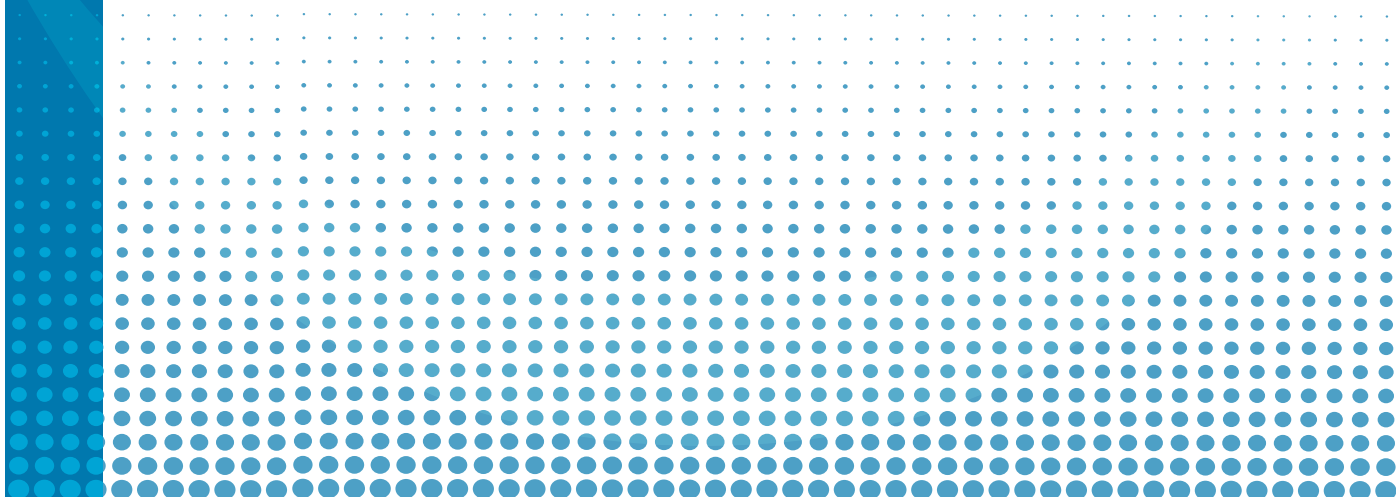


# Renewable Energy Jobs:

STATUS, PROSPECTS & POLICIES

BIOFUELS AND GRID-CONNECTED  
ELECTRICITY GENERATION



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Renewable Energy Jobs: Status, Prospects & Policies

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# Acronyms

**APEC EWG** - Asia-Pacific Economic Cooperation Energy Working Group

**BNEF** - Bloomberg New Energy Finance

**GCN** - Global Climate Network

**GSEP** - Global Sustainable Energy Partnership

**GSPR** - General Secretariat of the Presidency of the Republic (Brazil)

**IIGC** - International Investors Group on Climate Change

**IILS** - International Institute for Labor Studies

**ILO** - International Labour Organization

**IOE** - International Organization of Employers

**IPCC** - Intergovernmental Panel on Climate Change

**ITUC** - International Trade Union Confederation

**MWGSW-CEM** - Multilateral Working Group for Wind and Solar Technologies-Clean Energy Ministerial

**REN21** - the Renewable Energy Policy Network for the 21st Century

**SEFI** - Sustainable Energy Finance Initiative

**UNEP** - United Nations Environment Program

# Key lessons for policy-makers

This working paper shows that large-scale renewable energy electricity and biofuels for transport industries involve a large variety of jobs, which differ in skill levels required, and may also differ according to the supply chain of technologies. Although data information is incomplete, 2010 estimates placed gross employment at over 3.5 million (REN21). Of these jobs, 630,000 were related to the wind industry; 350,000 to the solar PV industry; and as much as 1.5 million to biofuels. The majority of jobs are currently located in a small number of major economies – China, Brazil, Germany, India and the United States. Some countries have significant employment across a wide range of renewable energy technologies, whereas in others employment is clustered around a particular technology, such as wind power in Denmark or ethanol in Brazil.

For fuel-free renewable energy technologies, the greatest number of jobs is generally concentrated in the installation, manufacturing, and administration phase, while for fuel-based technologies feedstock production and distribution of biofuels account for the largest share. Even though labour productivity evolves through time, studies have shown that renewable energy technologies are currently more labour-intensive than fossil fuel technologies, with solar PV technology accounting for the highest number of job-years per GWh over the lifetime of the facility.

Projections indicate that there is considerable future potential for gross job creation in renewable energy. While the extent of employment effects may be debated, most studies suggest that renewable deployment can be associated with net job creation. However, the number of jobs will depend on a range of factors. Key among these are: success of deployment; industrial and labour policy; ability to take advantage of export markets; and the multiplier effects of deployment on the rest of the economy.

If job creation is to be one of the central motivations for developing and deploying renewable energy, government should account for the associated opportunity costs and balance them against the anticipated benefits. Policies to promote job creation should be formulated with reference to a country's specific circumstances. Experience suggests that employment benefits are more likely to be maximised where there are active labour market interventions to support acquisition of necessary skills. Further increases in jobs can be realised through the development of a manufacturing industry, which would call for further intervention.

The analysis of the current state of play, future potential and policy frameworks suggests the following key lessons for policy-makers.

1. **Caution is needed in relying on existing data.** The data on renewable energy jobs is generally weak and many studies rely on the same sources. The sample of countries is also low and may not necessarily be comparable for all economies. Moreover, many estimates are derived from countries with large-scale deployment and successful manufacturing industries. More information is needed on the net job impact of increased renewable energy deployment, but this can be expensive and highly sensitive to modelling assumptions.

- 2. There is potential for net job creation.** Available studies show that renewable energy is associated with significant gross job creation. Net effects are generally also shown to be positive. They will also vary across countries depending on the level of job losses elsewhere in the economy and the opportunity costs of deploying renewable energy. In making such an assessment, it is important to be clear as to which effects are attributable solely to an increase in renewable energy and which are caused by other factors. In particular, job losses in conventional energy to date have been the result of changes in the industry itself, not renewable energy deployment, although there is the potential for this to change in the future.
- 3. There are job opportunities across the whole value chain.** Although countries that manufacture, deploy and export renewable energy technologies are likely to create the largest number of gross jobs, countries without local and/or export industries will still enjoy employment benefits. Indeed, significant shares of renewable energy jobs exist at the point of project development and installation, as well as in operation and maintenance.
- 4. Job creation is one of the reasons that speak in favour of renewable energy.** Despite the weaknesses in the data available and the sensitivity of net job creation to underlying assumptions, it is unlikely that job benefits alone are a sufficient reason to deploy renewables. Assessing the value of job benefits is one part of a broader assessment needed to determine the cost-effectiveness of policies, including other important benefits of renewable energy, such as enhanced energy security, reduced carbon dioxide emissions, reduced energy price volatility, energy access improvements and technological development.
- 5. Sustainable job creation depends on stable and predictable deployment policies.** Assuming there are net employment benefits from deploying renewables, the jobs created will be cost-efficient when policies are stable, consistent, and long-term. In order for deployment policies to effectively fulfill their job creation potential along the renewable energy supply chain, policies should minimise non-economic barriers, as well as address economic barriers through various financing methods. Furthermore, support schemes for renewable energy are often explicitly used to stimulate job creation. However, greater efforts must be allocated towards ensuring the realisation of intended job benefits.
- 6. Industrial policy will influence the jobs that are created.** Although a range of installation and maintenance jobs are likely to be created by deployment alone, targeted industrial policy can help establish domestic manufacturing capacity with potential for access to export markets. Policies for the development of a domestic manufacturing industry can be aimed at both the demand and the supply side. On the demand side, financial and other incentives can be a key tool to establish manufacturing facilities and encourage demand for local components. On the supply side, government can support the establishment of manufacturing facilities in a number of ways, including fiscal measures, promotion of R&D, facilitation of technology transfer co-operation, and the training of human capital.
- 7. Increased training and education in renewables is crucial.** A wide range of skills are required in the renewable energy sector. In order to achieve deployment targets and maximise job benefits, it is necessary to facilitate and increase education and training. A large-scale shift to renewable energy will require some skills similar to those needed in the conventional energy workforce and other skills that are specific to certain renewable technologies. It is therefore advisable to conduct a skills mapping exercise to identify existing skills, and skills gaps. This should then be used to develop appropriate training and education policies. Other labour policies include taking into account existing skills strengths when formulating deployment and industrial policy; providing services to help match jobs and workers; and focusing job creation in areas with low employment. Constructive dialogue between government, business and unions can ensure that any needs and challenges are identified and addressed.



# Introduction

Over the past years, interest has grown in the potential for the renewable energy industry to create jobs. Governments are seeking win-win solutions to the dual challenge of high unemployment and climate change. By 2010, US\$ 51 billion had been pledged to renewables in stimulus packages (UNEP, SEFI & BNEF, 2010), and by early 2011 there were 119 countries with some kind of policy target and/or support policy for renewable energy, such as feed-in tariffs, quota obligations, favourable tax treatment and public loans or grants (REN21, 2011), many of which explicitly target job creation as a policy goal. Policy-makers in many countries are now designing renewable energy policies that aim to create new jobs, build industries and benefit particular geographic areas (IPCC, 2011).

But how much do we know for certain about the job creation potential for renewable energy?

This working paper aims to provide an overview of current knowledge on five questions:

1. How can jobs in renewable energy be characterised?
2. How are they shared out across the technology value chain and what skill levels are required?
3. How many jobs currently exist and where are they in the world?
4. How many renewable energy jobs could there be in the future?
5. What policy frameworks can be used to promote employment benefits from renewable energy?

This paper focuses on grid-connected electricity generation technologies and biofuels. Since the employment potential of off-grid applications is large, it will be covered by a forthcoming study by IRENA on job creation in the context of energy access, based on a number of case studies.



# 1. How can jobs in renewable energy be characterised?

In any sector, three job categories can be identified according to the level of proximity to the economic activity in question: direct, indirect and induced jobs (see Box 1). Renewable energy jobs can be classified further into jobs related to fuel-free technologies and jobs related to fuel-based technologies, which involve two different employment patterns according to their value chain.

## 1.1 JOBS RELATED TO FUEL-FREE TECHNOLOGIES

Fuel-free technologies, such as solar or geothermal heat and power, wind, ocean and hydro power, use energy inputs that are freely available and simply have to be harnessed. These technologies typically involve jobs in the processing of raw materials; the manufacture of technology; project design and management; installation and/or plant construction; operations and maintenance; and eventual

decommissioning. Depending on the technology, this can draw on a range of occupations, and the share of jobs can fall across different parts of the value chain.

As illustrated in **Figure 1** in the case of direct jobs related to solar PV, engineers and technicians will be required to process raw materials such as silicon or other semiconductor materials, depending on the exact make-up of the solar PV cell. Engineers and technical workers are also required for the assembling of the system components at the

### Box 1

#### DIRECT, INDIRECT AND INDUCED JOBS

**Direct jobs** are relatively easy to measure and understand. Although precise definitions vary, these are jobs related to a sector's core activities, such as feedstock conversion, manufacturing, project development (including site preparation and installation) and operations and maintenance. It must be noted, however, that countries may estimate direct employment according to a narrower or broader definition of the renewable energy industry, making cross-country comparison of estimates difficult.

**Indirect jobs** include all those involved in supplying the renewable energy industry. These are jobs in the industrial input sectors in the production and the operation and maintenance

of renewable energy technologies. Examples might include the labour required to extract and process raw materials, such as steel for wind turbine towers as well as positions in government ministries, regulatory bodies, consultancy firms and research organisations working on renewables.

**Induced jobs** are created when wealth generated by the renewable energy industry, directly or indirectly, is spent elsewhere in the economy, thus stimulating demand in industries that may be entirely unrelated. Renewable energy technicians, for example, may spend part of their wages on a holiday, thus inducing jobs in the tourism industry.

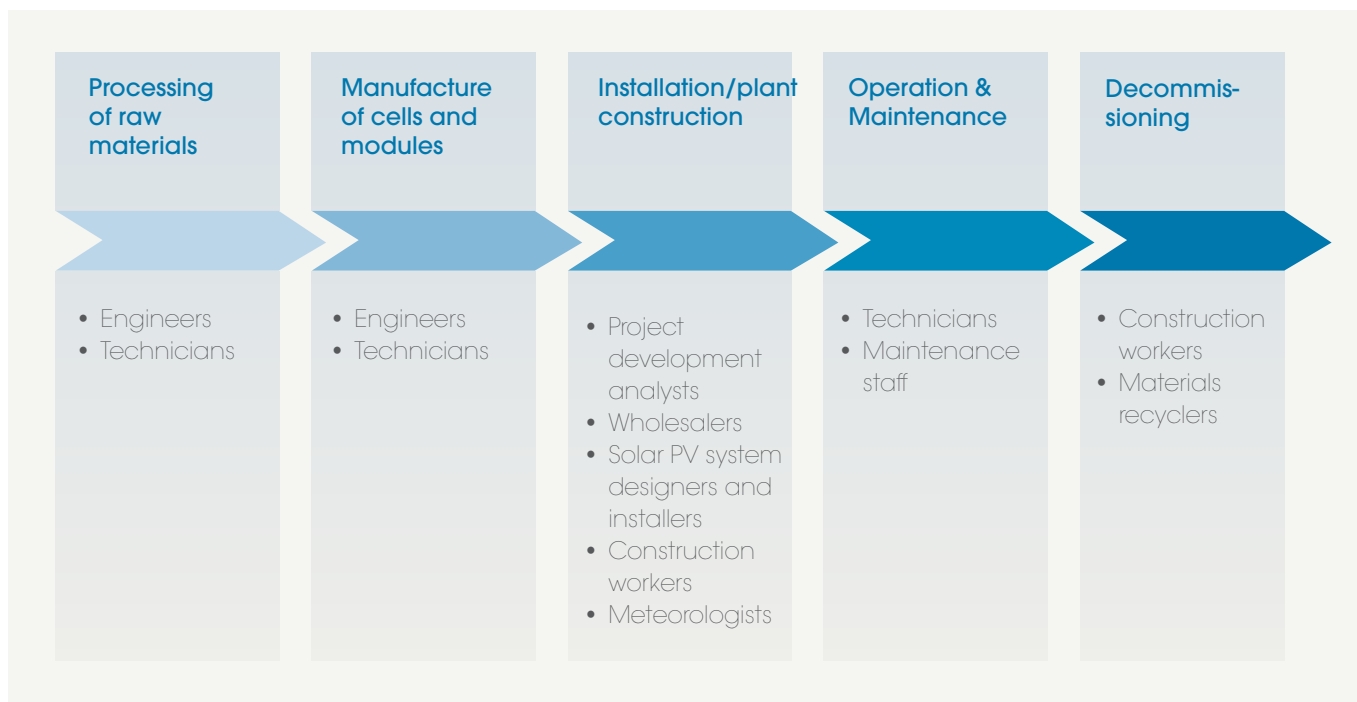


FIGURE 1. DIRECT JOBS ACROSS THE SOLAR PV VALUE CHAIN

Source: Authors' own compilation

manufacturing stage. The project development stage needs qualified personnel to conduct solar resource assessments, solar PV system designers, energy experts and business managers, financial analysts, as well as wholesalers. Construction workers, technical personnel and electricians will then be required for installation purposes. Maintenance during the lifecycle of the project will also involve technical staff. Finally, at the decommissioning stage, construction workers are needed, as well as jobs related to materials recycling.

The exact jobs across this general value chain will differ according to the technology in question. In the case of wind power, the supply chain includes a wide range of components, each requiring a specific set of skills and education: supply of raw materials (such as casting, forging, fibres, resins), manufacture of the components (mainly gearboxes, generators, bearings, converters, transformers), manufacture of turbines, blades and towers, project design, construction, and operation and maintenance.

Different skills are needed at each step of the value chain. Workers in manufacturing towers will require

experience with steel, and experience in high-precision production processes is needed in turbine manufacture. The project design will demand experts in resource assessment, engineers, and experts in finance. The construction of wind farms will be carried out by teams that have the capacity to lay foundations, erect turbine towers and will include crane operators to assemble the blades to the turbine. Operations and maintenance tasks are different too – from monitoring the smooth operation of turbines to cleaning blades and calibrating electronic sensors (Ayee, Lowe & Gereffi, 2008).

Regarding geothermal for power production, resource assessment entities, deep drilling companies, civil engineering services, supply companies, project developers, and power plant builders are needed. Drill and process engineering skills are also needed for heating and cooling technologies.

The value chain of fuel-free technologies also includes a wide range of indirect jobs. Scientists and engineers will contribute to the ongoing development of the industry through Research & Development (R&D). Energy specialists in

government and regional agencies are responsible for energy planning. Industries such as steel and concrete will supply raw materials. The trade of raw materials will also be facilitated by buyers and logistics professionals. Testing facilities and personnel may be needed to certify the quality of components and equipment. Some degree of loading and transport is required following processing, manufacture and decommissioning. Project development may involve energy consultancy firms and regulators. Administration personnel are required throughout.

## 1.2 JOBS RELATED TO FUEL-BASED TECHNOLOGIES

Fuel-based technologies, such as biomass-based electricity and generation and liquid biofuels for transport, require energy inputs that are not freely available, such as dedicated crops or bio-residues from various industries. The value chain of these technologies is different, ranging from the production/collection of feedstock; their processing into fuel; distribution of the fuel; and its ultimate combustion.

In the case of biofuels for transport, jobs related to feedstock production depend on the feedstock in question. For dedicated energy crops, agricultural jobs – such as farmers and seasonal labour – are required. Where industry residues are used, jobs are involved in their collection and pre-treatment. Refining ethanol and the transesterification of biodiesel requires workers such as chemists, machine operators and engineers, after which the biofuel can be distributed.

The use of biomass for power and heat generation creates similar jobs during feedstock production: farmers, seasonal labour and jobs in collection and pre-treatment. The jobs that are involved in the rest of the value chain depend on the type of fuel and technology used.

Solid biomass fuel, for example, is used in some industries – such as paper and pulp, lumber producers, furniture manufacturers, agricultural industries – to produce heat and/or power on-site. Typically, solid biomass fuel is produced as a by-product of the industry's primary production

process, thus requiring no employment related to transport. In other cases, forest slash or logging residues are processed on site into wood chips and then transported to a combustion site in order to produce power and/or heat in dedicated plants. This requires drivers and loaders to transport a regular supply of the fuel. Wherever combustion takes place, jobs are involved in the construction and operation of requisite installations. This might involve technical and financial analysts for project development, engineers and construction workers, plant operators, technicians and maintenance staff, and ultimately, decommissioning staff. Solid biomass fuel is also used extensively at the household level, for example, for heating in pellet boilers, which creates jobs in retail, installation and maintenance.

# 2. How are jobs shared out across the value chain and what skills are required?

## 2.1 JOBS ACROSS THE VALUE CHAIN

**Fuel-free technologies** that are on-grid, such as wind power and solar PV, tend to involve the highest levels of employment during manufacturing and construction. **Fuel-based technologies**, by contrast, are most labour-intensive at the point of feedstock production and, in the case of biofuels, distribution.

Research by Pollin, Heintz and Garrett-Peltier (2009) has estimated how jobs are shared out across the renewable and fossil energy sectors in the United States (**Figure 2**). In the study, manufacturing and construction represented over 50% of the jobs in the wind and solar PV sectors. Jobs in agriculture accounted for over 60% of employment in the biomass sector. Professional occupations – such as lawyers, accountants and technical or scientific personnel – also made up a significant proportion of employment across the renewable energy technologies. By contrast, the largest share of employment in the oil, natural gas and coal sectors was found in resource extraction and administrative and professional occupations.

It should be noted, however, that estimates of such shares can vary significantly among regions and countries as a result of economic conditions and methodology used. For instance, contrary to the estimation for the US by Pollin et al. (2009), Greenpeace and EPIA (2008) estimate that only 18% of jobs related to solar PV derive from manufacturing, as compared to 62% from installation.

## 2.2 SKILLS REQUIREMENTS

Many essential jobs in the renewable energy industry require a skilled workforce. Industry surveys in Germany have suggested that on average renewable energy jobs are relatively high-skilled, across both fuel-free and fuel-based technologies: 82% of employees in the industry have vocational qualifications and almost 40% of these have a university degree, compared to an average for the whole industrial sector of 70% and 10%, respectively (Lehr et al., 2011).

It is hard, however, to establish clear data on the exact proportion of unskilled to skilled jobs for different renewable energy technologies. This is partly because studies consider different scopes of direct and indirect jobs, and partly because countries have different educational norms.

Nevertheless, a range of skilled and unskilled occupations are involved in all renewable energy technologies, across their lifecycles. For fuel-free technologies, graduate level qualifications are necessary to fill positions in fields such as engineering, meteorology, project development and research and development. By contrast, jobs in areas such as system design and installation or construction are more likely to require vocational qualifications. A number of unskilled jobs may also be created in construction, as well as in indirect jobs, such as transport and administration.

The key variation in fuel-based technologies is the extent of vocational and unskilled labour that may be involved in the production or collection of fuel feedstock, such as farmers and seasonal labourers. Studies of Brazil, for example, have estimated that without mechanisation, unskilled agricultural and

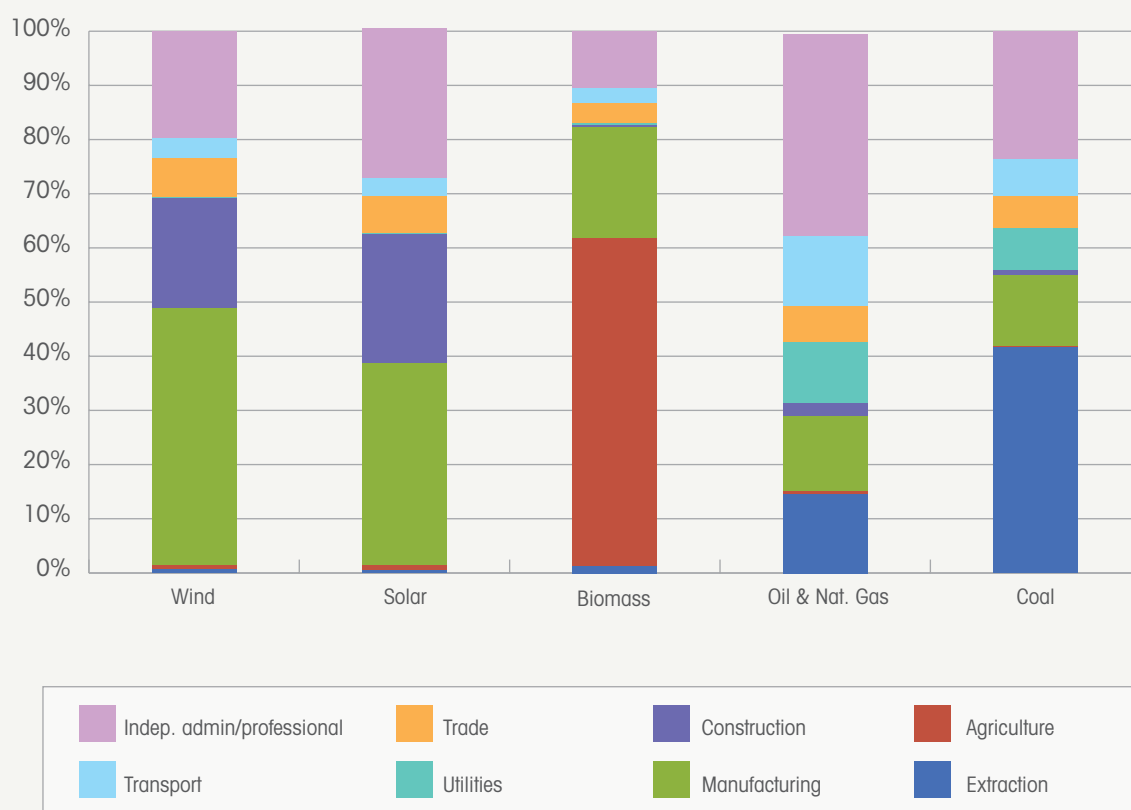


FIGURE 2. SHARE OF TOTAL JOBS ACROSS DIFFERENT PARTS OF RENEWABLE AND FOSSIL FUEL ENERGY SECTORS

Source: Pollin et al. (2009)

Note: percentages for solar energy and oil and natural gas do not sum exactly to 100% in the original source, presumably due to rounding.

industrial labourers make up 60% of the biofuels workforce, with semi-skilled truck and tractor drivers representing an additional 10% and the remaining 30% made up of skilled supervisors and industrial workers (APEC EWG, 2010). However, the introduction of mechanisation could change this picture. According to government estimates from Brazil, one mechanical harvester can replace the jobs of 80 to 100 unskilled sugar cane cutters, which currently make up the majority of employment in the sector (GSPR Brazil, 2008).

Renewable energy technologies are evolving fast and offer a wide range of possible applications. This confronts actors in the already complex

energy sector with a variety of skills and capacity challenges. Many studies conclude that education and training is still not sufficiently provided (MWGSW-CEM, 2010; Asia Business Council, 2009). (See Section 5.2 of this paper for a discussion of policy frameworks that can be used to promote the skills needed for renewable energy jobs).

## Box 2

### ARE RENEWABLE ENERGY JOBS “DECENT”?

In addition to identifying the type of jobs and skills related to renewable energy, it is also important to ask – what quality are renewable energy jobs? The ILO (International Labour Organisation) promotes “decent work”, under the definition of “work that takes place under conditions of freedom, equity, security and dignity, in which rights are protected and adequate remuneration and social coverage is provided” (UNEP, ILO, IOE & ITUC, 2008). Decent work has four components: employment; rights (such as wages, freedom of association, collective bargaining, occupational health and safety); social dialogue; and social protection.

By substituting for traditional energy generation, renewable energy can sometimes improve the decency of work. For example, according to a study conducted by the ILS (2010), a substantially lower number of wind power employees in China reported experience with high temperature, noise, dust and radiation than employees at small and large thermal energy companies. Similarly, the Windpower Group was found to have the best health conditions, with 89.1% reporting that they had not developed any occupational disease, as opposed to 45.6% and 55.4% in large and small thermal power plants, respectively, who suffered from ailments such as silicosis, neurasthenia and tinnitus. Wages were also found to be slightly higher among wind power employees. Renewable energy jobs can offer other social benefits: for example, bioenergy and wind power can help provide local economic opportunities that prevent the need for migration from rural areas.

However, poor working conditions can also exist in renewable energy jobs if the correct legal frameworks are not in place. An agricultural activity – for example, biofuel production in some countries – may be affected with bad practices, such as poor working conditions or gender discrimination (Oxfam, 2007). A report on the quality of green jobs in the United States, commissioned by the Sierra Club and the Laborers International Union of North America, found that wages at many wind and solar manufacturing facilities were below the national average (Mattera et al., 2009).

Achieving decent work is important in all sectors of the economy and the renewable energy sector should not be an exception. On the contrary, leadership from this sector in terms of working conditions could broaden support for its ongoing development.

# 3. How many jobs currently exist and where are they in the world?

## 3.1. METHODOLOGIES

Jobs estimates can use two different measures for employment: gross or net. Gross employment refers to the sum of positive employment effects resulting from investments in renewable energy and does not take into account negative employment effects that may be experienced in other sectors. Net employment accounts for both positive and negative effects.

The choice of metric will depend upon the purpose of the study and the resources that are available as well as the characteristics of the region/country being assessed. Studies examining the state of employment related to the renewable energy sector at any single point in time will be most interested in gross employment. Studies that aim to predict how total employment will change as a result of renewable industry growth and public policy will prefer a net estimate. However, estimating net employment impacts requires a significant amount

of data and is relatively expensive. Renewable energy promotion in industrialised countries with high levels of energy production and consumption might face job losses in conventional plans as a result of a substitution effect toward renewable energy. However, those countries where the substitution effect will likely not happen, because the energy consumption level is growing, will not need to assess job-creation vs. job-loss effects. Estimating net employment impacts also rests strongly on assumptions about the extent to which job losses in conventional energy industries are a result of internal industry dynamics or increased deployment of renewable technologies. Net employment estimates do not currently exist for any developing countries, mainly due to a lack of data.

Three broad methodologies can be used to derive gross or net estimates: employment factors, a supply chain approach and input-output economic models. (See Box 3)

### Box 3

## METHODOLOGIES TO MEASURE EMPLOYMENT

An employment factor approach estimates the average number of jobs per unit of capacity installed or energy generated and multiplies this by total capacity or generation. Factors are specific to technologies and stages in the value chain. The method is usually only used to estimate direct jobs.

A supply chain approach maps out the details of the supply chain for a technology and estimates the material costs, labour costs and profit margin at each link in the chain. The labour requirements

can then be added up and used to determine employment factors. A supply chain approach can be used to estimate direct and indirect jobs, depending on the extent to which the chain is mapped out.

Input-output models predict macroeconomic outcomes based on tracing linkages across the entire economy. They can therefore give an estimation of direct, indirect, and induced employment benefits in all sectors.

It should be noted that regardless of the method used, estimating the total number of jobs in a sector or the total change of jobs across an economy is highly complex. Furthermore, the models tend to give aggregated numbers rather than a full picture of labour market effects. In particular, they rarely take account of different effects that occur across regions, within countries, or across parts of the workforce. For example IITUC and Sustainlabour (2009) notes that women may not be as well

placed to benefit as men. It is similarly likely that there may be a different impact between younger and older workers. Finally, more qualitative factors are often missing, such as the standard and sustainability of jobs lost and created. These factors are crucial for the development of policy, and should be borne in mind by policy-makers when using data.

Source	Year of estimate	Scope	Job category	All Renewables	Specific technologies						
					Wind	Solar PV	Solar thermal	Hydro-power	Geo-thermal	Biomass	Biofuels
REN21 (2011); (2010);(2008); (2005);(2005 b.)	2010	Global	Varies <sup>1</sup>	3,500,000+ <sup>13</sup>	630,000	350,000	315,000 <sup>2</sup>	na	na	na	1,500,000+
	2009	Global	Varies	3,000,000+	500,000+	300,000					1,500,000+
	2006	Global	Mostly direct	2,400,000+							1,100,000
	2004	Global	Mostly direct	1,700,000+	70,280 <sup>3</sup>	39,097	517,486 <sup>4</sup>	70,140 <sup>5</sup>	18,800	85,840	933,000 <sup>6</sup>
Greenpeace (2009)	2008	Global, elec. only <sup>7</sup>	Varies	1,300,000 to 1,700,000	300,000	170,000					
UNEP et al., (2008)	2006	Global	Varies	2,332,000+	300,000	170,000 <sup>8</sup>	624,000+	39,000+	25,000		1,174,000
WWEA (2011)	2010	Global	Direct & indirect		670,000						
McCrone, Peyvan, & Zinder (2009)	2009	Global	Direct & indirect			169,000	4,000 <sup>10</sup>				
Greenpeace & EPIA (2011); (2008)	2009	Global	Direct			228,000					
	2007	Global	Direct			119,145					
APEC EWG (2010)	2008	Asia-Pacific	Direct & indirect								242,000 <sup>11</sup>
Ragwitz et al. (2009)	2005	EU	Direct & indirect and induced	1,381,000	180,000	55,000		230,000		700,000+ <sup>12</sup>	100,000+

TABLE 1. SUMMARY OF GLOBAL AND REGIONAL ESTIMATES OF JOBS IN THE RENEWABLE ENERGY INDUSTRY

Notes: 1) where job type “varies”, this is due to studies drawing on a range of sources, some of which do and some of which do not consider both direct and indirect jobs; 2) of these jobs, 300,000 relate to solar hot water and 15,000 to solar thermal power; 3) all estimates reported for specific technologies are upper-bound estimates as described in (REN21, 2005 b.), which form the basis for the overall global estimate of over 1.7 million; the lower bound global total implied by the lower bound estimates is 1.6 million jobs; 4) of these jobs, 517,206 are related to solar thermal heating and 280 to solar thermal electric power; 5) small hydro only; 6) of these jobs, 902,000 are related to ethanol and 31,000 to biodiesel; 7) technology-specific estimates derive from a range of national studies from India, Europe (including individual studies on Denmark, Germany and Spain) and the United States, with only estimates for wind and solar PV being labeled “worldwide” by the authors; in addition, global estimates are not the sum of these numbers, but derived from (UNEP et al., 2008) and (REN21, 2008), subtracting non-electrical RETs; 8) assuming that the Japanese solar PV industry employs roughly the same number of people as Germany; 9) study not publicly available; 10) concentrating solar power only; 11) of these jobs, 45,000 were related to ethanol production and 197,000 to biodiesel production; 12) of these jobs, 450,000 are related to non-grid biomass use; 100,000 to biowaste, 100,000 to biomass on-grid and 50,000 to biogas; 13) The numbers do not sum up to 3.5 million in the original REN21 publication.



### 3.2 OVERVIEW OF GROSS GLOBAL ESTIMATES

As summarised in **Table 1**, estimates of gross global renewable energy employment have increased from 1.3 to more than 3.5 million jobs worldwide between 2004 and 2010. It is likely that the actual number of jobs will be towards the upper end of this scale, as one of the most extensive studies estimated that there were almost 1.4 million jobs in the European Union alone in 2005 (Ragwitz et al., 2009). In general, the variance between estimates can be explained by the scope of technologies considered and the methodologies and assumptions used in different studies. The total number of jobs today is almost certainly higher than these estimates, given the significant increase in renewable energy deployment in the intervening years and difficulties in data collection.

Among fuel-free technologies, wind and solar PV reached 630,000 and 350,000 jobs, respectively.

However, because of the different methodologies used by different studies, it is not possible to infer any trends based on how estimates compare between years. Given massive expansion of investments and capacities in 2010, even these estimates may be too low. The largest number of jobs related to any one fuel-free technology was in the solar thermal sector. It was estimated that this sector involved over 600,000 jobs in 2006.

Most studies conclude that a high proportion of jobs are related to **fuel-based technologies**. The biofuels sector alone accounted for about half of the jobs in the renewable energy industry (1.5 million in 2010). While global estimates tend to report that fewer jobs are related to biomass-based electricity generation, Ragwitz et al. (2009) reported 700,000 biomass-related jobs in the European Union in 2005.

Estimates vary when it comes to calculating the relative labour intensity of particular technologies.

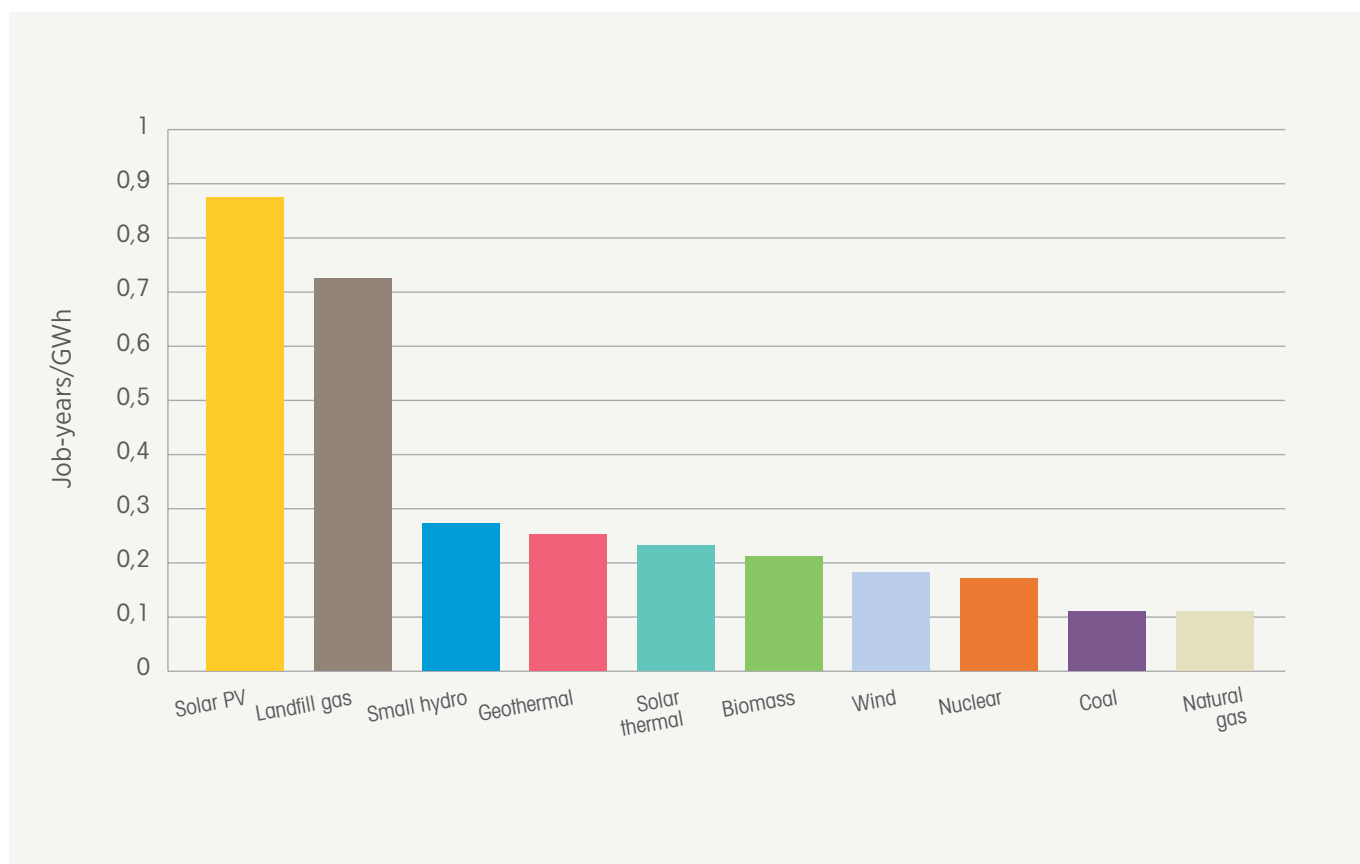


FIGURE 3. COMPARISON OF JOB-YEARS ACROSS TECHNOLOGIES (JOB-YEARS/GWh)

Source: Wei et al. (2010)

In a study that levelises and averages estimates across a range of studies, Wei, Patadia, and Kammen (2010) find that wind energy has the lowest total job-years per GWh over the life of the facility and solar PV the highest. Their findings also show that all renewable energy technologies have higher labour intensity than fossil energy technologies (see **Figure 3**). This implies greater job creation and many countries have identified the promotion of renewable energy as an efficient way of addressing poverty by creating additional incomes, new jobs and new enterprises. Of course, it should be borne in mind that productivity is not static. As renewable energy technologies are still evolving, their productivity has the potential to increase when compared to mature conventional technologies (see Section 4.2).

### 3.3 OVERVIEW OF NATIONAL ESTIMATES<sup>1</sup>

As summarised in **Table 2**, estimates indicate that the largest numbers of renewable energy jobs are found in China, Brazil, Germany, India and the United States, which are also leading industrial players in the renewable sector. The top five wind turbine manufacturers are from Denmark, China, the United States, and Germany; and the top five solar PV cell manufacturers are from China and the United States (REN21, 2011). These are generally countries which have offered long-term policy support to renewable energy, and have significant national markets for the technologies in question.

Among the fuel-free technologies, wind power is a significant source of employment across a broad range of countries. In 2010, this included estimates of around 150,000 jobs in China, 96,000 jobs in Germany and 55,000 jobs in Spain. Compared to the size of its labour force, the 24,700 jobs reported in Denmark in 2009 were also significant. The highest jobs estimate related to solar PV in 2010 was in China with 120,000 jobs, closely followed by India, with 112,000 jobs. Solar PV-related jobs were also numerous in Germany and Spain in 2010, with over 107,000 and 28,000 jobs respectively.

The latest jobs census conducted in the United States estimates over 100,000 jobs in the solar energy sector, though without reporting how this breaks down across solar PV and solar thermal. In

the solar thermal sector, China stands out as a focus of employment in 2006.

Among fuel-based technologies, employment related to ethanol production is estimated to be large in Brazil and the United States, with job estimates of 730,000 in 2010 and 163,000 in 2006 respectively, and low numbers of employment in biodiesel. By contrast, biodiesel is estimated to represent the highest proportion of biofuel-related employment among Asia-Pacific economies, with over 114,000 jobs in Indonesia alone. Estimates indicate that jobs in biomass-based electricity generation are concentrated in China, India and Brazil, although the number of jobs in Germany is also significant, given the size of its labour force.

Little detailed information exists on where jobs fall within economies. According to a study by the European Commission (Ragwitz et al., 2009), two-thirds of the jobs that could be attributed to renewable energy in 2005 were in small and medium-sized enterprises. However, this may be changing. UNEP et al. (2008) report that in its initial stages the German renewable energy industry was dominated by small- and medium-sized enterprises, followed by a period of consolidation. According to REN21 (2011), there is now a global trend towards increased consolidation as traditional energy companies move into renewable energy markets and supply chains become vertically integrated. A new trend in solar PV manufacture, for example, has been to expand into project development, with manufacturers moving into direct retail, installation and after-sales service.

<sup>1</sup> Note that since estimates derive from a range of years and a range of studies, they are at a maximum indicative, and should be interpreted accordingly.

Country	Source	Year of estimate	Type of jobs	All RE	Specific technologies							
					Wind	Solar PV	Solar thermal	Hydro-power	Geo-thermal	Biomass	Biofuels	
Brazil	REN21 (2011)	2010	Not stated		14,000							730,000
	GSPR Brazil (2008)	2007	Direct									688,564 <sup>1</sup>
China	REN21 (2011)	2010	Not stated		150,000	120,000	250,000					
	Junfeng et al. (2010)	2009	Direct		150,000							
	UNEP et al. (2008)	2006	Direct	943,200	22,200	55,000	600,000				266,000	
Denmark	DWIA (2010)	2009	Direct		24,700							
		2008	Direct		28,400							
Germany	O'Sullivan, Edler, van Mark, Nieder, & Lehr (2011)	2010	Direct and indirect	367,400	96,100 <sup>2</sup>	107,800	13,100 <sup>3</sup>	7,600	13,300	98,900 <sup>4</sup>	23,100	
		2009	Direct & indirect	339,500	102,100 <sup>5</sup>	64,700	15,900 <sup>6</sup>	7,800	14,500 <sup>7</sup>	99,200 <sup>8</sup>	26,100	
India	MNRE, (2010)	2009	Direct & indirect	350,000	42,000	112,000 <sup>9</sup>	41,000	12,500 <sup>10</sup>			142,500 <sup>11</sup>	
	Suzlon, in UNEP et al. (2008)	2007	Direct		10,000							
Indonesia	APEC EWG, (2010)	2008	Direct & indirect									114,700 <sup>12</sup>
Spain	MITC & IDAE, (2010)	2010	Direct & indirect	115,722	55,172	28,350	9,798	1,563	577	7,344 <sup>13</sup>	1,952	
	Nieto Sainz J, in UNEP et al. (2008)	2007	Direct	89,001	32,906	26,449	9,142 <sup>14</sup>	6,661 <sup>15</sup>	3,494 <sup>16</sup>	7,930 <sup>17</sup>	2,419	
United States	The Solar Foundation (2011)	2011	Direct,			100,237						
	GEA (2010)	2010	Direct, indirect & induced						13,100			
	REN21 (2011)	2010	Not stated		85,000	17,000	1,000 <sup>18</sup>		9,000	66,000		
	APEC EWG (2010)	2008	Direct & indirect									47,000 <sup>19</sup>
	Bezdek, in UNEP et al. (2008)	2006	Direct & indirect	446,320 <sup>20</sup>	36,800	15,700	1,900	19,000	21,000	152,000	160,300 <sup>21</sup>	

TABLE 2. SUMMARY OF NATIONAL ESTIMATES OF JOBS IN THE RENEWABLE ENERGY INDUSTRY

Notes: 1) of these jobs, 497,670 are in sugarcane cultivation and 190,894 in the production of ethanol; 2) of these jobs, 89,200 are related to onshore wind and 6,900 to offshore; 3) of these jobs, 11,100 are related to solar thermal heat and 2,000 to solar thermal power plants; 4) of these jobs, 36,400 are related to small biomass plants, 24,500 to combined heat and power biomass plants, 35,100 to biogas and 2,900 to liquid biomass; 5) of these jobs, 95,600 relate to onshore wind and 6,500 to offshore wind; 6) of these jobs, 13,900 are related to solar thermal heat and 2,000 to solar thermal power plants; 7) of these jobs, 1,300 are geothermal and 12,000 are near-surface geothermal; 8) of these jobs, 41,400 relate to small biomass plants, 26,600 to combined heat and power biomass plants, 30,900 to biogas and 3,000 to liquid biomass; 9) of these jobs, 40,000 are recorded as on-grid and 72,000 as off-grid; 10) small hydro only; 11) of these jobs, 35,000 are related to biomass on-grid, 22,500 to biomass gasifiers and 85,000 to biogas; 12) of these jobs, 114,000 are related to biodiesel and 700 to ethanol; 13) of these jobs, 5,999 jobs are related to biomass and 1,345 to biogas; 14) of these jobs, 8,174 are related to thermal heat and 968 to thermal electricity; 15) small hydropower only; 16) estimate for geothermal and hydrogen together; 17) of these jobs, 4,948 are related to biomass and 2,982 to biogas; 18) solar thermal power only; 19) of these jobs, 38,000 are related to ethanol production and 9,000 to biodiesel production; 20) total jobs estimate also includes non-technology-specific estimates of employment in government, research and professional associations; 21) of these jobs, 154,000 relate to ethanol and 6,300 to biodiesel.

# 4. Future possibilities: **what is** the potential for global job creation in the renewable energy industry?

The current deployment and employment patterns in the renewable energy industry described above set the starting point for the issue that is of primary concern for most countries – namely the number and types of jobs that can be expected from increased deployment of renewable energy in the future. Two opposing arguments are advanced: on the one hand, that increased deployment will create a significant number of new jobs due to opportunities arising in the industry itself and in its supporting sectors; and on the other hand, that job creation in the renewable energy industry will be modest or even negative due to job losses in both the conventional energy sector and the broader economy.

A number of studies have attempted to quantify future employment effects using the techniques outlined in the description of methodologies in Section 3. These studies differ in their methodology and assumptions, geographic and technical scope, and the type of employment effects being covered. These variations need to be borne in mind when assessing results, and when developing policies based on empirical evidence. For example, while studies may report positive net impacts based on a global scope, this will not necessarily apply at a country level, particularly when the effects of competitive national export strategies are taken into account.

**Table 3** reports the results of four separate studies looking at the effects of renewable energy deployment on job creation – three of the studies are global in reach and one focuses on the EU.<sup>2</sup> All but one scenario show positive employment effects, with gross employment effects of up to 20 million jobs by 2030 when indirect and direct jobs are considered (UNEP et al., 2008). When the scope is restricted to net direct employment, the employment effects are much less significant. Where other assumptions are conservative, as in the IEA Reference Scenario, the net effects identified

by modelling exercises may even be negative (Greenpeace, 2009). There is also variation across renewable technologies, with UNEP et al. (2008) estimating much higher job creation in the biofuel sector (up to 12 million) than in the solar (6.3 million) or wind sectors (2.1 million) by 2030.

In assessing the net impacts of renewable energy deployment, it is important to consider the assumptions that are made regarding the dynamics of the conventional energy industry, and how these vary over time. Renner (2001) notes that job losses in the fossil fuels industry to date have been driven by factors internal to the industry, rather than renewable energy targets and policies. Extending into the future, Greenpeace (2009) projects that under a business as usual scenario, where countries remain dependent on fossil fuels, energy sector jobs will decline 0.5 million by 2030 (from 9.2 million in 2010 to 8.6 million in 2030) as a result of increasing labour productivity in coal mining and coal-powered electricity generation. By contrast, a scenario that assumes wider deployment of renewable energy results in a net increase of two million jobs in the energy sector compared to 2010, to a total of 11.3 million, of which 6.9 million are renewable energy jobs.

<sup>2</sup> For country specific studies on the United States see (Kammen, Kapadia, & Fripp, 2004); and for Germany, see (Lehr et al., 2011).

The variety of results reported in **Table 3** and in other studies reflects the range of assumptions that are often made. For example, expectations about the potential for renewable energy deployment will have a strong influence on job impacts. **Table 3** illustrates how assumptions regarding policy targets can influence results – for example, Greenpeace and EPIA (2007) suggest that jobs created in the solar PV industry could vary from 0.3 million to 6.3 million depending on the deployment target implemented. The multiplier effects assumed (the extent to which each job creates indirect and induced jobs) is another key variable. Depending on assumptions, final estimates may greatly vary. However, the use of country-specific economic data, such as input-output tables, can give realistic estimates (Lehr, 2011).

Another important factor relates to assumptions about labour productivity. The higher the expected productivity the lower the number of jobs created. For instance, it is estimated that one mechanical harvester can replace 80 to 100 unskilled cane cutters in the ethanol industry in Brazil (SGPR Brazil, 2008).

Uncertainty also exists around the exact impacts that generation costs of renewable energy will have on the level of employment. On the one hand, renewable energy technologies may require support schemes to overcome high upfront costs – resources that will then not be spent elsewhere in the economy and that will also translate into higher

costs paid by consumers (Gülen, 2010). On the other hand, once the capital costs for renewable energy are fully depreciated, generation costs are close to zero and prices for fuel-free technologies of power should consequently fall. The assumptions made around such pricing effects will affect the estimated employment impacts.

Finally, assumed future competitiveness of national companies in export markets can lead to significant variations. The results reported by Ragwitz et al. (2009) and summarised in **Table 3** show that employment benefits in the EU increase with exports. At the country level, both Lehr et al. (2011) and GCN (2010) note that projections of net employment increases in Germany are dependent on the success of domestic industry in export markets.

**Table 3** only reports studies that assess the number of jobs created. Other metrics such as the cost per job are also of relevance, especially where governments are looking to maximise the potential benefits of scarce financial resources. Based on a review of the literature, Kammen et al. (2004) conclude that the number of jobs generated per dollar of investment or per unit of capacity is generally higher in renewable energy than in fossil fuel generation. However, the magnitude and possibly the direction of these effects can be expected to vary by country and by sector, with distribution of benefits being uneven across countries.

Source	Type	Estimate	Notes
UNEP et al. (2008)	Gross employment	Solar: 6.3m Wind: 2.1m Biofuel: up to 12m	Global scope
Greenpeace (2009)	Gross employment, direct	All Energy Sector: 8.6 m Renewable Energy: 2.7 m	Global scope, based on IEA 2007 forecast, business as usual
		All Energy Sector: 11.3 m Renewable Energy: 6.9 m	Global scope, 30% renewable electricity target
Ragwitz et al. (2009)	Gross employment, direct and indirect	All Renewables: 1.8 m All Renewables: 2.3 m All Renewables: 3.4 m	EU, based on no policies EU, current policy, moderate exports EU, advanced policy, moderate exports
	Net employment direct and indirect	All Renewables: 0.2 m All Renewables: 0.5 m All Renewables: 0.3 m All Renewables: 0.7 m	EU, current policy, moderate exports EU, advanced policy, moderate exports EU, current policy, high exports EU, advanced policy, high exports
Greenpeace & EPIA (2007)	Gross employment (Not stated whether direct or indirect)	Solar: 6.3 m Solar: 3.0 m Solar: 0.3 m	Global scope, advanced deployment Global Scope, moderate deployment Global Scope, IEA Reference Scenario

TABLE 3. PROJECTIONS OF FUTURE EMPLOYMENT IN 2030

# 5. Policy frameworks: **how can** countries promote the employment benefits of renewables?

**E**ach country will have a different set of reasons for deploying renewable energy sources. Commonly cited among these reasons are: energy security, improved access to energy, reduced emissions of carbon dioxide, and development of a renewable energy industry.<sup>3</sup> In either case, there are a number of policy lessons and interventions which could increase the likelihood of positive employment effects.

## 5.1 DEPLOYMENT POLICY

It is widely accepted that countries with stable policy regimes have seen great success in the deployment of renewable energy – the IIGCC (2009) and IPCC (2011) conclude that strong, stable, transparent and credible national policy is the single most significant driver of private sector investment in renewable energy. Factors cited as contributing to deployment and the related creation of jobs include ambitious renewable energy targets; adequate institutions; minimisation of non-economic barriers; and addressing economic barriers through measures such as financial support for renewable technologies, carbon dioxide pricing, and elimination of subsidies for conventional power generation (see (Ragwitz et al., 2009) and (ILO, 2011), among others). Key among these policies is the provision of financial support (GCN, 2010) – this can be provided through a range of mechanisms, dependent on the technology question and local conditions.

While the effectiveness of various policy instruments is debated, there is agreement that they should be clear, consistently applied, and flexible enough to accommodate modification as necessary (GCN, 2010). Unstable support policies are likely to have a substantial negative impact on job creation. For example, this is illustrated by

the recent cut in feed-in-tariffs for large-scale PV applications in the UK, expected to result in the loss of thousands of jobs.

Where policies are inconsistently applied or subject to frequent amendments, the likelihood of investment is lower (McAdams, 2011; UCS, 2011). For example, the level of financial support and the duration need to be clearly defined so as to reduce risk for private investors (de Jager et al., 2011). Further, while adequate incentive levels will facilitate investment, they should not be so high that they cannot be maintained. Finally, policy should also allow for gradual removal of support as technologies reach maturity, and for different levels of support by technology so as to prevent expenditure in excess of the level required for deployment (IEA, 2008; Ragwitz et al., 2007).

The effectiveness and efficiency of policies for deployment is also crucially dependent on the removal of non-economic barriers such as lack of policy coordination, costly and time-consuming administrative hurdles, difficulties in securing grid access, lack of skills and knowledge, inadequate information and social acceptance (IEA, 2008; Ragwitz et al., 2007; Ecorys Nederland BV, 2010). These barriers drive up the risks and hamper investments in renewables and increase the costs of support policies and related job creation.

<sup>3</sup> For country case studies see ILO (2008) on Bangladesh and ILO (2011) on Lebanon

## Box 4

# RENEWABLE ENERGY SUBSIDIES AND JOB CREATION: A GOOD DEAL?

**In a time** of high unemployment across much of Europe and the United States, subsidies for renewable energy are often explicitly linked to job creation. But it is controversial whether government subsidies to renewable energy are an efficient way to stimulate job growth.

**Anecdotal evidence** is often debated in the media. In the United States, for example, Sempra Energy was reported to have received US\$ 55 million in federal tax credits and state incentives to build a solar facility in Boulder City, Nevada, and to have created only five full-time jobs (Robison, 2011). According to Kenneth P. Thomas (Thomas, 2011), a professor of political science specialising in investment incentives, solar generator Fotowatio Renewable Ventures, Inc. is reported to have received a US\$ 45.6 million loan guarantee, creating four jobs, and Granite Reliable's wind generation facility, which received a US\$ 135.8 million loan guarantee, is said to have created six jobs. In other articles (Brooks, 2011), companies such as Solyndra are reported to have received public funding before declaring bankruptcy. Even where indirect and induced jobs are created, there is no guarantee that they will be based in the subsidising country. Some companies receiving public support have invested in manufacturing facilities in other countries (Brooks, 2011).

**Counter-arguments** typically object that such statistics fail to take into account the full picture, rarely accounting for indirect and induced jobs, and in some cases based on job creation during the planning stage of projects, before business is truly underway or funds have been fully disbursed. For example, a Johnson Controls plant in Holland, Michigan, was accused of creating only 148 jobs after receiving a US\$ 299 million government grant, despite that fact that these positions were

only involved setting up the plant, which would ultimately require 3,000 workers (Romm, 2011). Anecdotes of positive examples are often cited in turn, where industries have created large numbers of jobs (James, Hendricks, & Madrid, 2011). Evidence from the US also suggests that there is increasing recognition of the need to ensure that the intended job benefits are realised. Mattera et al. (2009) note that payment of subsidies is often dependent on the realisation of certain wage levels and that provisions are often incorporated in agreements to enable clawback in the event of commitments not being realised.

**This issue** is not a new one. There are examples of subsidies to the semiconductor, steel, automobile and banking data sectors in the United States that are in excess of US\$ 1 million per job. Research suggests that developing countries such as Brazil, Vietnam and India may be offering even more generous incentives than industrialised nations (Thomas, 2011). While a more comprehensive assessment is ultimately needed, the history of industrial policy suggests that sustainable jobs are most likely to be created in countries with long-term policies and holistic approaches that address barriers all along the renewable energy supply chain. It also suggests that careful, ongoing analysis and controls on spending are essential components of any policy to deploy renewable energy or otherwise support the renewable energy industry.

For a policy-maker, therefore, the focus should be on creating a supportive policy environment for renewable energy deployment that takes into account economic and non-economic barriers. The relevance of specific factors will vary by country and over time – for example, in some countries deployment may be constrained by planning barriers whereas in others there may be limited availability of finance (see Ecorys Nederland BV (2010) for discussion of variations in EU member states). The policies adopted by a country should be based on an assessment of the specific circumstances and also on the financial, human and technical resources available. A study by UNIDO (2009) discusses these needs in reference to renewable energy deployment in Africa, noting that technologies and policies should reflect the local context. Finally, implementation of policies is likely to require coordination across government bodies and between the private and public sector (GSEP, 2011).

## 5.2 LABOUR MARKET POLICY

The employment effects of renewable energy are crucially dependent on conditions in the labour market. While economic models frequently predict that the net effects of renewable deployment will be positive, this is often based on assumption of perfect labour markets where workers are mobile between jobs and locations and where there is sufficient supply of labour with necessary skills (Michaels & Murphy, 2009). In reality, the process of structural transformation of the economy is likely to involve dislocation and imbalances in the number and type of jobs available. The need to address these imbalances and to ensure a just transition to a greener economy is discussed in a number of studies (ILO, 2009).

While renewable energy may be associated with increases in gross employment, without policies such as retraining to address such dislocation, net employment effects of renewable energy policies may be negative. Also, renewable energy development and deployment require a specific set of skills without which positive benefits will not be realised. However, it is frequently the case in both developed and developing economies that these skills do not exist or are in short supply (UNEP et al., 2008; Asia Business Council, 2009). Finally, jobs that were previously associated with other sectors may shift their focus to

renewable energy – for example a grid engineer may increasingly address the integration of renewable power sources.

If targets and policy ambitions are to remain credible and achievable, these imbalances and gaps need to be addressed. As noted by Martinez-Fernandez et al. (2010), there is no one set of policies that can be prescribed for achieving this, but a multiplicity of potential approaches. However, as a first step in developing policies, it is recommended that countries perform a mapping exercise to identify existing skills and knowledge, and those that are required to support the deployment of renewable energy technologies. In the United Kingdom, for example, a special research group was set up to assess renewable energy skills needs in Scotland, using workforce planning tools set up by the European Union, and building on findings from a number of public and industry initiatives (Scottish Government, 2009). This will enable an assessment of any gaps that may exist (capacity needs assessment) and the subsequent development of programmes to address them. There is a role for both the public and private sector in the development and implementation of policies for education and training and the broader labour market (ILO, 2009).

### Policies for education and training

To address the structural changes arising as a result of the shift to renewable energy, it will be necessary to implement training programmes. ILO (2009) recommends that intensive, vocational and tailor-made courses, directed toward specific needs of employers, are the best means by which to deliver this training. For example, renewable energy training centres such as the China Wind Power Center (CWPC) have been identified as a way to deliver effective and solution-oriented training for workers (MWGSW-CEM, 2010).

The emergence of new jobs and an increased focus on renewable energy in existing jobs will also require the implementation of new vocational training programmes and the adjustment of existing programmes. Such programmes can be delivered at the level of the company, the industry, or government, but the ILO (2009) suggests that multi-level policies are generally the most effective



in ensuring employment needs are met. In the formal education sector, university curricula need to also be amended to take account of emerging requirements, either through introducing new programmes such as degrees in renewable energy engineering, or by adjusting those that already exist by adding modules relating to renewable energy.

The programmes developed need to extend beyond the workforce involved in the direct manufacture and installation of equipment and also address employees in supporting institutions. In particular, knowledge and capacity may need to be developed in government agencies and ministries, in financial institutions and other business services, and in the private sector if the full employment benefits are to be realised. Given the central role of small and medium enterprises in developing and deploying technologies, policies should also aim to address their capacity needs (Poschen, 2008).

In summary, both vocational and formal educational policies should encompass not only specialised education and training for the renewable energy industry, but also broader education requirements in areas such as mathematics, engineering and management (CEDEFOP, 2010). Programmes are most effective when based on effective coordination and communication between industry and government bodies (ILO, 2009).

### Other labour market policies

Governments concerned with job losses and skills gaps could also consider how best to develop renewable energy policy to take account of the existing skills that are available. For example, the UK could take advantage of expertise in the oil and gas sector to develop capability in the manufacture and installation of foundations and jackets for offshore wind projects (GCN, 2010; Esteban, Leary, Zhang, Utama, & Ishihara, 2010), or in financial and legal services (Carbon Trust, 2008). Hausmann and Klinger (2006) suggest an approach by which countries map out the products and services, and focus on areas that are similar to the ones they currently occupy. Otherwise they will be pushing the development of sectors for which their economies do not have a workforce with the necessary skills, or even related skills.

However, skills and knowledge development is not the only policy that is necessary to ensure matching of workers and jobs. In addition, measures should be adopted to ensure that job-seekers are both aware of, and able to take advantage of, job opportunities in the renewable energy sector. This could include the development of job placement services, policies to encourage mobility of employers and employees, and measures to ensure non-discriminatory recruitment policies (Rosemberg, 2010).

Governments could consider introducing incentives for renewable energy and try to maximise the benefits of job creation by encouraging the development of renewable energy industries in locations with high levels of unemployment and low levels of economic activity. These could include investment tax credits and wage subsidies (UNEP et al., 2008). For example, in Portugal, success in the bidding rounds for wind power projects is partly dependent on the extent to which projects assisted in the creation of investment and employment in one of the country's underprivileged locations (Martinez-Fernandez, Hinojosa, & Miranda, 2010). Similarly UNEP et al. (2008) quote examples from the United States, Germany and Spain where it has been possible to increase employment in poorer areas of the country through deployment of renewable energy.

Throughout this process, a constructive dialogue between government, business and unions can ensure that the needs and challenges of the sector are identified, and that suitable measures are put in place to address these challenges (Rosemberg, 2010; Martinez-Fernandez, Hinojosa, & Miranda, 2010).

## 5.3 INDUSTRIAL POLICY

A country looking to develop and deploy renewable energy sources can adopt various strategies, with different implications for job creation.

First, a country may focus solely on the deployment of renewables and not be concerned with developing a manufacturing industry. While numbers will vary across technologies, studies focusing on solar PV and wind energy suggest that significant numbers of jobs can be created through installation and maintenance activities (Greenpeace & EPIA, 2007; Kirkegaard, Hanemann, & Weischer,

2009). In this case, the most important factor is to focus on deployment policies and on labour market policies to ensure that the relevant skills exist.

Second, a country may wish to build up a manufacturing industry to support domestic deployment, and thereby capture jobs along the renewable energy supply chain and increase potential for adding value. As a final stage, sustaining income and related employment benefits over the long term is likely to depend upon the ability of the industry to compete in international markets (The Pew Centre, 2011). Moreover, access to export markets may enable development of manufacturing capacity in countries where domestic markets are too small to support production. In the past, development of a domestic industry and subsequent success in export markets has typically been tied to national level deployment of renewable energy sources since this gives a basis for gaining experience and understanding of a technology and how it operates (Lewis & Wiser, 2005). This suggests a central role for policies aimed at deployment. Further policies for the development of a domestic manufacturing industry can be aimed at both the demand and the supply side.

On the demand side, Lewis & Wiser (2005) suggest a number of policies that have proved effective in stimulating manufacturing capacity in the past. Key among these are financial or other incentives for developers that use locally-produced components. Local content requirements mandating that project developers use a certain percentage of locally-produced components have also been employed in a number of countries but may be subject to dispute under the rules of the World Trade Organization.

On the supply side, government can encourage investment through providing financial incentives for the establishment of manufacturing facilities and reducing the cost of finance by making loans available at favorable rates or by participation in projects (de Jager et al., 2011). Government also has a central role to play in developing the physical and human capital necessary to support a manufacturing industry. Finally, the development of a local industry can be promoted by establishing

R&D centres and by facilitating technology transfer co-operation. In some cases, where market potential is significant, a government may be able to attract inward investment from overseas companies and use this to establish a local manufacturing basis. Examples of this type of investment include inward investment into the US by Suntech and Gamesa (The New York Times, 2009; Mattera et al., 2009). However, the capacity of a country to attract such investment will also be dependent on the existence of appropriate conditions such as macroeconomic growth and infrastructure provision (White & Walsh, 2008).

Expansion of a local manufacturing capacity to export markets will depend on the competitiveness of domestic industry in the global market place (see Section 3.2). However, a government can take steps to promote domestic industry. These include working with industry to develop or participate in a quality certification scheme in order to ensure international acceptance. Financial assistance may also be implemented: UNEP-SEFI (n.d.) suggests that Export Credit Agencies have a central role to play here through provision of guarantees, insurance and low-cost loans. More directly relevant to the labour market, the competitiveness of a domestic industry will depend on the availability and skills of the labour force and measures to ensure this.



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