Does Solar Energy Create Inclusive Employment Opportunities?

The Case of Tunisia

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Jonas Fitzke

Kevin Hempel

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1. Rationale

The expansion of renewable energy is a strategic focus to mitigate global warming. The commitment to limit global warming to 1.5% is a designated goal of the United Nations. To achieve this objective, the transition from fossil-based systems of energy production to renewable energy sources is crucial. According to the International Energy Agency, solar energy technology could be the key driver of this transition (IEA, 2021, p.14).

The deployment of renewable energy technologies is also considered to have significant job creation potential. In 2019, Forbes reported that the investment in renewable energies led to a boom in job creation in the USA, fostering economic opportunities all over the country (Forbes, 2019). Similarly, a study on China estimated that the development of renewable energy technologies would create over 7 million jobs until 2020 (Cai et al., 2014, p.1162). Based on such experience, the director of the International Renewable Energy Agency states that many governments worldwide associate the transition to renewable energy with significant job creation potential. Besides the ambition to achieve global climate goals, the opportunity to generate economic growth is one of the key drivers for the transition to renewables (IRENA, 2019, p.3).

Tunisia places renewable energy technologies at the core of its national energy transition. Besides the country's commitment to the COP 26 agreement, the national energy strategy of Tunisia aims at increasing the country's energy independence and energy security, reducing costs, and diversifying energy sources. The country plans to increase the share of renewable energy of the total electricity production from 3% in 2019 to 30% by 2030. The main tool to achieve these strategic goals is the Tunisian Solar Plan (TSP), a Public-Private Partnership initiated in 2009 that comprises multiple publicly and privately funded projects with an estimated investment volume of up to 10 billion USD (IRENA, 2021, p.32). The TSP was updated several times over the years and accompanied by regulatory reforms in 2015 through a new law (Law No. 2015-12) that established a legal framework for large scale renewable energy projects.

This research brief assesses the employment potential of solar energy and the inclusiveness of these employment opportunities in the case of Tunisia. To assess if the hopes of the government and the public about job creation are justified, section 2 discusses the international experience regarding the employment potential of solar technology. In particular, the section describes the types of jobs created and compares international estimates of employment generation. Section 3 looks at the case of Tunisia and the inclusiveness of the employment potential for women. Section 4 summarizes the main insights and gives recommendations on how to realize the potential of gender-inclusive job creation of solar technology in Tunisia.

2. Employment opportunities in the solar energy sector: International experience

2.1 Profile of jobs

Broadly speaking, the expansion of photovoltaic (PV) technology creates direct, indirect, and induced jobs (IRENA, 2011, p.7; Cameron & van der Zwaan, 2015, p.162). These jobs differ regarding how closely they are related to the initial investment. In this context, the initial investment would aim at the deployment of PV technology.

- **Direct jobs:** These jobs are directly related to the deployment of PV technology. Direct jobs exist in the manufacturing, the installation, and the operation & management of PV panels. They include the assembling of PV modules, the setting up of PV modules on the plant site and the maintenance of the plant.
- **Indirect jobs:** These jobs emerge to enable the deployment of PV technology and support the direct jobs. Indirect jobs exist for example in the sourcing and processing of raw materials to provide the inputs required for the manufacturing, installation, and operation & management of PV panels. Moreover, they include services in transportation, construction, administration, and consulting to support the deployment of the PV technology.
- **Induced jobs:** These jobs are created because the workers who are employed in jobs that are directly and indirectly related to the deployment of PV technology spend their money in the local economy. For instance, induced jobs are created in sectors such as consumer goods, gastronomy, or other services with no link to the solar energy sector.

The expansion of PV technology creates jobs throughout three different phases of deployment and in cross cutting supportive functions.

- **The manufacturing phase** includes the production of the PV modules. The manufacturer often does not produce all inputs for the PV modules himself but purchases the required parts from suppliers. Therefore, the manufacturer often only does the final assembling of parts.
- **The installation phase** includes the setting up of the PV modules. This includes the preparation of the plant site (e.g., leveling the ground), the transportation of the modules to the site, the installation of the modules and the cabling of the entire plant.
- **The operation & management phase** includes the day-to-day management of the PV plant and the safekeeping of the modules’ functionality (e.g., reparation, replacement, cleaning of PV modules).
- **Business and administrative functions** support these three phases of deployment along the entire project lifecycle. The business functions include positions such as accountants, recruiters, and management staff. Administrative functions include for example the position of public officials responsible for approving construction.

All three phases provide direct and indirect jobs. Figure 1 summarizes the job profiles created directly and indirectly in the different phases of deployment and supportive activities.

Figure 1: Job profiles throughout the three phases of PV deployment

	Manufacturing	Installation	Operation & Management
Direct	• Manufacturing of cells and modules • Design of PV systems	• Installation of PV modules	• Ensuring operativity of the plant (e.g., clean, repair, and replace modules)
Indirect	• Sourcing and processing of raw materials • Research related to solar energy technology • Business and administrative functions	• Transportation • Plant construction • Research related to the installation of PV panels (e.g., identification of the ideal location) • Business and administration functions	• Business and administration functions

Source: Author based on Cameron & van der Zwaan, 2015, p.162; IRENA, 2011, p.7

The expansion of PV technology creates jobs that require different skill-levels. Skills requirements for different jobs associated with the deployment of PV can be broadly classified into three different educational levels: secondary or lower education, technical and vocational education or training, and higher education. Even though all three deployment phases require a workforce with mixed educational backgrounds the relevance of each educational background varies throughout different stages. For instance, the manufacturing and installation phases rely heavily on workers with secondary or lower education. In contrast, the operation & management phase offers fewer employment opportunities for less educated workers. Table 1 summarizes the job profiles needed directly or indirectly in each deployment phase and categorizes them according to the required level of educational.

Table 1: Job profiles throughout the deployment of PV technology (considering direct and indirect jobs)

	Secondary education or lower	Technical and vocational education or training[1]	Higher education
Manufacturing	• **Mine and plant workers** to source and process raw materials (e.g., engineering craft machinist)	• **Workers** to assemble PV modules (e.g., electronic assembler, welder)	• **Engineers** to design the processes and techniques for sourcing and processing of raw materials, production of parts, assembly of the PV modules (e.g., commercial solar PV designer, cell manufacturing engineer) • **Scientists** to locate raw material sources and to conduct R&D on PV technology (e.g., geologists)
Installation	• **Logistic workers** to transport modules to plant sites and to enable mobility of workers (e.g., truck and bus drivers,	• **Technicians & Electricians** to set up modules, expand energy grid, wiring of the plant (e.g., solar electrician)	• **Engineers** to design the solar plant (e.g., construction project manager, grid engineer) • **Scientists** to identify the ideal plant location and to

[1] Typically, at post-secondary level.

	railroad conductors) • **Construction workers** to prepare the plant site, set up modules, and expand energy grid (e.g., construction craft worker, welder)		conduct R&D (e.g., energy meteorologist)
Operation & Management	• **Maintenance staff** to clean or replace PV modules (e.g., construction craft worker)	• **Technicians & Electricians** to ensure operativity of the plant (e.g., solar & battery storage technician)	• **Engineers** to ensure performance of the plant (e.g., senior operations manager) • **Scientists** to support planning and performance management of plants (e.g., energy meteorologist)
Business & Administrative Functions	n/a	• **Clerk staff** for administration and management of activities (e.g., accountant, human resource expert, lawyers)	

Source: Author based on Moreno & Lopez, 2008, p. 746, 747; IRENA, 2011, p.7; Pollin, Heintz, & Garret-Peltier, 2009, p.31; IEA, 2019, p.7

The jobs created across the different phases of deployment differ in their sustainability. The demand for workers in the manufacturing and installation phase is not constant over time since it depends on the rate at which new PV modules are needed and installed. Consequently, the jobs created in these fields are likely to diminish as soon as the required capacities in energy production are met. That said, there may be a stable demand for new PV modules to replace broken or less efficient ones. Nevertheless, this will require only a reduced workforce in manufacturing and installation. In contrast, the demand for workforce in the operation and management phase is more stable since it is aligned with the life span of the PV plant (Cameron & van der Zwaan, 2015, p.165, 166).

The variation in sustainability of employment opportunities impacts different groups of workers differently. In particular, the sustainability of employment opportunities varies across workers' educational levels. Since the manufacturing and installation phases rely heavily on lower skilled workers, as shown in table 1, the employment opportunities for these workers tend to disappear in the long-term with slowing demand for new PV production capacities. In contrast, those with higher education are employed throughout all three phases and are better equipped to adapt to a decrease in demand for workforce in manufacturing and installation (Cameron & van der Zwaan, 2015, p.165, 166).

2.2 Estimated employment potential

There is no reliable estimate of the employment potential of the expansion of PV technology. While there've been multiple studies estimating the job creation potential of solar energy globally, these studies are often not comparable due to different methodologies used.

- Studies use different sources and methods to generate data. Some rely on country specific Input/Output models which allow to calculate the potential spill-over effects of investments from one sector into other sectors of the national economy. Others rely on the analysis of primarily qualitative data, namely interviews with industry experts and employers.
- Studies use different units to quantify their estimations. Some use units based on full-time jobs per MW installed production capacity for the duration of one year. Others use units based on full-time jobs per MW installed production capacity for the duration of the plants' lifespan.
- The jobs created are categorized in different ways. For example, different definitions for direct, indirect, and induced jobs are used. As a result, the estimations for the number of direct, indirect, or induced jobs differ. Beyond that, studies estimate the employment potential for each deployment phase. However, the allocation of specific activities and with of employment potential to each deployment phase may differ.
- Furthermore, the activities that a specific job profile includes differ according to the individual understanding of the job profile. For instance, an author might state that the assembly of photovoltaic modules produces jobs for workers with a lower education or for higher educated specialists, depending on his understanding of a task and the characteristics of a job profile, statements about how many jobs are created for a certain job profile are incomparable (Cetin & Egrican, 2011, p.7184).

Available sources often show large variations in the estimated impact of solar energy on employment. In a review of 10 country specific case studies, Cameron and van der Zwaan (2015, p.166) show that the estimated number of direct and indirect jobs created varies widely (measured in jobs created per Megawatt of deployed production capacity in PV technology).[2] For instance, the estimations for the number of direct jobs created in the manufacturing phase vary from 6.0 to 34.5. Similarly, the estimated job creation during the installation phase ranges from 6.4 to 33.0 (see table 2).

The manufacturing and installation phase have the highest direct employment potential. Despite these variations, there is a clear picture that manufacturing and installation have a higher job creation potential than O&M (Cameron & van der Zwaan, 2015, p.166). That said, studies come to different conclusions regarding the phase with the highest job creation potential. Pollin, Heintz and Garret-Peltier (2009, p.32) state that in the USA the most jobs related to the solar energy sector are created in the manufacturing phase. In contrast, Greenpeace and EPIA (2008, p.49) estimated that in 2025 72% of all jobs related to the solar energy sector worldwide will be due to the installation of PV modules.

Table 2: Minimum, median and maximum direct employment factors, by phases of deployment for PV

	Manufacturing [full-time for 1 year/MW]	Installation [full-time for 1 year/MW]	O&M [full-time for plant life span/MW]
Minimum	6.0	6.4	0.1
Median	18.8	11.2	0.3
Maximum	34.5	33.0	1.7

Source: Author based on Cameron & van der Zwaan, 2015, p.165

[2] While for the manufacturing and installation phase one job represents one full-time equivalent employment for one year, for the operation & management phase one job represents one full-time employment for the entire life span of the plant.

Traditionally, the employment created through solar energy mainly benefits men. A study on the employment potential of the renewable energy industry in China states that the additional jobs in the sourcing and processing of raw materials and manufacturing of PV modules will aggravate the gender imbalance in the labor market, since women are typically underrepresented in those sectors (Cai et al., 2014, p.1160). While the jobs requiring higher education such as engineering or project management match the educational profile of many women, experience from India shows that the traveling and on-site deployment required for those occupations hinder many women from taking up those occupations (IEA, 2019, p.19). As a result, men and women do not benefit equally from the employment potential regardless of the required educational level.

2.3 Reasons for regional differences

Besides the differences in methodology, the job creation potential differs due to the characteristics of the local solar energy sector. Key differences lie in the maturity of the local solar energy sector, the share of local production, and the technology employed.

- **Share of local production.** As shown in *table 2,* a significant share of jobs depends on the manufacturing of PV modules. However, in many countries, the PV modules or the parts necessary to produce them are imported from countries that specialized in the technology early on. As a result, not all employment effects of the manufacturing can be realized locally. For instance, in 2020 China accounted for 69.8% of the global solar photovoltaic module production followed by Vietnam with 7.9%. Beyond that, China supplies over 50% of raw materials such as aluminum, antimony, raw steel, and tellurium. Additionally, the country is the main producer for polysilicon (79%), wafers (97%), and cells (85%) – parts crucial for the manufacturing of solar photovoltaic panels (IEA, 2022, p.58, 59). This concentration of production capacity implies that the employment effects of the manufacturing of solar technologies as well as the sourcing of raw materials will not benefit all countries that deploy PV technology equally.

- **Maturity of the local solar energy sector.** The maturity of the sector indicates how much know-how on the processes necessary for the deployment of renewable energy technologies is available in a country. Usually, this know-how is more developed in countries which have been deploying such technologies for a longer time. Based on the experiences related to the production, deployment and operation of solar technology, a mature sector operates more efficiently in terms of workforce required to generate a certain amount of energy. For instance, evidence from Germany indicates that the need for workers in the O&M phase decreased by 8% per year in 2007-2011 (Cameron & van der Zwaan, 2015, p.163). Consequently, the different maturity of the renewable energy sector of countries causes variation in the magnitude of employment generation.

- **The PV technologies used.** The employment factors are not only influenced by the maturity of the energy sector but also by the efficiency of the PV technology that is deployed. In fact, the more efficient a PV module can produce energy the less workforce is necessary to build the required production capacity. This implies that the expected employment effects of the solar PV industry will decrease in the future with the efficiency gains (Cameron & van der Zwaan, 2015, p.166).

3. Case study: Employment opportunities for women in Tunisia's solar sector

Tunisian women have fairly high levels of education, but this does not necessarily translate into higher employment rates. For instance, 33% of all women born around 1989 attained secondary or postsecondary education, compared to 23% of men in the same age group (Assaad et al., 2016, p.7). Following a long-term trend, 63% of Tunisian university students in 2019-2020 were women. Despite the predominance of women among higher education graduates, their representation in the labor market remains low. The labor force participation rate of women stagnated at around 25% since the 2000's. Furthermore, the Tunisian economy offers predominantly jobs which only require lower levels of education. Consequently, women with higher education have a higher unemployment rate compared to peers with lower education (Mouelhi & Goaied, 2017, p.3, 6, 21).

The educational and occupational profile of women is currently not well aligned with the characteristics of most jobs in the solar energy sector. As discussed earlier, the expansion of PV technology creates jobs predominantly in the sectors for the sourcing and processing of raw materials, the manufacturing of PV cells and modules, as well as for transportation and construction activities related to the installation. Table 3 shows the relative share of female workers in the four sectors benefiting most from the expansion of PV technology. Women represent only a small share in mining and quarrying (7.1%), construction (1.3%), and transport (6.2%). While the share of women in manufacturing is significantly higher (42.5%), many women in the manufacturing sector are employed in the textile industry (Mouelhi & Goaied, 2017, p. 22).

Table 3: Economic activity of women per sector in Tunisia.

Economic activity	Number of female workers	Share of female workers in the sector	Share of all employed women working in the sector
Mining and quarrying	1,200	7.1 %	0.1 %
Manufacturing	273,700	42.5 %	31.2 %
Construction	6,400	1.3 %	0.7 %
Transport, storage and communication	16,200	6.2 %	1.9 %

Source: Author based on ILOSTAT, 2019

Employment opportunities for women with higher education are also limited in the solar energy sector. Besides the low concentration of women in solar energy jobs that require only a limited education level, international experience suggests that they are also less likely to occupy the high-skill jobs created such as onsite engineers or project managers. Although these jobs align well with the educational profile of Tunisian women,[3] the jobs specifications often hinder women from applying or staying in these occupations. For example, experience from India indicates that the need for travelling to project sites, contractors or clients and related security concerns is the main reason for low female representation in engineering positions. According to the study in India, women with a high educational level primarily work in office-based jobs related to the design of projects or in corporate support functions such as finance, procurement, or human resources (IEA, 2019, p.12, 13, 19). In the Indian rooftop solar industry, the highest

[3] The women who attended university in the academic year 2019-2020 were strongly enrolled in business and administrative studies (18% of all female students, where they represented 65% of all students in this field) and engineering (11%), next to other fields of study with a high concentration of women such as literature (11%) and health (11%) (Ministère de l'Enseignement Supérieur et de la Recherche Scientifique, p.5).

share of women (over 30%) worked in support functions such as accountants and HR specialists (IEA, 2019, p.14).

Based on the experiences in other countries, job creation through the expansion of solar PV technology in Tunisia will benefit women much less than men. In summary, there are three factors limiting women's occupation in the jobs that will be created. Primarily, the expansion of solar PV technology fosters job creation in the fields of mining and quarrying, construction, and transport – sectors where women's representation traditionally is low. Secondly, although many Tunisian women work in the manufacturing sector, they are concentrated in the textile industry (traditional female industry) which makes it unlikely that they can easily shift towards employment in the renewable energy sector. Thirdly, the characteristics of specialized jobs that match the educational profile of many women often make them unattractive to women. Therefore, to ensure that women can benefit more strongly from the job creation associated with the expansion of PV technology in Tunisia, proactive measures are needed.

4. Conclusions & way forward

The expansion of the PV technology in Tunisia has strong potential for employment creation, though this potential is difficult to quantify. International experience suggests that the manufacturing, installation, and operation & management of PV technology can create a substantial number of direct and indirect jobs, as well as additional (induced) jobs through higher private spending of the people who are employed in the industry (e.g., on consumer goods and services). While most jobs are associated with the manufacturing and installation phases, many of these jobs can eventually disappear again when the desired production capacity is reached. The types of jobs created vary widely, from assembly workers to truck drivers, electricians, engineers, and meteorologists. Nevertheless, quantifying this job creation potential is difficult, and international studies show large variations due to different estimation methodologies and country characteristics such as the share of local production, the maturity of the local solar energy sector, and the PV technologies employed.

Realizing the employment potential of solar energy will depend on an adequate local workforce. Without an adequately trained workforce covering the broad range of job profiles required during the different phases of deployment, Tunisia risks to not fully take advantage of the industry's full job creation potential. Indeed, many of the potential manufacturing jobs related to the sourcing of inputs and production of modules could be lost to other counties. For instance, while Tunisian companies such as Ifri-Sol successfully established local production capacities for the assembly of PV solar modules, they rely on the import of key parts such as the cells from countries like Germany or China. Beyond that, Tunisia's access to critical minerals is very limited. Therefore, jobs related to the sourcing and processing of raw materials are unlikely to be created locally. Similarly, even for jobs related to installation and O&M, developers of solar plants may bring specialized workers from abroad if they cannot find sufficiently trained personnel locally (e.g., technicians, engineers, etc.).

Without concerted action, job creation linked to the expansion of solar energy in Tunisia will barely benefit the country's women, thus reinforcing existing gender imbalances in the labor market. While the jobs created through solar energy provide opportunities across different education levels, they are largely biased towards traditional male occupations, leading to relatively low employment rates for women in this industry globally. Labor market data from Tunisia paints a similar picture, whereby many of the economic activities that tend to benefit most from the expansion of solar power, such as mining, construction, or transportation, feature very low female employment rates. In addition, while most higher education graduates in Tunisia are female, many of them study unrelated fields such as literature and health. And even though Tunisia also features a relatively high share of female graduates in engineering, experience from other countries suggest that many of the engineering jobs in the solar sector may still be largely filled with men due to working conditions that are not attractive to women, such as frequent traveling to plant sites, clients and contractors. As a result, women may largely be left to work on supportive business and administrative functions.

To realize the employment potential of PV solar energy in Tunisia and ensure that it benefits different parts of society, including women, concerted efforts by government, private sector and development partners are needed.

- **A targeted workforce development strategy** is needed to ensure that the skills for the deployment of PV technology are readily available in Tunisia**.** Much of the discussions on promoting renewable energies in general, and solar power in particular (in connection with the Tunisian Solar Plan), have focused on regulatory, administrative and financial aspects to facilitate private investments in the sector. In contrast, relatively less attention has been paid to the human resource implications of expanding solar energy production in the country. Yet, to maximize the employment potential over the years to come, a clear strategy and targeted measures are needed to ensure that both TVET and higher education institutions produce the quantity and quality of workers needed by this growing industry (across the different phases of PV deployment, incl. production, installation, and operation). Workforce development strategies like MANFORM that are already in place should clearly diagnose current gaps and highlight intervention areas with high relevance to the development of the solar energy sector. Lehr et al. (2012) state that a close cooperation with the Agence Nationale pour la Maîtrise de l'Energie in Tunisia is crucial to ensure the relevance of such programs. The project for "Capacity and human resource building for solar market development in Tunisia" commissioned by the German Federal Foreign Office is a promising example for providing a PV training platform in cooperation with private partners (GIZ, 2018). Furthermore, workforce development strategies could point to the need for adding new specializations to existing study programs in universities (for specialized engineers and technicians) and vocational training institutes (e.g., related to mechanics and electricians), and define the quality standards (e.g., ISO) that should be met to satisfy international investors.

- **Intentional measures to make relevant study fields and jobs in the solar industry more attractive and accessible to women.** Increasing the share of women in currently male-dominated occupations in the solar sector should be a core objective, thus giving Tunisian women better access to well-paying jobs in this industry. This can only be achieved through a combination of measures, such as:

    - **Setting gender targets in relevant national strategies and plans.** At the policy level, setting targets related to women's economic participation in the sector may be needed to increase the commitment of different stakeholders, such as policymakers and the private sector. For instance, South Africa's Energy Policy specifically addresses female participation, while Kenya has approved a specific Gender Policy for the energy sector (GGGI, 2020).
    - **Strengthening awareness of educational and career pathways in STEM subjects in general and in the solar sector in particular with a particular focus on young women, including through female role models.** For instance, in Italy the government supports summer school initiatives that fight gender stereotypes and foster girls' interest for STEM subjects (GGGI, 2020). In the USA, the "Women in Solar Initiative" primarily focuses on developing female role models through targeted programs aiming at the training of women as team leaders in construction and installation (Breaking Energy, 2014).

- **Fostering exposure to different firms and jobs in the industry.** Attracting young women to work in the solar sector will also require stronger exposure to potential employers and jobs as part of their education and training. This can include a mix of approaches, including company visits, volunteering positions in installation projects, as well as tailored internship programs. These programs should be developed in partnership with local and international firms.
- **Provide working conditions and recruitment processes that meet the preferences and needs of women.** Flexible working arrangements and a save working environment for women on- and off site are key. This implies that working arrangements (work hours, etc.) need to accommodate a work-life balance and support working mothers. Moreover, recruitment processes should be designed in a way that encourage women to apply (targeted outreach, language used in job descriptions, etc.). Hence, investors and Tunisian companies working in the sector should be encouraged to review their human resource policies from a gender lens.

- **More research and data on workforce trends in the Tunisian renewable energy sector.** Having quality data is a precondition to understand current trends and identify potential issues related to the quantity, quality, and inclusiveness of the jobs created in the solar sector (and other renewables). Hence, different types of research should be considered, such as regular studies on employment patterns in the solar energy industry, studies on training and hiring needs, or an in-depth solar industry diversity study.

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