SolarPower Europe

# EU Solar Jobs Report 2022

## Addressing the solar skills challenge

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# **Foreword** by Commissioner Nicolas Schmit

**Welcome to SolarPower Europe's EU Solar Jobs Report 2022.**

At a time when Europe is facing both long- and short-term challenges in its energy security, notably because of Russia's war of aggression against Ukraine, energy policy has become one of the top concerns of citizens and businesses. Our commitment, in line with the European Green Deal and the European Climate Law, to reach climate neutrality by 2050 implies a significant transition of energy systems. Renewable energies, including solar power areas key to successfully reaching our goals and to accelerate energy transition to ensure energy security, economic prosperity, and maintain and create quality jobs in the EU. The 2022 Solar Jobs Report is very pertinent in this context.

The employment and social implications of the energy transition are increasingly visible: opportunities, like job creation in renewable electricity production should be reaped whereas challenges, such as job losses in coal-related sectors must be tackled in parallel. This is of course on top of the immediate issue of how to tackle soaring energy prices and make sure households and companies are supported this winter and beyond. We must reinforce our training systems so that workers have the necessary skills to successfully master the transitions, notably by transferring to emerging sectors, such as solar power. Europeans want an energy system that meets their needs when it comes to affordable prices, while creating quality jobs, and contributing to protecting the environment. Accordingly, in June 2022, the Council of the European Union adopted a Recommendation on ensuring a fair transition towards climate-neutrality, as part of the second Fit for 55 package. Through this Recommendation, Member States commit to adopt measures addressing the employment and social aspects of climate, energy and environmental policies.

Promoting solar energy is at the forefront of the European Commission's efforts as it does not only contribute to our climate and energy policy goals, but also has substantial job creation potential – in 2021 alone 460,000 jobs were created in the solar industry. In May 2022, the Commission proposed a new Solar strategy, which aims to more than double solar photovoltaic capacity by 2025 and install 600 $GW_{AC}$ by 2030 (up from 160 $GW_{DC}$ at end 2021). One of its components, the European Solar Rooftop initiative, sets a legal obligation to install solar panels on new buildings, as well as public buildings. By 2030, under a 750 $GW_{DC}$ solar capacity scenario, solar energy employment could even reach 1 million jobs.

In order to effectively support job creation, the solar strategy sets out an EU large-scale EU partnership to ensure and accelerate re- and upskilling of the workforce needed to produce, install and maintain solar panels, including the skills needed to put in place smooth and efficient planning and permitting procedures. The acceleration of requalification of the workforce towards green skills endeavour is supported by EU funding programmes such as the European Social Fund Plus and the Recovery and Resilience Facility.

I am convinced that this highly topical Report will contribute to a lively discussion and generate further interest by prospective workers and investors for the solar industry.

NICOLAS SCHMIT
EU Commissioner
for Jobs and
Social Rights

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SolarPower Europe


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**Please cite as:** SolarPower Europe (2022): *EU Solar Jobs Report 2022 – Addressing the solar skills challenge.*

**Published:** September 2022.

**ISBN**: 9789464518689.

**Thanks to our sponser members:**

**Design:** Onehemisphere, Sweden. contact@onehemisphere.se

**Front cover image:** © BayWa r.e.

# Executive summary

The EU solar market will break another installation record this year. SolarPower Europe's latest forecast estimates a range of 34 to 40 GW of newly installed capacity in 2022, translating into up to 42% year-on-year growth. Demand for solar power systems is much higher than actual installations testify, as citizens and businesses are desperately looking for rapid and tailored protection against skyrocketing power and gas prices. Familiar obstacles to building a solar power system remain, with permitting challenges and supply chain issues receiving much-needed political attention. However, an underestimated, and major bottleneck, is tightening in several member states right now: a lack of installers. Even where administrative barriers are resolved and solar panels are readily available, Europeans report delays of up to a year to install solar rooftop systems, and even longer if combined with battery storage or heat pumps.

The EU Solar Jobs Report, built and modelled in-house, is published annually to analyse the development of direct and indirect employment in a sector producing and installing a technology that is supposed to be the leading power generation source of the continent in the future.

Our 2022 edition shows that in 2021, the solar sector employed 466,000 full time employees (FTEs) in the EU, that's 108,000 more than 2020. While 44% of the total, 205,000 FTEs, were employed directly in the solar sector, a slightly higher share were indirect jobs - 56% and 261,000 FTEs -, which encompasses work in process materials and logistics industries.

The major share of jobs provided by the solar industry are related to the installation phase. Direct and indirect jobs linked to solar deployment amounted to 367,000 FTEs, equalling 79% of total jobs in 2021. Solar Manufacturing contributed 9%, and so did Operations & Maintenance, while Decommissioning & Recycling jobs have remained a minor source of employment, with a 3% share. This is a very similar picture as in the previous year, which means growth can be seen consistently across the solar value chain.

Regarding employment, new solar power generation capacities are exceptionally valuable as solar is the most job-intensive among low carbon and renewable energy technologies, in particular rooftop solar, which creates 5-7 times more construction jobs than any new centralised power plants. The countries hosting most solar jobs in 2021 were again Poland, Germany, Spain, the Netherlands – the EU's leading solar markets, with rooftop solar mostly dominating their national installation landscape.

Solar manufacturing jobs amounted to 44,000 in 2021, where inverter production provided the bulk, with 31,000 FTEs and around 70% market share. New jobs were also created in the other segments of EU solar manufacturing, with the nascent production capacities in the ingot/wafer segment and solar cell segment only offering under 1,000 jobs combined at that time.

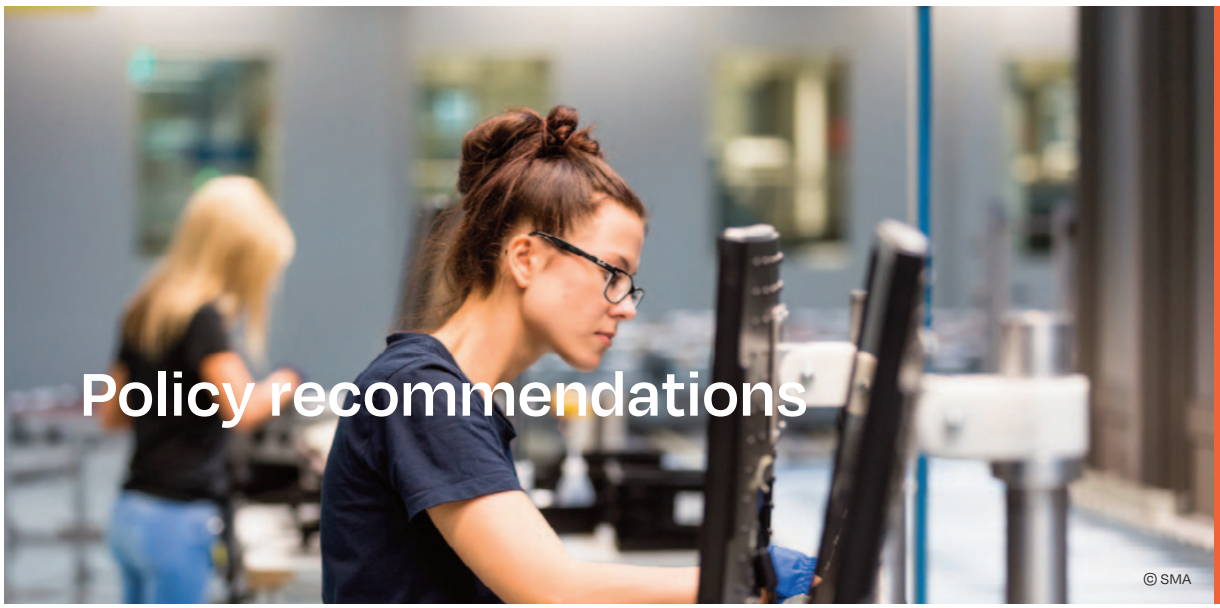
Our forecast shows solar jobs on a steady rise in 2022 too, with an anticipated 14% annual growth to about 530,000 FTEs under the Medium Scenario's 34 GW capacity additions. However, if the 40 GW High Scenario becomes reality, we will see jobs increasing by 30% to 606,000.

The EU Solar Jobs Report provides a five-year outlook for solar job creation in the EU, based on the scenarios developed by SolarPower Europe's Global Market Outlook 2022-2026 published in May. According to the Medium Scenario, further growth could lead to 764,000 jobs in 2026 – that would be a 64% growth compared to 2021 levels.

Our modelling indicates that reaching the 2030 solar target of 750 $GW_{DC}$ of the European Commission's REPowerEU package will result in the creation of over 1 million direct and indirect jobs in the EU solar industry in that year, more than doubling the employment in the sector compared to 2021.

While the REPowerEU targets are going in the right direction, the ambition remains 26% lower than Solar Power Europe's Accelerated High Scenario, which is calling for 1 TW of solar power generation capacity by 2030 in order to keep the 1.5°C Paris Climate Agreement target alive. If the EU installed 1 TW of solar by 2030, jobs in the sector would reach almost 1.5 million FTEs in the same year, which is 45% higher than in the REPowerEU scenario.

For solar to contribute its share to the EU Climate Targets and Energy Independence it requires not only strong ambition with a minimum EU 45% renewable energy target and further improvements in policy frameworks in member states. It is of the utmost importance to launch accessible training programmes that are assessed and monitored in all member states, while the EU should ensure that the new Solar Skills Partnership targets the whole workforce. In this context, on 1 December 2022, SolarPower Europe will launch its #SolarWorks Jobs online employment platform during its first edition of an annual #SolarWorks online Job fair, a project to connect job seekers and foster solar education.




# Policy recommendations

1. **Skilled workforce requires urgent attention and policy support.** As REPowerEU sets new solar ambition, the availability of skilled workforce emerges as a potential bottleneck. Member states must assess and monitor the need for upskilling and training programmes, while the EU must advance with the new Solar Skills Partnerships as a matter of priority.
2. **More local solar creates more local jobs.** Deployment of new PV systems is the main driver for quality employments, especially in the rooftop segment. Solar rooftop mandates create much-needed visibility on local solar deployment and are a great opportunity for member states to create local employment. The scope of the mandate should be extended to all non-residential buildings and to renovation activities.
3. **Delivering on EU solar manufacturing.** Manufacturing provides a small percentage of jobs today, but of high strategic importance. Reshoring EU manufacturing capacity in line with the Solar PV Industry Alliance will create jobs while retaining EU leadership in R&I and increasing energy independence.

1. **An enabling framework for workforce and skills.** In May 2022, the European Commission published a first-of-its-kind EU Solar Strategy under the framework of REPowerEU, increasing solar deployment ambition in Europe by 43% and uncovering several steps to speed up solar installations. With proposals targeting about 400 $GW_{DC}$ by 2025 and 750 $GW_{DC}$ by 2030, key steps have already been taken to achieve this renewed level of ambition, including legislative proposals tackling crucial challenges such as permitting. However, the sector is now confronted with bottlenecks around the availability of skilled workforce, especially at installation level. **The skilled labour gap may well become the key bottleneck that stops Europe from reaching its energy security and climate goals.**

   Technical careers and education in solar jobs must be promoted as a matter of priority to solve the sector's issue of lacking skilled labour.

   - First, member states must assess the need for upskilling and training and ensure that enough training programmes are in place and that enough people are incentivised to join the relevant trainings. The dual challenge of skills and workers shortages is addressed by the EU Commission's ITRE Committee in the report on the revision of RED II (RED III) adopted on 13 July.[1]
   - Second, as indicated in RED III, member states must develop indicators monitoring performance on skills deployment that should be used in the

1 https://www.europarl.europa.eu/doceo/document/A-9-2022-0208_EN.pdf

European Semester as part of the Skills Partnership on onshore renewables. Measures tackling the skills gap should be also reported in the National Energy and Climate Plans (NECPs).

- Third, to address the installers shortage, member states should set up enabling frameworks for installers, both at the individual and company level, such as financial incentives for instance through tax reductions.

  The efforts from member states must be supported at EU level. The European Commission has already proposed the new Solar Skills Partnership as part of the Pact for Skills, ensuring an exchange of best practices, and to explore ways to access available funding for skills development. As a major tool for the EU Skills Agenda, the Pact for Skills should not be limited to the industry and strive to involve national and regional public authorities.

2. **More local solar creates more local jobs.** If stability in the solar market is the essential precondition for a sustainable solar jobs landscape, accelerating the pace of PV deployment will increase the amount of jobs in the sector. Since most solar jobs are linked with annual PV installations, a growth in the solar market will have direct positive impacts on solar employment too. EU and national policymakers need to strive to improve the framework conditions for solar to reap these double dividends. In the upcoming revision of NECPs taking place in 2023, member states should set ambitious national solar targets and clear roadmaps to reach them.

   Special emphasis should be given to rooftop solar deployment. Rooftop solar is three times more job intensive than utility-scale solar, and further, it creates more local jobs. With these in mind, the rooftop solar mandates for commercial buildings, outlined in REPowerEU, should be leveraged to support solar deployment while creating employment opportunities. In particular, mandatory solar installations on new buildings should be extended to all buildings undergoing a major renovation, renovations of the building skin, and renovations that lead to a significant increase in electricity consumption. Moreover, any non-residential building – including industrial buildings, carports, as well as public and commercial buildings below 250 $m^2$ floor area – should be included in the provisions for new, renovated, and existing buildings. Rooftop solar mandates, together with oil and gas boiler bans, provide much-needed visibility on solar deployment, allowing member states to create local employment and bring together all relevant stakeholders to mobilise and reskill workers such as roofers, electricians, and construction workers.

**Box 1. #SolarWorks**

The solar industry is currently experiencing a critical shortage of solar workers with the necessary skills, especially at manufacturing and installation level. SolarPower Europe is creating the #SolarWorks Jobs platform, which will help companies along the solar value chain access the skilled workforce needed to drive the energy transition. This platform will connect job seekers to solar companies through a skill matching algorithm. When missing skills are identified in a job seeker profile relevant training programmes are suggested to the applicant, thanks to the platform's engagement with a broad range of educational institutions, from engineering universities to technical PV installing courses. By comparing job seekers' skills and the skills companies are looking for, we will also be able to further analyse the skills gap and take action accordingly.

The platform will be launched officially on 1 December 2022, on the first edition of the annual #SolarWorks online Job Fair: an online exhibition space connecting potential solar workers to companies. The Job Fair will be the place where the European solar community gathers top talents from all over the world, with the participation of educational institutions to further enhance cooperation between industry and training stakeholders.

The target audience for both projects will be potential solar workers at any step of their professional development, ranging from students who are looking for an impactful career to people who are currently working in declining industries such as coal mining.

For more information, stay tuned for the launch of our dedicated platform and website in December this year.

3. **An industrial strategy for EU solar manufacturing.** Today, solar manufacturing jobs provide a comparatively small share of total EU solar jobs. This is partly because manufacturing is less job intensive than capacity deployment, but also due to the limited PV manufacturing capacity left in the EU. At present, the vast majority of global PV manufacturing capacity is outside of the EU, primarily in China.

   As the EU looks to strengthen its position in global solar PV supply chains, including by reshoring manufacturing to Europe, it is essential that the skills dimension is integrated in that agenda. This is all more important given that the gradual reduction of Europe's industrial base has created discontinuity in manufacturing skills and knowledge. The new EU Solar PV Industry Alliance, aiming at reshoring at least 20 GW of solar manufacturing capacity by 2025, must therefore look at educating skilled labour for this part of the solar value chain too.

   Retaining and strengthening EU solar manufacturing brings a number of benefits: maintaining EU leadership in a critical research and innovation industry; supporting the availability of permanent and high skilled jobs; decreasing EU dependence on global supply chains and; strengthening energy independence.

**Box 2. Diversity in the solar sector – industry commitment**

Just as revolutionary solar technology changes the way we look at energy generation, the solar sector must do our part to take society forward in other ways, and dismantle any outdated, unfair barriers to employment that face underrepresented groups. Every workplace must be inclusive, regardless of gender or sexual identity, race or cultural background, or disability status.

The solar sector is made better by a workforce that brings together a diversity of experience that is representative of the world around us. Improving gender equality alone has clear benefit for productivity, and could take EU GDP from 1.95 to 3.15 trillion EUR by 2050, according to the European Institute for Gender Equality.

Encouraging more women to join the solar workforce is a valuable action to begin with. The renewable energy sector employs a significantly higher number of women compared to the energy sector overall; still, women cover only 32% of renewable energy jobs, and the percentage of women in the areas of science, technology, engineering, and mathematics is just 28%. As part of efforts to promote Diversity, Equity, and Inclusion (DEI) excellence across the sector, SolarPower Europe presents a Solar Diversity Champion Award annually, building on the inaugural Solar Gender Champion Award in 2021. The Award brings visibility to the importance of DEI, celebrating existing best practices within solar companies, while recognising the substantial efforts that are still needed for a more inclusive workforce. Lightsource BP is the winner of the 2022 edition, with a DEI policy 'woven' into the fabric of this leading solar developer. Lightsource BP's DEI strategy strives to enhance employee experience, improve diverse recruitment, and ensure meaningful workshops, as well as equitable events.

SolarPower Europe is currently working on its own DEI strategy, which will include a roadmap to making the European solar sector a more diverse and inclusive work environment.

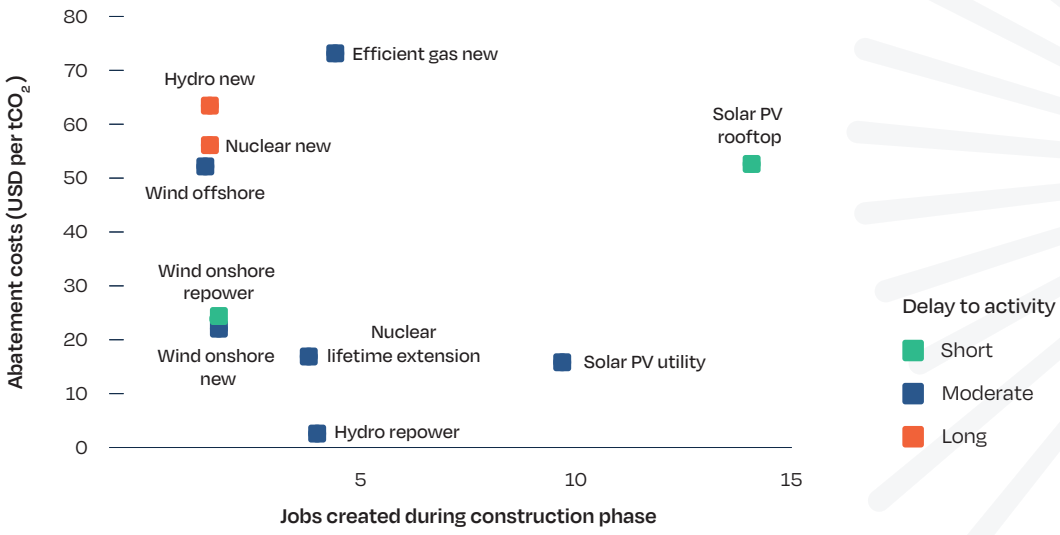

SolarPower Summit 2022: Solar Diversity Champion Award presented to Lightsource BP by the 2021 winners of the inaugural Solar Gender Champion Award, Sonnedix.


# 1 Introduction and methodology

**If last year's EU Solar Jobs Report 2021 looked at solar job creation in a perspective of expanding PV markets to achieve long-term climate targets, one year later the climate and energy landscape has entirely changed.** Solar capacity deployment is not solely driven by long-term climate concerns anymore – it is now considered as an effective short-term solution to curb soaring energy prices and decrease dependence from Russian fossil fuels. Our analysis from the Global Market Outlook for Solar Power 2022-2026 shows a quickly growing solar market in the EU, with the bloc adding 27.9 GW in 2021, up 40% from the previous year. As policymakers, businesses and households will increasingly look at solar as a solution to their energy needs, the market is set to further grow to 33.6 GW in 2022 and reach 66 GW in 2026 under a Medium Scenario. With the hardships of COVID-19 restrictions fully left behind, the years to come appear extremely bright for solar. Such positive market dynamics are reflected into job creation at all levels.

As solar has turned into the primary force driving the EU energy transition – last year, about 153% more solar capacities were installed than the second largest power generation source – its contribution to creating long-term employment in Europe is also quickly growing. Regarding employment, new solar power generation capacities are exceptionally valuable 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.

The aim of this study is to illustrate the current and future job creation associated with solar power in the European Union, based on historical data and the market scenarios from SolarPower Europe's Global Market Outlook 2022-2026. Moreover, the analysis provides a long-term outlook for solar job creation in the EU, reflecting different levels of ambition towards 2030. The impacts on job creation of the 2030 REPowerEU target is compared to a higher level of ambition whereby 1 TW of deployed PV capacity is reached by the end of the decade.

### 1.1. Methodology

This 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.[2] 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.

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 because of 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.[3]

Direct jobs in Manufacturing as well as Decommissioning & Recycling are calculated through employment factors, while direct jobs in Deployment as well as Operation & Maintenance (O&M) are obtained through a CAPEX-OPEX model. Employment factors indicate how many jobs are created in the manufacturing (or end-of-life management) for 1 MW of solar capacity in a given country, with specific values for each value chain segment. By contrast, the CAPEX-OPEX model approach determines the aggregate cost of labour as a share of total CAPEX (for deployment) or OPEX (for O&M) and divides it by the cost of labour per worker, obtaining the number of jobs resulting from solar installations in a given member state. Deployment jobs are based on annually installed capacity, while O&M jobs derive from cumulative installed capacity.

Moreover, to quantify the indirect effects of solar PV investments, the report uses an Input/Output table that encompasses the 27 EU member states and

**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 |

2 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.

3 Induced jobs, which are created through money flows resulting from household spending of labour income, are not included in the scope of this study.

63 sectors covering all economic activities. The Input/Output table provides FTE multipliers that allows 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.

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 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 |

### 1.2. Manufacturing scenarios

EU manufacturing capacities through 2026 are based on three different scenarios:

- A **Low Scenario**, in which EU production capacity remains limited and overall aligned to current levels;
- A **Medium Scenario**, in which the European Solar Initiative (ESI) targets endorsed by the EU Solar PV Industry Alliance are only partly achieved;
- A **High Scenario**, in which ESI targets are achieved.

The scenarios are presented in more detail in Table 3.

TABLE 3 EU MANUFACTURING SCENARIOS DESCRIPTION

| SEGMENT | LOW SCENARIO | 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 beyond existing capacity. | Domestic ingots and wafers production increases to serve the domestic cell production, but does not reach ESI targets. | Domestic ingots and wafers production is established at 20 GW level by 2025 to serve the domestic cell industry and continues expansion in 2026. |
| Cells | Incumbent players' plans to open new cell factories are realised with some delay, but no others develop. | Incumbent players' plans to open new cell factories are realised without delay, but no others develop. | The EU industry manages to redevelop a 20 GW cell production capacity by 2025 and continues expansion in 2026. |
| 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 and new factories for module assembly open. | In addition to existing module manufacturing doing mere assembly, additional module manufacturing comes online together with the above mentioned cell projects. Module manufacturing exceeds 20 GW by 2025 and continues expansion in 2026. |
| 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 3. 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 recent studies published in 2021 and 2022 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, the National Solar Jobs Census 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. Different methodological approaches for the calculation of indirect employment can also result in a large variation in final numbers. The scope of indirect jobs in EurObserv'ER study, which used to be the basis for the IRENA Job Report, only includes secondary activities such as transport. Our approach includes a broader scope for indirect employment, which leads to a higher amount of job creation. The full direct and indirect scope of EurObserv'ER is approximately equivalent to our direct scope only, as confirmed by the results of the two studies: The total 166,000 FTEs in 2020 from EurObserv'ER is close to our 162,000 direct-only jobs in the same year. The year taken into consideration also plays an important factor on total jobs, considering that the EU solar market in 2021 was 40% larger than in 2020.

TABLE 4 OTHER JOB STUDIES

| STUDY | REFERENCE YEAR | METHODOLOGY | SCOPE | TYPE OF JOBS | RESULTS |
|---|---|---|---|---|---|
| SolarPower Europe 2021 | 2021 | Hybrid | Solar PV, EU-27 | Direct and indirect | 466,000 FTEs |
| IRENA 2021 | 2020 | Employment factors | Solar PV, EU-27 | Direct and Indirect | 194,000 FTEs |
| EurObserv'ER | 2020 | 'Follow-the-money' | Solar PV, EU-27 | Direct and Indirect | 166,000 FTEs |
| IEA 2022 | 2019 | Employment Factors | Solar PV, Europe | Direct, and indirect for manufacturing of direct input only | 260,000 FTEs |
| Breyer et al. | 2020 | Employment Factors | Solar PV, Europe | Direct | 356,000 FTEs |
| IREC | 2021 | Survey-based | Solar PV, United States | Solar workers[4] | 255,000 FTEs |

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

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### 1.3. Changes from EU Solar Jobs Report 2021

Compared to the previous edition of this study, this year's analysis has improved the level of detail in EU solar manufacturing capacities. We have reviewed and updated manufacturing capacities for all value chain segments, based on public company announcements and thanks to the insights from our members. The granularity in the geographic allocation of production capacities across member states has been improved to better reflect the impacts in employment in specific member states, whenever that information is available. For this reason, some results in the manufacturing jobs have slightly changed compared to last year's report. These are marginal changes compared to the overall job creation. A snapshot of the manufacturing capacity across the EU is available at page 18.

In light of our exchanges with SolarPower Europe members and other industry experts, we have also reviewed other relevant parameters, such as employment factors in solar manufacturing and decommissioning, and FTE multipliers. These changes result in slight increases or decreases of the values compared to last year. Whenever possible, labour costs and CAPEX values have also been updated with the latest publications available.

Further information on the methodology employed in the study is available in the Annex.

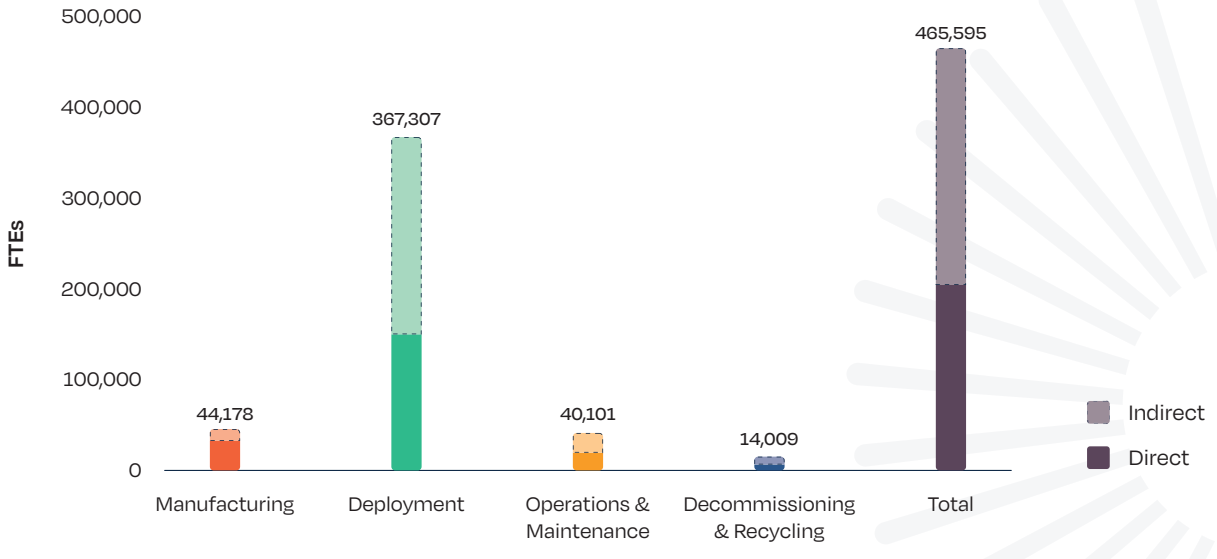
# 2 EU solar jobs


## 2.1. Update 2021

In 2021, the solar sector has employed 466,000 FTEs in the EU. 205,000 of these FTEs, 44% of the total, are direct jobs, while the remaining 56% (261,000 FTEs) are indirect jobs (Figure 2).

The largest share of jobs provided by the solar industry are associated to the deployment phase. Direct and indirect jobs linked to solar deployment amount to 367,000 FTEs and make up 79% of total jobs (see Figure 3). Solar manufacturing and Operations & Maintenance contribute with a 9% share each, while

**FIGURE 2** EU-27 SOLAR JOB MARKET IN 2021



Decommissioning & Recycling jobs still remain a minor source of jobs, with a 3% share.

The predominance of Deployment jobs over the Operation & Maintenance segment stems from the fact that solar PV has a rather high CAPEX intensity and a low OPEX intensity. While it is very job intensive to put solar on rooftops and fields, once installed, little physical maintenance is needed.

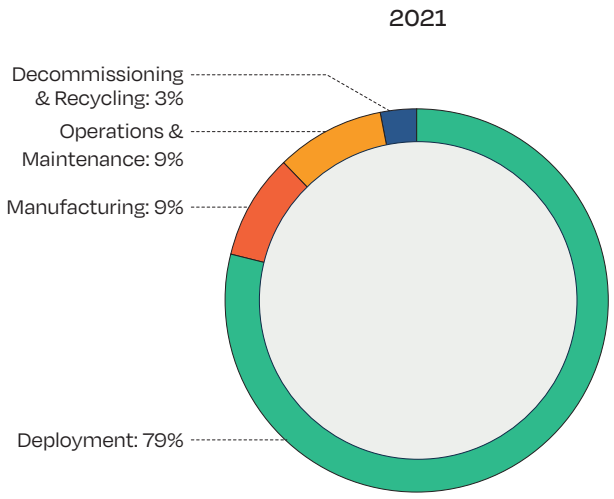
Not differently from 2020, Decommissioning & Recycling FTEs cover the smallest portion of the total FTEs as the solar PV waste streams are still low in volume – and so they will remain for quite some time. Solar PV waste streams are expected to become significant only from 2030 onwards, when the first larger wave of installed systems in Europe will reach the end of their lifetime.

The FTE figures represent job creation on an annual basis, which depends on a series of both short- and long-term factors. Deployment jobs are connected to how much solar capacity has been installed over a year, and therefore depend on the annual market size. Thanks to the sustained 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. With the EU market rising from 8.1 GW in 2018 to 27.9 GW in 2021, with a 51% CAGR over the last three years, jobs in solar deployment have grown accordingly.

Conversely, Operation & Maintenance jobs rather depend on total solar installations and are therefore less susceptible to annual market fluctuations. While the growth of total solar capacity in the EU has also progressed, the pace of expansion is lower. Over the same three-year period, the EU solar fleet has grown from 102.7 GW to 167.3 GW, with a 18% CAGR.

Manufacturing jobs in the EU solar sector are closely linked to the operating production capacities across member states. The EU PV industry has significant manufacturing capacities in certain steps of the value chain, primarily for polysilicon, inverters, and, to a minor extent, modules. At the same time, at present there is a severe lack of production capacity for ingots/wafers and cells within the EU, which the industry is trying to address.

**FIGURE 3** EU-27 TOTAL SOLAR JOBS BREAKDOWN IN 2021

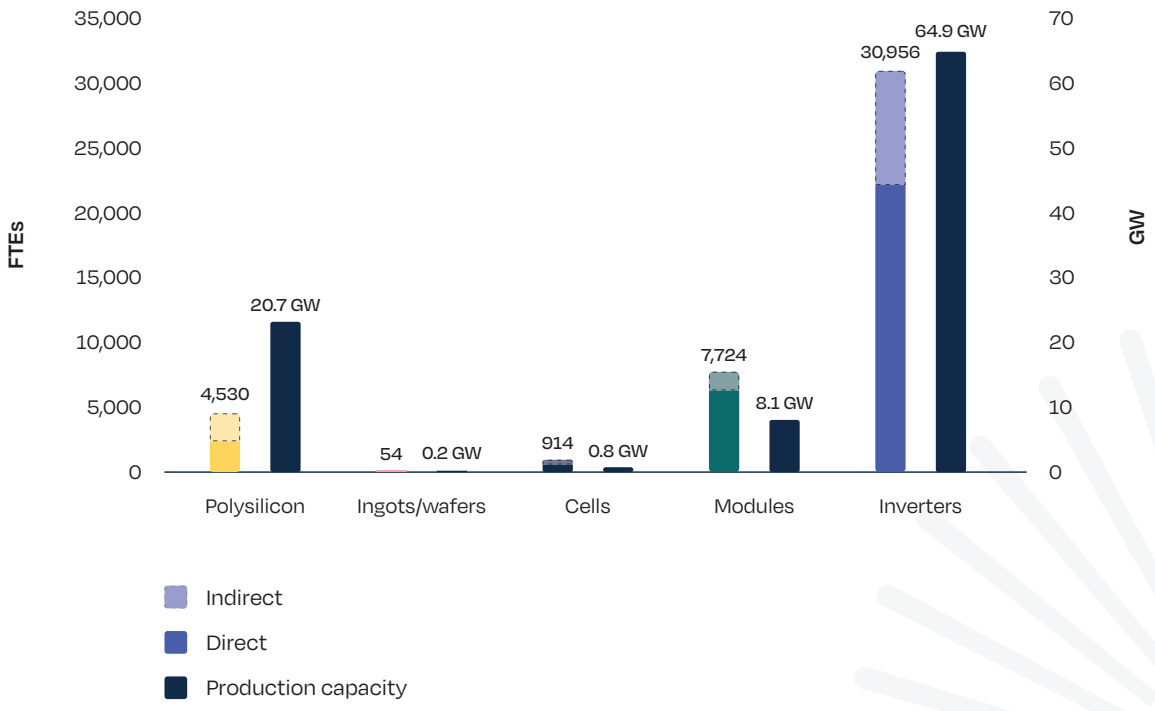


Inverter manufacturing provides the large majority of EU solar manufacturing jobs – about 31,000 direct and indirect jobs, which is 70% of the total FTEs in manufacturing (Figure 4). This is no surprise, since inverter companies are widely present across Europe, including several global market players.

Module production and polysilicon production also provide significant shares (17% and 10% respectively, equivalent to 7,700 and 4,500 jobs). As a result of low production capacity for ingots/wafers and cells within the EU today, less than 1,000 jobs are created by these activities together, with a 2% share combined.

Job intensity is higher for cell and module production, lower for inverters and ingot/wafer production, and much lower 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 4** EU-27 SOLAR MANUFACTURING JOBS AND PRODUCTION CAPACITY IN 2021



**Box 4. Status of solar manufacturing capacity in the EU-27 and Norway**

Europe has a vibrant and growing solar manufacturing scene, which represents the second largest employment base of the solar PV value chain at the European scale. Solar manufacturing activities provide jobs for 44,000 Europeans. Prospects for the sectors are positive with companies looking at opportunities to invest and play their part in the quickly growing solar industry. The map below illustrates the state of play of solar manufacturing in the EU-27 and Norway in 2021.[5]

The number of jobs per value chain step reflects how much that production phase is developed in Europe. With a production capacity over 60 GW, the **inverter** industry employs 70% of all manufacturing jobs. The main EU inverter producers operate at multi-GW scale


5 Production capacity from Norway only considers ingot & wafer manufacturing.

factory level, among them SMA from Germany and Fronius from Austria. Europe's largest inverter producer SMA recently unveiled plans for a new factory at its headquarters in Niestetal that will bring the company's production capacity to 40 GW by 2024, up from 21 GW today.

When looking into the European Union's solar module value chain, the largest manufacturer is active upstream, in the **polysilicon** segment. Wacker Chemie is the EU's only company to operate polysilicon production facilities, with a capacity of around 60 metric tons in Germany that translates into over 20 GW of cell/module products. Since polysilicon production process is less human capital-intensive than the other steps of the value chain, this translates in a relatively limited number of jobs compared to the production capacity's size.

**Silicon ingot & wafer** manufacturing, the next step in the solar value chain after polysilicon production, is barely existing in the European Union, which is reflected in the very small number of workers in the sector. Most of Europe's 1.7 GW wafer capacity is located outside of the EU, more precisely in Norway, where low-cost hydro enables production at competitive cost and low carbon footprint. Only one small integrated module producer in France has few ingot/wafer capacities. However, the EU is home to a promising next-generation wafering start-up, NexWafe, which raised 39 million EUR in October 2021 to expand its activities. A first pilot facility is targeted to come online this year, with plans to reach 500 MW in 2024, expandable to 3 GW.

The EU's **solar cell** production capacity stands at only around 0.8 GW, but several companies are planning to expand or enter that segment. Among the few active cell manufacturers in the EU today is Meyer Burger, which has opened a 400 MW factory for high-efficiency heterojunction solar cells in 2021 in Germany, following on Enel Green Power's 200 MW line in Italy, which was opened in 2020. Both companies have already announced expansion plans, Meyer Burger to 1.4 GW in Europe in 2023 and 7 GW by 2027, and Enel Green Power to 3 GW by July 2024. Enel has notably won a grant from the EU Innovation Fund to proceed to the scale up of its factory in Catalonia. These manufacturers are producing for internal use only as they also assemble solar modules.

As pure **solar module** manufacturing requires the lowest investment cost among the different stages of the solar module chain, this PV manufacturing segment has been seeing the largest activity, though mostly from small and local companies, each with capacities in the sub-GW range. In 2021, at least 49 module manufacturers operated factories in the European Union. Though the module market is currently represented by many smaller actors, wind of change has begun to blow as, in addition to Meyer Burger and Enel Green Power, several announcements for GW factories, often vertically integrated and for high-efficiency cell technologies, have been made in the past year.

The most advanced cell/module project seems REC Solar, which was also awarded a grant from the EU Innovation Fund in July 2022 to build a 2 GW heterojunction fab in France. Enel Green Power and REC are the two first PV projects awarded grants from the fund's large scale project segment. France is home to other PV manufacturing project plans: French start-up Carbon has plans to open a 500 MW pilot line in 2024 with the ambition to integrate the ingots, wafers, cells and module segments with 5 GW of production in 2025 and 15-20 GW in 2030. The company aims to create 2,000 direct and 4,000 indirect jobs. Moreover, Voltec Solar and Systovi have announced a joint project named Bélénos to produce up to 1 GW of solar modules, which is currently waiting for public financial support.

To support the many industrial consortia that have put forward new industrial projects and are looking for financing to establish or expand production in Europe, 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** (ESI; www.europeansolarinitiative.eu). 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 aim is to establish at least 20 GW PV silicon-to-module manufacturing capacity in Europe by 2025, enabling local PV manufacturers to capture a significant portion of the EU market, which is expected to deploy around 50 GW by that year. Major progress regarding solar manufacturing has been reached at the policy level. The 20 GW manufacturing target has been endorsed by European Commission in its first Solar Strategy as part of the REPowerEU package published in May 2022. As a next step a Solar PV Industrial Alliance is being created.

The overall ESI 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.

*This PV manufacturing Map is an ongoing project. If you believe that your company should be featured, please contact us at info@solarpowereurope.org.*

In 2021, about 113,000 solar jobs were created in Poland, establishing the country as the largest provider of solar jobs across the EU with a 24% share (Figure 5). Poland's role should not appear surprising any longer, although the country is only the third largest EU market, and is not a large PV manufacturer. First and foremost, the majority of the 3.8 GW installed in Poland in 2021 are residential PV systems, which are small rooftop systems whose installation creates more jobs than larger PV systems in the C&I or utility-scale segment. In addition to 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. Moreover, Eastern European countries generate more indirect jobs from deployment activities than the rest of the EU. These factors lead to a significantly higher job creation. 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 34,000 jobs created.

Though gross labour costs are higher in the largest PV markets in Europe – Germany, Spain, the Netherlands and France – they all feature in the top 7, with 87,000, 66,000, 36,000 and 33,000 FTEs respectively.

Across the member states that contribute the most to EU solar job creation, the majority of jobs stem from the rooftop segment (Figure 6). If Poland's favourable support framework for residential systems led to over 90% rooftop jobs, other GW-scale PV markets like Germany and the Netherlands are also dominated by this segment, both having a 77% share of rooftop jobs. Spain, and to a smaller extent France, are the exceptions to this trend, due to their focus on utility-scale solar. However, even in a market led by utility-scale solar like Spain, the share of rooftop jobs has grown from 28% in 2020 to 44% in 2021.

FIGURE 5 EU-27 TOP 7 FTE COUNTRIES AND ANNUAL INSTALLED SOLAR PV CAPACITY 2021

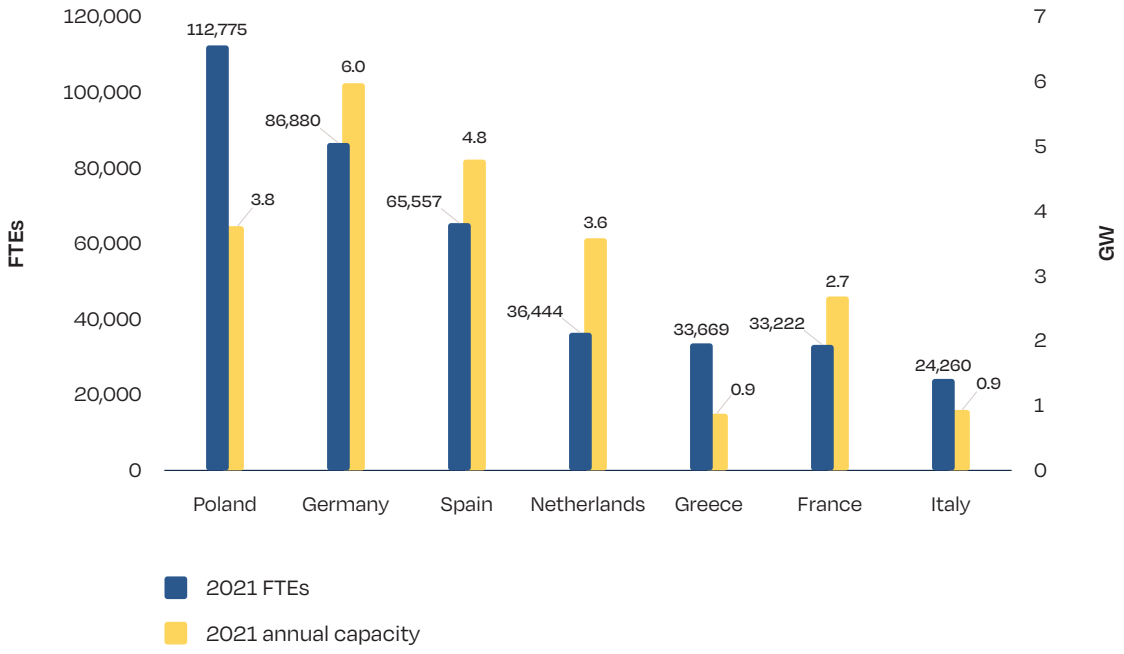
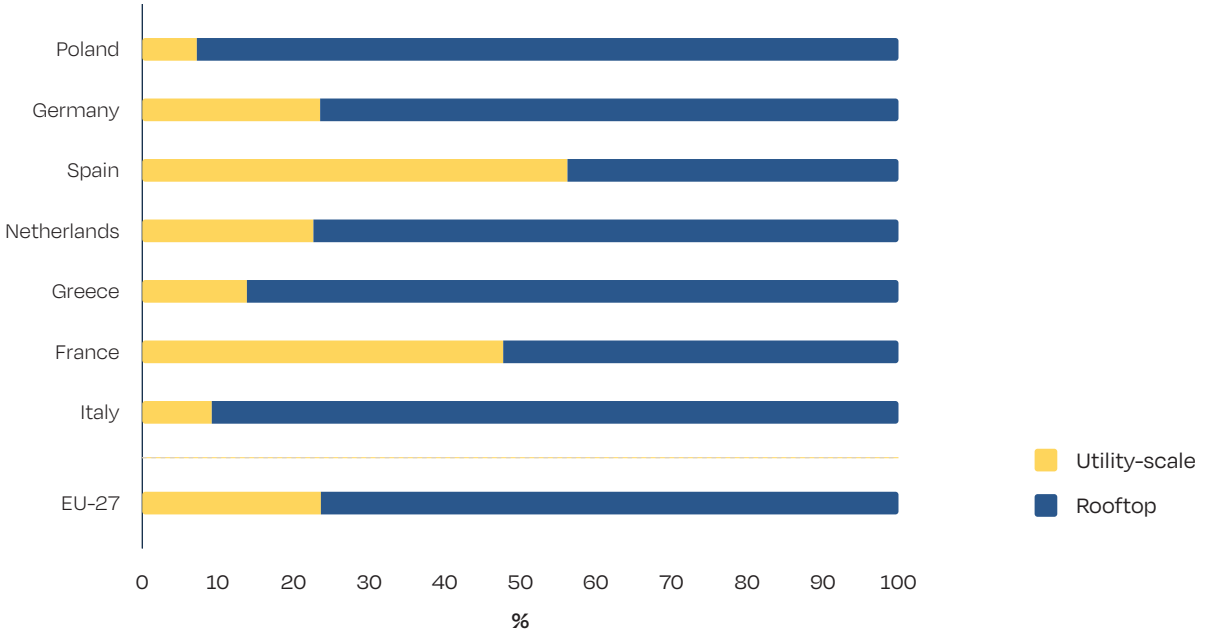


**FIGURE 6** EU-27 TOP 7 FTE COUNTRIES - ROOFTOP VS. UTILITY-SCALE JOBS BREAKDOWN 2021






Throughout the EU-27, job creation remains clearly skewed towards rooftop PV, which provided 76% of total FTEs in 2021, although the share of rooftop installations in that year was a little lower at 61%, showing the higher job intensity of the solar rooftop segment.

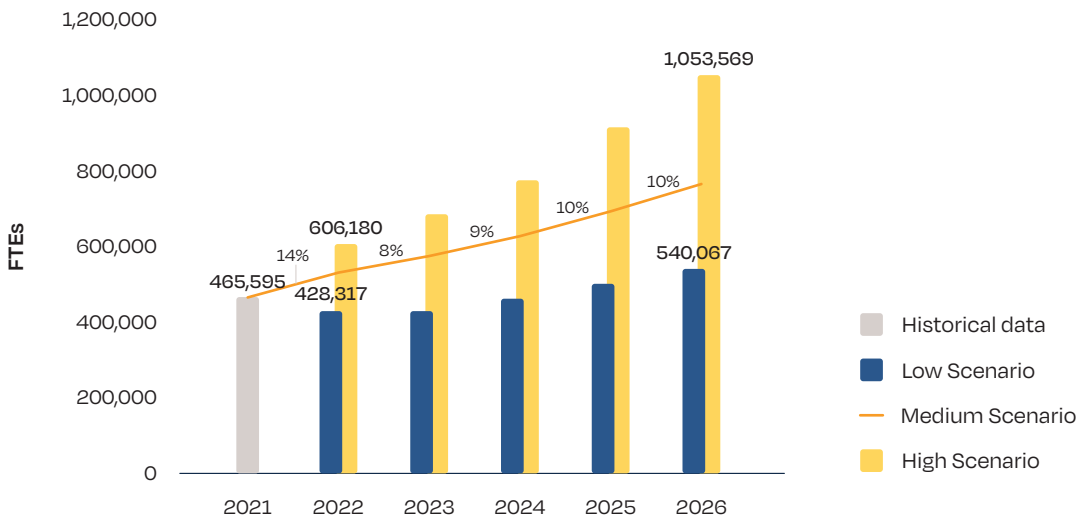
### 2.2. Prospects 2022-2026

Although last year's record performance in solar jobs growth will not be repeated, the amount of EU solar jobs is poised to increase in 2022. Since solar jobs are highly dependent on annual PV installations, the 20% growth of the EU solar market we expect in 2022 will have positive repercussions on job creation. Our forecast shows solar jobs on a steady rise in 2022, with an anticipated 14% annual growth to 530,000 FTEs under the Medium Scenario's 34 GW capacity additions (Figure 7). However, if our 40 GW High Scenario becomes reality, we will see a 42% year-on-year market growth in 2022 and jobs increasing by 30% to 606,000. According to our Medium Scenario, further growth could lead to 764,000 jobs in 2026 – that is a 64% growth compared to 2021 levels.

With an increased policy ambition leading to higher solar deployment and improved energy independence, also through larger manufacturing capacities deployed across the EU, solar jobs could exceed 1 million FTEs in 2026 – a 126% growth compared to 2021. In contrast, in our unlikely Low Scenario, which anticipates limited market growth matched with sustained dependence on global solar supply chains, the increase of solar jobs would be limited, with 540,000 FTEs a year in 2026 or a 16% growth from 2021.

Looking at the manufacturing sector, the number of jobs created in the next five years will strongly depend on the success rate of the new EU Solar PV Industry Alliance and the achievement of the European Solar Initiative objective of creating a minimum of 20 GW of solar manufacturing in Europe by 2025.

**FIGURE 7** EU-27 SOLAR PV FTE SCENARIOS 2022-2026

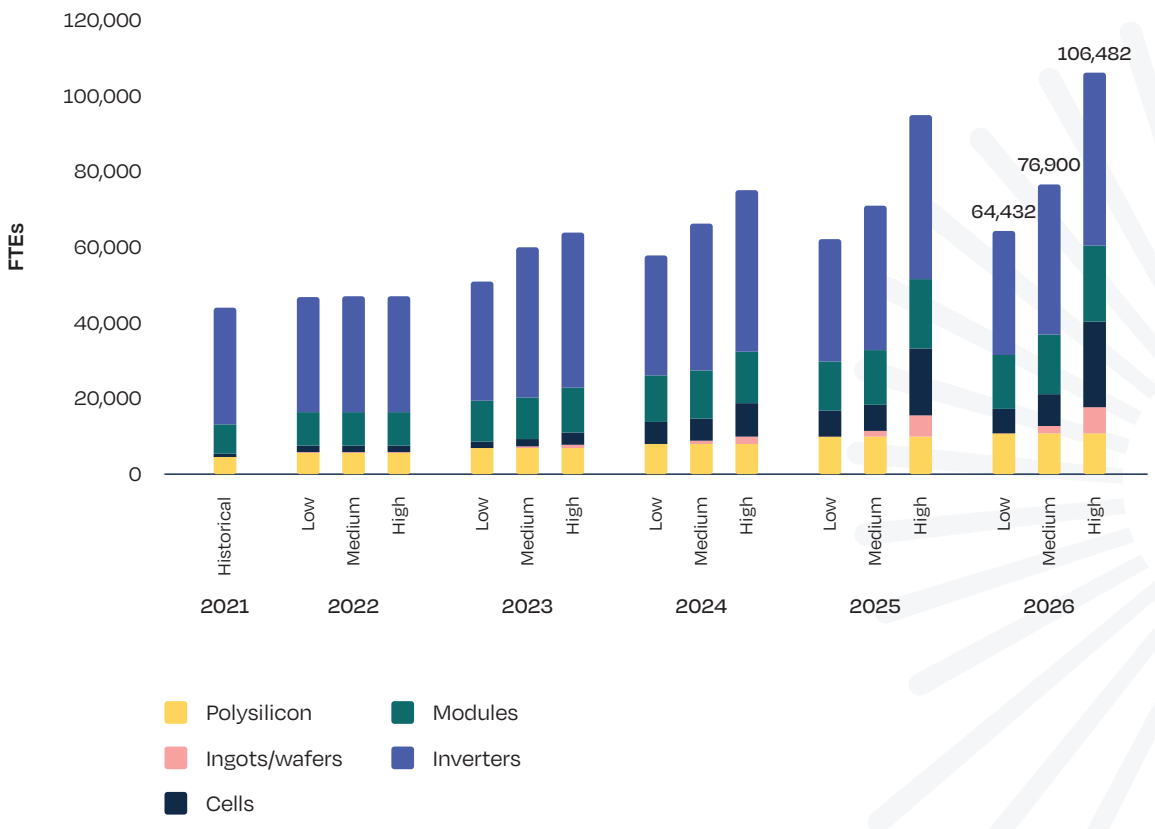


According to our Medium Scenario, whereby ESI targets for 2025 are only partially achieved, EU manufacturing jobs stand at 47,000 FTEs in 2022 and reach 77,000 units by 2026, a 74% increase compared to 2021 (Figure 8).

By contrast, in a low-ambition scenario with limited growth in EU production capacity, manufacturing jobs reach only 64,000 FTEs by 2026, a 46% growth compared to 2021. 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 would reach as much as 106,000 units in 2026, which means a 141% increase from 2021. Growth would take place in all value chain segments, including those that hardly contribute to EU employment at present: 7,000 jobs from wafer/ingot production and 23,000 jobs from cell production are anticipated in the High Scenario in 2026. Strong EU manufacturing deployment would also mean raising module manufacturing jobs from 8,000 to 20,000 FTEs in 2026, and inverter manufacturing jobs from 31,000 to 46,000 by the same year.

The difference in manufacturing jobs across the three scenarios is very low in the short term, because the industry plans for new production facilities coming online will take some time to realise and it is unlikely that additional large manufacturing capacities are built in a short period of time when looking at today's low starting levels in various segments along the value chain, in particular ingots and wafers. The spread becomes more visible towards the last years of the observed period. Due to the lengthy times in planning, securing financing and constructing manufacturing plants, decisions taken today have effects only a few years later.

**FIGURE 8** EU-27 SOLAR MANUFACTURING JOBS SCENARIOS 2022-2026



Activities in procurement, construction, installation and other parts of deployment of PV systems are expected to generate 419,000 jobs in 2022, a 14% raise from 2021 (see Figure 9). Looking beyond 2021, Deployment jobs will continue growing, reaching 574,000 FTEs in 2026 in our Medium Scenario. Highly dependent on the fluctuations of the annual EU solar market, Deployment jobs could be as low as 377,000 or as high as 818,000 by 2026.

Differently from Deployment jobs, which rely on the annual PV market and are more susceptible to yearly variations, Operation & Maintenance jobs depend on the total operating solar fleet and are much easier to predict. It is expected that these jobs undergo a steady two-digit growth between 2022 and 2026 without any major variations. The 40,000 FTEs working in solar O&M in 2021 are poised to grow by 17% to 47,000 FTEs in 2022 and to reach 80,000 units in 2026 (Figure 10).

**FIGURE 9** EU-27 SOLAR DEPLOYMENT JOBS SCENARIOS 2022-2026

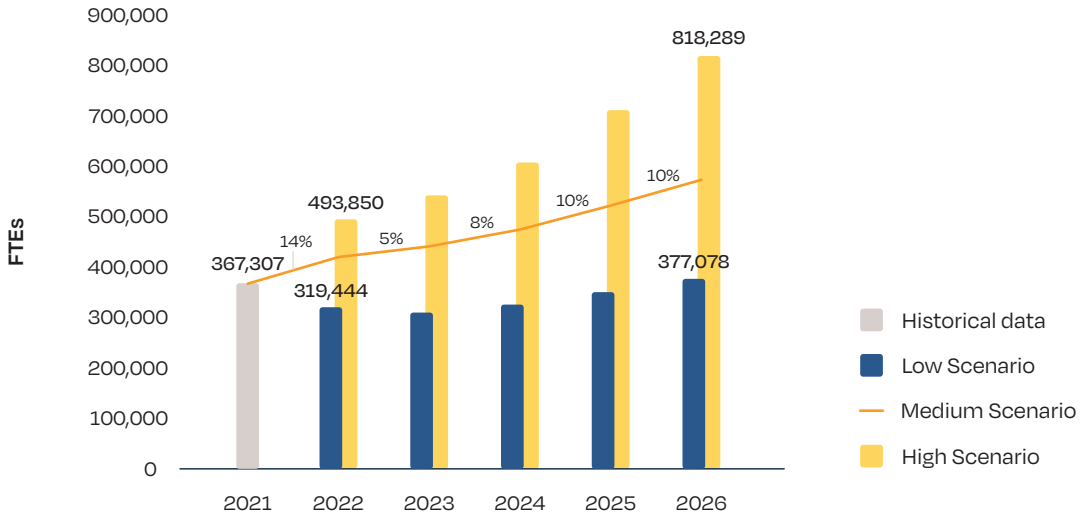
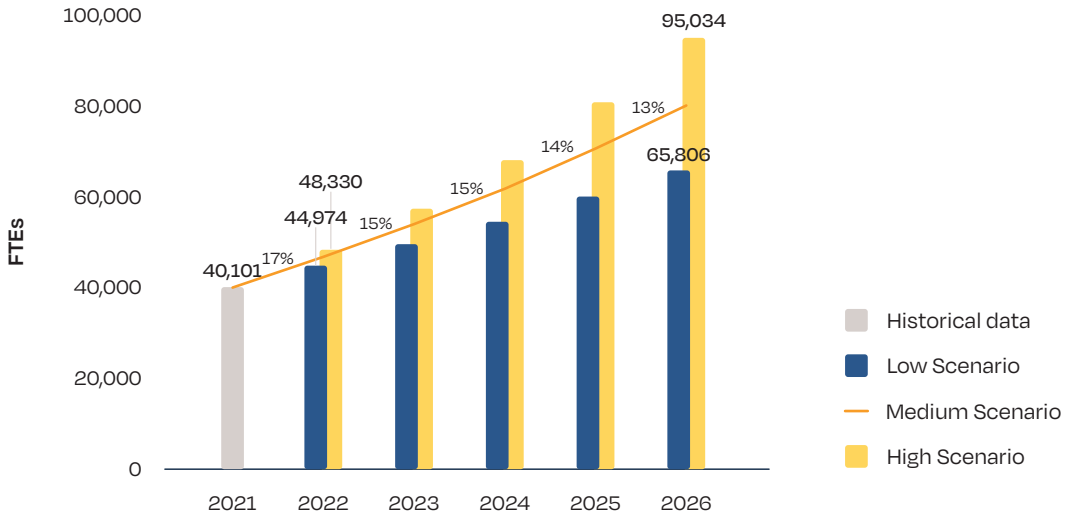


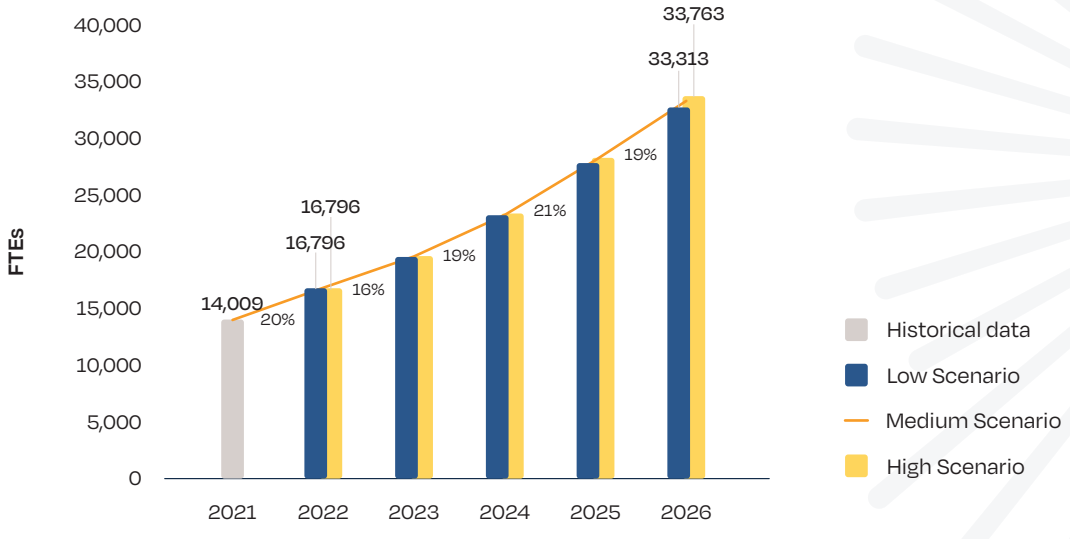
**FIGURE 10** EU-27 SOLAR O&M JOBS SCENARIOS 2022-2026





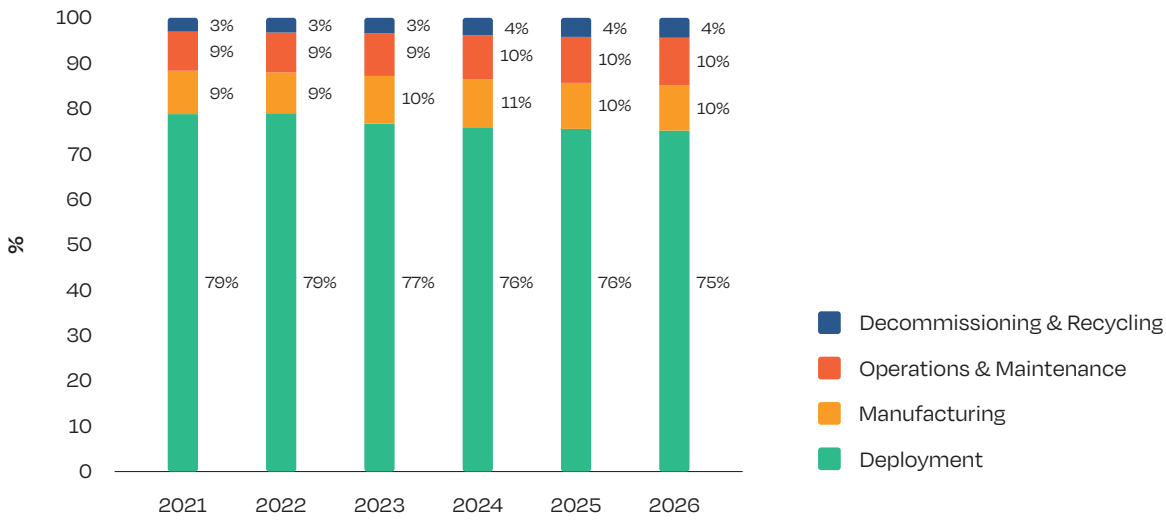

Jobs from the Decommissioning & Recycling segment remain marginal compared to total solar jobs, because PV products reaching the end of their lifetime are still a small fraction of today's installed capacities – even in a place like Europe, where several countries were among the solar pioneers. However, in about a decade's time this will change, when more and more PV systems will start to eventually reach the end of their operational lifetime and will enter the waste stream. Jobs from this segment are limited today, but increasing also in the short to mid run. In 2026, solar jobs from Decommissioning & Recycling are expected to reach 33,000 FTEs, up from 14,000 today (Figure 11).

**FIGURE 11** EU-27 SOLAR DECOMMISSIONING & RECYCLING JOBS SCENARIOS 2022-2026



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 slightly change. Figure 12 displays the evolution of the solar job breakdown according to the Medium Scenario. Although jobs associated with Deployment will remain the most numerous by far, their share will decrease a little from 79% to 75% in the observed period. The three other segments will all marginally increase their shares, Manufacturing and Operation & Maintenance jobs both rising from 9% to 10%, and Decommissioning & Recycling jobs growing from 3% to 4%.

**FIGURE 12** EU-27 SOLAR JOBS BREAKDOWN EVOLUTION 2021-2026

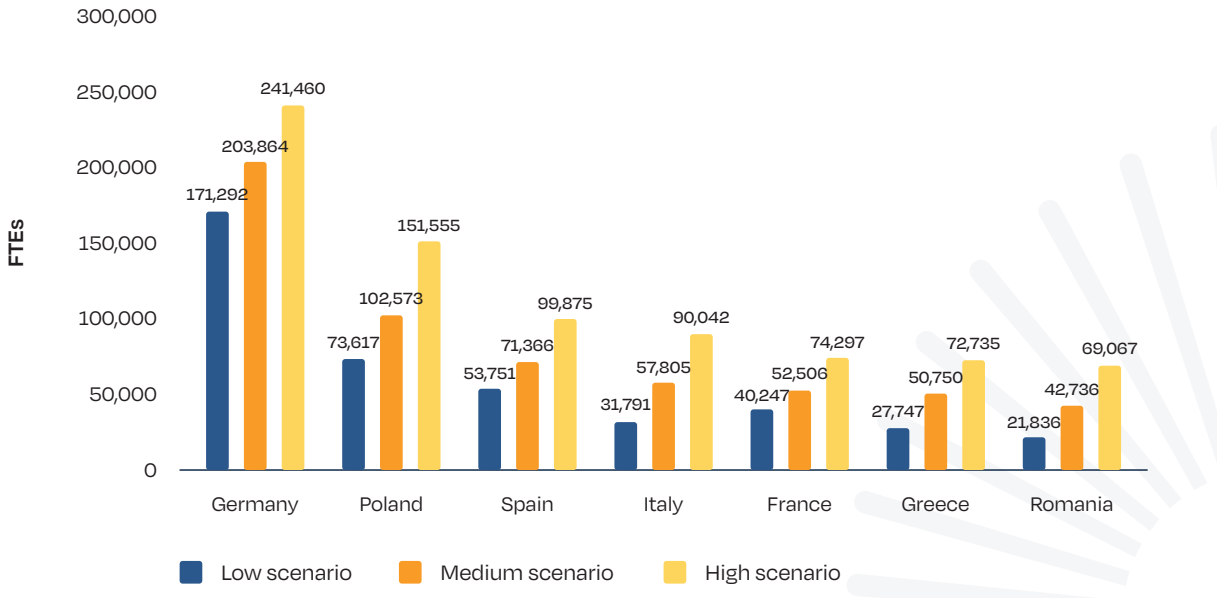





Member states' contributions to solar job creation in 2026 are expected to change considerably compared to today (see Figure 13). Germany, at present the largest EU solar market but not the biggest job provider, will take the lead on this front as well. With 204,000 FTEs in the Medium Scenario, Germany is poised to contribute with twice the number of jobs of the current #1, Poland, which will be ranked second in 2026. By that year, Germany will have accompanied a large growth in its solar market to 23 GW per year and a 133 GW cumulative capacity with an increase in its manufacturing capacity.

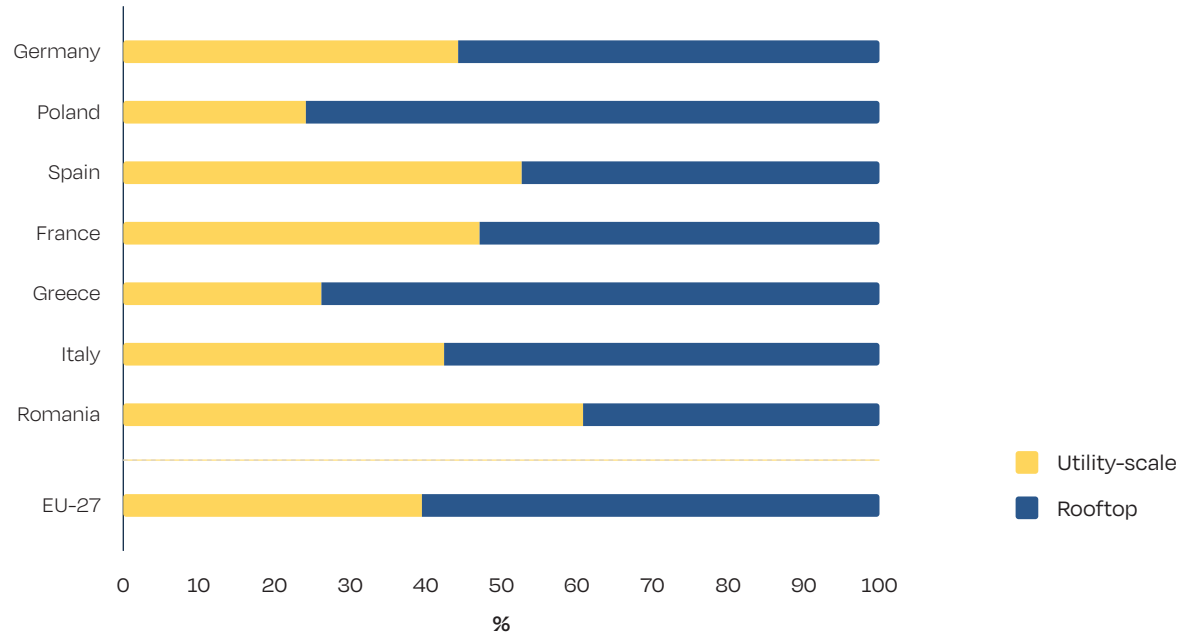
Despite the termination of its residential support scheme, in light of the energy crisis Poland will remain a significant solar market and a major contributor to EU solar jobs, with 103,000 FTEs in the Medium Scenario in 2026. In addition to Spain, Italy, France, and Greece, which are already in the top job contributors' list, a surprise to some will be the presence of Romania in this top 7. We expect the Romanian market to have reached the GW scale for a few years 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 582,000 FTEs or 76% of total EU solar jobs in 2026, with the remaining 20 member states contributing with a 24% share.

**FIGURE 13** EU-27 TOP 7 FTE COUNTRIES SCENARIOS 2026



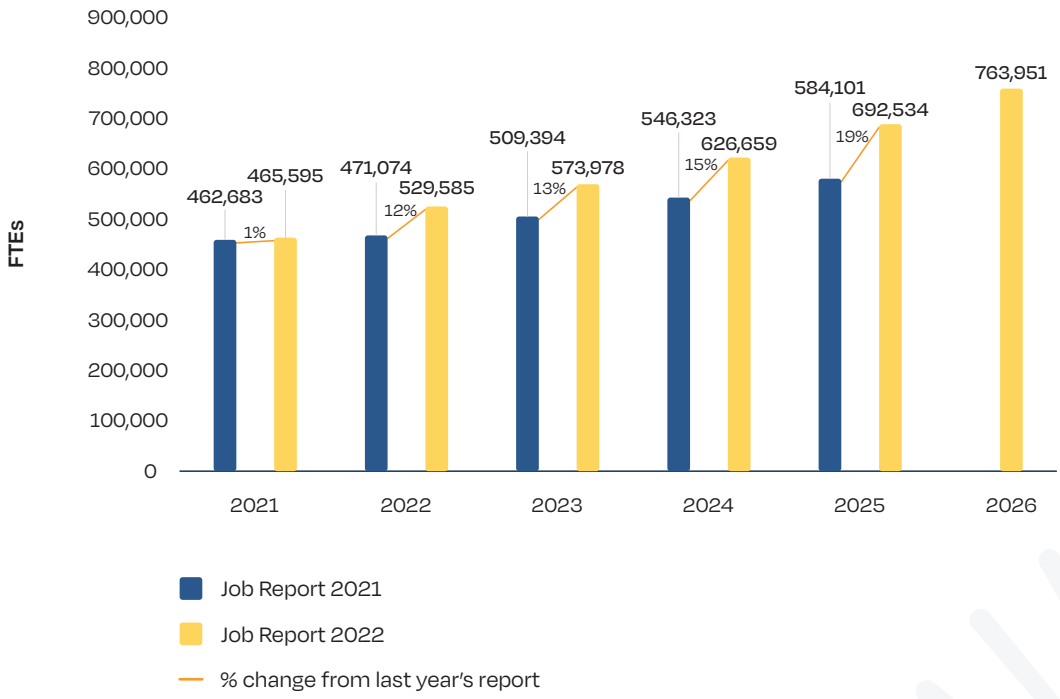
As the breakdown between rooftop and utility-scale capacity will be different than today, with the majority share held by utility-scale PV power plants installed in 2026, the breakdown between jobs stemming from the rooftop segment and jobs from the utility-scale segment will also change (Figure 14). An increase of large-scale installations is expected across Europe, as policymakers find in solar parks the cheapest and fastest solution to their countries' energy needs and as permitting and administrative barriers are progressively lifted. As a result, individual country breakdowns are less skewed than today towards rooftop job creation. Across the EU, utility-scale job contribution grows from 24% to 40%.

**FIGURE 14** EU-27 TOP 7 FTE COUNTRIES - ROOFTOP VS. UTILITY-SCALE JOBS BREAKDOWN 2026



Our expectations in last year' EU Solar Jobs Report about the status of solar employment in 2021 were largely in line with the actual job creation that took place last year. Back then, our Medium Scenario anticipated 463,000 jobs, which gives a difference of only 3,000 jobs from the number we registered in this year's edition. Our revised Medium Scenario outlook is more positive than a year ago: we forecast higher job creation for all comparable years (2022-2025), with increases ranging between 12% and 19%.

**FIGURE 15** COMPARISON MEDIUM SCENARIO OF JOB REPORT 2021 AND JOB REPORT 2022

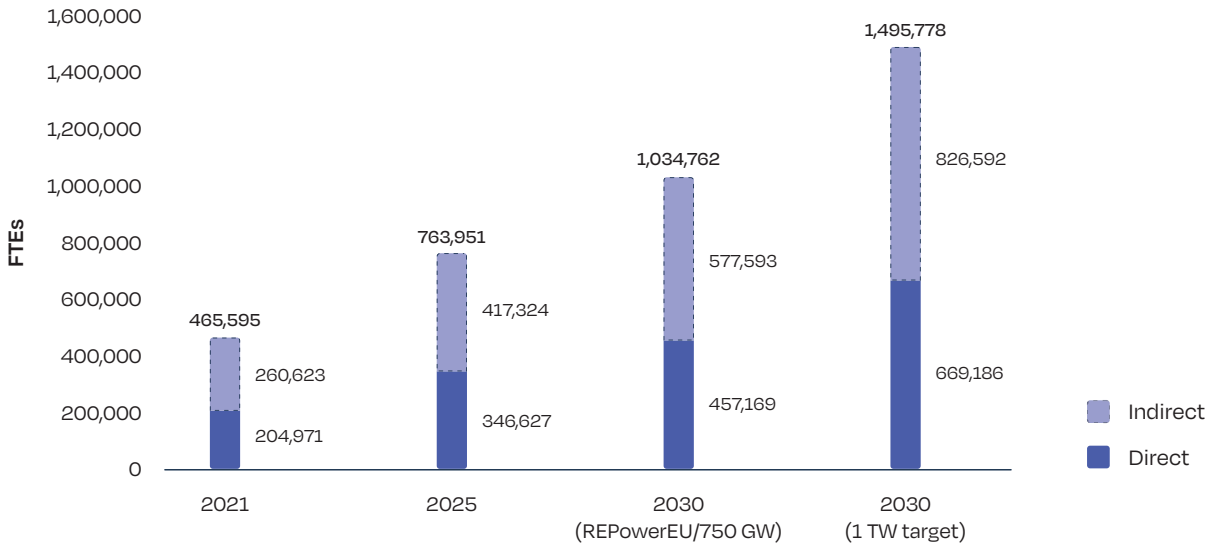


### 2.3. Outlook to 2030

In its REPowerEU package published in May 2021, the EU Commission has put together a set of measures to reduce EU dependence on Russian energy imports. One of the key actions in REPowerEU is boosting renewable energy, in particular solar energy. Solar capacity targets have been raised considerably through this package, which aims to reach 400 $GW_{DC}$ by 2025 and about 750 $GW_{DC}$ by 2030, up from 167 GW end of 2021. This increase in EU solar ambition is positive news for solar jobs as well. Our modelling indicates that reaching the 2030 solar target will result in the creation of over 1 million direct and indirect jobs in the EU solar industry, more than doubling the employment in the sector (see Fig. 16).

If the REPowerEU targets are certainly going in the right direction, the ambition still remains 26% lower than the 1 TW target our Accelerated High Scenario is calling for in order to stay within a 1.5°C Paris-aligned trajectory. This would not only be cost-efficient and more climate friendly but would also lead to a large increase in employment. If the EU installed 1 TW of solar by 2030, jobs in the sector would reach almost 1.5 million FTEs by the same year, which is 45% higher than in the REPowerEU scenario.

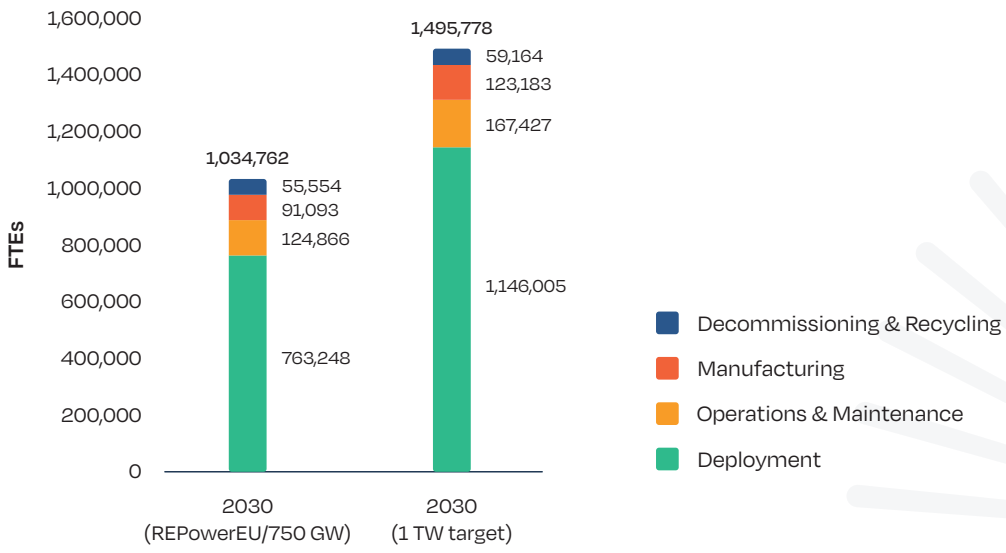
**FIGURE 16** EU-27 SOLAR JOBS SCENARIOS 2021-2030



A comparison of the two 2030 scenarios is provided in Figure 17. In the REPowerEU scenario, 1,035,000 FTEs are created across the solar value chain. While the majority of these jobs (74%) will still belong to the Deployment sector, FTEs from all value chain segments increase considerably in absolute terms. Thanks to a rapid expansion of the operating solar fleet, Operation & Maintenance jobs will amount to 125,000 FTEs, making up 12% of total jobs. 91,000 FTEs from Manufacturing and 56,000 FTEs from Decommissioning & Recycling would complete the picture. These would represent respectively 9% and 5% of total solar jobs.

Raising the ambition to 1 TW level translates into 461,000 additional solar jobs. Most of these extra jobs are in the Deployment segment, which takes 1,146,000 FTEs alone, 77% of the total. Deployment jobs in the 1 TW Scenario are 50% higher than in the REPowerEU Scenario. Further, the increase in cumulative installed capacity also means more Operation & Maintenance jobs, which are 34% higher than the REPowerEU scenario and amount to 167,000 FTEs. Our modeling assumes that more solar demand also brings more manufacturing capacities in the EU, increasing solar jobs in the sector by 35% to 123,000 FTEs. By contrast, the Decommissioning & Recycling jobs increase is only marginal – the effects of extra installed capacity on these jobs will only take place in the long term.

**FIGURE 17** EU-27 SOLAR JOBS IN 2030 - REPOWEREU TARGET VS 1 TW TARGET



# Annex

ANNEX TABLE 1 SUPPLY CHAIN NACE CODES USED IN FTE MULTIPLIERS FOR THE CALCULATION OF INDIRECT JOBS

| VALUE CHAIN | EMPLOYMENT TYPE | NACE CODE | NACE SECTOR |
|---|---|---|---|
| Manufacturing | Polysilicon | C20 | Manufacturing of chemicals and chemical products |
| | Ingot/wafer | C26 | Manufacturing of computer, electronic and optical products |
| | Cells | C26 | Manufacturing of computer, electronic and optical products |
| | Modules | C26 | Manufacturing of computer, electronic and optical products |
| | Inverters | C27 | Manufacturing of electrical equipment |
| Deployment | Deployment | F | Construction |
| Operation & | O&M | F | Construction |
| Decommissioning & recycling | Decommissioning | F | Construction |
| | Recycling | E37T39 | Sewerage, waste management and remediation activities |
| Source: Eurostat. | | | |

ANNEX TABLE 2 EMPLOYMENT FACTORS USED FOR SOLAR MANUFACTURING JOBS (FTE/MW)

| YEAR | POLYSILICON | INGOTS/WAFERS | CELLS | MODULES | INVERTER |
|---|---|---|---|---|---|
| 2020 | 0.12 | 0.25 | 0.8 | 0.8 | 0.36 |
| 2030 | 0.08 | 0.13 | 0.4 | 0.4 | 0.25 |
| Source: Industry survey. | | | | | |

# Annex

ANNEX TABLE 3 CAPEX OF PV SYSTEMS IN EU-27 MEMBER STATES

| CAPEX OF PV SYSTEMS (EUR/W) IN 2021 (PRICES WITHOUT VAT) | | | | |
|---|---|---|---|---|
| COUNTRY | RESIDENTIAL | COMMERCIAL | INDUSTRIAL | UTILITY-SCALE |
| Austria | 1.61 | 1.03 | 0.78 | 0.72 |
| Baltic States | 1.37 | 0.91 | 0.72 | 0.63 |
| Belgium | 1.30 | 0.98 | 0.81 | 0.75 |
| Bulgaria | 1.12 | 0.76 | 0.66 | 0.49 |
| Czech Republic | 0.86 | 0.58 | 0.50 | 0.38 |
| Denmark | 1.39 | 0.95 | 0.88 | 0.77 |
| Finland | 1.37 | 0.91 | 0.72 | 0.63 |
| France | 1.84 | 1.35 | 1.04 | 0.94 |
| Germany | 1.61 | 1.14 | 1.04 | 0.70 |
| Greece | 2.75 | 1.87 | 1.61 | 0.76 |
| Hungary | 0.86 | 0.58 | 0.50 | 0.38 |
| Italy | 1.36 | 1.07 | 0.94 | 0.78 |
| Netherlands | 1.47 | 1.22 | 1.15 | 1.07 |
| Poland | 1.09 | 0.92 | 0.78 | 0.76 |
| Portugal | 1.35 | 1.11 | 0.96 | 0.94 |
| Romania | 1.54 | 1.05 | 0.91 | 0.77 |
| Slovakia | 1.10 | 0.75 | 0.65 | 0.49 |
| Slovenia | 1.12 | 0.76 | 0.66 | 0.49 |
| Spain | 1.40 | 0.91 | 0.85 | 0.76 |
| Sweden | 1.43 | 1.17 | 1.02 | 0.86 |
| Rest of EU | 1.42 | 1.15 | 1.07 | 0.98 |

Source: IRENA, IEA-PVPS, Fraunhofer ISE.

# Annex

ANNEX TABLE 4 CAPEX BREAKDOWN FOR ROOFTOP AND UTILITY-SCALE PV SYSTEMS

| CAPEX BREAKDOWN – ROOFTOP SYSTEMS | | |
|---|---|---|
| **MAIN COSTS** | **COST CATEGORY** | **PERCENTAGE** |
| Hardware costs | Module | 27.19% |
| | Inverter | 10.54% |
| | BOS | 17.54% |
| Installation labour | Installation labour | 14.80% |
| Soft cost | Customer acquisition | 3.28% |
| | Procurement & permitting | 5.89% |
| | Margin | 20.75% |
| Source: IEA-PVPS. | | |
| **CAPEX BREAKDOWN – UTILITY-SCALE SYSTEMS** | | |
| **MAIN COSTS** | **COST CATEGORY** | **PERCENTAGE** |
| Hardware costs | Modules | 36.7% |
| | Inverters | 6.6% |
| | Racking & mounting | 17.2% |
| | Grid connection | 8.5% |
| | Cabling/wiring | 2.5% |
| | Safety & security | 1.9% |
| | Monitoring & control | 2.4% |
| Installation labour | Mechanical installation | 6.1% |
| | Electrical installation | 2.3% |
| | Inspection | 0.5% |
| Soft costs | Margin | 5.5% |
| | Financing costs | 1.5% |
| | System design | 4.7% |
| | Permitting | 2.2% |
| | Incentive application | 1.0% |
| | Customer acquisition | 0.6% |
| Source: IRENA, industry survey. | | |

SolarPower Europe

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ISBN NUMBER 9789464518689