Chapter 10
Just Transition: Employment Projections for the 2.0 °C and 1.5 °C Scenarios

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Abstract This section provides the input data for two different employment development calculation methods: The quantitative analysis, which looks into the overall number of jobs in renewable and fossil fuel industries and the occupational analysis which looks into specific job categories required for the solar and wind sector as well as the oil, gas, and coal industry. Results are given with various figures and tables.

10.1 Introduction: Employment Modelling for a Just Transition

The transition to a 100% renewable energy system is not just a technical task. It is also a socially and economically challenging process, and it is imperative that the transition is managed in a fair and equitable way. One of the key concerns is the employment of workers in the affected industries (UNFCCC 2016; ILO 2015). However, it should be noted that the 'just transition' concept is concerned not only with workers' rights, but also with the well-being of the broader community (Smith 2017; Jenkins et al. 2016; Sovacool and Dworkin 2014). This includes, for example, community participation in decision-making processes, public dialogue, and policy mechanisms to create an enabling environment for new industries, to ensure local economic development.

Although it is acknowledged that a just transition is important, there are limited data on the impacts that the transition will have on employment. There is even less information on the types of occupations that will be affected by the transition, either by project growth or a decline in employment. This study provides projections for jobs in construction, manufacturing, operations and maintenance (O&M), and fuel and heat supply across 12 technologies and 10 world regions, based on the energy

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scenario from the Leonardo Di Caprio project (see Chap. 3 ff. This study is funded by the German Greenpeace Foundation and builds on the methodology developed by UTS/ISF (Rutovitz et al. 2015), with an updated framework that disaggregates jobs by specific occupations. Projected employment is calculated regionally, but in this chapter, we present an overview of the global data, which are an aggregate of the results for the 10 world regions. Further details, including a further regional breakdown of employment data, are provided in the full report (Dominish et al. 2018).

10.2 Quantitative Employment Modelling

This section discusses the calculation factors used for the quantitative employment modelling (an overview of the methodology is given in Sect. 3.6 of Chap. 3). The factors were analysed on a regional basis where possible, to take into account the significant economic differences between world regions. The results are then presented in the following section.

10.2.1 Employment Factors

Employment factors were used to calculate the number of jobs required per unit of electrical or heating capacity, or per unit of fuel. The employment factors differ depending on whether they involve manufacturing, construction, operation and maintenance, or fuel supply. Information about these factors usually comes from OECD countries because that is where most data are collected, although local data were used wherever possible. For job calculations in non-OECD regions, regional adjustments were made when a local factor was not available (see Sect. 10.2.2). The employment factors used in the calculations are shown in Table 10.1.

The employment factors were based on coal supplies, because employment per tonne varies significantly across the world regions and because coal plays a significant role in energy production in many countries. In Australia and the USA, coal is extracted at an average rate of more than 9000 tonnes per person per year, whereas in Europe, the average coal miner is responsible for less than 1000 tonnes per year. China has relatively low per capita productivity at present, with 650 tonnes per worker per year, but the annual increases in productivity are very high. India and Eurasia have significantly increased their productivity since a similar analysis was performed in 2015. Local data were also used for gas extraction in every region except India, the Middle East, and Non-OECD-Asia. The calculation of coal and gas employment per petajoule (PJ) drew on data from national statistics and company reports, combined with production figures from the BP Statistical Review of World Energy 2018 (BP-SR 2018) or other sources. Data were collected for as many major coal-producing countries as possible, and coverage was obtained for 90% of the world coal production (Table 10.2).

Table 10.1 Summary of employment factors used in a global analysis in 2012

	Construction/installation	Manufacturing	Operations & maintenance	Fuel – PRIMARY energy demand
	Job years/ MW	Job years/ MW	Jobs/MW	
Coal	11.4	5.1	0.14	Regional
Gas	1.8	2.9	0.14	Regional
Nuclear	11.8	1.3	0.6	0.001 jobs per GWh final energy demand
Biomass	14.0	2.9	1.5	29.9 jobs/PJ
Hydro-large	7.5	3.9	0.2	
Hydro-small	15.8	11.1	4.9	
Wind onshore	3.0	3.4	0.3	
Wind offshore	6.5	13.6	0.15	
PV	13.0	6.7	0.7	
Geothermal	6.8	3.9	0.4	
Solar thermal	8.9	4.0	0.7	
Ocean	10.3	10.3	0.6	
Geothermal – heat	6.9 jobs/ MW (construction and manufacturing)			
Solar – heat	8.4 jobs/ MW (construction and manufacturing)			
Nuclear decommissioning	0.95 jobs per MW decommissioned			
Combined heat and power	CHP technologies use the factor for the technology, i.e. coal, gas, biomass, geothermal, etc., increased by a factor of 1.5 for O&M only.			

Note: For details of sources and derivation of factors see Dominish et al. (2018)

Table 10.2 Employment factors used for coal fuel supply (mining and associated jobs)

	Employment factor Jobs per PJ	Tonnes per person per year (coal equivalent)
World average	36.2	943
OECD North America	3.5	9613
OECD Europe	36.2	942
OECD Asia-Oceania	3.6	9455
India	33.6	1016
China	52.9	645
Africa	13.7	2482
Eastern Europe/Eurasia	36.0	948
Developing Asia	6.5	5273
Latin America	12.5	2725
Middle East	Used world average because no employment data were available	

10.2.2 Regional Adjustments

The employment factors used in this model for energy technologies other than coal mining were usually for OECD regions, which are typically wealthier than other regions. A regional multiplier was applied to make the jobs per MW more realistic for other parts of the world. In developing countries, there are generally more jobs per unit of electricity because those countries have more labour-intensive practices. The multipliers change over the study period, consistent with the projections for GDP per worker. This reflects the fact that as prosperity increases, labour intensity tends to fall. The multipliers are shown in Table 10.3.

10.2.2.1 Local Employment Factors

Local employment factors were used where possible. These region-specific factors were:

- *OECD Americas*—gas and coal fuel, photovoltaics (PV) and offshore wind (all factors), and solar thermal power (construction and operation and maintenance (O&M)
- *OECD Europe*—gas and coal fuel, offshore wind (all factors), solar thermal power (construction and O&M), and solar heating
- *OECD Pacific*—gas and coal fuel
- *Africa*—gas, coal, and biomass fuel
- *China*—gas and coal fuel, and solar heating
- *Eastern Europe/Eurasia*—gas and coal fuel
- *Developing Asia*—coal fuel
- *India* – coal fuel and solar heating
- *Latin America*—coal and biomass fuels, onshore wind (all factors), nuclear (construction and O&M), large hydro (O&M), and small hydro (construction and O&M).

Table 10.3 Regional multipliers used for the quantitative calculation of employment

	2015	2020	2030	2040	2050
OECD (North America, Europe, Pacific)	1.0	1.0	1.0	1.0	1.0
Latin America	3.4	3.4	3.4	3.1	2.9
Africa	5.7	5.7	5.6	5.2	4.9
Middle East	1.4	1.5	1.5	1.4	1.3
Eastern Europe/Eurasia	2.4	2.4	2.2	2.0	1.8
India	7.0	5.6	3.7	2.7	2.0
Developing Asia	6.1	5.3	4.2	3.5	2.9
China	2.6	2.2	1.6	1.3	1.1

Source: Derived from ILO (2012) Key Indicators of the Labour Market, eighth edition software, with growth in GDP per capita derived from IEA World Energy Outlook 2018 and World Bank data

10.2.2.2 Local Manufacturing and Fuel Production

Some regions do not manufacture the equipment (e.g., wind turbines or solar PV panels) required for the introduction of renewable technologies. This model includes estimates of the percentages of renewable technology that are made locally and assumes that the percentage of local manufacturing will increase over time as the industry matures. Based on this, the jobs involving the manufacture of components for export were calculated for the region in which the manufacturing occurs. The same applies to coal and gas, because they are traded internationally, so the jobs in fuel supply were calculated regionally, based on historical data.

10.2.2.3 Learning Adjustments or 'Decline Factors'

Learning adjustments are used to account for the projected reductions in the costs of renewables over time, as technologies and companies become more efficient and production processes are scaled up. Generally, jobs per MW are projected to fall in parallel with this trend. The cost projections for each of the calculated energy scenario regions (see Sect. 5.3 of Chap. 5) were used to derive these factors.

10.2.3 Results of Quantitative Employment Modelling

The 2.0 °C and 1.5 °C Scenarios will result in an increase in energy-sector jobs in the world as a whole at every stage of the projection. The 1.5 °C Scenario will increase the renewable energy capacities faster, so employment will increase faster than in the 2.0 °C Scenario. By 2050, employment in te energy sector will be within the same range in both scenarios, at around 48–50 million jobs.

- In 2025, there will be 29.6 million energy-sector jobs in the 5.0 °C Scenario, 42.3 million in the 2.0 °C Scenario, and 48.1 million in the 1.5 °C Scenario.
- In 2030, there will be 30.3 million energy-sector jobs in the 5.0 °C Scenario, 49.2 million in the 2.0 °C Scenario, and 53.8 million in the 1.5 °C Scenario.
- In 2050, there will be 29.6 million energy-sector jobs in the 5.0 °C Scenario, 50.4 million in the 2.0 °C Scenario, and 47.8 million in the 1.5 °C Scenario.

Figure 10.1 shows the changes in job numbers under the 5.0 °C, 2.0 °C, and 1.5 °C Scenarios for each technology between 2015 and 2030. the 5.0 °C Scenario, jobs will drop to 4% below the 2015 levels by 2020 and then remain quite stable until 2030. Strong growth in renewable energy will lead to an increase of 44% in the total energy-sector jobs in the 2.0 °C Scenario and 66% in the 1.5 °C Scenario by 2025. In the 2.0 °C (1.5 °C) Scenario the renewable energy sector will account for 81% (86%) in 2025 and 87% (89%) in 2030, with PV having the greatest share of 24% (26%), followed by biomass, wind, and solar heating.

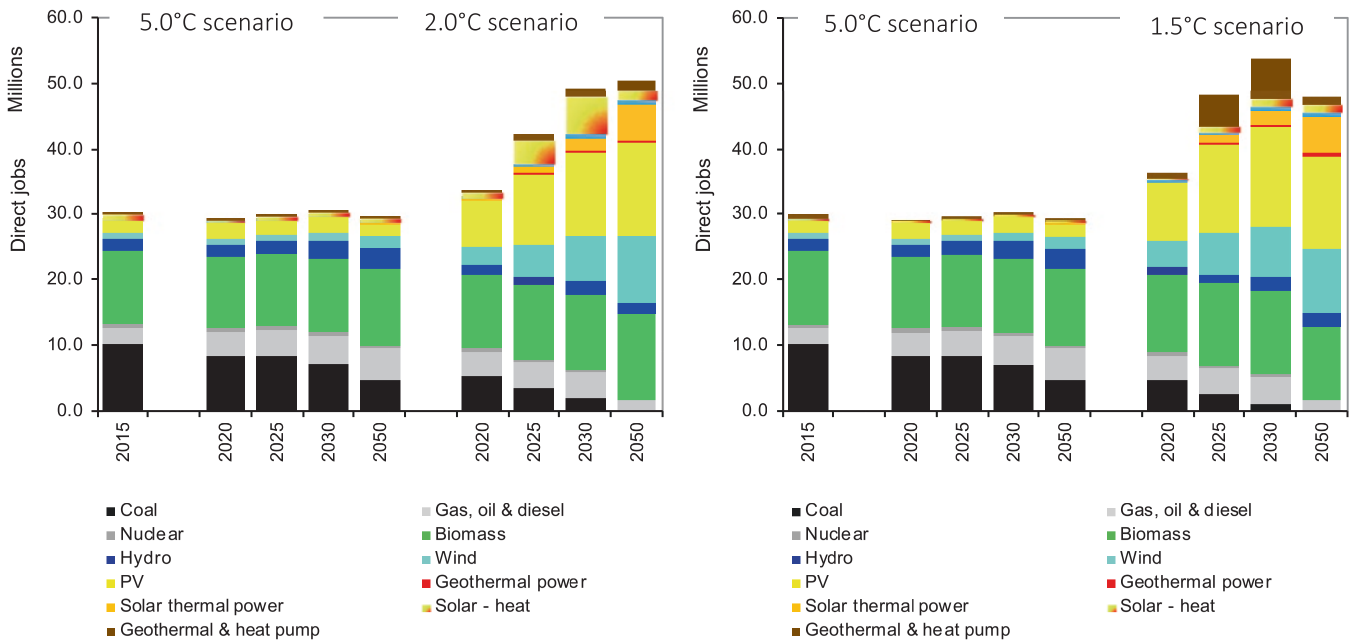

Fig. 10.1 World employment in the energy sector under the 5.0 °C and 2.0 °C Scenarios (*left*) and the 5.0 °C and 1.5 °C Scenarios (*right*)

10.3 Occupational Employment Modelling

To plan for a just transition, it is important to understand the occupations and locations at which jobs are likely to be lost or created. The modelling of employment by type of occupation is based on a new framework developed by UTS/ISF and financed by the German Greenpeace Foundation. The framework is applied to the results of the employment modelling discussed in Sect. 10.2. This information can be used to attempt to understand where labour is likely to be required in the renewable energy transition, and where job losses are likely to occur.

10.3.1 Background: Development of Occupational Employment Modelling

The occupational employment modelling framework used in this study was developed for renewable energy (solar PV, onshore wind, offshore wind) and fossil fuels (coal and gas). The three primary studies that classified and measured the occupational composition of renewable energy industries were conducted by the International Renewable Energy Agency (IRENA). Through surveys of around 45 industry participants across a range of developed and developing nations, IRENA estimated the percentages of person–days for the various occupations across the solar PV and onshore and offshore wind farm supply chains (IRENA 2017a, b, 2018). Figure 10.2 is an example (in this case, for solar PV manufacturing).

IRENA's studies are the most detailed estimates of the occupational compositions of the solar PV and onshore wind industries to date. ISF has extended the application of IRENA's work in two key ways:

1. **Mapping IRENA's job categories against the International Standard Classification of Occupations (ISCO):** IRENA uses its own occupational classification system, which does not match the ISCO, which is the basis for national statistical agency data. For example, 'regulation and standardization experts' is not a category in the ISCO. Consequently, the IRENA job categories have been mapped and translated across to the ISCO to facilitate comparisons between renewable energy technologies and fossil fuel sectors. The best fit for each of the occupations in the IRENA studies has been identified at one-digit, two-digit, three-digit, and four-digit levels of the ISCO.
2. **Unpacking mid- and low-skill job categories in IRENA's study**: Some of the categories in the IRENA studies containe jobs that are of interest from a just transition perspective. Specifically, IRENA combines:

   - 'Factory workers' for solar PV and onshore and offshore wind manufacturing
   - 'Ship crews' for offshore wind construction and operation and maintenance
   - 'Construction workers' for solar PV, onshore wind farm construction, and operation and maintenance.

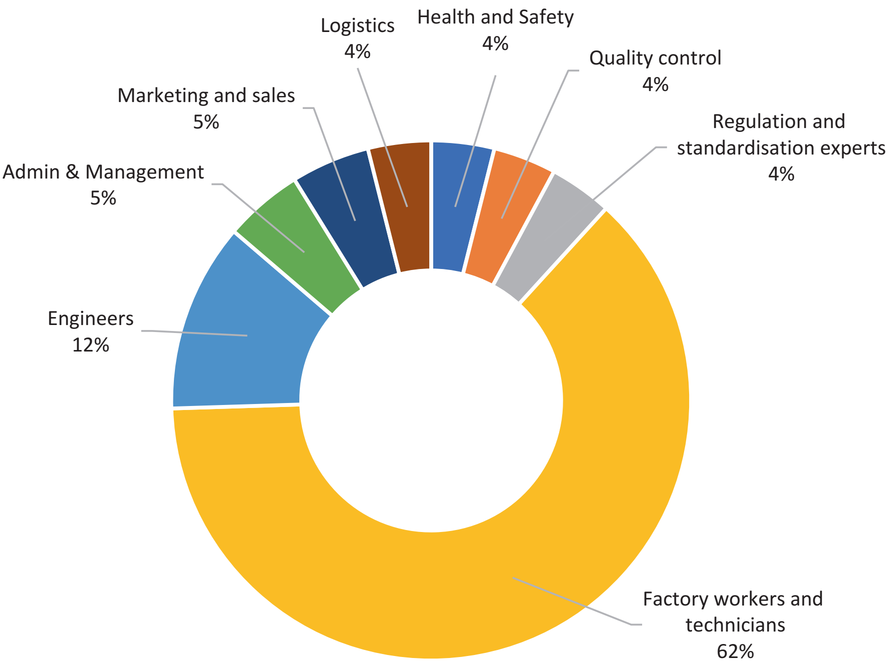

Fig. 10.2 Distribution of human resources required to manufacture the main components of a 50 MW solar photovoltaic power plant. (IRENA 2017a)

These categories combine a range of technicians, trades, machinery operators, drivers, and assemblers, and labourers.

For factory workers, industry data from the *Benchmarks of Global Clean Energy Manufacturing* study by the Clean Energy Manufacturing Analysis Centre was combined with the occupational framework from the Australian census. The international standard classification of industries used for the Benchmarks of Global Clean Energy Manufacturing study were translated across to the Australian New Zealand Standard Classification of Industry framework (which is based on the international classification standard) (Australian Bureau of Statistics & Statistics New Zealand 2013).

Data from the Australian census on the occupational composition of these manufacturing sectors were then used to derive the breakdown of employment (Australian Bureau of Statistics 2017). The census includes a comprehensive stocktake of employment, with data at one-, two-, three- and four-digit levels for each industry. The Australian–New Zealand Standard Classification of Occupations is based on the ISCO. Clean Energy Manufacturing Analysis data on the relative share of the value added by component was used to weight the shares of employment. The Australian manufacturing sectors used are not wind or solar PV manufacturing activities, but as the Clean Energy Manufacturing Analysis Centre notes, 'Large portions of the wind energy supply chain connect well to core manufacturing indus-

Table 10.4 Wind and solar PV manufacturing–study methodology

Technology	Component	I-O Industry Category	Equivalent ANZSIC Classification
Wind	Nascelles	Machinery & equipment manufacturing, not elsewhere classified	22 fabricated metal product manufacturing 222 structural metal product manufacturing 2221 structural steel fabricating
	Blades	Manufacturing not elsewhere classified	22 fabricated metal product manufacturing 222 structural metal product manufacturing 2221 structural steel fabricating
	Towers	Fabricated metal product manufacturing	22 fabricated metal product manufacturing 222 structural metal product manufacturing 2221 structural steel fabricating
	Steel	Basic metal manufacturing	21 primary metal and metal product manufacturing 211 basic ferrous metal manufacturing 2110 Iron Smelting & Steel Manufacturing
	Generators	Electrical machinery & apparatus manufacturing,	24 Machinery & Equipment Manufacturing 243 electrical equipment manufacturing 2439 other electrical equipment manufacturing
Solar PV	Modules	Computers, electronic and optical equipment manufacturing	24 Machinery & Equipment Manufacturing 243 electrical equipment manufacturing 2439 other electrical equipment manufacturing
	Cells		
	Wafers		

tries' (CEMAC 2017). To clarify construction worker categories for onshore wind and PV construction, and for the operation and maintenance of solar PV, interviews were conducted with project managers who were currently overseeing or had recently completed construction projects (Table 10.4).

The IRENA studies are the richest data source on employment in solar PV and onshore wind projects, but further work is required to directly match renewable energy job levels against existing fossil fuel sectors and to generate data on mid- and low-skill jobs, which are of primary interest from a just transition perspective.

As an example, Table 10.5 shows the occupational hierarchy for solar PV construction and how it is matched against ISCO. ISCO classifies occupations from a one-digit level (left) to a four-digit level (right). Each level is more detailed than the previous one in terms of the labour force required for the type of work. This methodology has been transferred to an occupational hierarchy that has been constructed for solar PV, onshore wind, and offshore wind using IRENA and other data sources to map jobs against the ISCO. The result is a matrix with percentages allocated to each occupation at the one-, two-, three-, and four-digit levels of aggregation.

The framework for fossil fuels was derived from labour statistics from the Australian 2016 national census for coal mining, gas supply, and coal and gas generation (Australian Bureau of Statistics 2017). Although these data are specific to Australia, these statistics provide the best source of data, and regional multipliers in the quantitative modelling can adjust the results to account for economic differences between regions.

Table 10.5 Occupational hierarchy, solar PV construction

ILO 1-digit		ILO 2-digit		ILO 3-digit		ILO 4-digit	
1 MANAGERS	1.7%	Production and specialised service MANAGERS (13)	1.7%	Manufacturing, mining, construction and distribution MANAGERS (132)	1.7%	Supply, distribution and related MANAGERS (1324)	1.7%
2 PROFESSIONALS	12.0%	Science & engineering PROFESSIONALS (21)	4.4%	Physical, life & earth science PROFESSIONALS (211)	0.1%	Geotechnical experts (2114)	0.1%
				Life science PROFESSIONALS (213)	2.1%	Environmental protection professionals (2133)	2.1%
				Engineering PROFESSIONALS (214)	1.0%	Mechanical engineers (2144)	0.8%
		Health professionals (22)	4.4%	Electrotechnology engineers (215)	0.8%	Civil engineers (2142)	0.3%
				Other health professionals (226)	4.4%	Electrical engineers (2151)	0.8%
						Environmental and occupational health and hygiene professionals (2263)	4.4%
		Business & administrative PROFESSIONALS (24)	3.4%	Finance PROFESSIONALS (241)	2.6%	Financial analysts (2413)	1.9%
				Administration PROFESSIONALS (242)	0.8%	Accountants (2411)	0.7%
						Policy administration professionals (2422)	0.8%
3 TECHNICIANS and Associate professionals	27.8%	Business and administration Associate professionals (33)	0.6%	Business services agents (333)	0.7%	Real estate agents and property managers (3334)	0.7%
		Science and engineering TECHNICIANS and supervisors (31)	24.9%	Physical and science engineering TECHNICIANS (311)	11.9%	Civil engineering technicians (3112)	7.0%

		Information & communications technicians (35)	2.1%			Electrical engineering technicians (3113)	4.9%
				Mining, manufacturing & construction supervisors (312)	13.0%	Construction supervisors (3123)	13.0%
				ICT Operations & Support Technicians (351)	2.1%	ICT operations technicians (3511)	2.1%
4 Clerical Support workers	0.3%	Numerical and material recording clerks (43)	0.3%	Numerical clerks (431)	0.3%	Accounting and bookkeeping clerks (4311)	0.2%
						Payroll clerks (4313)	0.2%
7 Craft and related TRADES workers	31.6%	Electrical and electronics TRADES workers (74)	31.6%	Electrical equipment installers and repairers (741)	31.6%	Building Frame & Finisher Trades (711 & 712)	9.9%
						Sheet & Structural Metal Workers (721)	7.9%
						Electricial equipment installers (741)	13.8%
8 Plant and machine operators and assemblers	22.0%	Assemblers 821	9.8%	Assemblers 821	9.8%	Mechanical machinery assemblers (8211)	4.2%
		Drivers and mobile plant OPERATORS (83)	12.1%	Heavy truck and bus drivers (833)	4.3%	Electrical assemblers (8212)	5.6%
						Truck and lorry drivers (8332)	4.3%
				Mobile plant OPERATORS (834)	7.8%	Earthmoving plant operators (8342)	3.5%
						Crane, hoist and related plant operators (8343)	4.3%
9 Elementary occupations	4.3%	Labourers in mining, construction, manufacturing and transport (93)	4.3%	Mining & construction labourers (931)	4.3%	Civil engineering Labourers (9312)	4.3%

For each modelling run, the results for the installed capacity of the renewable energy technologies (MW) and full-time-equivalent jobs (FTE/MW) were used to generate an aggregate level of employment for construction, manufacturing, and operation and maintenance. The matrix was then used to calculate the number of jobs at different levels of disaggregation (Sect. 3.6.1.)

The final framework is shown in Table 10.4. This is based on a composite profile for each technology using a mix of one-, two-, three-, and four-digit levels of occupation, depending on which best illustrates the breakdown of jobs and allows comparison to be made across technologies. Choices have been made based on the proportion of jobs and the labels that are most readily understandable to readers (noting that the categories used in the ISCO do not always correspond to popularly used titles). Note, for example, that 'Managers' is a one-digit category, but trades are broken down into construction trades, metal trades, and electricians because this provides more meaningful descriptions.

In the example shown in Table 10.6, it is notable that wind and solar farms employ higher proportions of professionals and technicians for their operations and maintenance than coal mining, and similar or higher proportions of elementary occupations, but much lower proportions of machinery operators and drivers.

10.3.1.1 Methodology and Limitations

- At the aggregate level, it is assumed that rising labour productivity over time will reduce the labour intensity (i.e., less FTE/MW) that is applied in the construction, manufacture, and operation and maintenance of each renewable energy technology. No assumptions have been made about changes to the relative labour intensity between occupations. Over time, we would expect that the proportion of less-skilled jobs would fall as a result of mechanization. Therefore, the share of less-skilled jobs is likely to be overestimated.
- IRENA estimates a single global figure for each occupation, averaged from surveys of industry participants across different global markets. In practice, there are variations in labour intensity and the compositions of jobs across supply chains between different regions (broadly speaking, supply chains in lower-wage nations are more labour intensive). ISF takes account of regional conditions in the job factors applied at the level of major sub-sectors (construction, manufacturing, operation and maintenance), but not at the disaggregated level. Therefore, it is likely that the proportion of less-skilled jobs is overestimated for rich economies and underestimated for less-developed economies.
- The breakdown of the category of 'construction workers' is based on interviews with some Australian solar and wind project managers. The project managers had overseen recent projects and provided detailed estimates of the contributions of different jobs. Nonetheless, the breakdowns are based on a limited sample, and further research is required to generate more-accurate estimates.

Table 10.6 Occupational compositions for renewable and fossil fuel technologies

		Solar PV			Onshore Wind			Offshore wind			Fossil fuels		
ISCO category	Name	Construction	Manufacturing	O&M	Construction	Manufacturing	O&M	Construction	Manufacturing	O&M	Coal mining	Gas supply	Coal and gas generation
1	Managers	1.0%	4.2%	6.3%	1.7%	7.6%	1.5%	2.2%	4.6%	3.0%	6.7%	16.8%	13.0%
2	Other professionals (Legal, finance, scientific)	5.0%	12.7%	4.4%	10.6%	11.3%	11.6%	7.0%	26.0%	15.8%	10.0%	14.7%	6.7%
2	Engineers (Industrial, electrical & civil)	3.8%	14.3%	14.7%	1.8%	8.7%	27.0%	6.2%	6.3%	7.7%	0.0%	5.6%	8.5%
3	Technicians & associate professionals	7.2%	6.3%	26.2%	27.8%	6.5%	46.9%	0.1%	3.5%	25.1%	7.5%	10.5%	22.5%
4	Clerical support workers	3.3%	4.9%	1.3%	0.3%	4.6%	4.7%	0.2%	9.2%	8.4%	5.1%	18.8%	12.1%
7	Construction trades	0.8%	0.0%	0.0%	9.9%	2.5%	0.0%	0.0%	2.0%	5.5%	0.0%	13.9%	1.6%
7	Metal trades	1.8%	7.9%	0.0%	7.9%	28.4%	0.0%	0.0%	23.3%	0.0%	16.3%	0.0%	12.1%
7	Electricians	14.2%	21.6%	32.3%	13.8%	4.0%	4.1%	0.2%	3.3%	5.5%	5.5%	0.0%	11.2%
8	Plant & machine operators & assemblers	55.6%	10.6%	0.0%	21.9%	18.3%	0.0%	12.9%	15.0%	20.0%	46.4%	13.2%	6.0%
9	Elementary occupations (Labourers)	7.4%	17.5%	14.7%	4.3%	8.2%	4.1%	0.8%	6.7%	8.9%	2.6%	6.5%	6.4%
	Ship crew							70.3%					

10.3.2 Results of Occupational Employment Modelling

There will be an increase in jobs in the 1.5 °C Scenario across all occupations between 2015 and 2025, except in metal trades, which will display a minor decline of 2%, as shown in Fig. 10.3.

There will be an increase in jobs across all occupations between 2015 and 2025 in the 2.0 °C Scenario, as shown in Fig. 10.4. The occupations with the highest number of jobs will be plant and machine operators and assemblers, followed by technicians (including electrical, mechanical, civil, and IT technicians) and electricians. The occupations that will have the largest percentage increase in jobs from 2015 to 2025 will be labourers, engineers, electricians, and construction trades. The results are similar in the 1.5 °C Scenario, except for managers and metal trades, which will experience minor reductions in overall jobs (3% each) (Table 10.7).

However, the results are not uniform across regions. For example, China and India will both experience a reduction in the number of jobs for managers and clerical and administrative workers between 2015 and 2025, as shown in Table 10.8.

Table 10.8 and Fig. 10.6 show the employment changes between 2015 and 2025 under the 1.5 °C Scenario. Across all eight employment groups, the net effect of the energy transition will positive or stable (Fig. 10.5).

However, the results are not uniform across regions. For example, China and India both foresee a reduction in the number of jobs for managers and clerical and administrative workers between 2015 and 2025, as shown in Table 10.9.

Table 10.10 and Fig. 10.5 show the employment changes between 2015 and 2025 under the 2.0 °C Scenario. Across all eight employment groups, the net effect of the energy transition is positive. Further research is required to identify the training needs for all employment groups.

10.4 Conclusions

Under both the 1.5 °C and 2.0 °C Scenarios, the renewable energy transition is projected to increase employment. Importantly, this analysis has reviewed the locations and types of occupations and found that the jobs created in wind and solar PV alone are enough to replace the jobs lost in the fossil fuel industry across all occupation types. Further research is required to identify the training needs and supportive policies needed to ensure a just transition for all employment groups.

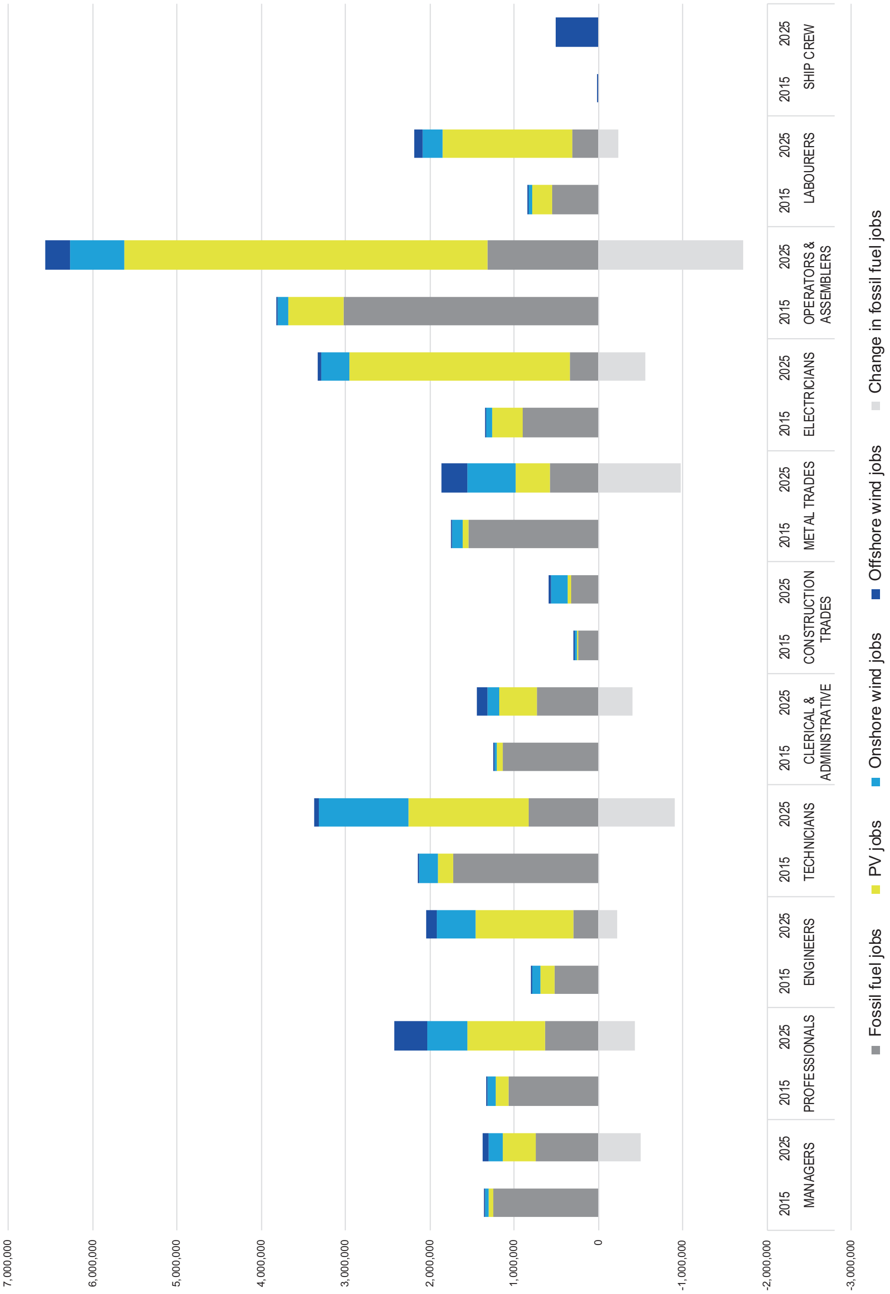

Fig. 10.3 Division of occupations between fossil fuels and renewable energy in 2015 and 2025 under the 1.5 °C Scenario

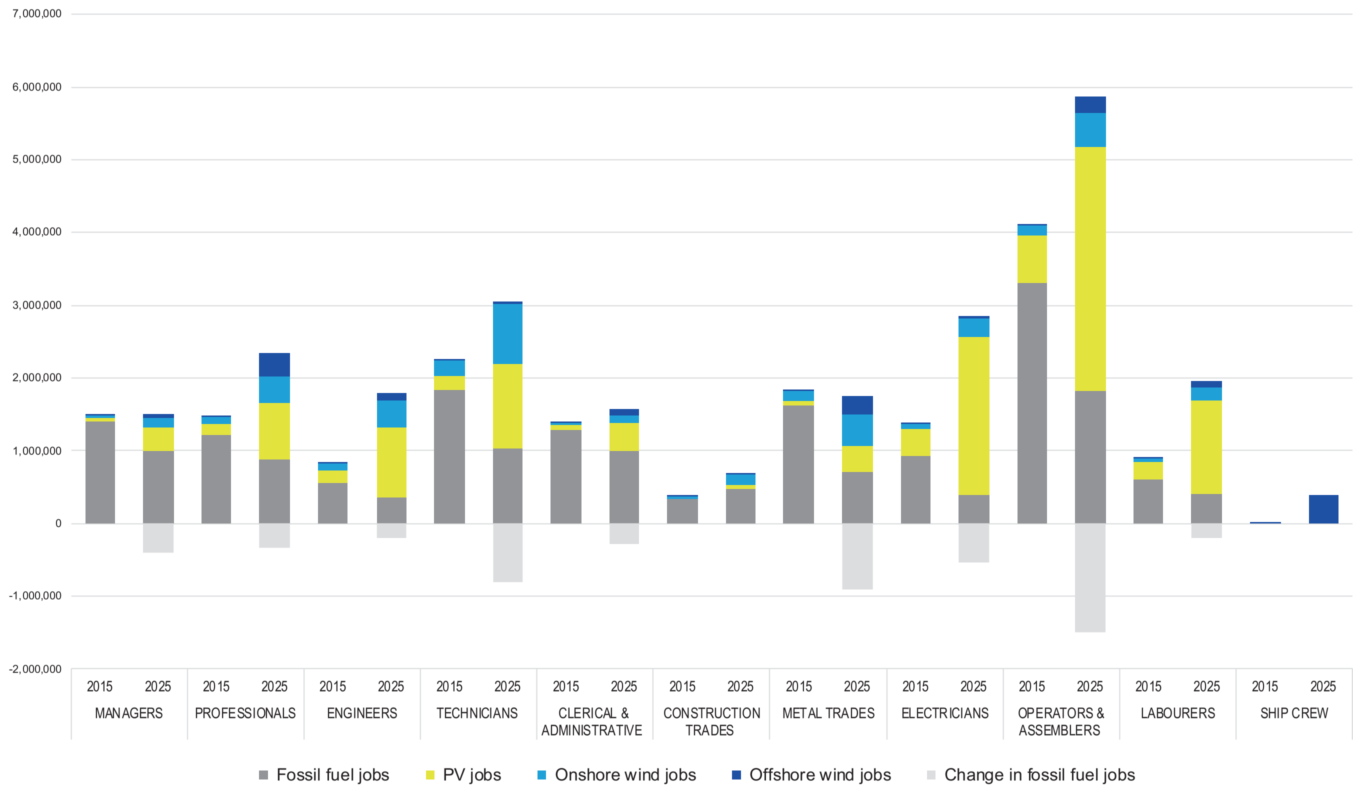

Fig. 10.4 Division of occupations between fossil fuels and renewable energy in 2015 and 2025 under the 2.0 °C Scenario

Table 10.7 Jobs created and lost between 2015 and 2025 under the 1.5 °C Scenario

	Jobs created or lost				Total jobs		Difference in jobs	
	Fossil fuels	PV	Wind – onshore	Wind – offshore	Total jobs in 2015	Total jobs in 2025	Total difference	% difference
Managers	−505,000	355,000	130,000	75,000	1,345,000	1,380,000	35,000	3%
Professionals (Social, Legal, finance, scientific)	−430,000	770,000	375,000	385,000	1,330,000	2 430,000	1,100,000	83%
Engineers (Industrial, electrical & civil)	−225,000	990,000	365,000	125,000	790,000	2,050,000	1,260,000	159%
Technicians (Electrical, mechanical, civil & IT)	−900,000	1,240,000	840,000	55,000	2 130,000	3 365,000	1 235,000	58%
Clerical & administrative workers	−395,000	375,000	100,000	120,000	1 235,000	1,440,000	200,000	16%
Construction trades	80,000	45,000	155,000	30,000	290,000	600,000	310,000	107%
Metal trades	−970,000	335,000	450,000	295,000	1,750,000	1,860,000	110,000	6%
Electricians	−560,000	2,250,000	260,000	45,000	1 335,000	3 330,000	1,995,000	150%
Plant & machine operators & assemblers	−1,700,000	3,360,000	505,000	290,000	3,820,000	6 560,000	2,740,000	72%
Labourers (Manufacturing, construction & transport)	−235,000	1,300,000	190,000	95,000	835,000	2,185,000	1,350,000	162%
Total	**−5 845,000**	**11,300,000**	**3,370,000**	**1,510,000**	**14 900,000**	**25 195,000**	**10 335,000**	**70%**
Ship crew	–	–	–	490,000	12,000	500,000	490,000	4000%

Table 10.8 Jobs created or lost between 2015 and 2025 by region under the 1.5 °C Scenario

	OECD North America	Latin America	OECD Europe	Africa	Middle East	Eastern Europe/ Eurasia	India	Developing Asia	China	OECD Pacific	Global
Managers	138%	57%	26%	13%	42%	42%	−14%	36%	−24%	40%	3%
Professionals (Social, legal, finance, scientific)	383%	185%	113%	186%	119%	119%	133%	194%	1%	172%	83%
Engineers (Industrial, electrical & civil)	414%	306%	199%	201%	179%	179%	140%	200%	82%	214%	159%
Technicians (Electrical, mechanical, civil & IT)	236%	189%	65%	140%	153%	153%	46%	125%	−5%	138%	58%
Clerical & administrative workers	165%	63%	50%	24%	47%	47%	−7%	53%	−13%	52%	16%
Construction trades	145%	75%	137%	202%	64%	64%	107%	93%	124%	115%	107%
Metal trades	258%	76%	44%	50%	112%	112%	33%	83%	−36%	76%	6%
Electricians	489%	556%	165%	237%	500%	500%	157%	346%	24%	206%	150%
Plant & machine operators & assemblers	390%	456%	53%	326%	502%	502%	166%	649%	−29%	178%	72%
Labourers (Manufacturing, construction & transport)	475%	395%	209%	220%	221%	221%	181%	266%	48%	210%	162%
Total	**327%**	**237%**	**87%**	**159%**	**168%**	**168%**	**90%**	**199%**	**−10%**	**152%**	**70%**
Ship crew	4150%		731%					68,465%	1462%	8742%	4000%

Table 10.9 Jobs created and lost between 2015 and 2025 under the 2.0 °C Scenario

	Jobs created or dlost				Total jobs		Difference in jobs	
	Fossil fuels	PV	Wind – onshore	Wind – offshore	Total jobs in 2015	Total jobs in 2025	Total difference	% difference
Managers	−382,067	255,887	89,967	56,041	1,444,621	1,464,449	19,828	1%
Professionals (Social, legal, finance, scientific)	−305,186	609,373	260,542	288,834	1,421,732	2 275,295	853,563	60%
Engineers (Industrial, electrical & civil)	−191,753	764,217	250,117	94,195	830,073	1,746,850	916,776	110%
Technicians (Electrical, mechanical, civil & IT)	−778,902	945,091	580,639	41,848	2,195,839	2,984,516	788,677	36%
Clerical & administrative workers	−278,592	297,860	69,929	91,610	1,350,727	1,531,534	180,807	13%
Construction trades	129,278	37,123	109,843	21,101	371,818	669,163	297,345	80%
Metal trades	−844,156	267,032	315,134	222,511	1,752,952	1,713,473	−39,479	−2%
Electricians	−504,687	1,740,194	182,757	34,307	1,342,336	2,794,906	1,452,570	108%
Plant & machine operators & assemblers	−1,350,554	2,949,489	354,152	215,137	3,903,199	6,071,423	2,168,224	56%
Labourers (Manufacturing, construction & transport)	−186,954	1,013,583	133,271	71,034	881,189	1,912,124	1,030,935	117%
Total	−4,693,573	8,879,851	2,346,350	1,136,618	15,494,487	23,163,733	7,669,246	49%
Ship crew	–	–	–	355,791	12,199	367,990	355,791	2917%

Table 10.10 Jobs created or lost between 2015 and 2025 by region under the 2.0 °C Scenario

	OECD North America	Latin America	OECD Europe	Africa	Middle East	Eastern Europe/ Eurasia	India	Developing Asia	China	OECD Pacific	Global
Managers	132%	35%	14%	16%	40%	40%	−20%	36%	−26%	26%	1%
Professionals (Social, legal, finance, scientific)	308%	106%	80%	151%	82%	82%	102%	120%	−5%	137%	60%
Engineers (Industrial, electrical & civil)	369%	187%	134%	144%	126%	126%	90%	124%	53%	172%	110%
Technicians (Electrical, mechanical, civil & it)	223%	111%	39%	100%	114%	114%	18%	82%	−13%	105%	36%
Clerical & administrative workers	154%	38%	33%	29%	43%	43%	−11%	46%	−16%	38%	13%
Construction Trades	140%	50%	100%	163%	52%	52%	87%	72%	101%	54%	80%
Metal trades	202%	26%	29%	48%	101%	101%	20%	56%	−38%	61%	−2%
Electricians	456%	378%	100%	203%	416%	416%	102%	239%	11%	180%	108%
Plant & machine operators & assemblers	369%	258%	30%	317%	289%	289%	130%	398%	−27%	164%	56%
Labourers (Manufacturing, construction & transport)	436%	230%	136%	191%	143%	143%	125%	167%	31%	176%	117%
Total	**298%**	**134%**	**55%**	**138%**	**113%**	**113%**	**60%**	**129%**	**−14%**	**127%**	**49%**
Ship crew	1724%		644%					43,668%	1098%	8610%	2917%

Fig. 10.5 Employment changes between 2015 and 2025 by occupational breakdown under the 2.0 °C Scenario

Fig. 10.6 Employment changes between 2015 and 2025 by occupational breakdown under the 1.5 °C Scenario

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