs, which are created through money flows resulting from household spending of labour income, are not included in the scope of this study.

An overview of the value chain activities included in the study is presented in Table 2. While FTEs in Deployment, Operations & Maintenance and Decommissioning & Recycling are inferred based on EU installed capacity scenarios, solar jobs associated with Manufacturing derive from EU production capacities for different value chain products, including polysilicon, ingots/wafers, cells, modules and inverters. A separate assessment of job creation associated with the manufacturing of each of these products has been carried out. For Deployment, the study evaluated both installation labour and soft labour (engineering, procurement, customer acquisition and permitting). Direct Operation & Maintenance jobs include the replacement of components and inverters, as well as cleaning and reparations, whereas jobs in Decommissioning & Recycling relate to the removal, collection, and treatment of end-of-life modules (Table 2).

TABLE 2 SCOPE OF SOLAR PV CHAIN FOR CALCULATION OF DIRECT FTES

CATEGORY	CATEGORY SECTION	CATEGORY BREAKDOWN
Manufacturing	Polysilicon	Polysilicon Manufacturing
	Ingot/wafer	Ingot/wafer Manufacturing
	Cells	Cell Manufacturing
	Modules	Modules Assembly
	Inverter	Inverter Manufacturing
Deployment	Installation Labour	Mechanical
		Electrical
	Soft Labour	Procurement
		Engineering
		Customer Acquisition
		Permitting
Operation & Maintenance	Operation & Maintenance Labour	Components replacement
		Inverter replacement
		Cleaning
		Reparations
Decommissioning & Recycling	Decommissioning	Removal of Modules
	Recycling	Collection of waste
		Treatment of waste

EU manufacturing capacities through 2025 are based on three different scenarios: a Low Scenario or Business as Usual scenario in which production capacity remains aligned to current levels; a High Scenario in which European Solar Initiative (ESI) targets are achieved; and a Medium Scenario in which European Solar Initiative targets are only partly achieved. The scenarios are presented in more detail in Table 3.

TABLE 3 EU MANUFACTURING SCENARIOS DESCRIPTION

SEGMENT	LOW SCENARIO (BAU)	MODERATE SCENARIO	HIGH SCENARIO (ESI)
Polysilicon	Polysilicon manufacturing retains 20% of the global market, serving both the domestic market and exports.	Polysilicon manufacturing retains 20% of the global market, serving both the domestic market and exports.	Polysilicon manufacturing retains 20% of the global market, serving both the domestic market and exports.
Ingots & Wafers	Ingot and wafer production does not expand.	Domestic ingots and wafers production increases to serve the domestic cell production.	Domestic ingots and wafers production is established at 20-GW level to serve the domestic cell industry.
Cells	The current plans for new cell factories open their doors, but no other develop.	Most serious cell factory plans announced in 2020/2021 complete financing and open factories before 2025.	The EU industry manages to redevelop a 20-GW cell production capacity.
Modules	In addition to existing module manufacturing doing mere assembly, additional module manufacturing comes online together with the above mentioned cell projects.	In addition to existing module manufacturing doing mere assembly, additional module manufacturing comes online together with the above mentioned cell projects.	In addition to existing module manufacturing doing mere assembly, additional module manufacturing comes online together with the above mentioned cell projects.
Inverters	Inverter manufacturing in Europe grows but decreases its current share of the global market, serving both the domestic market and exports.	Inverter manufacturing in Europe grows and retains its current share of the global market, serving both the domestic market and exports.	Inverter manufacturing in Europe grows and expands its current share of the global market, serving both the domestic market and exports.

Box 2. Comparison with other job studies

To evaluate the results of this study and look at them in a broader context, we have compared them with a selection of previous studies that investigated solar or renewable energy job creation. An overview of the benchmark with other studies is provided below. The previous job studies we considered in this assessment have different temporal, geographic and sectoral scopes, use different methodologies to calculate job creation, and at times also have different job types within their scope. For this reason, results are difficult to compare. For example, Solar Foundation's data on PV jobs in the US is based on questionnaires to solar industry players throughout the value chain and uses statistical analysis to generate information on the jobs; moreover, the type of jobs considered differs from all other studies considered. While older solar job studies dating back from when the market was smaller are leaning more towards the conservative side of the spectrum, the recent study by Breyer *et al*. provides much more optimistic estimates of solar job creation. The study results indicate 356,000 FTEs for Europe in 2019, a number very close to our total assessment – however, these are only direct jobs, which, according to our model, resulted in 150,000 in 2020.

TABLE 4 OTHER JOB STUDIES

STUDY	REFERENCE YEAR	METHODOLOGY	SCOPE	TYPE OF JOBS	RESULTS
SolarPower Europe 2021	2020	Hybrid	Solar PV, EU-27	Direct and indirect	357,000 FTEs
EY & SolarPower Europe	2016	Input/Output approach	Solar PV, EU-28	Direct and indirect	81,000 FTEs
EurObserv'ER	2018	Input/Output approach	Solar PV, EU-28	Direct and indirect	118,000 FTEs
O' Sullivan et al.	2018	Input/Output approach	Solar PV, Germany	Direct and indirect	39,000 FTEs
Breyer et al.	2020	Employment Factors	Solar PV, Europe	Direct	356,000 FTEs
Solar Foundation	2020	Survey-based	Solar PV, United States	Solar workers[5]	231,000 FTEs

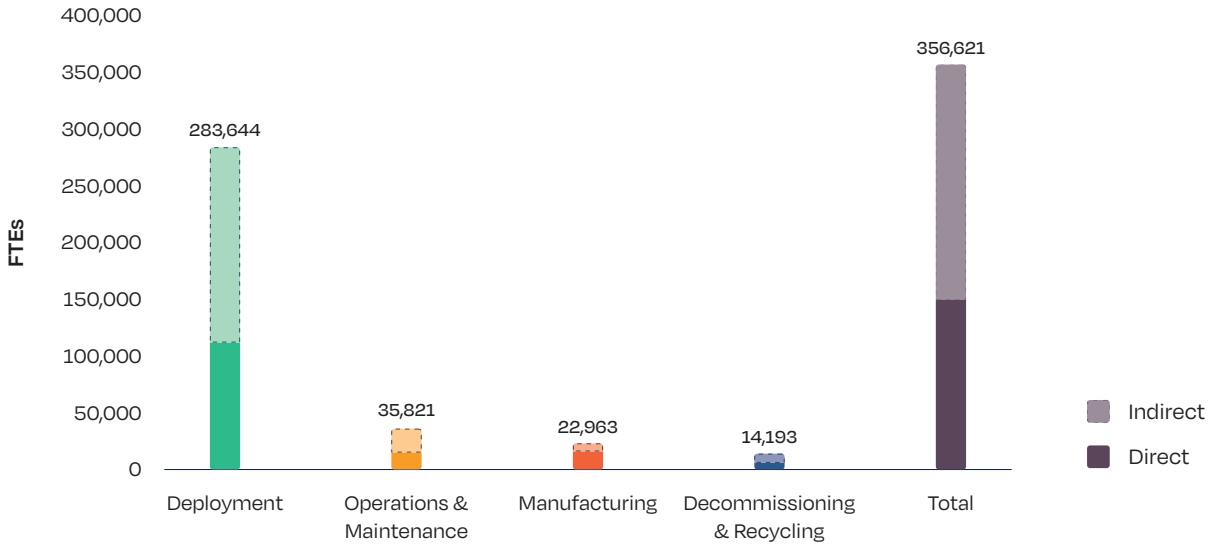
5 In this report, a "solar worker" is any person who spends more than 50% of their working hours on solar-related work.

2.1. Update 2020

In 2020, 357,000 FTEs have been created by the solar sector in the EU. 150,000 FTEs, 42% of the total, are direct jobs, while 207,000 are indirect jobs (Figure 2).

The great majority of jobs (80%) are associated with solar deployment activities (Figure 3). Operation & Maintenance jobs are 10% of the total, with the remaining share belonging to Manufacturing, at 6%, and Decommissioning & Recycling, at 4%. The

FIGURE 2 EU-27 SOLAR JOB MARKET IN 2020



predominance of Deployment jobs over Operations & Maintenance jobs is a consequence of the fact that solar PV has a rather high CAPEX intensity and a low OPEX intensity. Decommissioning & Recycling FTEs cover the smallest portion of the total FTEs as the solar PV waste streams are still low in volume. Solar PV waste streams will only become significant from 2030 onwards, when the first larger wave of installed systems in Europe will reach the end of their lifetime.

Annual job creation depends on both short-term and long-term factors. Intuitively, Deployment jobs are connected to how much solar capacity has been installed on a yearly basis, and therefore depend on the annual market size. Thanks to a rapid growth of the EU market in recent years, Deployment jobs have risen considerably compared to pre-2019 levels, when the annual market had been consistently below the 10 GW mark for several years. Conversely, Operation & Maintenance jobs rather depend on total solar installations and are therefore less susceptible to annual market fluctuations.

Manufacturing jobs in the EU solar sector are closely linked to the production capacities currently present in the EU. The European Union's PV industry has significant manufacturing capacities in certain steps of the value chain, primarily for polysilicon, inverters, and, to a minor extent, modules. Inverter manufacturing provides about 11,000 direct and indirect jobs, which is nearly half of total manufacturing jobs (Figure 4). Polysilicon production and module production provide 29% and 22% of total manufacturing jobs respectively, equivalent to about 7,000 and 5,000 FTEs. By contrast, due to the lack of production capacity for ingots/wafers and cells within the EU today, less than 1,000 jobs are created by these activities together. Job intensity is higher for cell and module production, low for inverters and ingot/wafer production, and very low for polysilicon production. This explains why polysilicon production, despite currently having a higher equivalent production output than inverters and modules, generates fewer direct jobs.

FIGURE 3 EU-27 TOTAL SOLAR JOBS BREAKDOWN IN 2020

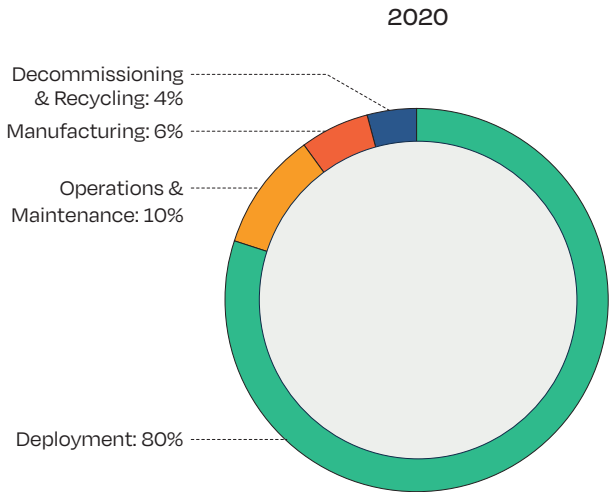
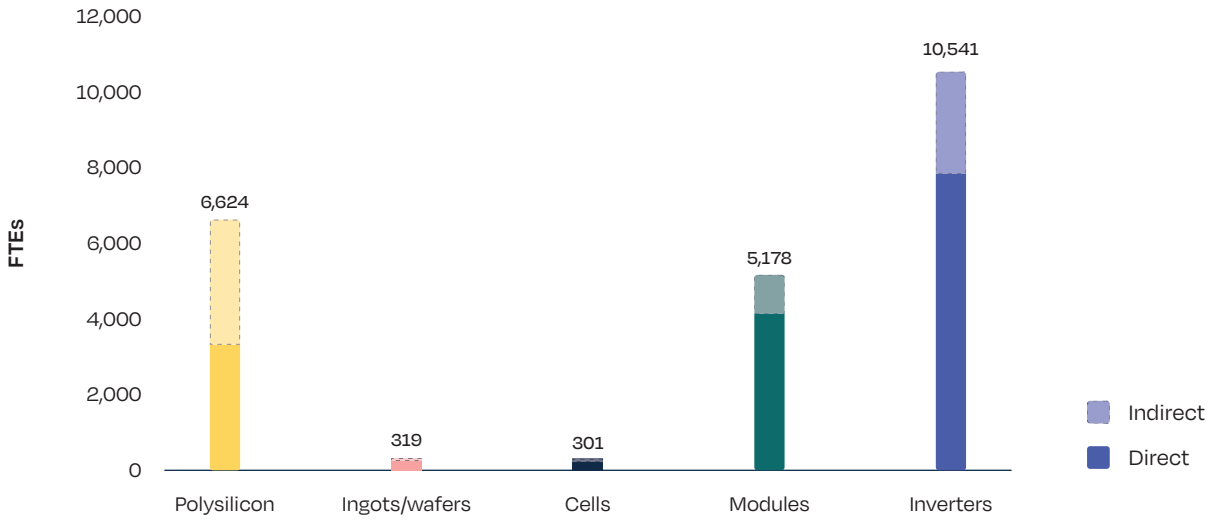


FIGURE 4 EU-27 SOLAR MANUFACTURING JOBS IN 2020



Box 3. Status of solar manufacturing capacity in Europe – and why we need much more.

After most European wafer-to-module production capacities were dismantled in the aftermath of the first solar boom phase over a decade ago, the Continent's next solar boom phase has started. This next wave will be much larger, and more sustained, as the technology has been identified as the key tool to combat climate change. While around 23,000 people worked in solar manufacturing in 2020, we expect this number to more than double to 50,000 by 2025 in our Medium Scenario, and more than triple to up to 74,000 in our High Scenario.

Despite the previous demise of wafer and cell manufacturing, the European Union is still home to world leading PV manufacturers along the value chain. Many small module manufacturers have been active in recent years, and Europe has world leading players in the Balance-of-System (BOS) field, including mounting structures and inverters, as well as in processing materials for cell/modules, cell and module production equipment, and polysilicon.

The core of Europe's in-depth solar technology knowledge is a vast and well-connected R&D ecosystem based on specialised PV research institutes in several countries, such as IMEC in Belgium, Fraunhofer ISE & CST and FZ Jülich in Germany, CEA-INES and IPVF in France, TNO in the Netherlands, and CSEM in Switzerland.

Wacker, one of the global leaders in the field of polysilicon, the raw material for nearly all solar cells, is headquartered and producing mostly in Germany. A start-up, Norwegian Crystals, have recently began producing ingots in Norway. Two companies have established facilities for making high-efficiency solar cells and modules in Germany and Italy – former PV equipment maker Meyer Burger and electric utility Enel.

Much of the equipment needed for producing solar cells and modules can be sourced from European companies, for example from Von Ardenne in Germany, a global leader in deposition equipment for solar cell production. The same is true for processing materials, such as encapsulation sheets to protect the solar cells in a module, which are offered by Borealis from Austria.

Solar modules are made in the EU by around 30 companies – and several are expanding, like Solarwatt in Germany, which has launched new production lines in September for both PV panels and solar batteries.

While the module is the heart of a solar system, the inverter is its brain – and Europe has quite a bit of it, represented by SMA from Germany, Fronius from Austria, Fimer from Italy, and several more. One global technology leader, SolarEdge from Israel, produces a share of its grid-connection devices in Hungary. Inverter companies employ the largest amount of solar manufacturing jobs, 46% in 2020.

Europe's market for mounting systems to fix the solar panels on the roof or install them on the ground is mostly in the hands of domestic companies, such as Mounting Systems and K2 from Germany. Very large utility-scale plants are usually installed on tracking systems that can follow the path of the sun – and one of the global leaders is a European company, Soltec from Spain. Other European-made BOS products are connectors to electrically bridge inverters and solar modules, which are available from Stäubli of Switzerland.

Europe's researchers and solar industry are already preparing for the next generation of PV technology. UK's Oxford PV is building a factory in Germany for silicon-perovskite tandem solar cells that achieve much higher conversion efficiencies.

As the European solar market grows faster than most analysts had been forecasting, many industrial consortia have put forward new industrial projects and are looking for financing to establish or expand production in Europe.

To support this effort, SolarPower Europe, in partnership with EIT InnoEnergy and with the support of the partners of the Solar Manufacturing Accelerator, has launched the European Solar Initiative (www.europeansolarinitiative.eu), which aims to re-establish 20 GW PV silicon-to-module manufacturing capacity in Europe by 2025, up from less than 1 GW cell capacity today. The initiative combines an industrial platform that gathers and structures the industry, and an investment platform that aims to de-risk and accelerate new manufacturing projects. The overall ambition is to improve European energy security by investing in jobs for a technology that already adds more power generation capacities than any other and will shoulder the major responsibility of keeping European lights on in the long term.

Note: *The solar companies and institutes mentioned are examples for European PV manufacturers along the value chain and members of SolarPower Europe, representing leading stakeholders of the European PV sector.*

Over 90,000 solar jobs, 26% of total jobs, were created in Poland in 2020 (Figure 5). This makes the country the largest provider of solar jobs in the EU in 2020. At first, this might appear surprising, considering that Poland is only the fourth largest EU market, and is not a large PV manufacturer. This apparent contradiction is due to a combination of factors. One is the fact that the bulk of its annual 2.4 GW market is mostly comprised of residential PV systems, which are small rooftop systems whose installation create more jobs than larger PV systems in the C&I or utility-scale segment. Another factor is that the gross labour costs in the country are much lower than in any other EU GW-scale market, which are located in Western and Central Europe and have higher labour costs. The availability of lower labour costs leads to more jobs created. This trend is visible as well in Greece, which, despite having the lowest annual capacity among the top 7 FTE providers, is ranked fifth with 24,000 jobs created. The largest PV markets in Europe – Germany, Spain and the Netherlands – are also present in the top 5, with 79,000, 40,000 and 27,000 FTEs respectively.

Across the member states that contribute the most to solar job creation, the majority of jobs stem from the rooftop segment (Figure 6). In GW-scale PV markets such as Germany and the Netherlands, over 75% of the jobs are connected to the rooftop segment. In the top 7 of the largest contributors, there is only one noteworthy exception – Spain. In the Iberian market, which is dominated by utility-scale solar, only 28% of total jobs are associated with the rooftop segment. As a result, job creation throughout the EU-27 is clearly skewed towards rooftop PV, which provides about 80% of total FTEs.

FIGURE 5 EU-27 TOP 7 FTE COUNTRIES AND ANNUAL INSTALLED SOLAR PV CAPACITY 2020

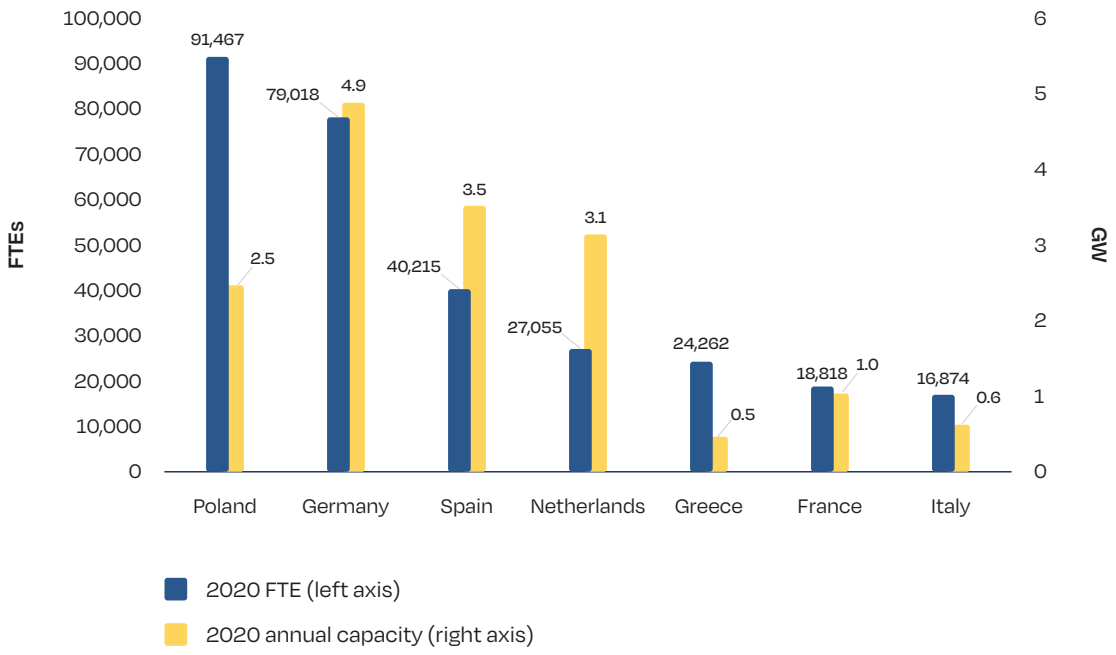
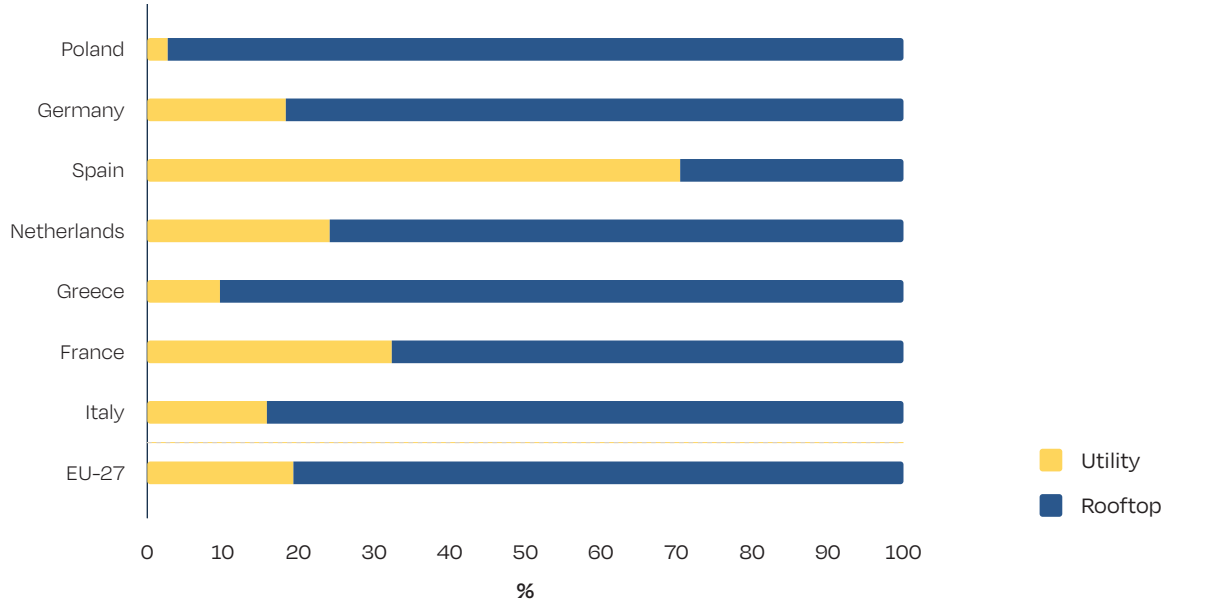


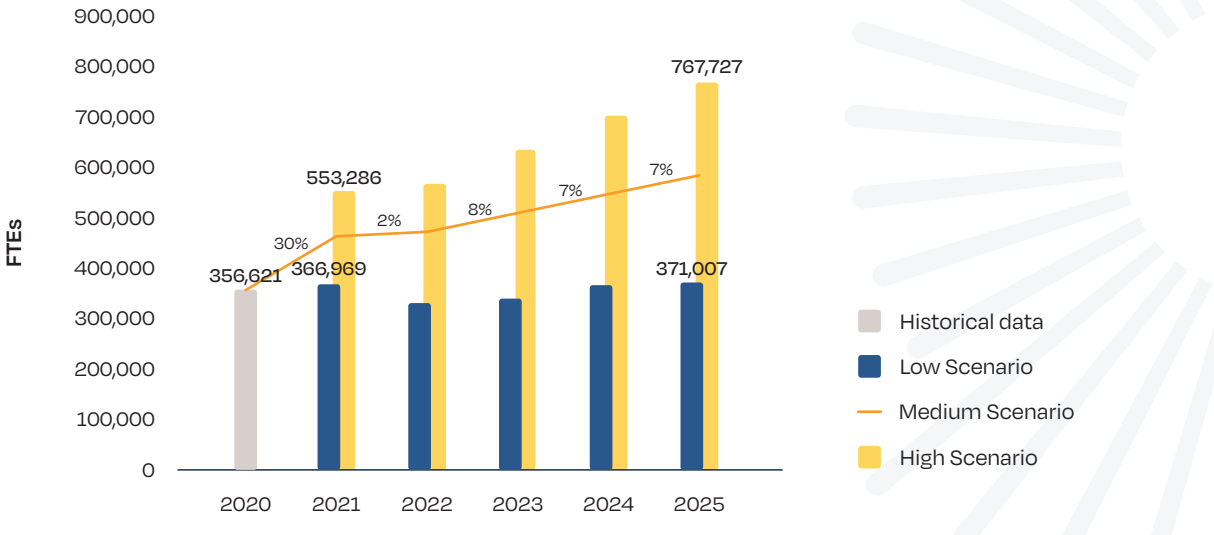
FIGURE 6 EU-27 TOP 7 FTE COUNTRIES - ROOFTOP VS. UTILITY-SCALE JOBS BREAKDOWN 2020



2.2. Prospects 2021-2025

Thanks to the strong growth of the annual market expected in 2021, solar jobs are also set to rise significantly, with an anticipated 30% increase year-on-year, resulting in 463,000 jobs (Figure 7). According to our Medium Scenario, further growth could lead to 584,000 jobs in 2025 – that is a 64% growth compared to 2020 levels. With an increased policy ambition leading to higher deployment and reaching the ESI

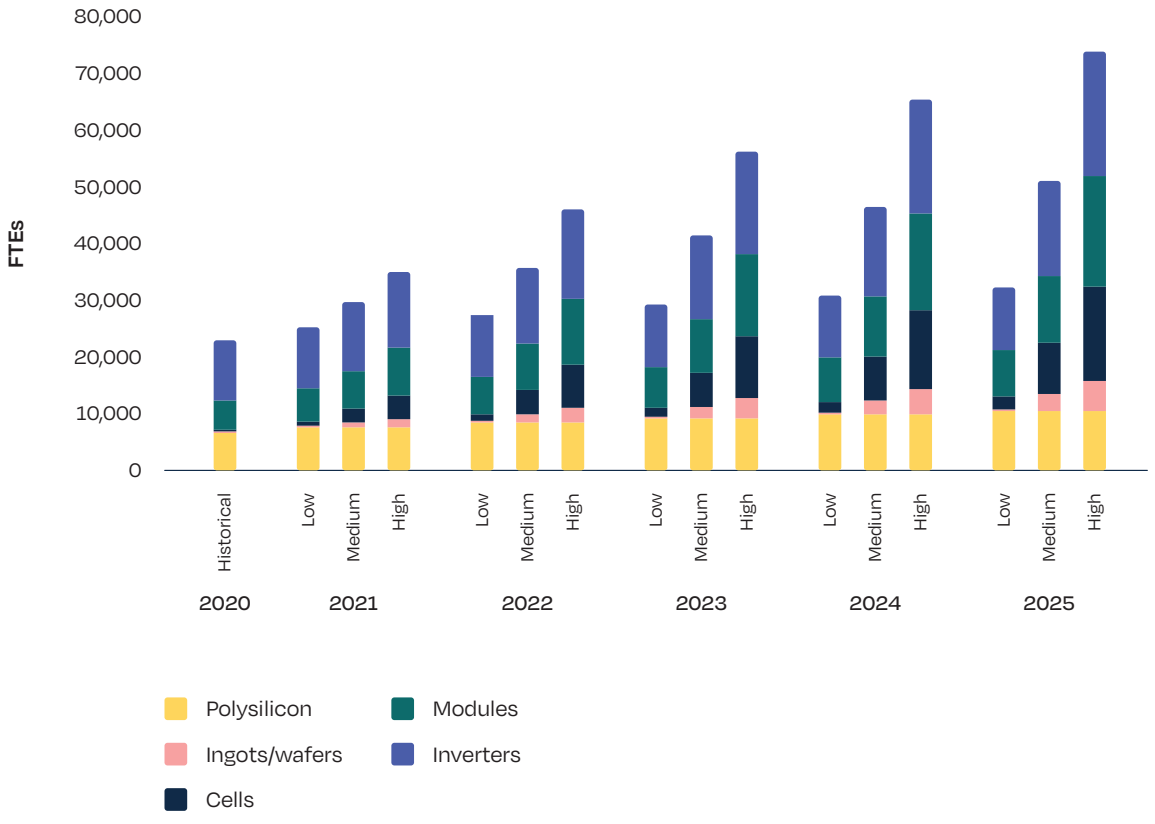
FIGURE 7 EU-27 SOLAR PV FTE SCENARIOS 2021-2025



manufacturing targets, solar jobs could be as high as 768,000 in 2025 – a 115% growth compared to 2020. However, in our Low Scenario, which anticipates limited market growth and missing the ESI target, solar jobs would barely increase from 2020 levels, with 371,000 FTEs a year in 2025 or a 4% growth.

The amount of jobs created in the PV manufacturing sector will greatly depend on the extent to which the European Solar Initiative targets are reached. According to our Medium Scenario, whereby ESI targets for 2025 are only partially achieved, in 2021, EU manufacturing jobs grow by 29% to 30,000 FTEs (Figure 8). At the end of our forecasting period, these jobs will have increased by 122% compared to 2020, reaching 51,000 FTEs. By contrast, in a low-ambition scenario with limited growth in EU production capacity, manufacturing jobs grow by 10% in 2021 and 41% in 2025. However, with the right political support to establish a strong manufacturing base in the EU and decrease supply chain dependency from third countries, domestic solar manufacturing jobs could reach 35,000 units in 2021 and as much as 74,000 units in 2025, which is equal to a growth by 52% and 222% respectively. Growth would take place in all value chain segments, including 5,000 jobs from wafter/ingot production and 17,000 jobs from cell production, which currently barely contribute to employment. Reaching the ESI target would also mean raising module manufacturing jobs from 5,000 to 19,000 FTEs in 2025, and inverter manufacturing jobs from 11,000 to 22,000 by the same year.

FIGURE 8 EU-27 SOLAR MANUFACTURING JOBS SCENARIOS 2021-2025



Activities in procurement, construction, installation etc. of PV systems are expected to generate 375,000 jobs in 2021, a 32% raise from 2020 (see Figure 9). Looking beyond 2021, despite our Medium Scenario forecasting continued annual solar capacity growth, Deployment jobs will increase only to a limited extent, and will actually decrease marginally in 2022. This is due to the termination of the Polish support scheme for small-scale installations, which has provided an exceptional contribution to job creation. In 2025, nevertheless, Deployment jobs will reach 434,000 units, up 53% from today's values. Depending on the evolution of the PV market in the next five years, jobs could be as low as 253,000 or as high as 585,000.

Unlike Deployment jobs, which rely on the annual PV market and are more susceptible to yearly fluctuations, Operation & Maintenance jobs depend on the total operating solar fleet and are much easier to forecast. Consequently, we expect these jobs to undergo a steady two-digit growth between 2021 and 2025 without any major bumps. The 36,000 FTEs working in solar O&M in 2020 will grow by 15% to 41,000 FTEs in 2021 and 82% to 65,000 FTEs in 2025 (Figure 10).

FIGURE 9 EU-27 SOLAR DEPLOYMENT JOBS SCENARIOS 2021-2025

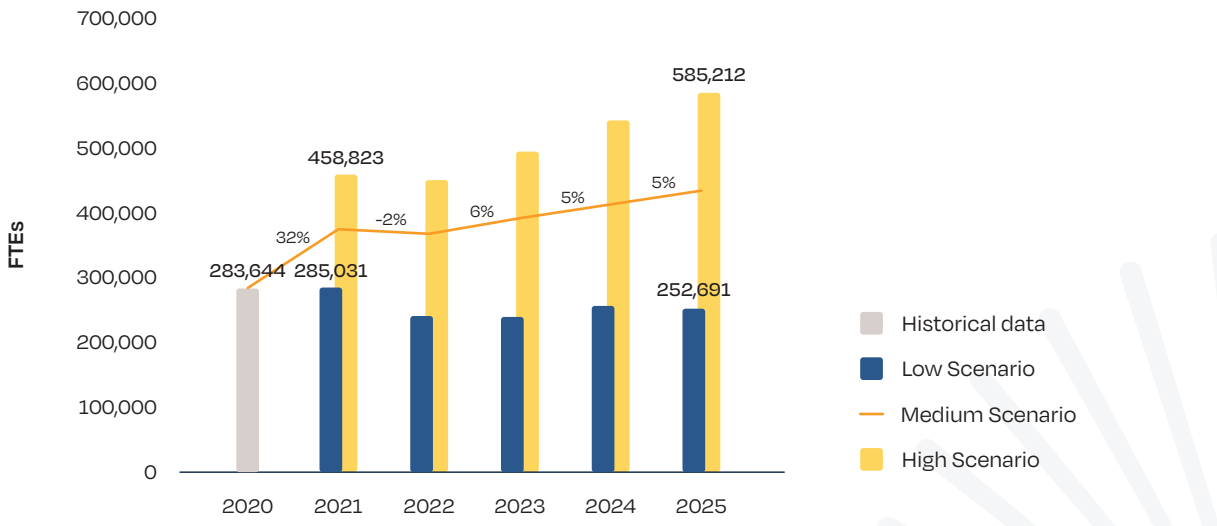
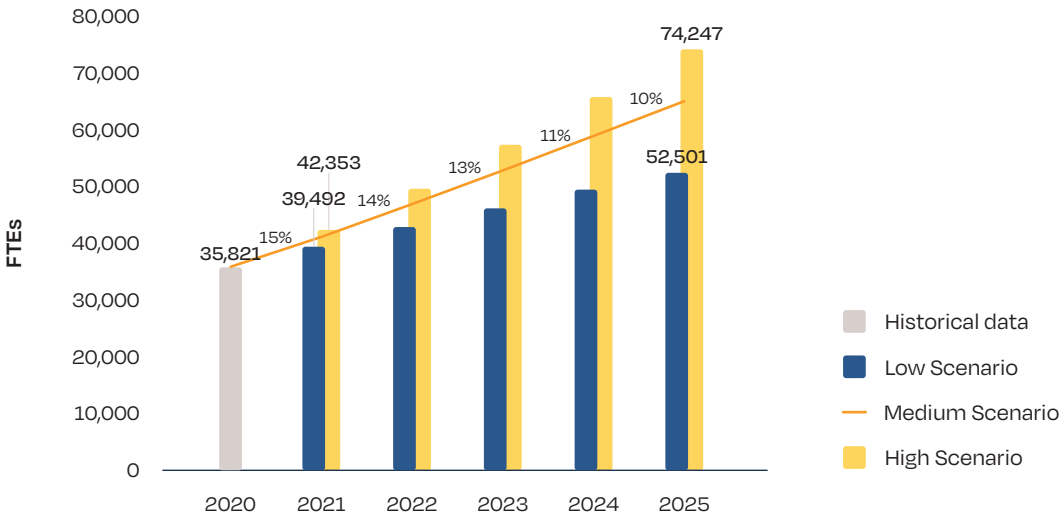
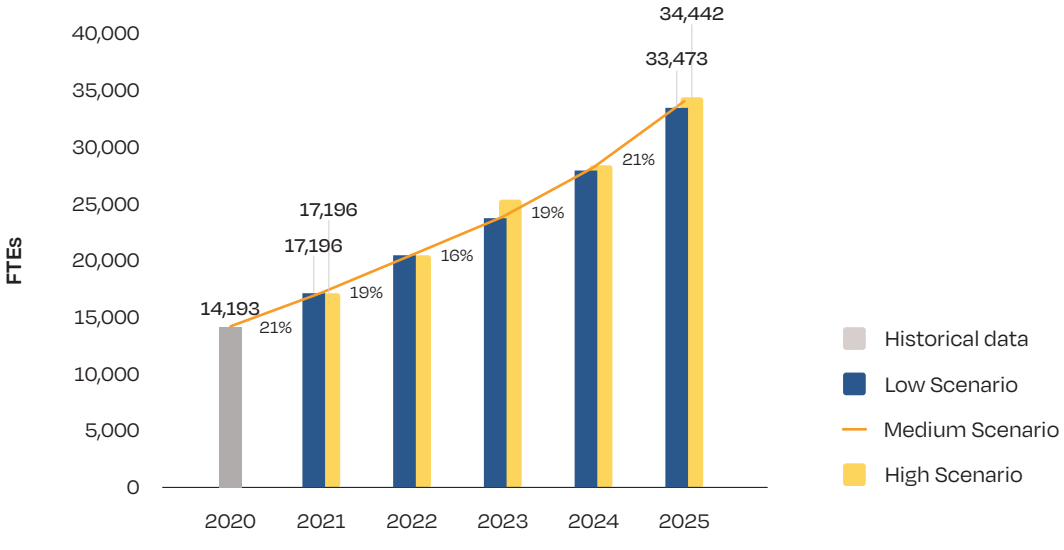


FIGURE 10 EU-27 SOLAR O&M JOBS SCENARIOS 2021-2025



Jobs from the Decommissioning & Recycling segments are still marginal on the current solar map, because PV products reaching the end of their lifetime are still a tiny fraction of today's installed capacities. This trend is poised to change in the medium to long term, when more and more PV systems will eventually reach the end of their operational lifetime and will enter the waste stream. Jobs from this segment are limited today, but rapidly increasing. By 2025, solar jobs from Decommissioning & Recycling will grow 140% from 14,000 to 34,000 units (Figure 11).

FIGURE 11 EU-27 SOLAR DECOMMISSIONING & RECYCLING JOBS SCENARIOS 2021-2025



While the absolute number of EU solar jobs will grow across all four value chain segments in our five-year forecast period, their relative share will somewhat change. Figure 12 displays the evolution of FTE contribution shares according to the Medium scenario. The breakdown of job creation by value chain steps shows that jobs associated with Deployment will remain the biggest contributor, but their share will decrease from 80% to 74% in the observed period. The three other segments will become more relevant, with Operation & Maintenance jobs rising from 10% to 11%, Manufacturing jobs expanding from 6% to 9%, and Decommissioning & Recycling jobs growing from 4% to 6%.

Looking at the EU markets contributing the most to job creation in 2025, we can see a rather different picture compared to today's values (see Figure 13). Germany, which is expected to be the largest solar market in that year, is poised to be ranked first in the provision of solar jobs in the EU, with 137,000 FTEs in the Medium Scenario. Europe's largest economy will not only retain the largest EU annual market until 2025, but also continue to operate the largest solar fleet and the largest manufacturing capacity across the value chain. Poland's job creation will decrease after the exceptional performance granted by its residential PV support scheme. However, the country will remain a major contributor to EU solar jobs, with 62,000 FTEs in the Medium Scenario. In addition to France, Spain, Greece and the Netherlands, which are already in the top job contributors' list, a surprise to some will be the presence of Romania in this top 7. We expect the Romanian market to reach the GW scale by then, with a relevant share of rooftop PV systems and the availability of lower labour costs compared to other EU markets of similar size. In our Medium Scenario, the top 7 markets will provide 419,000 FTEs or 72% of total EU solar jobs, with the remaining 20 member states contributing with a 28% share.

In 2025, the breakdown between jobs stemming from the rooftop segment and those from the utility-scale segment is quite different from the snapshot of 2020 (see Figure 14). The increase of large-scale installations across Europe is driven by very competitive costs and is facilitated by the progressive easing of administrative and permitting procedures,

FIGURE 12 EU-27 SOLAR JOBS BREAKDOWN EVOLUTION 2021-2025

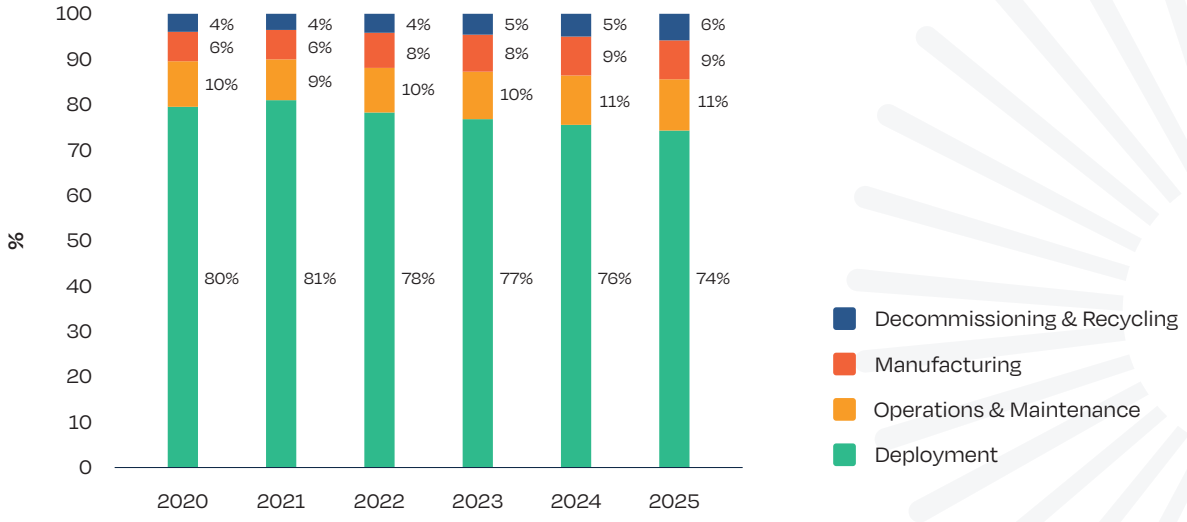
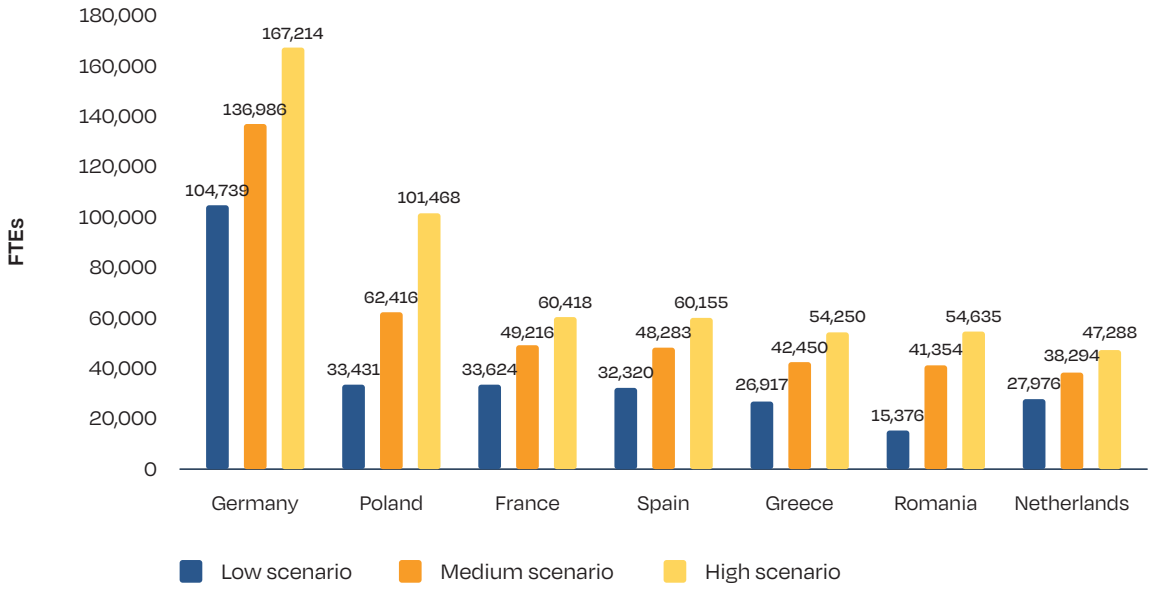
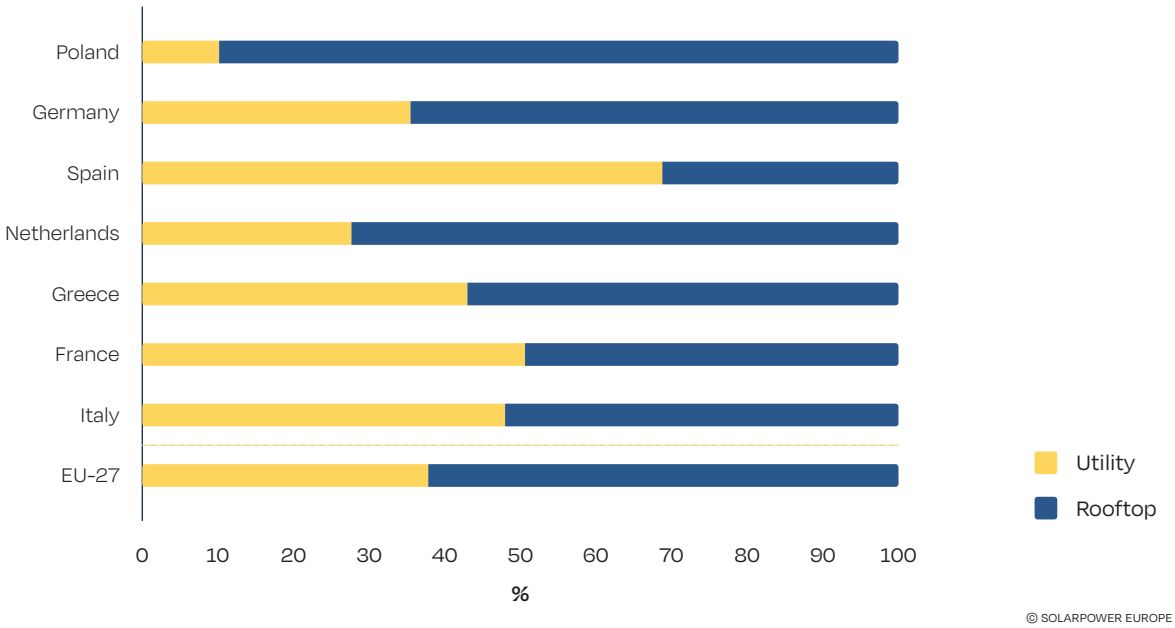


FIGURE 13 EU-27 TOP 7 FTE COUNTRIES SCENARIOS 2025



which today still pose a challenge to this segment. As a result, individual country breakdowns are less skewed towards rooftop job creation, with several countries – such as Greece, France and Italy – getting close to a 50-50 allocation between rooftop jobs and utility-scale jobs. Across the EU, utility-scale job contribution grows from 19% to 38%.

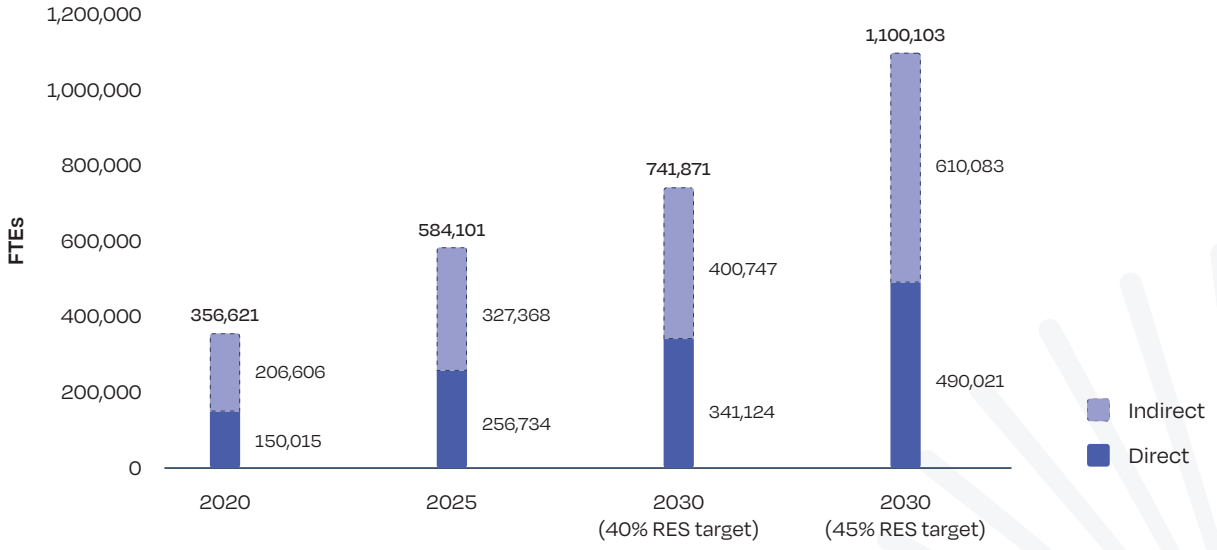
FIGURE 14 EU-27 TOP 7 FTE COUNTRIES - ROOFTOP VS. UTILITY-SCALE JOBS BREAKDOWN 2025



2.3. Outlook to 2030

Future EU solar job creation will be influenced by the level of ambition in setting the new EU renewable energy target for 2030. This study models the effects of the European Commission's 40% RES target on solar employment and compares it with the 45% RES target that SolarPower Europe campaigns for. The lower level of ambition of the 40% RES target results in fewer solar installed capacities, and, as a consequence, a lower number of solar jobs (Figure 15). With a 40% target, solar jobs would double compared to today's levels, reaching 742,000 FTEs in 2030. If the ambition in solar's contribution to the EU energy transition would be increased as part of a 45% RES target, solar jobs would *triple*, totaling 1,100,000 FTEs in 2030. In other words, solar's contribution to EU employment will become prominent even with a lesser level of climate ambition; at the same time, this analysis shows that raising the bar in the 2030 RES target would not only be Paris-aligned and enable a more cost-efficient energy transition, it would also see the EU surpass 1 million solar jobs.

FIGURE 15 EU-27 SOLAR JOBS SCENARIOS 2020-2030



Box 3. Why a 45% RES target by 2030?

The current Renewable Energy Directive (REDII) Amending Directive proposal published in July 2021 by the European Commission is based around an increase in the overall renewable energy target to 40% of renewable energy in gross final energy demand by 2030, up from 32% in the REDII, which entered into force in December 2018. According to updated SolarPower Europe and LUT modelling, such a target could lead to the deployment of 660 GW of solar capacity by 2030, up from the potential 588 GW that the EU is already on track to deploy by 2030 in our Medium Scenario. According to our modelling, this 660 GW would correspond to almost double the capacities pledged by member states in the EU's National Energy and Climate Plans (335 GW). It would be also higher than the 479 GW of solar assumed by the European Commission's impact assessment for a 40% renewables share by 2030.

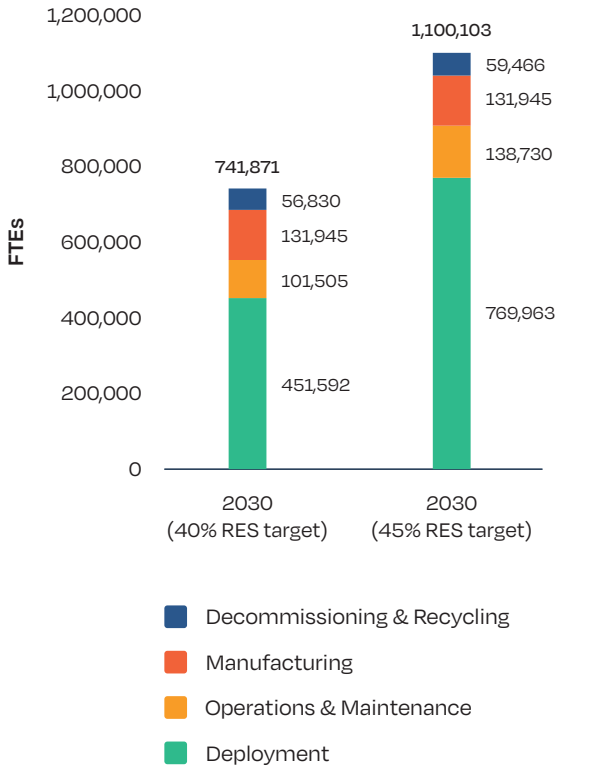
Still, according to our modelling this is insufficient to reach the required 55% GHG emissions reduction target by 2030 established in the EU Climate Law and set the EU on a cost-efficient track to reach climate neutrality by 2050. Furthermore, this level of ambition is not in line with a 1.5 °C Paris Agreement Scenario.

Our modelling shows that in order to reach the minus 55% target, much more renewable capacity needs to be deployed by 2030. A 45% RES share target would allow to achieve the required GHG emission reduction target and be in trajectory with a cost-efficient climate neutrality goal for 2050. As a result, 870 GW of solar energy should be installed by 2030, which is 210 GW or 32% more than in a 40% RES share scenario.

A comparison of the two 2030 RES scenarios is provided in Figure 16. In a 40% RES scenario, 742,000 FTEs are created across the solar value chain. If, like in 2020, the majority of these jobs (61%) are still belonging to the Deployment sector, the contribution from the other value chain segments will have increased both in absolute and in relative terms. Manufacturing jobs would amount to 132,000 FTEs, making up 18% of total jobs. In addition, 102,000 FTEs from Operation & Maintenance and 57,000 FTEs from Decommissioning & Recycling would be created. These would represent respectively 14% and 8% of total solar jobs.

Raising the ambition to a 45% RES scenario would create 358,000 additional solar jobs. Most of these extra jobs will be in the Deployment segment, which is expected to grow by 70% to 770,000 FTEs compared to the 40% RES scenario. Further, the increase in cumulative installed capacity also means more Operation & Maintenance jobs, which would grow 37% to 139,000 FTEs. By contrast, the Decommissioning & Recycling job increase is only marginal – the effects of extra installed capacity on these jobs will only take place in the long term. Our model assumes that a stronger renewable ambition for 2030 does not have an impact on EU solar manufacturing capacities – this is the reason why manufacturing jobs do not change in the two scenarios. However, a more ambitious RES target for 2030 would send a clear political signal to the industry,

FIGURE 16 EU-27 SOLAR JOBS IN 2030 - 40% VS. 45% RES TARGET SCENARIOS



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SolarPower Europe

SolarPower Europe - Leading the Energy Transition
Rond-Point Robert Schuman 3, 1040 Brussels, Belgium
T +32 2 709 55 20 / F +32 2 725 32 50
info@solarpowereurope.org / **www.solarpowereurope.org**

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