IRENA
International Renewable Energy Agency

RENEWABLE ENERGY BENEFITS

LEVERAGING LOCAL CAPACITY FOR ONSHORE WIND

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ABOUT IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity. **www.irena.org**

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DISCLAIMER

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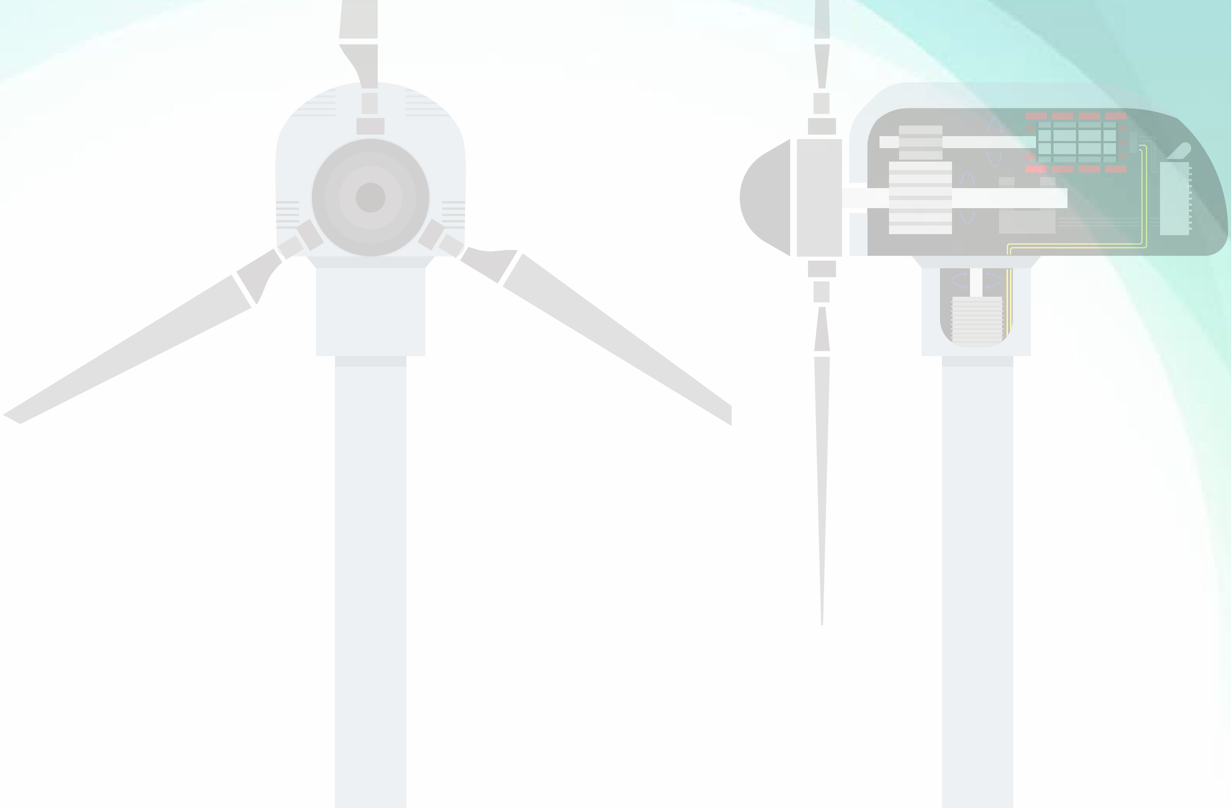

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INTRODUCTION

Developing a renewable energy sector brings immense opportunities to fuel economic growth, create new employment opportunities and enhance human health and welfare. Many countries increasingly consider the socio-economic benefits of renewable energy development as a key driver to support its deployment (IRENA, 2016a).

Analysis by the International Renewable Energy Agency (IRENA) shows that an accelerated deployment of renewable energy and energy efficiency, as needed to meet the goals laid out in the Paris Agreement, would increase global GDP by 0.8% in 2050 and support around 26 million jobs in the global renewable energy sector by 2050 (IRENA, 2017a). In recent years, job creation has been an important co-benefit of accelerated renewable energy deployment. IRENA estimates that the sector employed 9.8 million people in 2016 (IRENA, 2017b). Employment opportunities are created throughout the value chain for renewable energy deployment, from project planning to manufacturing, installing, operating and maintaining, as well as decommissioning.

This report assesses the types of jobs created along the value chain, in order to provide policy makers with an understanding of the human resources and skills required to produce, install and decommission renewable energy plants. It assesses the materials and equipment needed in each segment of the value chain to identify areas with the greatest potential for local value creation. The objective is to allow for an informed feasibility assessment of procuring the components and services domestically rather than from abroad. The study can help decision makers identify ways to maximise domestic value creation by leveraging existing industries if they want to do so. It is part of IRENA's extensive work on renewable energy benefits (see Box 1).

Box 1 ■ **IRENA's work on renewable energy benefits**

This summary is part of a growing body of work by IRENA which began in 2011. It includes *Renewable Energy and Jobs (2013), The Socio-Economic Benefits of Solar and Wind Energy (2014), Renewable Energy Benefits: Measuring the Economics (2016) and Renewable Energy and Jobs: Annual Review (2014, 2015, 2016 and 2017)*. This study is part of a series of reports analysing the opportunities for value creation through deployment of renewable energy technologies, including solar photovoltaics (IRENA, 2017c) as well as upcoming reports on solar water heaters and offshore wind.

The full report can be downloaded from **www.irena.org/Publications**

The data presented in the report were obtained through surveys and interviews with internationally recognised experts and from desktop research that gathered information published by leading companies and specialised institutions in the wind industry. Forty-nine stakeholders were interviewed or responded to questionnaires on the requirements to develop a wind industry. They included project developers, component manufacturers, service providers, energy authorities and national and global associations for wind and renewable energy. The study also draws on public reports of wind energy companies, including annual reports; technical specifications and equipment handbooks; and public price lists.[1] The scope of the study is global, covering Brazil, China, the European Union, India, Japan, Mexico, South Africa and the United States.

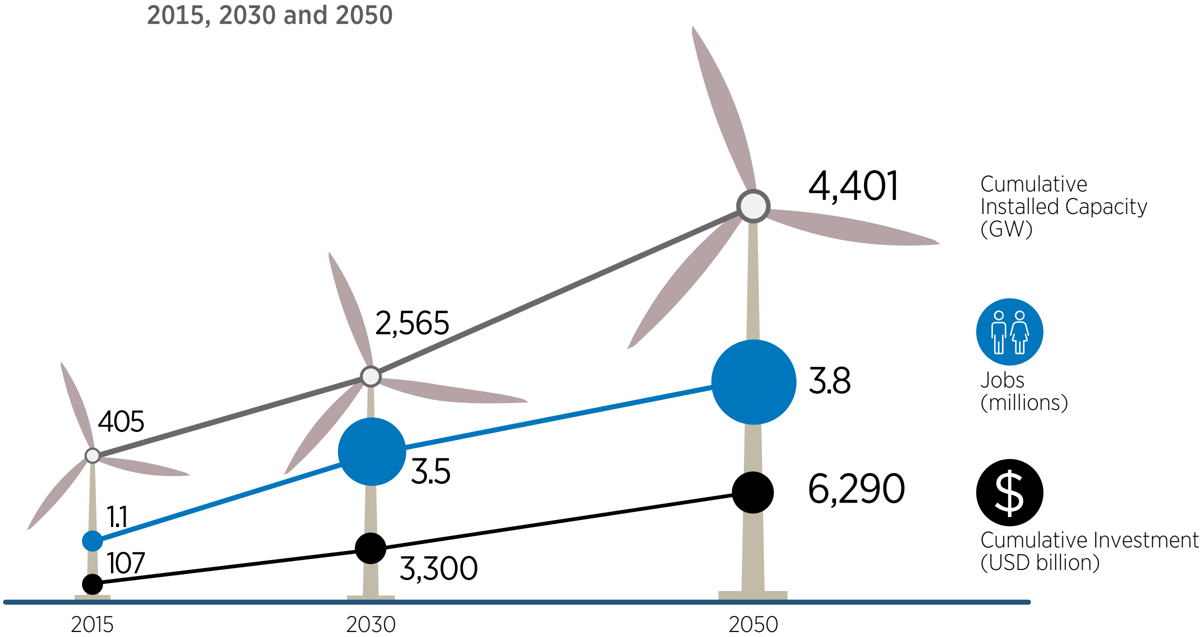
The first section of the report discusses the current and projected socio-economic benefits of wind energy deployment. The second section analyses the requirements (in terms of skills, materials and equipment) to develop wind projects along each segment of the value chain. The third section presents recommendations on how to maximise value creation from the development of a domestic wind industry while leveraging existing industries.

[1] Public information comes from the following institutions: ABB, Acciona, ACWA Power, the African Wind Energy Association, the American Council on Renewable Energy, the Asociación de Productores de Energías Renovables (APPA), the Asociación Empresarial Eólica, the China Datang Corporation, the China Guodian Corporation, Clean Energy Resource Teams, the Danish Energy Agency, Delattre Levivier Maroc, Deutsche Energie Agentur, EDF, EDP Renovavéis, Enel Green Power, Enercon, EURO FORES, Fraunhofer, Gamesa, GE, Gestamp Wind, the Global Wind Energy Council, Goldwind, Iberdrola, the Inter-American Development Bank, the International Energy Agency, the International Monetary Fund, the Latin America Wind Energy Association, LM Wind Power, NextEra Energy, Nordex, North American Wind Power, REN21, Schneider, Senvion, Siemens, Sinovel Wind Group, Suzlon Energy, the UK Energy Agency, the UK Renewable Association, United Power, the US Department of Energy, Vestas, WindEurope and the World Bank.

1. VALUE CREATION IN THE WIND ENERGY SECTOR

The installed capacity of wind energy has risen steadily for nearly two decades, increasing from about 92.5 gigawatts (GW) in 2007 to more than 466.5 GW in 2016, out of which about 452.5 GW is onshore (IRENA, 2017b). IRENA estimates that achieving the energy transition in the G20 countries would require cumulative investments in the wind energy sector of about USD 3.3 trillion by 2030 and USD 6.3 trillion by 2050 (IRENA, 2017a). Such investments can create value, and result in socio-economic benefits including income generation and job creation (see Figure 1).

Figure 1 **Estimated cumulative capacity, investments and employment in wind, 2015, 2030 and 2050**



Note: Investment in 2015 is annual, not cumulative.
Sources: IRENA, 2016b; IRENA, 2017a

Worldwide employment (direct and indirect) in onshore and offshore wind energy grew at a steady pace reaching 1.2 million jobs in 2016 (see Box 2). Furthermore, wind power could support more than 3.8 million jobs in 2050 (IRENA, 2017b) (see Figure 1).

Box 2 ■ Overview of jobs in wind energy in 2016

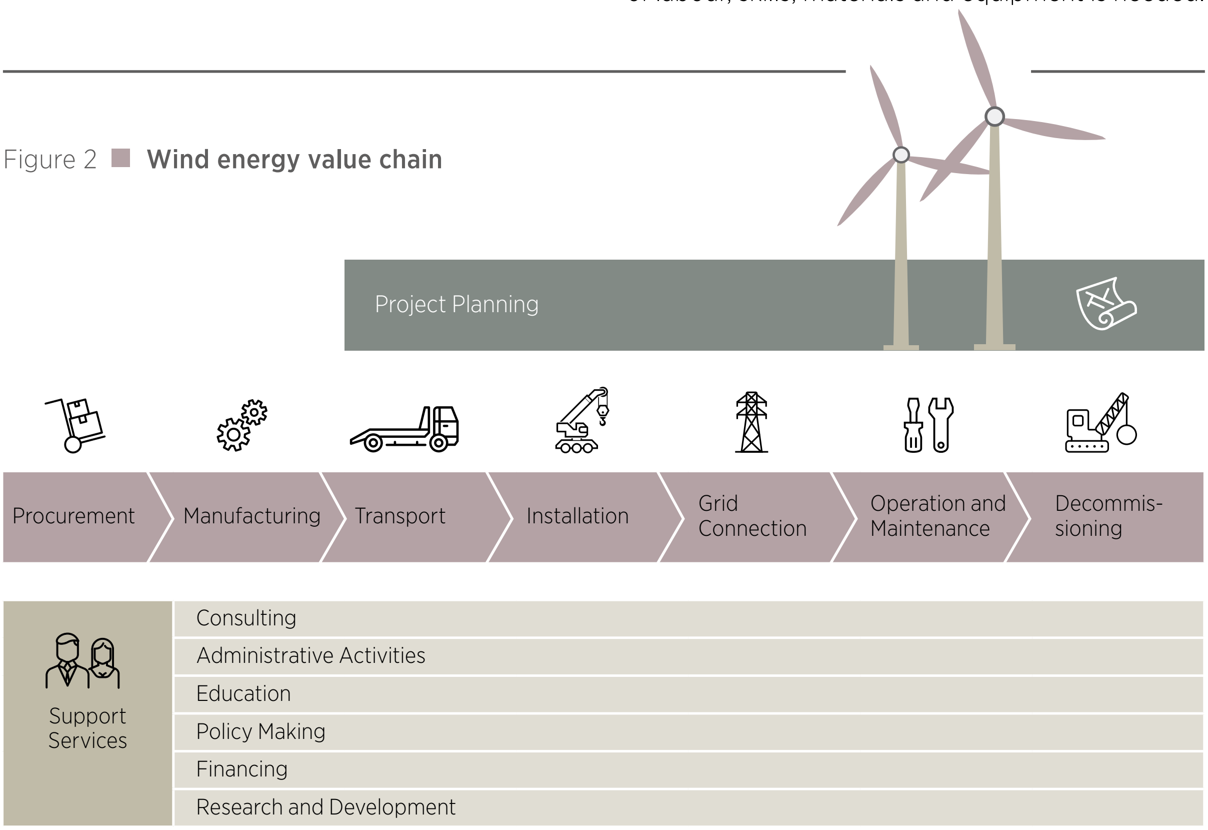
The wind energy sector employed an estimated 1.2 million in 2016, primarily fuelled by deployment in China, the United States, Germany, India and Brazil. More than half of these jobs were in Asia, where the share of global wind energy employment increased from 54 percent in 2014 to 56 percent in 2016. Over this period, employment in the sector rose by 35 percent in North America, 9 percent in Latin America, and 3 percent in the European Union.

Source: IRENA, 2017b

For a country deploying wind energy, the potential to generate income and create jobs will depend on the extent to which the local industry along the different segments of the value chain can leverage existing economic activities, and create new ones. The analysis in this study focuses on the core segments of the value chain: project planning, procurement, manufacturing, transport, installation and grid connection, operation and maintenance (O&M) and decommissioning (see Figure 2)[2].

In designing policies to support value creation from the development of a domestic wind industry, a deeper understanding of the requirements in terms of labour, skills, materials and equipment is needed.

Figure 2 ■ **Wind energy value chain**



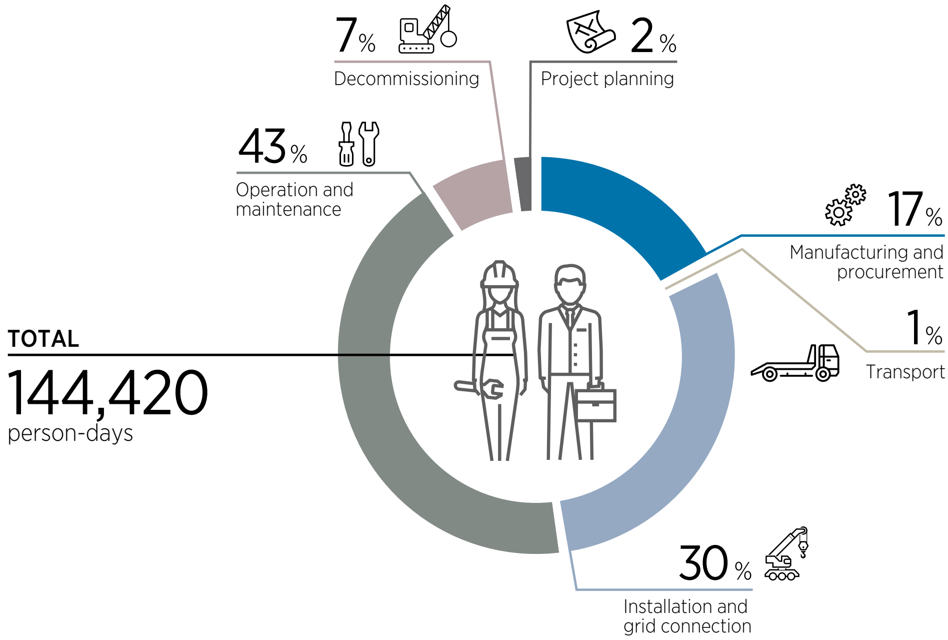
[2] An analysis of the support services is beyond the scope of this study.

2. REQUIREMENTS FOR ONSHORE WIND ENERGY DEVELOPMENT

The manufacturing and installation of wind turbines are the main cost components in developing wind projects, accounting for 64–84 percent of an onshore wind project's total installed costs (IRENA, 2016c). These activities offer considerable opportunities for value creation.

With a total of 144,420 person-days needed to develop a wind farm of 50 megawatt (MW), labour requirements vary across the value chain. As illustrated in Figure 3, there is a heavy concentration in operation and maintenance (43 percent of the total)[3], installation and grid connection (30 percent) as well as equipment manufacturing (17 percent).

Figure 3 **Distribution of human resources required along the value chain for the development of a 50 MW wind farm, by occupation**

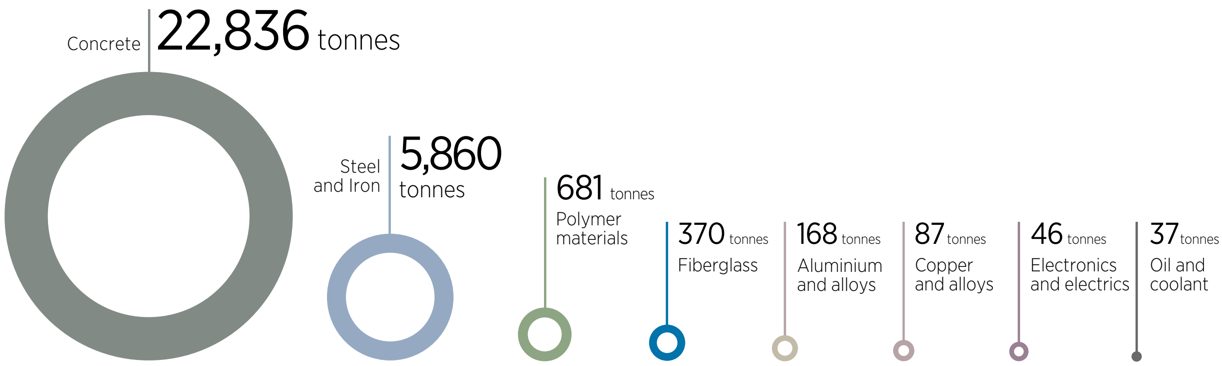






[3] The person-days required for the first year of O&M is estimated to be 2,665. The total is cumulative person-days over 20 years of project lifetime, assuming labour productivity improvement of 0.4% per year.

Figure 4 ■ **Materials needed to develop a 50 MW wind farm (tonnes)**



Source: Vestas, 2015

Figure 4 illustrates the quantities of materials needed to develop a 50 MW wind farm with 2 MW turbines. Table 1 shows the distribution of the materials needed along the main components of a wind farm. It covers the labour, materials, equipment and information required for each segment of the value chain. Almost 23,000 tonnes of concrete are needed for the foundations, and nearly 6,000 tonnes of steel and iron go into the turbines and the foundations, constituting the bulk of the material needed. More than 360 tonnes of fiberglass go into the turbines and almost 700 tonnes of polymers are needed for the turbines and cables. While not very significant in terms of weight (low density), these materials remain essential for the production of components locally.

Table 1 ■ **Distribution of the materials needed to develop a 50 MW wind farm (tonnes), by component**

MATERIAL	Turbines	Foundations	Cables	Site switch-gears and transfomers
Concrete	–	22,836	–	–
Steel and iron	4,607	1,228	–	25
Fiberglass	368	–	1	1
Polymer materials	325	1	355	–
Electronics/electrics	46	–	–	–
Copper and alloys	32	1	41	13
Oil and coolant	18	–	–	19
Aluminium and alloys	9	–	159	–

Source: Vestas, 2015

2.1 Project planning

Activities at the project planning phase include site selection, technical and financial feasibility studies, engineering design and project development. In the first two activities, the resource potential of a site is measured and the environmental and social impacts of the project are assessed. Engineering design covers the technical aspects of the mechanical and electrical systems; the civil engineering work and infrastructure; the construction plan; and the O&M model. Project development consists of administrative tasks, such as obtaining land rights, permits, licenses and approvals from different authorities; managing regulatory issues; negotiating and securing financing and insurance contracts; contracting engineering companies; negotiating the rent or purchase of the land; and managing the procurement processes.

Site selection

Feasibility studies

Engineering design

Project development

Table 2 **Human resources required for the project planning of a 50 MW wind farm (person-days) and breakdown by activity**

TYPE OF HUMAN RESOURCES	Site selection	Feasibility analysis	Engineering design	Project development	Total by occupation
Legal, energy regulation, real estate and taxation experts	140	60	100	720	**1,020**
Financial analysts	–	30	–	700	**730**
Logistic experts	–	–	–	360	**360**
Electrical/civil/mechanical/ energy engineers	50	90	150	–	**290**
Environmental experts	50	30	–	–	**80**
Health and safety experts	–	–	50	–	**50**
Geotechnical experts	50	–	–	–	**50**
Total (as %)	**290** (11 %)	**210** (8 %)	**300** (12 %)	**1,780** (69 %)	**2,580**

Planning a 50 MW wind farm with 2 MW turbines requires an estimated 2,580 person-days of labour. Project development activities account for about 70 percent of this labour (1,780 person-days), followed by engineering design (12%), site selection (11%) and feasibility analysis (8%). Table 2 presents a breakdown of the total labour force needed in project planning by activity.

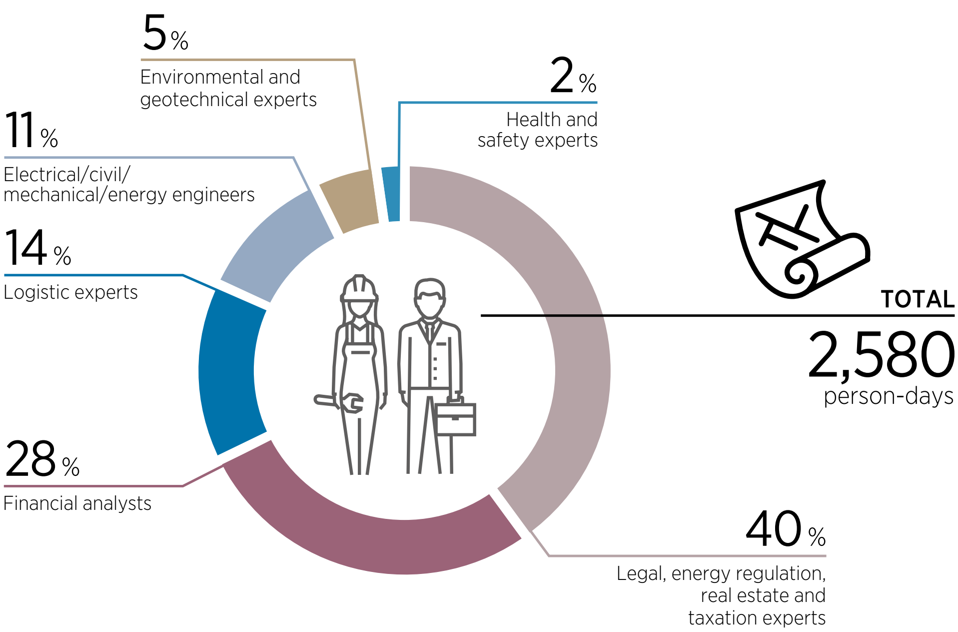
As for the skills needed, almost 40 percent of the labour (1,200 person-days) falls in the 'legal, energy regulation, real estate and taxation experts' category, indicating the importance of knowledge of the local context. While some of these needs can be fulfilled by foreign experts, they offer considerable opportunities for domestic employment. About 16 percent of the total labour (420 person-days) requires specialised engineers, and environmental and geotechnical experts with knowledge of the wind sector (see Figure 5). These professionals can be hired from abroad on a temporary basis or skills can be developed domestically through education and training policies designed to meet future skills needs in the sector.

Project planning requires equipment to measure wind resources at the site selected, such as anemometers and wind vanes, along with wind energy simulators and programmes to measure wind speeds and direction and predict wind behaviour.[4] Computers and software to run simulations and produce feasibility analyses are also required.

Technical information is necessary to identify soil characteristics and climatic features at the site (such as snow or sand storms) that might affect a project's structural and operational requirements or place limitations on the wind turbines. Information about policies and regulations related to support schemes for renewable energy, grid connection and land use is crucial for determining whether to proceed with the development of a wind farm.

In the project development stage, planners decide whether to procure domestically manufactured components (if available) or from foreign suppliers. The cost of technology and enabling conditions created by policies that support manufacturing, such as taxes on imports or local content requirements, affect this decision.

Figure 5 **Distribution of human resources required for the project planning of a 50 MW wind farm, by occupation**



[4] IRENA's *Global Atlas* provides high-resolution maps displaying suitability for projects according to the resource intensity, distance to power grids, population density, land cover, topography, altitude and protected areas.

2.2 Manufacturing and procurement

The main components of a wind turbine that decision makers may consider manufacturing domestically are the nacelle (along with its subcomponents)[5], the blades, the tower and the monitoring and control system.

Decisions concerning the local manufacturing of wind components are mainly driven by the expected local/regional demand for wind energy and will depend on: 1) the existence of government policies incentivising local value creation; 2) the availability of raw materials and presence of related domestic industries; and 3) the high costs and logistical challenges related to transporting bulky equipment.

Manufacturing the main components of 50 MW wind farm requires 19,000 person-days. The nacelle, along with its subcomponents, is the part that needs the most work (almost half of the total). The blades and tower each require another 24 percent of the total person-day requirements (see Table 3).

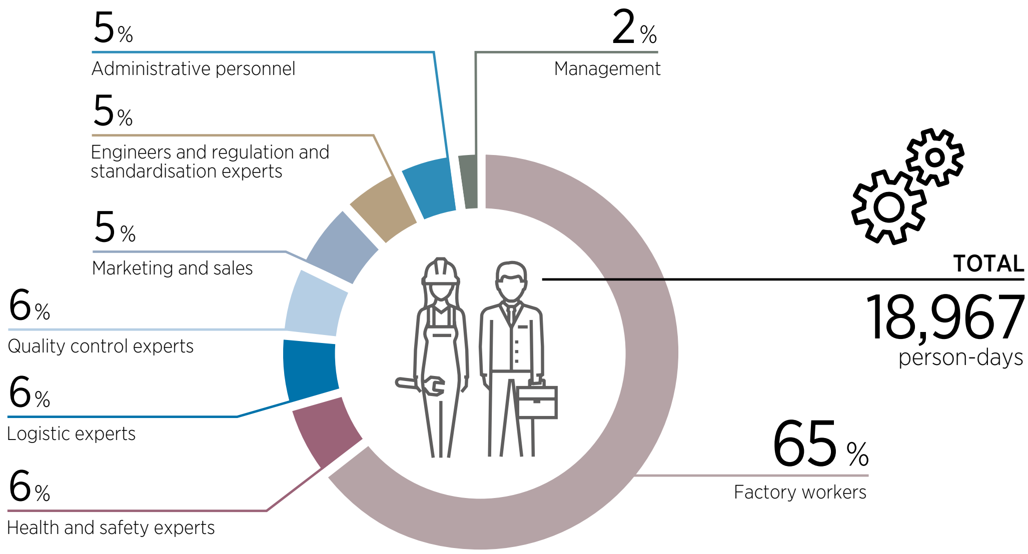
Much of the labour and skill requirements to produce the main components is low to medium skill jobs. Indeed, 66 percent of the labour required (12,500 person-days) to manufacture turbines is factory labour (see Figure 6), with medium to low skills related to wind energy. This may constitute a valuable proposition for governments to offer incentives for local manufacturing. The production of the technologically advanced subcomponents, such as the gearbox, the generator and the electronics requires highly specialised skills, which may not always be easy to source locally. Figure 6 shows the distribution of human resources required to manufacture the main components of a 50 MW wind farm by occupation.

Table 3 **Human resources required to manufacture the main components of 50 MW wind farm (person-days) and breakdown by main component**

TYPE OF HUMAN RESOURCES	Nacelle	Blades	Tower	Monitor and control system	Total by occupation
Factory workers	5,890	3,400	2,850	300	**12,440**
Health and safety experts	620	125	300	30	**1,075**
Logistic experts	620	125	300	15	**1,060**
Quality control experts	620	125	300	15	**1,060**
Marketing and sales personnel	480	290	230	45	**1,045**
Industrial engineers	480	277	232	15	**1,004**
Administrative personnel	480	113	230	45	**868**
Management	185	110	90	–	**385**
Telecommunication and computer engineers	–	–	–	15	**15**
Regulation and standardisation experts	–	–	–	15	**15**
Total (as %)	**9,375** (49%)	**4,565** (24%)	**4,532** (24%)	**495** (3%)	**18,967**

[5] Housing that includes all of the generating components in a wind turbine, including the generator, gearbox, drive train, and brake assembly.

Figure 6 ■ **Distribution of human resources required to manufacture the main components of a 50 MW wind farm, by occupation**



Although building a domestic manufacturing capacity for wind turbines has the potential to create employment and income, this phase is very capital-intensive. Moreover, in some countries where wind energy growth was slower than anticipated, capacity may have exceeded demand. In 2014, for example, global demand for wind turbines was estimated at less than 47 GW while manufacturing capacity exceeded 71 GW (Navigant Research, 2014). Some manufacturers in China, the United States and Europe were running below capacity and struggling for survival, leading them to consider moving factories overseas where wind development was picking up at a faster rate (AAE, 2014). Value creation from domestic manufacturing therefore requires the existence of a long-term market with growing demand for wind energy, which relies on support for locally produced equipment, access to finance and skills, competitiveness in the regional and global market and access to subcomponents (some highly specialised) and raw materials.

Maximising value creation from the development of a domestic wind industry relies on leveraging existing capacities used in other industries, such as aeronautics and construction, that can provide expertise, raw materials and intermediary products such as steel, concrete, aluminium, copper, fiberglass and glass-reinforced plastic. Table 4 shows the quantities of materials needed to manufacture the main components of a 2 MW turbine.

In terms of weight composition of each of the main components, the nacelle, including the gearbox and frame, is mostly made of steel and iron and casting material (around 56% and 35% of total weight respectively). The rotor including the blades is mostly composed of fiberglass, casting material, and steel and iron (almost 40%, 30% and 22% of total weight respectively). As for the tower, it is mostly made of steel and iron (see Figure 7).

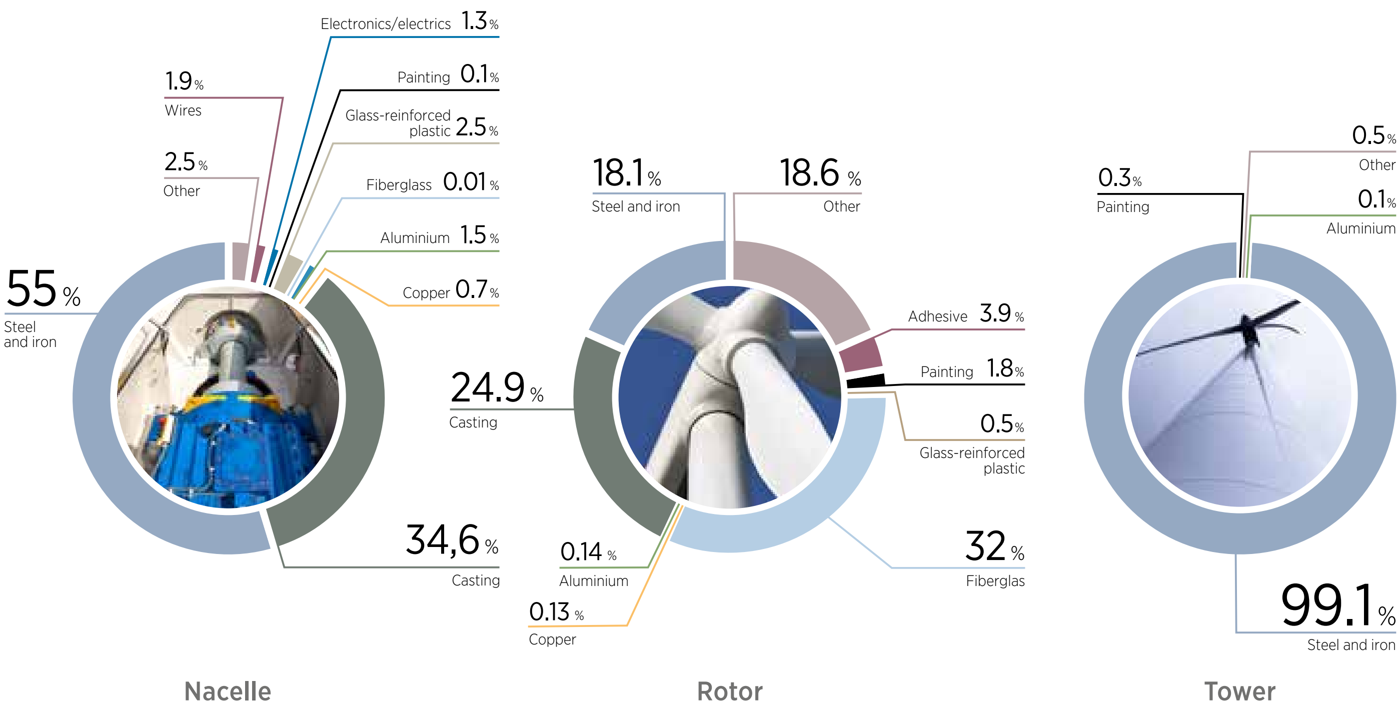
Table 4 **Materials needed to manufacture the main components of a 2 MW wind turbine (kilograms)**

Component	Nacelle			Rotor			Tower	Total
MATERIAL	Gearbox	Frame	Other	Blades	Hub[a]	Other		
Steel and iron	8,159	2,963	26,221	898	–	5,992	188,179	**232,412**
Casting	8,008	10,900	4,730	–	8,360	1,086	–	**33,084**
Fiberglass	–	–	10	12,152	–	–	–	**12,162**
Glass-reinforced plastic	3	–	1,713	–	–	186	–	**1,902**
Painting	38	1	36	682	–	–	580	**1,336**
Aluminium	3	54	978	–	–	50	237	**1,322**
Wires	–	–	1,280	–	–	–	–	**1,280**
Electronics/ electrics	192	–	713	–	–	–	–	**905**
Copper	–	–	522	53	–	2	–	**577**
Adhesive	–	–	–	1,475	–	–	–	**1,475**

a) Component of a wind turbine to which the blades are affixed

Source: Gamesa, 2013

Figure 7 **Materials needed to manufacture the main components of a 2 MW turbine**



Manufacturing the main components of wind turbines requires specialised equipment (see Table 5). It also requires welding, lifting and painting machines that are used in other industries, such as construction or the aeronautics industry.

Table 5 **Equipment needed to manufacture wind turbines**

Nacelle	Blade	Tower
• Lifting equipment • Welding equipment • Shot peening machines • Polishing equipment • Automated Paint Machines • Testing dock	• Vacuum bag moulding machine • Resin transfer moulding – LITE machine • Vacuum infusion moulding machine • Open moulding (hand lay-up, spray-up) machine • Liquid moulding composite machine • In mould coating (IMC) • Bonding and assembly • Composite tooling manufacture • Robotic routing and water jet • Automated paint machines • Painted or gel-coated surface finishers	• Heavy cranes • Rolling machine • Welding machines (different technologies depending on process) • Shot peening machines • Material handling equipment • Automated Paint Machines • Inspection equipment (NDT)

One of the biggest challenges facing the industry is transporting bulky parts, sometimes over long distances. Issues faced can include traffic congestion, road damage, the need for complex coordination and high costs. A single turbine can have blades 80 meters long weighing 33 tonnes each; it can require up to eight truckloads to transport it by land (one for the nacelle, one for the hub, three for the blades and three for the tower sections). For instance, one 150 MW wind farm in the United States required 689 truckloads, 140 railcars and 8 vessels (CN, 2009). Transport costs increase with the size of the turbines and the wind farm as well as with the distance travelled.

To reduce these costs, large turbine manufacturers are shifting parts of their supply chains to markets with high expected demand, such as Latin America. Domestic manufacturers in new markets produce bulky parts such as blades and towers (leveraging local steel and fiberglass industries if existent), following specifications and standards imposed by the main manufacturing company. The manufacturer generally produces the generator, gearbox and bearings, all of which require specialised knowledge.

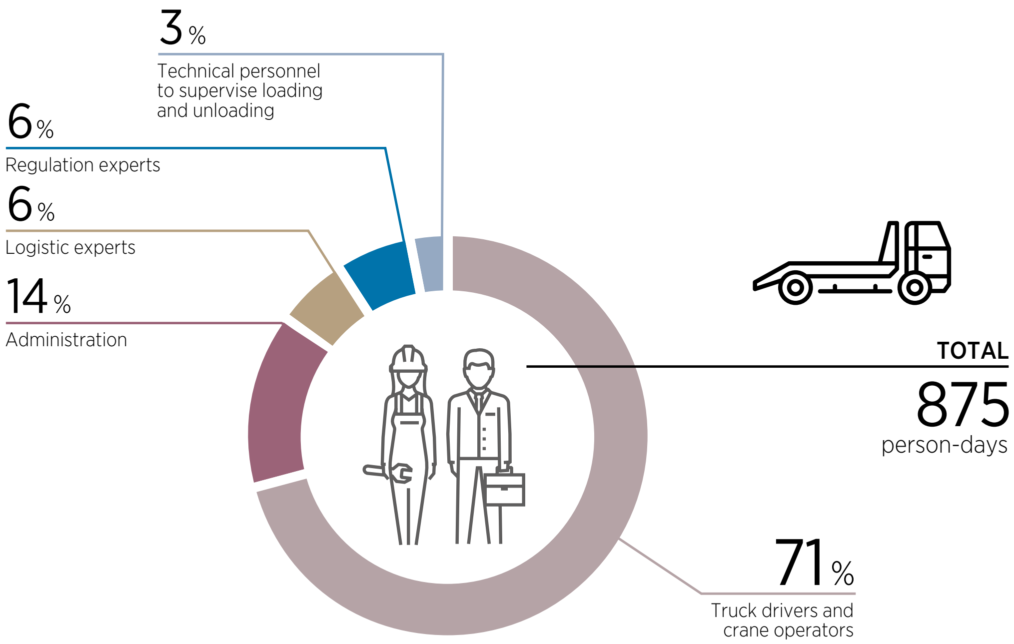
2.3 Transport

The estimated cost of transporting the components of a 50 MW wind farm by truck over a distance of 300 miles (480 km) can reach up to USD 750,000.

It takes about 875 person-days to transport the components of a 50 MW wind farm 300 miles by truck, most of which can be sourced domestically. The distribution of human resources needed is shown in Figure 8. Almost 70 percent of the labour needed consists of truck drivers and crane operators, who may require certified skills in some countries, but can generally be hired locally.

Special equipment needed includes high-capacity trucks and trailers that are specifically designed for transporting blades. Freight rail can be used if the land is flat and tunnels, bridges and sharp curves can be avoided. Moreover, vessels can be used if the transport is carried out by sea, with cranes needed to lift the equipment onto the truck or the vessel. The installation phase can start in parallel with the transport of equipment.

Figure 8 ■ **Distribution of human resources required to transport the components of a 50 MW wind farm (25 x 2 MW turbines), by occupation**



2.4 Installation and grid connection

The installation and grid connection phases last 12–20 months. They offer good opportunities for value creation, particularly where existing resources (equipment, labour and expertise) can be leveraged.

Installing and connecting a wind turbine takes about 34,500 person-days. The most labour-intensive activity is site preparation and civil works, which accounts for about half of the total (16,600 person-days). This activity is always sourced domestically, creating many opportunities for employment, especially for low- to medium-skilled workers. Assembling equipment account for 30% of the total labour needed, followed by cabling and grid connection (19% of the total) and commissioning (4%) (see Table 6).

More than three-quarters of the person-days require construction workers and technical personnel, most of whom are available domestically. The second-most prevalent occupations for the phase are crane operators and truck drivers, which account for about 10 percent of the total labour force (see Figure 9).

Site preparation and civil works

Assembling equipment

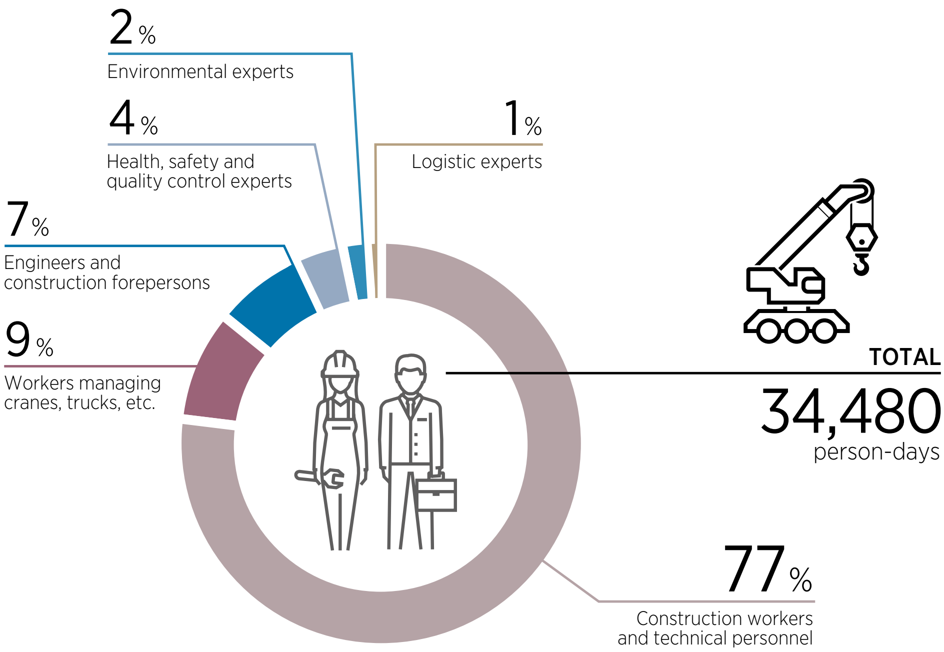
Cabling and grid connection

Commissioning

Table 6 **Human resources required to install and connect a 50 MW wind farm (person-days) and breakdown by activity**

TYPE OF HUMAN RESOURCES	Site pre-paration and civil works	Assembling equipment	Cabling and grid connection	Commis-sioning	Total by occupation
Construction workers and technical personnel	13,600	6,000	6,000	1,000	**26,600**
Professionals managing cranes, trucks, etc.		3,000			**3,000**
Engineers and construction foremen	1,320	600			**1,920**
Health and safety experts	720	600	100	100	**1,520**
Environmental experts	720				**720**
Electrical and mechanical engineers			180	200	**380**
Logistics experts	240				**240**
Quality control experts	–		100		**100**
Total (as %)	**16,600** (48 %)	**10,200** (30 %)	**6,380** (19 %)	**1,300** (4 %)	**34,480**

Figure 9 **Distribution of human resources required to install and connect a 50 MW wind farm, by occupation**



Materials and equipment needed for the installation phase are available in most countries. Materials include concrete (for the foundation), steel and iron, polymers, aluminium and alloys and copper (for cables). Highly porous soil requires a deeper foundation, which increases the amount of concrete needed. Equipment includes loaders, cranes, high-tonnage trucks and excavators as well as supervisory control and data acquisition (SCADA) equipment, electrical and electronic instrumentation and control systems used for grid connection.

2.5 Operation and maintenance

The operation and maintenance phase of a wind farm covers the expected lifetime of about 25 years. Modern wind farms are automated and controlled by SCADA. Their operation is normally monitored remotely, by operators who reset the systems after line or grid outages.

Preventive and corrective maintenance represents almost half of the total O&M costs of the companies surveyed for this report (see Table 7), followed by management and administration (about 20 percent of the total cost). It is usually undertaken by the turbine manufacturer as part of an O&M agreement tied to the sale of the turbine or subcontracted to engineering companies.

Although O&M itself is generally not handled locally, a large share of O&M costs is spent domestically (such as insurance and land rental).

Table 7 **Annual operation and maintenance costs of a typical wind farm (USD/MW) and breakdown by cost component**

COST COMPONENT	Annual cost (USD/MW)	Percent of total
Turbine maintenance	20,100 – 24,500	**47.6 – 49.3**
Management and administration	8,100 – 9,900	**19.2 – 19.9**
Insurances	7,500 – 9,800	**18.9 – 18.4**
Land rental	4,000 – 6,000	**11.7 – 9.8**
Electrical installation maintenance	1,100 – 1,300	**2.6**
Total	**40,800 – 51,500**	**100**

Source: Based on data provided by European renewable energy project developers with wind energy installed capacity in China, Italy, Portugal, Spain and the United States.

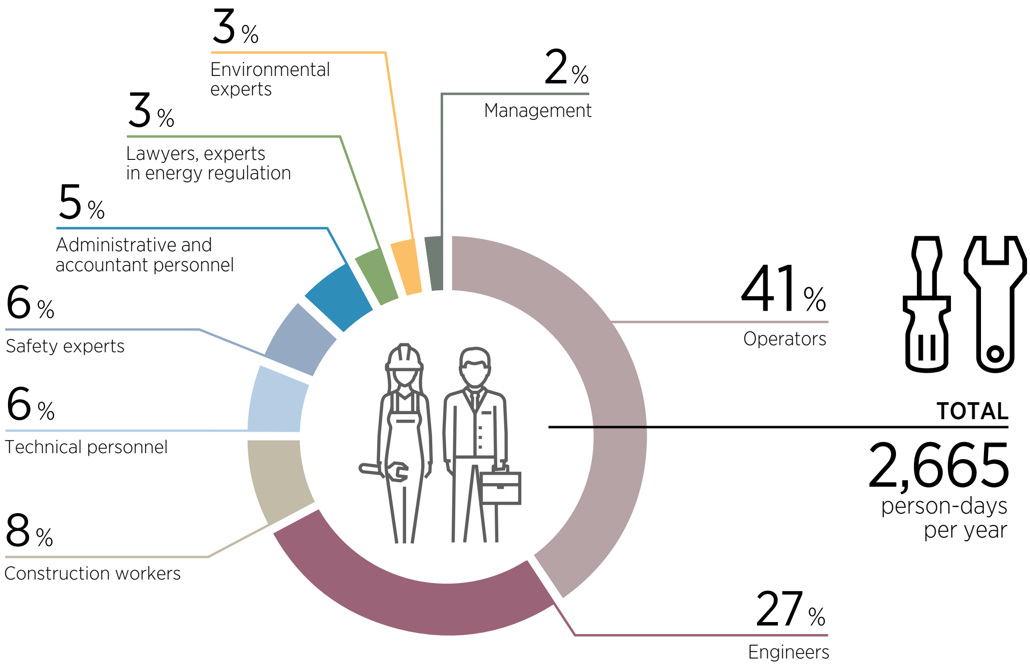
Operating and maintaining a 50 MW wind farm requires about 2,665 person-days per year. Of these, 66 percent are for operations (almost 1,800 person-days per year) and 34 percent for maintenance (almost 900 person-days per year) (see Table 8).

A skilled workforce with solid knowledge of wind farm operations makes up the majority of the human resources needed. Out of the almost 1,800 person-days per year required for operation, more than 1,000 are high-skilled operators, equivalent to more than 40 percent of the total O&M labour force. Highly skilled industrial and telecommunication engineers together account for another 720 person-days per year, around 27% of total O&M labour requirements (see Figure 10).

Table 8 **Human resources required to operate and maintain a 50 MW wind farm (person-days per year)**

TYPE OF HUMAN RESOURCES	Operation	Maintenance	Total by occupation
Operators	1,100	–	**1,100**
Telecommunication engineers	220	150	**370**
Industrial engineers	125	225	**350**
Construction workers	–	220	**220**
Technical personnel	–	150	**150**
Safety experts	–	150	**150**
Administrative and accountant personnel	125	–	**125**
Lawyers, experts in energy regulation	80	–	**80**
Environmental experts	80	–	**80**
Management	40	–	**40**
Total (as %)	**1,770** (66 %)	**895** (34 %)	**2,665**

Figure 10 **Distribution of human resources required to operate and maintain a 50 MW wind farm, by occupation**



2.6 Decommissioning

Finally, decommissioning a wind farm involves planning the activity, dismantling the project, recycling/ disposing of the equipment and clearing the site. These activities can usually be handled locally.

It takes about 8,420 person-days to de-commission a 50 MW wind farm. The most labour-intensive activity is dismantling the equipment and it requires 6,220 person-days (77 percent of the total). Clearing the site and disposing of equipment requires 1,220 and 900 person-days respectively (14 and 11 percent of the total) (see Table 9).

Technical and construction workers perform 65 percent of all decommissioning work. The second most-needed occupations in this phase are truck drivers and crane operators, who account for 20 percent of the total work (see Figure 11).

The equipment needed is the same as that required for construction and installation – all of it commonly available in countries with functioning construction sectors.

Planning the decommissioning

Dismantling the project

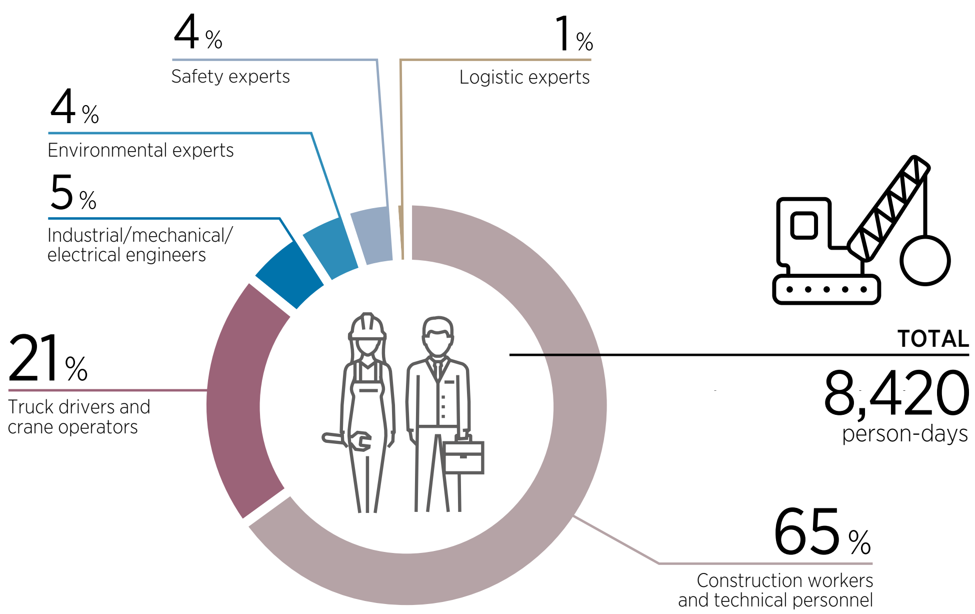
Disposing/recycling the equipment

Clearing the site

Table 9 **Human resources required to decommission a 50 MW wind farm (person-days) and breakdown by activity**

TYPE OF HUMAN RESOURCES	Planning	Dismantling	Disposing of equipment	Clearing the site	Total by occupation
Construction workers and technical personnel		3,700	800	1,000	**5,500**
Truck drivers and crane operators		1,800			**1,800**
Industrial/mechanical/ electrical engineers	30	360		40	**430**
Environmental experts	25	180	40	90	**335**
Safety experts		180	40	90	**310**
Logistic experts	25		20		**45**
Total (as%)	**80** (1%)	**6,220** (74%)	**900** (11%)	**1,220** (14%)	**8,420**

Figure 11 **Distribution of human resources required to decommission a 50 MW wind farm, by occupation**



3. CONCLUSION

The socio-economic benefits of renewable energy have become a key consideration in building the case for its wide deployment. Increasingly, governments see the potential to fuel economic growth, create employment opportunities and enhance welfare by investing in renewable energy.

Opportunities for domestic value creation can be created at each segment of the value chain, in the form of jobs and income generation for enterprises operating in the country.

To assess the case for domestic industry participation in onshore wind farm development, policy makers need to analyse the labour, materials and equipment requirements of each segment of the value chain. Based on such an analysis, opportunities for leveraging local labour markets and existing industries can be identified to maximise domestic value. Regional and global market dynamics also strongly influence the decision to pursue domestic industry development.

To realise the full range of socio-economic benefits from the development of renewable energy, a conducive environment needs to be established. Should countries choose to support the development of a local industry, a broad mix of policies are required, including those related to deployment and to other sectors of the economy:

- Setting clear targets for renewable energy development provides a long-term view of the market's development trajectory. These are effective when accompanied by suitable deployment policies which provide a stable and predictable environment for attracting investments into the sector.
- To meet the human resource requirements associated with deployment targets, education and training policies would need to consider the skills needs of the wind energy sector which would increase opportunities for local employment.
- To strengthen the industrial capability of domestic firms, policy measures and interventions are needed that contribute to increased competitiveness. Measures include industrial upgrading programmes, supplier development programmes, promotion of joint ventures, development of industrial clusters and investment promotion schemes.
- To ensure the full-fledged development of a nascent industry, policy support should be time-bound and include broader aspects beyond deployment, human resources and industrial development.

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