Fraunhofer ISI rütter+partner Energy Economics Group

"Economic and Industrial Development"
EID – EMPLOY

Methodological guidelines for estimating the employment impacts of using renewable energies in electricity generation

Annex 2: Country fact sheets

RE related gross employment in RETD member countries

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1 Overview

1.1 Introduction

This annex contains the results of a first application of the guidelines prepared in the IEA-RETD EMPLOY project[1]. The guidelines have been tested for the IEA-RETD member countries and Tunisia as an example of a developing country. The gross input-output modelling approach was applied to estimate the number of jobs that are related to renewable energy use in the respective countries. The following fact sheets contain, for each country, methodological remarks (especially deviations from the steps mentioned in the guidelines), the main data sources for generating the input data, the key results and country specific conclusions. Additionally all the input data and results are documented for each country in an Excel file[2]. The reference year for the calculations is 2009.

Employment was calculated for the part of the RE industry that is related to electricity generation, abbreviated as RE-E industry in the following. The following technologies for generating electricity from renewable sources were covered:

- Geothermal electricity
- Hydropower large (> 10 MW)
- Hydropower small (<= 10 MW)
- Solar thermal electricity
- Photovoltaics
- Tidal and wave electricity
- Wind - Offshore
- Wind - Onshore
- Biogas (incl. CHP)
- Biomass small scale (< 5 MW; incl. CHP)
- Biomass large scale (>= 5 MW; incl. CHP)
- Biomass co-firing (incl. CHP)
- Biowaste (incl. CHP)

[1] EMPLOY Economic and industrial development.

[2] http://iea-retd.org/publications.

For each of these technologies the life cycle phases manufacturing, construction and installation (MCI) and operation and maintenance (O&M) with the main economic activities, that generate employment, were considered. The demolition phase was neglected, since this phase is of minor importance for current employment, compared to the construction and operation phases, and data availability is poor. The full list of activities that is taken into account, can be found in the accompanying Excel files. As an example the following table shows an overview of activities taken into account for the wind onshore technology.

Table 1-1: Activities in the life cycle of onshore wind power plants

Life cycle phase	Employment generating activities
Planning and project development	• Planning and project development
Manufacturing, construction and installation	• Manufacturing of wind turbine (WT) nacelles • Manufacturing of WT rotor blades • Manufacturing of WT towers • Transport of WT components to installation site • Site preparation (e.g. road construction) • WT foundations • Installation of WTs on site • Connection of the wind power plant (WPP) to the net • Insurance • Miscellaneous activities
Operation and maintenance	• WPP operation • Maintenance • Land lease • Insurance services • Financial services • Power supply • Miscellaneous activities

Due to the restricted resources it was not possible to do a full scale study on RE related employment. Therefore some simplifications were necessary:

- Data on installation capacities, electricity generation and biomass input are country specific as well as data on specific installation, operation and fuel costs. As a simplification the same cost structures were used for all the countries.
- Comprehensive data on imports and exports of RE technology products is scarce. We covered the most important trade markets (wind, photovoltaics and hydro power, wood pellets), but assumed zero net trade for the other technologies. For wind technology, data on domestic production of wind technology industry, imports and exports were derived from the IEA wind annual reports 2009 and 2010 (IEA 2010b, IEA 2011b) and national wind energy industry associations. For photovoltaics, the

IEA PVPS trend reports for 2009 and 2010 were the main sources, beside IEA PVPS country reports and information from technical literature and industry associations. Import and export data for core hydro technology were extracted from the UN Comtrade database. Data on imports and exports of wood pellets (especially relevant for Canada as a major exporting country) were taken from reports of the IEA Bioenergy implementing agreement, task 40 on sustainable bioenergy trade (http://www.ieabioenergy.com).

- Since data on imports and exports is incomplete, we do not distinguish between employment induced by installation and operation of domestic facilities vs. exports, as proposed in the guidelines.
- To calculate capital costs, which are not included in the O&M costs, for all countries and all technologies a capital cost rate of 7% was assumed. The capital costs are only needed to estimate jobs in the financial services industry that are related to the supply of debt capital for investment in RE facilities.
- Data on installed capacity in the reference year t and the previous year t-1 allow to calculate net capacity increase in the reference year. To calculate expenditures for capacity replacement in the reference year, we multiply the capacity replaced in the reference year with specific installation costs. Assuming complete replacement of an investment generation after the end of the economic life-time n, the capacity replaced in the reference year t is the sum of new capacity installed in previous investment generations, which again is the sum of net capacity increase and capacity replacement in previous investment generations:

$$CR_t = \sum_{i=1}^{\infty} (NCI_{t-i\times n} + CR_{t-i\times n})$$

To estimate the capacity replaced in the reference year we use the following two approximations depending on the average annual growth rate of installed capacity since 1990, α.

– For technologies with a rather low growth rate of up to 3% per year, capacity replacement mainly depends on the capital stock and the technology's economic life-time n. It is approximated with the following formula that divides the average installed capacity over the last n-1 years by life-time.

$$CR_t = \frac{\frac{IC_t}{1+\alpha} + \frac{IC_t}{(1+\alpha)^n}}{2\times n}$$

– For technologies with a high average growth rate of more than 3% per year, capacity replacement is approximated by the series of net capacity increases over the last five technology generations. Net capacity increase is calculated by assuming geometric growth of installed capacity:

$$CR_t = \sum_{i=1}^{5} \left(\frac{IC_t}{(1+a)^{i*n}} - \frac{IC_t}{(1+a)^{(i*n+1)}} \right)$$

- Due to data available from international databases (e.g. the KLEMS database, www.euklems.net), employment is measured as the number of employed persons as opposed to full-time equivalents proposed in the guideline.
- IO tables and employment data are not yet available for the reference year 2009. Thus we used the most recent data available. For European countries the reference year is 2007 (2005 for the UK), for Canada 2008 and for Japan 2005. The error due to price base and productivity differences is of minor relevance.
- We assume that new RE capacities are fully constructed in the reference year. This simplification mainly concerns facilities with construction periods of more than one year, e.g. the construction of new hydro power plants. For a more realistic calculation the analysis of time series would be necessary.

Input data used in the calculation include data on installed capacities, electricity generation, biomass fuel input, specific costs, imports and exports of RE related products, domestic output of the RE industry by activity and the allocation of activities to industries of the respective national input-output tables. In the following, some remarks that are related to all countries are listed. Country specific remarks are included in the country chapters.

- Data on installed capacity, power generation, fuel inputs
  - Data on installed capacity and power generation of hydro power plants is net of pumped storage power plants.
  - Data on installed capacity and power generation of MSW incineration plants (biowaste) only reflects the biogenous share of waste incinerated, not the fossil share.
  - The electricity generation (capacity) of combined heat and power (CHP) plants is included in the capacity and generation data.
- Data on specific installation, O&M and fuel costs
  - Specific installation costs include total costs from planning of a facility to its connection to the electricity grid. Distribution of electricity or heat (in the case of CHP) is not included. In the case of biomass co-firing in coal-fired power plants only the necessary additional investment costs are recorded. For MSW incineration plants the input data refer to total investment costs. Based on Dettli et al. (2004), we assume that electricity and heat generation accounts for 20% of total investment costs. This share of total costs is used for calculating employment.
  - Installation costs of CHP plants also include the heat-related part. Consequently a heat credit is deducted from the O&M costs.

- Specific O&M costs do not include capital costs. These are estimated seperately as described above.
- With regard to fuel costs, the cost of waste supply to waste incineration plants (waste collection etc.) is not considered in calculating RE related employment. Waste collection and supply is not considered as part of the RE system boundaries, since collection for waste treatment would be necessary in any case, irrespective of energy recovery.
- All cost data reflect purchasers' prices, net of VAT, i.e. they include trade and transport margins.

1.2 Conclusions from the calculation experience

The following table contains an overview of the results for the RETD member countries. It shows employment in absolute terms and as a share of total employment in a country. The table reveals the large spread of employment in absolute and relative terms. In absolute terms Germany has the largest RE-E industry with 150'000 employed persons. Including the upstream supplying industries, 270'000 persons are related to RE use.

Table 1-2: Overview of results for RETD member countries

	Direct employment	Indirect employment	Total RE related employment	Share of total employment (direct)	Share of total employ ployment (direct + indirect)
	EP	EP	EP		
Canada	31'997	21'679	53'676	0.2%	0.3%
Denmark	27'233	21'680	48'913	1.0%	1.7%
France	29'790	19'110	48'900	0.1%	0.2%
Germany	150'057	120'533	270'591	0.4%	0.7%
Ireland	2'573	744	3'317	0.1%	0.2%
Japan	33'574	38'852	72'426	0.1%	0.1%
Netherlands	6'651	11'605	18'256	0.1%	0.2%
Norway	10'778	7'513	18'291	0.4%	0.7%
United Kingdom	16'152	11'027	27'179	0.1%	0.1%

In relative terms the RE-E industry has the largest share in total employment in Denmark. The RE-E industry itself accounts for 1% of total employment. Including indirect effects, 1.7% of employees work for RE deployment in Denmark and abroad. The detailed results in the following chapters reveal the specific structural characteristics of the RE-E industry in the RETD member countries with regard to technologies and life cycle phases.

The calculations for the RETD member countries have shown that in general the guidelines for the gross IO modelling approach are feasible for estimating employment that is related to renewable energy use. As in every modelling exercise the results are determined by the quality of input data and assumptions. In the following some conclusions are drawn with regard to data collection, methodology and results.

Data collection

- *Physical data on installed capacities, electricity generation and fuel inputs* usually are available from official statistics or industry associations, though the technology detail may vary. Thus the level of detail applied in a study has to be tailored to the available data or technical expertise has to be available to further differentiate the data.
- *Data on specific costs* are usually not available from statistical sources but from studies that analyse cost developments. It may be difficult to find costs that refer to a specific country.
- *Data on cost structures*, that distribute total costs to cost components and further to economic activities, are less abundant. Here it may be difficult to find comprehensive data for a specific country. In this case additional expertise may be required to adapt cost information to the respective country.
- With the available physical and cost data, the *expenditures* for construction and operation of domestic RE facilities can be calculated. It is more difficult to comprehensively determine *imports and exports*, that allow to calculate *output* of the domestic RE industry. If these data are not readily available, a survey of enterprises or industry associations may be required to some extent. For some countries a good coverage of imports and exports will be critical for the accuracy of results.

Methodology and results

The methodological approach is rather straightforward, but requires some knowledge on RE technologies and on input-output modelling. It can be flexibly adapted to different data availability situations. Existing data on turnover or direct employment in the RE industry can be integrated to improve the accuracy of the results. The latter is amongst others influenced by the fact that industry-average values from national accounts data on employment intensity and input structures are used as proxies for the enterprises in

the RE industry. If possible this assumption should be cross-checked with other available data to improve results.

Even though the guidelines are restricted to electricity generating technologies, they can easily be extended to heat generation and biofuel production from renewable sources.

2 Canada

This chapter contains a brief overview of methodological remarks, input data and results of the calculations for Canada. Detailed input data and results can be found in the annex Excel file “Annex_Data_Canada.xls”.

2.1 Methodological remarks

The employment calculations for Canada followed the methodological approach outlined in the guidelines with the following exceptions:

- Domestic output of PV modules was directly estimated from data on production in physical units (IEA 2010 and IEA 2011) and cost data, instead of calculating the data from expenditures, imports and exports, as foreseen in the guidelines (cf. chapter 4.3.3, calculation steps 2 and 3).

2.2 Input data

The input data used for the calculations are documented in detail in the Excel file. The following data sources were used to generate the input data:

Table 2-1: Input data for Canada

Data type	Source
Capacities, generation and fuel input of RE facilities 2009: • Installed capacity • Net capacity increase • Electricity generation • Biomass fuel input	Green-X database, based on data from Eurostat combined with own assessments/modelling (based on RE-Shaping scenarios, see Resch et al. 2012) for biomass in order to estimate detailed breakdowns by technology/feedstock
Specific costs 2009 • Specific installation costs • Specific O&M costs • Specific fuel costs	Green-X database (see also Resch et al. 2012)
Output of the RE industry, imports, exports	IEA (2010a), IEA (2010b), IEA (2011a), IEA (2011b), Bradley/Thiffault (2012), UN Comtrade database
Cost structures • Shares of cost components • Allocation to industries according to the IO model	Own assumptions based on various techno-economic studies
Input-output table of Canada 2008	Statistics Canada
Industry specific employment data 2008	Statistics Canada

2.3 Results

The following tables and figures contain an overview of the results for RE-E related employment in Canada. The results are distinguished by technology and life cycle phase and by direct, indirect and total employment related to renewable energy use. Hydro power includes small and large hydro power plants.

In 2009 the Canadien RE-E industry employed approximately 32,000 persons. Hydro technology (21,000 EP) accounts for the largest share of employed persons in the RE-E industry. Approximately 22,000 EP were indirectly related to RE-E use. They worked in upstream industries supplying the RE-E industry. Thus, in total almost 54,000 employed persons (EP) were related to renewable energy use. Installation and operation of RE facilities both triggered an equal share of total employed persons (25,000 EP respectively) 3,600 EP can be related to supply of biomass fuels.

Table 2-2: Direct employment in the Canadian RE-E industry

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	0	0		0
Hydro power	6,845	13,869		20,714
Solar thermal electricity	0	0		0
Photovoltaics	823	17		840
Tidal and wave electricity	0	0		0
Wind energy	3,618	617		4,234
Biogas (incl. CHP)	12	63	0	75
Biomass small scale (incl. CHP)	1,381	222	610	2,212
Biomass large scale (incl. CHP)	2,268	303	1,046	3,617
Biomass co-firing (incl. CHP)	39	34	229	302
Biowaste (incl. CHP)	0	3	0	3
Total	**14,986**	**15,126**	**1,885**	**31,997**

Source: Calculation Rütter+Partner

Table 2-3: Indirect RE-E-related employment in Canada

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. ex-port)	Total
	EP	EP	EP	EP
Geothermal electricity	0	0		0
Hydro power	4,662	9,131		13,793
Solar thermal electricity	0	0		0
Photovoltaics	566	12		579
Tidal and wave electricity	0	0		0
Wind energy	2,402	387		2,789
Biogas (incl. CHP)	8	41	0	49
Biomass small scale (incl. CHP)	904	132	584	1,621
Biomass large scale (incl. CHP)	1,485	183	926	2,594
Biomass co-firing (incl. CHP)	25	20	208	253
Biowaste (incl. CHP)	0	2	0	2
Total	**10,052**	**9,908**	**1,718**	**21,679**

Source: Calculation Rütter+Partner

Table 2-4: Total RE-E-related employment in Canada

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. ex-port)	Total
	EP	EP	EP	EP
Geothermal electricity	0	0	0	0
Hydro power	11,507	23,000	0	34,507
Solar thermal electricity	0	0	0	0
Photovoltaics	1,389	29	0	1,419
Tidal and wave electricity	0	0	0	0
Wind energy	6,019	1,004	0	7,023
Biogas (incl. CHP)	20	104	0	124
Biomass small scale (incl. CHP)	2,285	354	1,194	3,833
Biomass large scale (incl. CHP)	3,753	485	1,972	6,210
Biomass co-firing (incl. CHP)	64	54	437	555
Biowaste (incl. CHP)	1	4	0	5
Total	**25,038**	**25,034**	**3,603**	**53,676**

Source: Calculation Rütter+Partner

Figure 2-1: Direct employment in the RE-E industry by technology

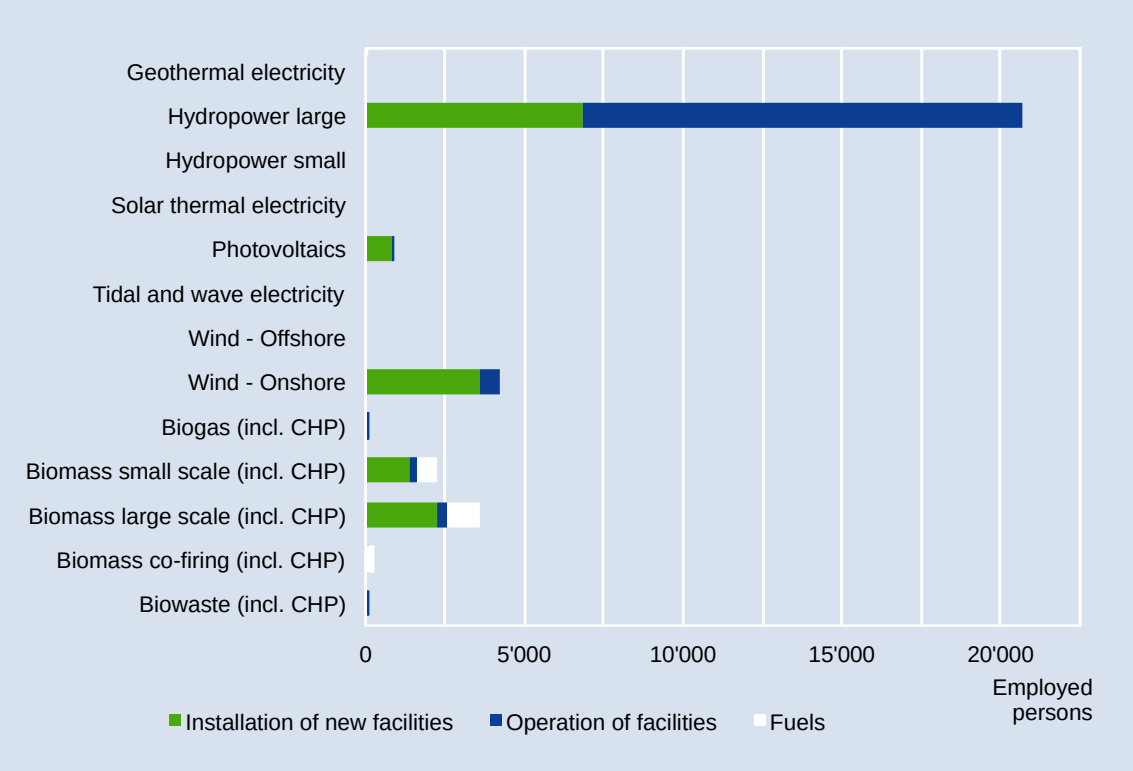
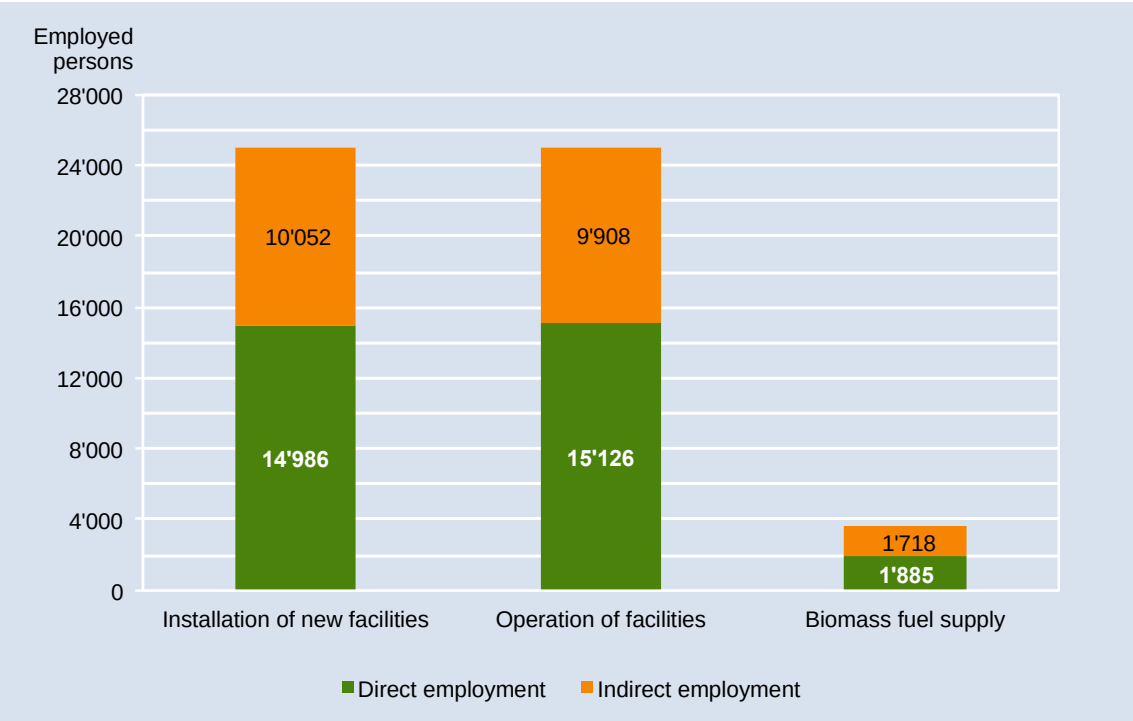


Figure 2-2: Total employment in the RE-E industry and upstream industries by life cycle phase



2.4 Conclusions

The application of the guidelines was feasible for Canada. Data on imports and exports could mainly be identified for wind, PV, partially for hydro technology and for wood pellets. A more comprehensive study could possibly improve data on imports and exports in the hydro and the biomass sector.

A comparison with existing studies (e.g. Delphi 2007) is difficult due to differing reference years, methodological approaches and input data. This would require an in-depth-analysis that was not feasible in this project. A rough comparison shows that the results of this study for the year 2009 generally lie between the results in Delphi (2007) for 2004 and the projections for 2012.

3 Denmark

This chapter contains a brief overview of methodological remarks, input data and results of the calculations for Denmark. Detailed input data and results can be found in the annex Excel file “Annex_Data_Denmark.xls”.

3.1 Methodological remarks

The employment calculations for Denmark followed the methodological approach outlined in the guidelines with the following exceptions:

- In Denmark annual data on employment, turnover and exports of the wind industry are collected by the Danish wind industry association via enterprise surveys (DWIA 2010). Therefore data on direct employment in the wind industry was directly taken from the DWIA. Output and exports of the wind industry were adjusted to match the DWIA data and distributed to cost components according to the cost structure of wind power plants (cf. guidelines, chapter 4.3.3, calculation steps 2 and 3).
- Domestic output of PV modules was directly estimated from data on production in physical units (IEA 2010a and IEA 2011a) and cost data, instead of calculating the data from expenditures, imports and exports, as proposed in the guidelines (cf. guidelines, chapter 4.3.3, calculation steps 2 and 3).

3.2 Input data

The input data used for the calculations are documented in detail in the Excel file. The following data sources were used to generate the input data:

Table 3-1: Input data for Denmark

Data type	Source
Capacities, generation and fuel input of RE facilities 2009: • Installed capacity • Net capacity increase • Electricity generation • Biomass fuel input	Green-X database, based on data from Eurostat combined with own assessments/modelling (based on RE-Shaping scenarios (see Resch et al. (2012)) for biomass in order to estimate detailed breakdowns by technology/feedstock
Specific costs 2009 • Specific installation costs • Specific O&M costs • Specific fuel costs	Green-X database (see also Resch et al. (2012))
Output of the RE industry by technology, imports, exports	DWIA (2010), IEA (2010a), IEA (2010b), IEA (2011a), IEA (2011b), UN Comtrade database

Data type	Source
Cost structures • Shares of cost components • Allocation to industries according to the IO model	Own assumptions based on various techno-economic studies
Input-output table of Denmark 2007	Download from Eurostat website (Eurostat 2011)
Industry specific employment data	KLEMS database; Download from www.euklems.net

3.3 Results

The following tables and figures contain an overview of the results for RE-E related employment in Denmark. The results are distinguished by technology and life cycle phase and by direct, indirect and total employment related to renewable energy use.

In 2009 the Danish RE-E industry employed approximately 27,000 persons. Direct employment is dominated by wind technology (approx. 25,000 EP). Almost 22,000 EP were indirectly related to RE-E use. They worked in upstream industries supplying the RE-E industry. Thus, in total almost 49,000 employed persons (EP) were related to renewable energy use. Installation of new RE facilities, mainly in foreign countries, accounted for the major share of total employed persons (over 46,000 EP). Operation of RE facilities and supply of biomass fuels have a much lower relevance with between 1,000 and 2,000 jobs in 2009.

Table 3-2: Direct employment in the Danish RE-E industry

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	0	0		0
Hydro power large (> 10 MW)	0	0		0
Hydro power small (<= 10 MW)	0	3		3
Solar thermal electricity	0	0		0
Photovoltaics	283	1		284
Tidal and wave electricity	0	0		0
Wind	24,027	673		24,700
Biogas (incl. CHP)	4	40	93	137
Biomass small scale (incl. CHP)	743	201	326	1,269
Biomass large scale (incl. CHP)	391	144	179	713
Biomass co-firing (incl. CHP)	9	35	28	72
Biowaste (incl. CHP)	20	36	0	56
Total	**25,477**	**1,131**	**625**	**27,233**

Source: Calculation Rütter+Partner

Table 3-3: Indirect RE-related employment in Denmark

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	0	0		0
Hydro power large (> 10 MW)	0	0		0
Hydro power small (<= 10 MW)	0	1		1
Solar thermal electricity	0	0		0
Photovoltaics	290	0		290
Tidal and wave electricity	0	0		0
Wind	19,810	293	0	20,103
Biogas (incl. CHP)	3	12	72	87
Biomass small scale (incl. CHP)	493	49	211	754
Biomass large scale (incl. CHP)	259	20	124	403
Biomass co-firing (incl. CHP)	6	3	15	24
Biowaste (incl. CHP)	14	5	0	19

Total	**20,875**	**383**	**422**	**21,680**

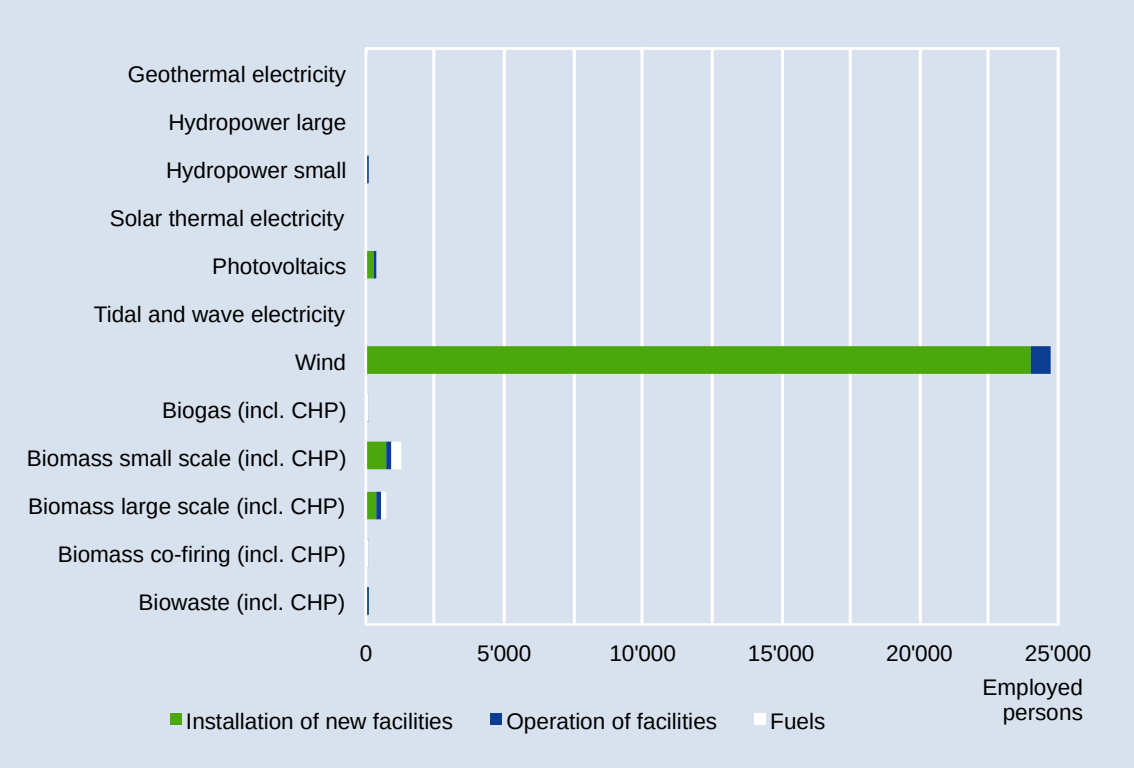
Source: Calculation Rütter+Partner

Table 3-4: Total RE-related employment in Denmark

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	0	0	0	0
Hydro power large (> 10 MW)	0	0	0	0
Hydro power small (<= 10 MW)	0	3	0	3
Solar thermal electricity	0	0	0	0
Photovoltaics	573	1	0	574
Tidal and wave electricity	0	0	0	0
Wind	43,837	966	0	44,803
Biogas (incl. CHP)	7	52	165	223
Biomass small scale (incl. CHP)	1,236	250	538	2,023
Biomass large scale (incl. CHP)	650	164	302	1,116
Biomass co-firing (incl. CHP)	15	38	42	95
Biowaste (incl. CHP)	34	41	0	75
Total	**46,352**	**1,515**	**1,047**	**48,913**

Source: Calculation Rütter+Partner

Figure 3-1: Direct employment in the RE-E industry by technology



Source: Calculation Rütter+Partner

Figure 3-2: Total employment in the RE-E industry and upstream industries by life cycle phase

Source: Calculation Rütter+Partner

3.4 Conclusions

The application of the guidelines was feasible for Denmark. Data availability is good and data quality is rather high in the dominating wind industry. Therefore the data from the Danish Wind Industry Association could be incorporated into the calculations.

4 France

This chapter contains a brief overview of methodological remarks, input data and results of the calculations for France. Detailed input data and results can be found in the annex Excel file “Annex_Data_France.xls”.

4.1 Methodological remarks

In France the expenditures for RE facilities, output and employment in the RE industry are regularly monitored (e.g. ADEME 2010). The method for calculating expenditures and output are close to the approach proposed in the guidelines. Direct employment is also calculated with a similar approach and with detailed data. The quality of results can be considered as high. We therefore generally adopted the data from the ADEME study for expenditures, output and direct employment (cf. guidelines, chapter 4.3.3, calculation steps 2, 3 and 4).

- The ADEME study does not allow to distinguish between biomass use for electricity and heat generation (with the exception of biogas and biowaste). Therefore we followed the approach described in the guidelines for small and large scale biomass plants and for biomass co-firing.
- The ADEME study specifies for each technology total value of produced energy but not the O&M and fuel expenditures needed for employment calculations. We therefore calculated these expenditures according to the guidelines.
- In the case of biogas electricity accounts for approximately half of the energy output. Therefore half of the expenditure, output and employment values were allocated to electricity use in biogas plants.
- Indirect employment was calculated according to the guidelines, since these are not included in the ADEME study.

4.2 Input data

The input data used for the calculations are documented in detail in the Excel file. The following data sources were used to generate the input data:

Table 4-1: Input data for France

Data type	Source
Capacities, generation and fuel input of RE facilities 2009: • Installed capacity • Net capacity increase • Electricity generation • Biomass fuel input	Green-X database, based on data from Eurostat combined with own assessments/modelling (based on RE-Shaping scenarios (see Resch et al. (2012)) for biomass in order to estimate detailed breakdowns by technology/feedstock *Exception*: technologies where we used data from ADEME (2010) as mentioned above
Specific costs 2009 • Specific installation costs • Specific O&M costs • Specific fuel costs	Green-X database (see also Resch et al. (2012)) *Exception*: technologies where we used data from ADEME (2010) as mentioned above
Expenditures, imports, exports, output of the RE industry by technology	ADEME (2010)
Cost structures • Shares of cost components • Allocation to industries according to the IO model	Own assumptions based on various techno-economic studies
Input-output table of France 2007	Download from Eurostat website (Eurostat 2011)
Industry specific employment data	KLEMS database; Download from www.euklems.net

4.3 Results

The following tables and figures contain an overview of the results for RE-E related employment in France. The results are distinguished by technology and life cycle phase and by direct, indirect and total employment related to renewable energy use.

In 2009 the French RE-E industry employed approximately 30,000 persons. Hydro power, wind energy and photovoltaics accounted for almost all of direct employment. Approximately 19,000 EP were indirectly related to RE-E use. They worked in upstream industries supplying the RE-E industry. Thus, in total almost 49,000 employed persons (EP) were related to renewable energy use. Installation of RE facilities triggered about two thirds of total employed persons (34,000 EP) while operation of facilities is responsible for approximately one third (14,000 EP). The employment related to biomass fuel supply is of minor relevance.

Table 4-2: Direct employment in the French RE-E industry

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	8	34		42
Hydro power	1,942	8,700		10,642
Solar thermal electricity	0	0		0
Photovoltaics	8,474	148		8,622
Tidal and wave electricity	0	0		0
Wind	8,670	915		9,585
Biogas (incl. CHP)	192	153		345
Biomass small scale (incl. CHP)	116	147	189	452
Biomass large scale (incl. CHP)	6	10	28	44
Biomass co-firing (incl. CHP)	1	17	6	23
Biowaste (incl. CHP)	2	34	0	36
Total	**19,410**	**10,157**	**223**	**29,790**

Source: Calculation Rütter+Partner

Table 4-3: Indirect RE-E-related employment in France

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	7	1		9
Hydro power large (> 10 MW)	2,150	3,008		5,158
Hydro power small (<= 10 MW)	238	393		631
Solar thermal electricity	0	0		0
Photovoltaics	4,787	64		4,851
Tidal and wave electricity	0	0		0
Wind	7,224	619		7,843
Biogas (incl. CHP)	158	42	0	200
Biomass small scale (incl. CHP)	112	61	193	367
Biomass large scale (incl. CHP)	5	2	14	22
Biomass co-firing (incl. CHP)	1	3	5	9
Biowaste (incl. CHP)	2	20	0	21
Total	**14,683**	**4,215**	**212**	**19,110**

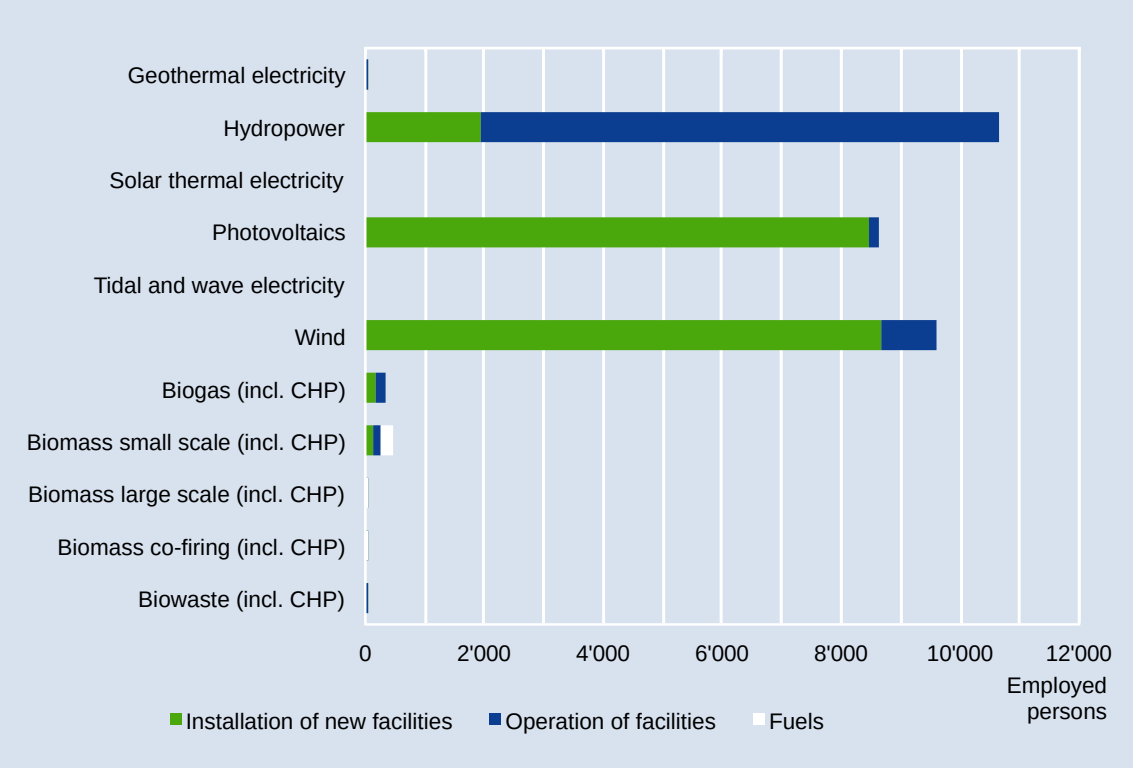
Source: Calculation Rütter+Partner

Table 4-4: Total RE-E-related employment in France

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	15	35	0	51
Hydro power	4,329	12,101	0	16,431
Solar thermal electricity	0	0	0	0
Photovoltaics	13,261	212	0	13,473
Tidal and wave electricity	0	0	0	0
Wind	15,894	1,534	0	17,428
Biogas (incl. CHP)	350	195	0	545
Biomass small scale (incl. CHP)	229	208	382	818
Biomass large scale (incl. CHP)	11	12	42	65
Biomass co-firing (incl. CHP)	2	19	11	32
Biowaste (incl. CHP)	3	54	0	57
Total	**34,094**	**14,372**	**435**	**48,900**

Source: Calculation Rütter+Partner

Figure 5: Direct employment in the RE-E industry by technology



Source: Calculation Rütter+Partner

Figure 6: Total employment in the RE-E industry and upstream industries by life cycle phase

Source: Calculation Rütter+Partner

4.4 Conclusions

The application of the guidelines was feasible for France. Since expenditures for renewable energy deployment, industry output and direct employment are regularly monitored in France, the most relevant input data are available in sufficient detail and good quality. The flexibility of the approach described in the guidelines allows to integrate the data on direct employment into the calculations.

5 Germany

This chapter contains a brief overview of methodological remarks, input data and results of the calculations for Germany. Detailed input data and results can be found in the annex Excel file “Annex_Data_Germany.xls”.

5.1 Methodological remarks

Germany is a country where RE related employment has been closely monitored for several years. Therefore data availability is good and data quality is high. Data on investment and O&M expenditures, turnover and employment in the RE industry for 2009 can be found in Lehr et al. (2011) and Nitsch et al. (2010), but also from industry associations. Where possible, we integrated published data into the calculation approach. We deviated from the steps mentioned in the guidelines for calculating domestic output by activity (cf. guidelines, chapter 4.3.3, calculation steps 2 and 3) as follows:

- For hydro power, solar thermal electricity, photovoltaics, wind energy and biogas, domestic output of RE companies was directly extracted from published data, instead of calculating the data from expenditures, imports and exports, as foreseen in the guidelines.
- For photovoltaics, domestic output of wafers, cells and modules was directly estimated from data on production in physical units (IEA, 2010 and IEA 2011) and cost data, before scaling the values to total PV-related domestic output published in Lehr et al. (2011). In other cases output was distributed to activities according to the technology specific cost structures.

For the other technologies this approach was not feasible due to lack of necessary data (Lehr et al. (2011) do not separate electricity generation from heat generation with regard to domestic output). Here the steps mentioned in the guidelines were followed. This is an example of how the methodological approach can be adjusted, when reliable data are already available for a country.

5.2 Input data

The following input data were used for the calculations:

Table 5-1: Input data for Germany

Data type	Source
Capacities, generation and fuel input of RE facilities 2009: • Installed capacity • Net capacity increase • Electricity generation • Biomass fuel input	Green-X database, based on data from Eurostat combined with own assessments/modelling (based on RE-Shaping scenarios (see Resch et al. (2012)) for biomass in order to estimate detailed breakdowns by technology/feedstock Nitsch et al. (2010) for wind energy and PV
Specific costs 2009 • Specific installation costs • Specific O&M costs • Specific fuel costs	Green-X database (see also Resch et al. (2012)) Nitsch et al. (2010) for wind energy and PV
Imports, exports, output of the RE industry by technology	Lehr et al. (2011), BWE/VDMA (2011), IEA (2010a), IEA (2010b), IEA (2011a), IEA (2011b)
Cost structures • Shares of cost components • Allocation to industries according to the IO model	Own assumptions based on various techno-economic studies
Input-output table of Germany 2007	Download from Eurostat website (Eurostat 2011)
Industry specific employment data	KLEMS database; Download from www.euklems.net

5.3 Results

The following tables and figures contain an overview of the results for RE related employment in Germany. The results are distinguished by technology and life cycle phase and by direct, indirect and total employment related to renewable energy use.

In 2009 the German RE-E industry employed approximately 150,000 persons. Wind technology (60,000 EP) and photovoltaics (45,000 EP) account for the largest share of employed persons in the RE-E industry. Approximately 120,000 EP are indirectly related to RE-E use. They work in upstream industries supplying the RE-E industry. Thus, in total more than 270,000 employed persons (EP) were related to renewable energy use. By far the major share of total employed persons (in total 215,000 EP) is triggered by installation of RE-E facilities in Germany and abroad. More than 32,000 EP can be related to operation and maintenance of RE-E facilities in Germany and almost 23,000 EP to supply of biomass fuels.

Table 5-2: Direct employment in the German RE-E industry

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	836	18		854
Hydro power large (> 10 MW)	2,191	1,486		3,677
Hydro power small (<= 10 MW)	0	866		866
Solar thermal electricity	1,280	0		1,280
Photovoltaics	42,699	1,871		44,570
Tidal and wave electricity	0	0		0
Wind - Offshore	3,285	47		3,332
Wind - Onshore	46,949	9,733		56,682
Biogas (incl. CHP)	8,345	4,104	9,142	21,591
Biomass small scale (incl. CHP)	7,045	1,749	5,774	14,568
Biomass large scale (incl. CHP)	783	282	696	1,761
Biomass co-firing (incl. CHP)	11	48	54	113
Biowaste (incl. CHP)	478	285	0	763
Total	**113,903**	**20,488**	**15,667**	**150,057**

Source: Calculation Rütter+Partner

Table 5-3: Indirect RE-E-related employment in Germany

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	512	8		520
Hydro power large (> 10 MW)	2,000	704		2,704
Hydro power small (<= 10 MW)	0	562		562
Solar thermal electricity	970	0		970
Photovoltaics	36,746	2,044		38,790
Tidal and wave electricity	0	0		0
Wind - Offshore	3,234	24		3,258
Wind - Onshore	44,605	5,394		49,999
Biogas (incl. CHP)	6,818	2,253	3,396	12,467
Biomass small scale (incl. CHP)	5,575	673	3,395	9,643
Biomass large scale (incl. CHP)	619	64	471	1,154
Biomass co-firing (incl. CHP)	12	7	45	64

Biowaste (incl. CHP)	332	70	0	402
Total	**101,422**	**11,804**	**7,307**	**120,533**

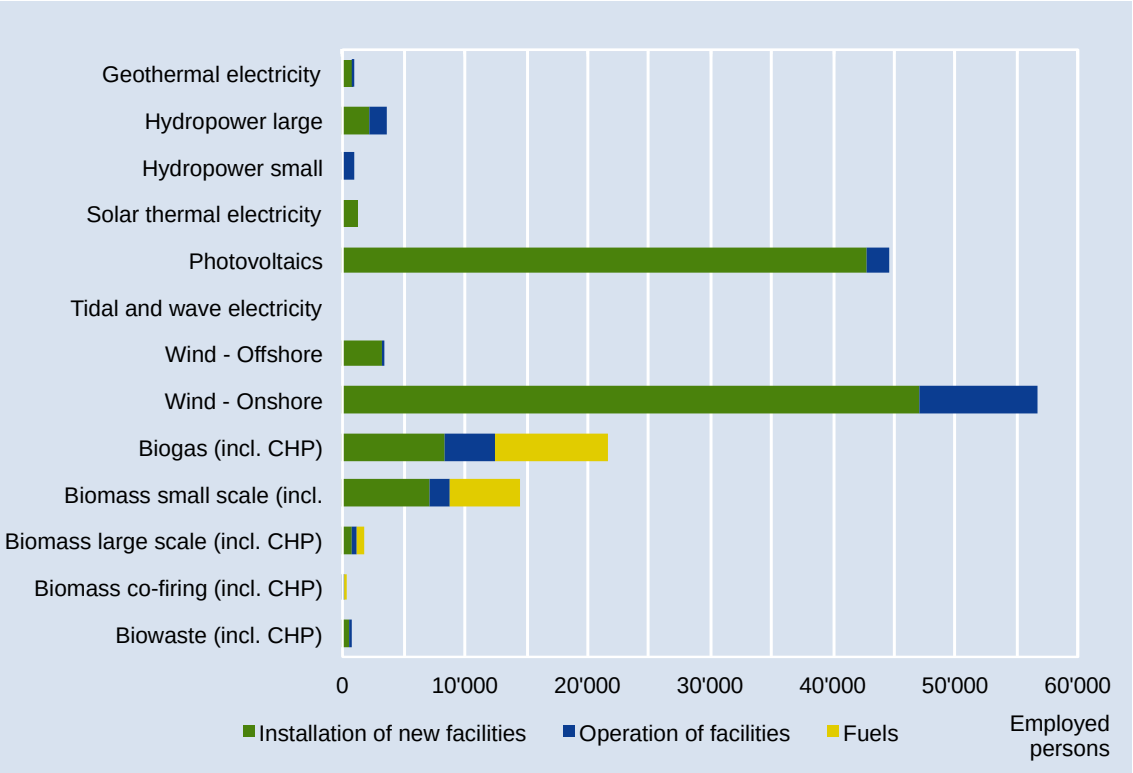
Source: Calculation Rütter+Partner

Table 5-4: Total RE-E-related employment in Germany

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. ex-port)	Total
	EP	EP	EP	EP
Geothermal electricity	1,348	26	0	1,373
Hydro power large (> 10 MW)	4,191	2,190	0	6,381
Hydro power small (<= 10 MW)	0	1,428	0	1,428
Solar thermal electricity	2,250	0	0	2,250
Photovoltaics	79,446	3,915	0	83,361
Wind - Offshore	6,519	71	0	6,590
Wind - Onshore	91,554	15,127	0	106,681
Biogas (incl. CHP)	15,163	6,357	12,538	34,059
Biomass small scale (incl. CHP)	12,620	2,422	9,169	24,211
Biomass large scale (incl. CHP)	1,402	346	1,167	2,915
Biomass co-firing (incl. CHP)	23	55	100	178
Biowaste (incl. CHP)	810	355	0	1,165
Total	**215,325**	**32,291**	**22,974**	**270,591**

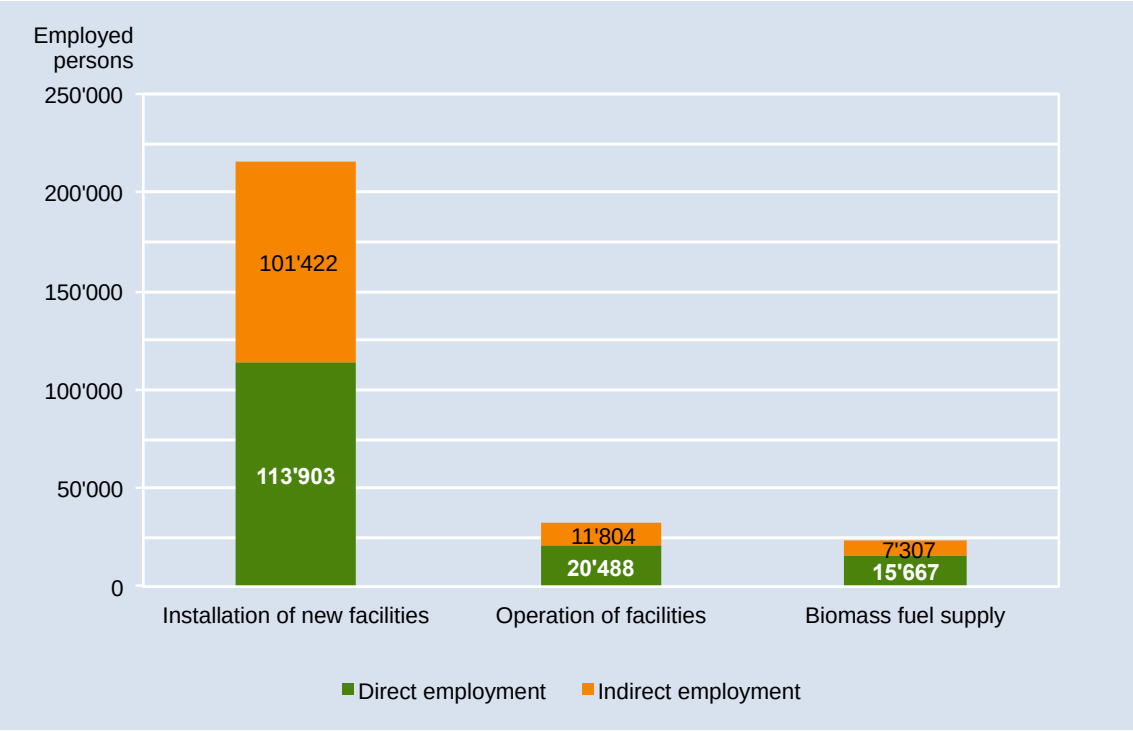
Source: Calculation Rütter+Partner

Figure 5-1: Direct employment in the RE-E industry by technology



Source: Calculation Rütter+Partner

Figure 5-2: Total employment in the RE-E industry and upstream industries by life cycle phase



Source: Calculation Rütter+Partner

5.4 Conclusions

The application of the guidelines was feasible for Germany. Data availability is good and data quality is rather high. In some cases assumptions were necessary to fit the input data into the list of economic activities. The results calculated in this study are higher for some technologies (esp. wind energy and photoltaics) than the results in Lehr et al. (2011). To identify the reasons for these differences would require an in-depth analysis of the calculation approach, input data and assumptions that was not feasible in this project. Though both approaches are based on input-output analysis, there are some significant differences in the details. With regard to input data the main difference is that Lehr et al. (2011) derive important input data from extensive enterprise surveys that are not publicly available. Due to the more sophisticated, but also more resource-intensive approach and the enterprise survey as an important database the results in Lehr et al. (2011) are probably more accurate than the estimations in this study.

6 Ireland

This chapter contains a brief overview of methodological remarks, input data and results of the calculations for Ireland. Detailed input data and results can be found in the annex Excel file “Annex_Data_Ireland.xls”.

6.1 Methodological remarks

The employment calculations for Ireland followed the methodological approach outlined in the guidelines with the following exceptions:

- Investment in wind power plants was directly adopted from the IEA wind annual report 2009 (IEA 2010b) and then distributed to cost components, as foreseen in the guidelines (cf. guidelines, chapter 4.3.3, calculation step 2.1 - 2.3).

6.2 Input data

The input data used for the calculations are documented in detail in the Excel file. The following data sources were used to generate the input data:

Table 6-1: Input data for Ireland

Data type	Source
Capacities, generation and fuel input of RE facilities 2009: • Installed capacity • Net capacity increase • Electricity generation • Biomass fuel input	Green-X database, based on data from Eurostat combined with own assessments/modelling (based on RE-Shaping scenarios, see Resch et al. (2012) for biomass in order to estimate detailed breakdowns by technology/feedstock
Specific costs 2009 • Specific installation costs • Specific O&M costs • Specific fuel costs	Green-X database (see also Resch et al. (2012))
Imports, exports, output of the RE industry by technology	IEA (2010a), IEA (2010b), IEA (2011a), IEA (2011b), UN Comtrade database
Cost structures • Shares of cost components • Allocation to industries according to the IO model	Own assumptions based on various techno-economic studies
Input-output table of Ireland 2005	Download from Eurostat website (Eurostat 2011)
Industry specific employment data 2005	KLEMS database; Download from www.euklems.net

6.3 Results

The following tables and figures contain an overview of the results for RE-E related employment in Ireland. The results are distinguished by technology and life cycle phase and by direct, indirect and total employment related to renewable energy use.

In 2009 the Irish RE-E industry employed approximately 2,600 persons. Wind technology (2,400 EP) accounts for the largest share of employed persons (EP) in the RE-E industry. Almost 750 EP were indirectly related to RE-E use. They worked in upstream industries supplying the RE-E industry. Thus, in total approximately 3,300 employed persons were related to renewable energy use. Installation of new RE-E facilities account for a major share of total employed persons (2,700 EP). 500 EP are induced by operation and management of RE-E facilities and 80 EP by supply of biomass fuels.

Table 6-2: Direct employment in the Irish RE-E industry

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	0	0		0
Hydro power large (> 10 MW)	0	56		56
Hydro power small (<= 10 MW)	0	11		11
Solar thermal electricity	0	0		0
Photovoltaics	0	0		0
Tidal and wave electricity	0	0		0
Wind - Offshore	4	14		18
Wind - Onshore	2,055	330		2,385
Biogas (incl. CHP)	16	19	0	36
Biomass small scale (incl. CHP)	5	2	49	57
Biomass large scale (incl. CHP)	0	0	0	0
Biomass co-firing (incl. CHP)	1	3	8	12
Biowaste (incl. CHP)	0	0	0	0
Total	**2,082**	**435**	**57**	**2,573**

Source: Calculation Rütter+Partner

Table 6-3: Indirect RE-E-related employment in Ireland

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	0	0		0
Hydro power large (> 10 MW)	0	14		14
Hydro power small (<= 10 MW)	0	2		2
Solar thermal electricity	0	0		0
Photovoltaics	0	0		0
Tidal and wave electricity	0	0		0
Wind - Offshore	1	2		4
Wind - Onshore	636	56		691
Biogas (incl. CHP)	5	3	0	8
Biomass small scale (incl. CHP)	2	0	19	22
Biomass large scale (incl. CHP)	0	0	0	0
Biomass co-firing (incl. CHP)	0	0	3	4
Biowaste (incl. CHP)	0	0	0	0
Total	**644**	**77**	**23**	**744**

Source: Calculation Rütter+Partner

Table 6-4: Total RE-E-related employment in Ireland

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	0	0	0	0
Hydro power large (> 10 MW)	0	69	0	69
Hydro power small (<= 10 MW)	0	12	0	12
Solar thermal electricity	0	0	0	0
Photovoltaics	0	0	0	0
Tidal and wave electricity	0	0	0	0
Wind - Offshore	5	16	0	22
Wind - Onshore	2,691	386	0	3,076
Biogas (incl. CHP)	22	22	0	44
Biomass small scale (incl. CHP)	7	3	69	78

Biomass large scale (incl. CHP)	0	0	0	0
Biomass co-firing (incl. CHP)	1	4	11	15
Biowaste (incl. CHP)	0	0	0	0
Total	**2,726**	**512**	**80**	**3,317**

Source: Calculation Rütter+Partner

Figure 6-1: Direct employment in the RE-E industry by technology

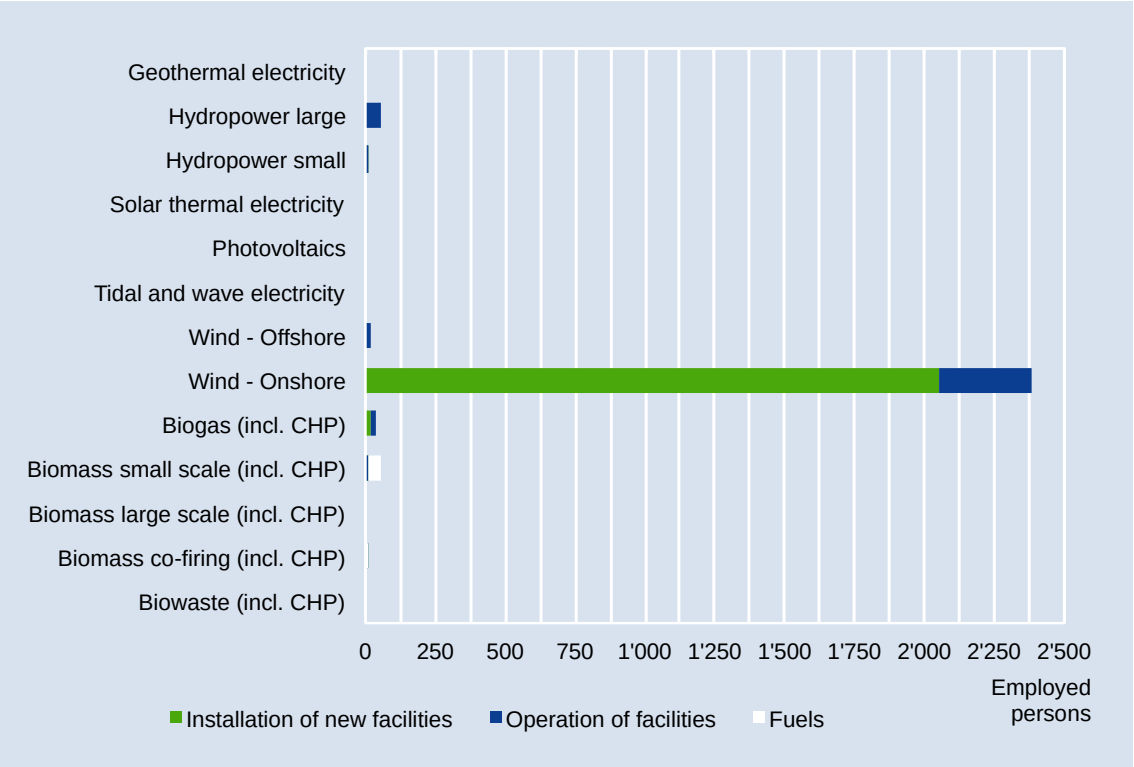


Figure 6-2: Total employment in the RE-E industry and upstream industries by life cycle phase

6.4 Conclusions

The application of the guidelines was feasible for Ireland. A comparison with the EurObserv'ER 2010 report for wind energy shows that results are similar (+10%).

7 Japan

This chapter contains a brief overview of methodological remarks, input data and results of the calculations for Japan. Detailed input data and results can be found in the annex Excel file “Annex_Data_Japan.xls”.

7.1 Methodological remarks

The employment calculations for Japan followed the methodological approach outlined in the guidelines with the following exceptions:

- Domestic output of PV modules was directly estimated from data on production in physical units (IEA 2010a and IEA 2011a) and cost data, instead of calculating the data from expenditures, imports and exports, as foreseen in the guidelines (cf. guidelines, chapter 4.3.3, calculation step 2.1 - 2.3).

7.2 Input data

The input data used for the calculations are documented in detail in the Excel file. The following data sources were used to generate the input data:

Table 7-1: Input data for Japan

Data type	Source
Capacities, generation and fuel input of RE facilities 2009: • Installed capacity • Net capacity increase • Electricity generation • Biomass fuel input	Green-X database, based on data from Eurostat and IEA combined with own assessments/modelling (based on RE-Shaping scenarios (see Resch et al. (2012)) for biomass in order to estimate detailed breakdowns by technology/feedstock
Specific costs 2009 • Specific installation costs • Specific O&M costs • Specific fuel costs	Green-X database (see also Resch et al. (2012))
Imports, exports, output of the RE industry by technology	IEA (2010a), IEA (2010b), IEA (2011a), IEA (2011b), UN Comtrade database, Matsumoto/Hondo (2010) for validation.
Cost structures • Shares of cost components • Allocation to industries according to the IO model	Own assumptions based on various techno-economic studies
Input-output table of Japan 2005	JSB (2012)
Industry specific employment data	JSB (2012)

7.3 Results

The following tables and figures contain an overview of the results for RE-E related employment in Japan. The results are distinguished by technology and life cycle phase and by direct, indirect and total employment related to renewable energy use. Hydro power includes small and large hydro power plants.

In 2009 the Japanese RE-E industry employed almost 34,000 persons. Photovoltaics (12,000 EP) and large hydro power (11,000 EP) were the most important technology areas, followed by large scale biomass (4,300 EP). Approximately 39,000 employed persons (EP) were indirectly related to RE-E use. They worked in upstream industries supplying the RE-E industry. Thus, in total more than 72,000 EP were related to renewable energy use. Installation of new RE-E facilities triggered the major share of total employed persons (48,000 EP). Operation of facilities was responsible for almost 15,000 EP and roughly 10,000 EP can be related to supply of biomass fuels.

Table 7-2: Direct employment in the Japanese RE-E industry

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	93	1,095	0	1,188
Hydro power	5,269	5,480	0	10,748
Solar thermal electricity	0	0	0	0
Photovoltaics	11,825	331	0	12,156
Tidal and wave electricity	0	0	0	0
Wind - Offshore	0	0	0	0
Wind - Onshore	1,549	376	0	1,925
Biogas (incl. CHP)	0	0	0	0
Biomass small scale (incl. CHP)	0	333	2,509	2,842
Biomass large scale (incl. CHP)	0	414	3,874	4,288
Biomass co-firing (incl. CHP)	0	49	306	354
Biowaste (incl. CHP)	0	72	0	72
Total	**18,736**	**8,150**	**6,688**	**33,574**

Source: Calculation Rütter+Partner

Table 7-3: Indirect RE-E-related employment in Japan

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	66	839	0	905
Hydro power	5,285	3,982	0	9,267
Solar thermal electricity	0	0	0	0
Photovoltaics	21,948	551	0	22,499
Tidal and wave electricity	0	0	0	0
Wind - Offshore	0	0	0	0
Wind - Onshore	1,787	333	0	2,120
Biogas (incl. CHP)	0	0	0	0
Biomass small scale (incl. CHP)	0	345	1,115	1,461
Biomass large scale (incl. CHP)	0	410	1,805	2,215
Biomass co-firing (incl. CHP)	0	57	250	306
Biowaste (incl. CHP)	0	80	0	80
Total	**29,086**	**6,596**	**3,170**	**38,852**

Source: Calculation Rütter+Partner

Table 7-4: Total RE-E-related employment in Japan

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	159	1,934	0	2,093
Hydro power	10,554	9,462	0	20,015
Solar thermal electricity	0	0	0	0
Photovoltaics	33,773	882	0	34,655
Tidal and wave electricity	0	0	0	0
Wind - Offshore	0	0	0	0
Wind - Onshore	3,336	709	0	4,045
Biogas (incl. CHP)	0	0	0	0
Biomass small scale (incl. CHP)	0	678	3,624	4,302
Biomass large scale (incl. CHP)	0	824	5,679	6,503
Biomass co-firing (incl. CHP)	0	105	555	660
Biowaste (incl. CHP)	0	152	0	152
Total	**47,822**	**14,747**	**9,858**	**72,426**

Source: Calculation Rütter+Partner

Figure 7-1: Direct employment in the RE-E industry by technology

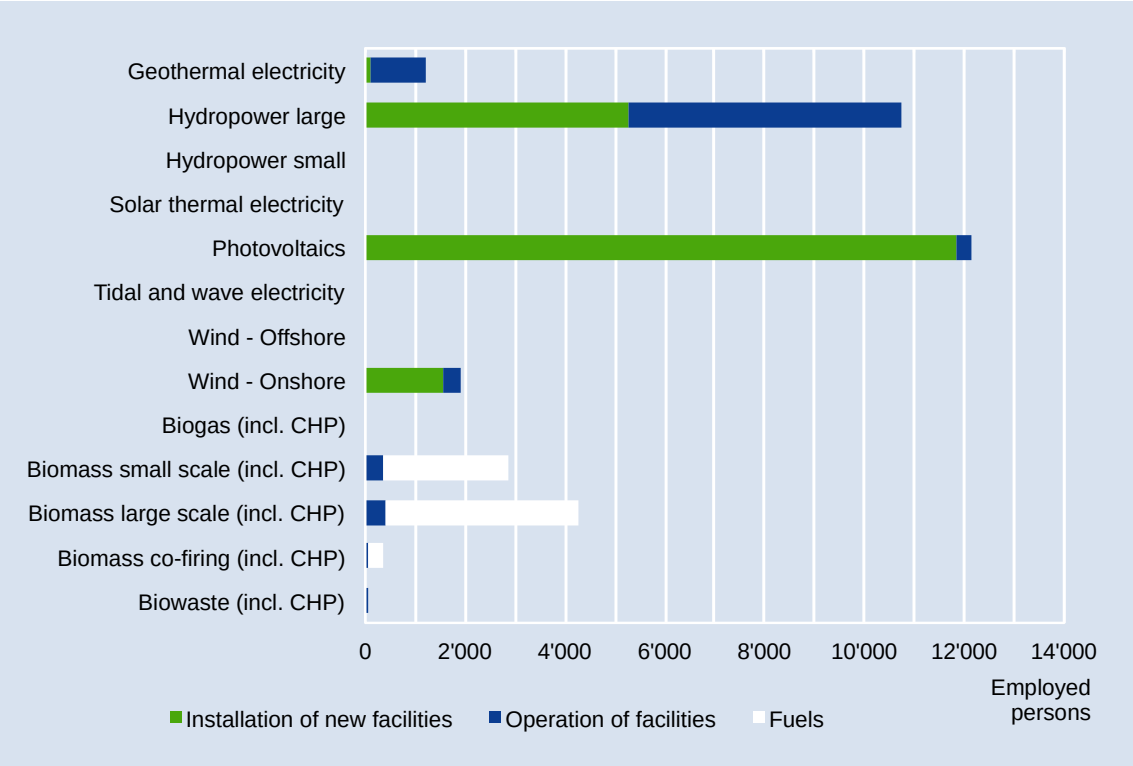
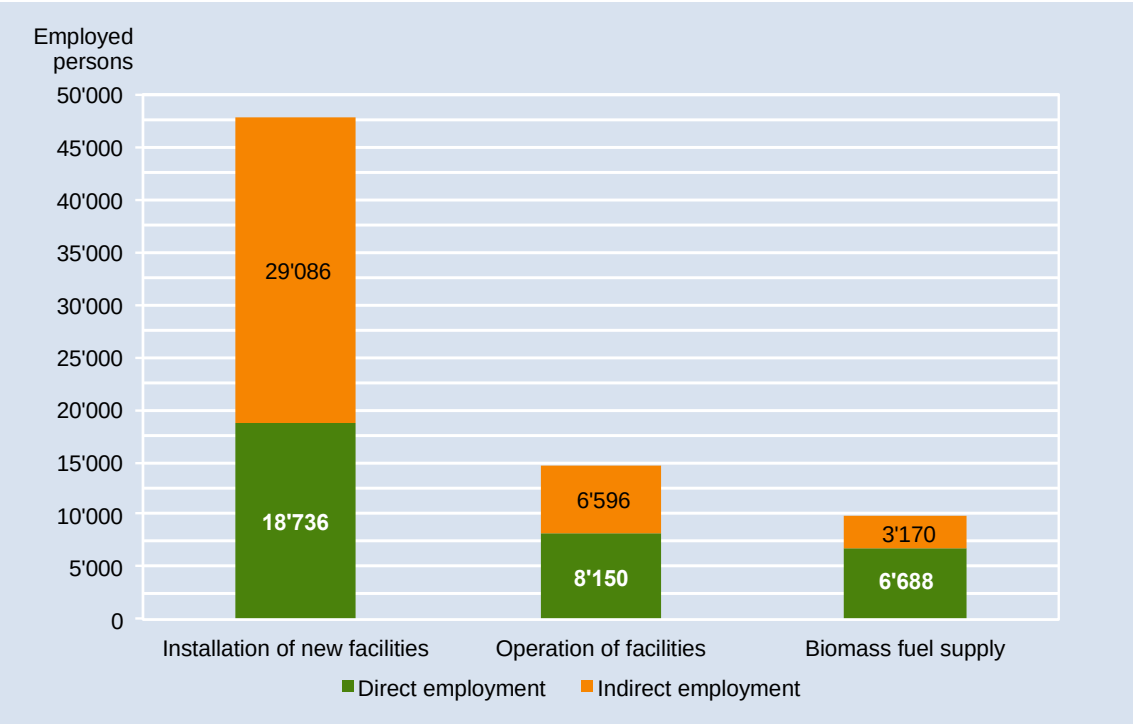


Figure 7-2: Total employment in the RE-E industry and upstream industries by life cycle phase



7.4 Conclusions

The application of the guidelines was feasible for Japan. The accuracy of results could be improved by collecting specific data on cost structures of Japanese facilities or by enhancing data on imports and exports, that may require conducting an enterprise survey or analysing business registers.

8 Netherlands

This chapter contains a brief overview of methodological remarks, input data and results of the calculations for the Netherlands. Detailed input data and results can be found in the annex Excel file “Annex_Data_Netherlands.xls”.

8.1 Methodological remarks

The employment calculations for the Netherlands followed the methodological approach outlined in the guidelines with the following exceptions:

- Turnover and employment of the Durch RE industry is regularly monitored by ECN (Lako/Beurskens 2011). This is done by identifying enterprises active in the RE field and by estimating turnover and employment related to renewable energy. The scope of the RE industry may in some areas be wider than in other studies since e.g. also manufacturers of equipment for PV cell or module producers are included. On the other hand it seems to focus on technology oriented companies, so that e.g. installation companies or wood suppliers may not be comprehensively covered. We adopted output and direct employment in the PV and wind subsector from this study, instead of calculating the data from expenditures, imports and exports, as proposed in the guidelines (cf. guidelines, chapter 4.3.3, calculation steps 2 and 3). For the biomass subsectors this is not feasible, since it is not possible to distinguish the share of electricity generation in turnover and employment. Here we followed the guidelines. Indirect employment was also calculated according to the guidelines.

8.2 Input data

The input data used for the calculations are documented in detail in the Excel file. The following data sources were used to generate the input data:

Table 8-1: Input data for the Netherlands

Data type	Source
Capacities, generation and fuel input of RE facilities 2009: • Installed capacity • Net capacity increase • Electricity generation • Biomass fuel input	Green-X database, based on data from Eurostat combined with own assessments/modelling (based on RE-Shaping scenarios (see Resch et al. (2012)) for biomass in order to estimate detailed breakdowns by technology/feedstock
Specific costs 2009 • Specific installation costs • Specific O&M costs • Specific fuel costs	Green-X database (see also Resch et al. (2012))

Data type	Source
Output of the RE industry by technology	Lako/Beurskens (2011), UN Comtrade database, Cocchi et al. (2011), Junginger et al. (2011)
Cost structures • Shares of cost components • Allocation to industries according to the IO model	Own assumptions based on various techno-economic studies
Input-output table of Netherlands 2007	Download from Eurostat website (Eurostat 2011)
Industry specific employment data	KLEMS database; Download from www.euklems.net

8.3 Results

The following tables and figures contain an overview of the results for RE-E related employment in the Netherlands. The results are distinguished by technology and life cycle phase and by direct, indirect and total employment related to renewable energy use.

In 2009 the Dutch RE-E industry employed over 6,500 persons. The most important subsectors are small scale biomass (2,300 EP), wind energy (2,200 EP) and photovoltaics (1,200 EP). Approximately 11,500 EP were indirectly related to RE-E use. They worked in upstream industries supplying the RE-E industry. Thus, in total more than 18,000 employed persons were related to renewable energy use. Installation of new RE-E facilities (incl. exports) triggered a major share of total employed persons (14,000 EP). The rest is almost equally shared by operation of RE-E facilities and supply of biomass fuels.

Table 8-2: Direct employment in the Dutch RE-E industry

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	0	0		0
Hydro power large (> 10 MW)	0	11		11
Hydro power small (<= 10 MW)	0	0		0
Solar thermal electricity	0	0		0
Photovoltaics	*1,180*	7		*1,187*
Wind - Offshore	*750*	*110*		*860*
Wind - Onshore	*1,022*	*338*		*1,360*
Biogas (incl. CHP)	134	89	181	404
Biomass small scale (incl. CHP)	790	279	1,277	2,345
Biomass large scale (incl. CHP)	48	23	112	183
Biomass co-firing (incl. CHP)	8	45	39	92
Biowaste (incl. CHP)	141	67	0	208
Total	**4,073**	**968**	**1,609**	**6,651**

Source: Calculation Rütter+Partner

Table 8-3: Indirect RE-related employment in Netherlands

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	0	0		0
Hydro power large (> 10 MW)	0	5		5
Hydro power small (<= 10 MW)	0	0		0
Solar thermal electricity	0	0		0
Photovoltaics	4,630	9		4,639
Wind - Offshore	1,811	262		2,073
Wind - Onshore	2,476	624		3,100
Biogas (incl. CHP)	130	42	114	286
Biomass small scale (incl. CHP)	752	98	405	1,254
Biomass large scale (incl. CHP)	46	5	23	73
Biomass co-firing (incl. CHP)	9	6	11	26

Biowaste (incl. CHP)	137	13	0	151
Total	**9,990**	**1,063**	**552**	**11,605**

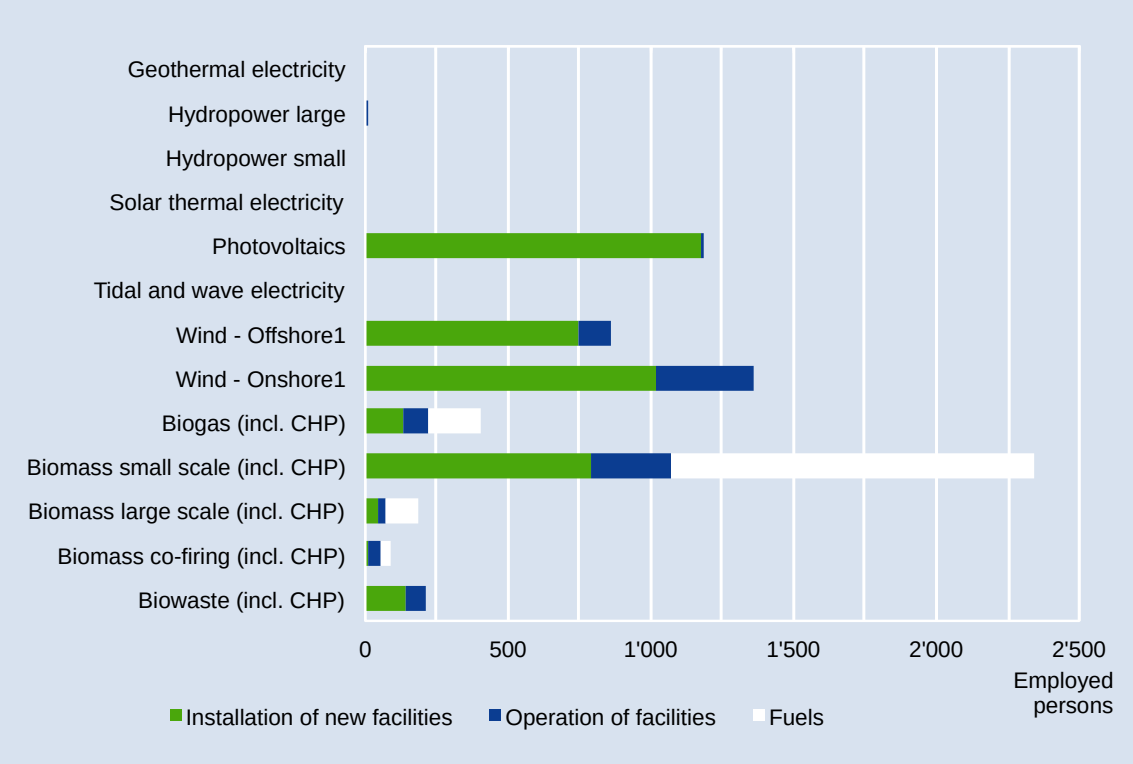
Source: Calculation Rütter+Partner

Table 8-4: Total RE-related employment in Netherlands

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. ex-port)	Total
	EP	EP	EP	EP
Geothermal electricity	0	0	0	0
Hydro power large (> 10 MW)	0	16	0	16
Hydro power small (<= 10 MW)	0	0	0	0
Solar thermal electricity	0	0	0	0
Photovoltaics	5,810	15	0	5,825
Wind - Offshore	2,561	372	0	2,933
Wind - Onshore	3,498	962	0	4,460
Biogas (incl. CHP)	264	131	295	690
Biomass small scale (incl. CHP)	1,542	376	1,681	3,600
Biomass large scale (incl. CHP)	94	28	134	256
Biomass co-firing (incl. CHP)	17	50	51	118
Biowaste (incl. CHP)	278	80	0	358
Total	**14,064**	**2,031**	**2,161**	**18,256**

Source: Calculation Rütter+Partner

Figure 8-1: Direct employment in the RE-E industry by technology



Source: Calculation Rütter+Partner

Figure 8-2: Total employment in the RE-E industry and upstream industries by life cycle phase

Source: Calculation Rütter+Partner

8.4 Conclusions

The application of the guidelines was feasible for Netherlands. Selected data for turnover and direct employment from an existing study were integrated into the calculations.

9 Norway

This chapter contains a brief overview of methodological remarks, input data and results of the calculations for Norway. Detailed input data and results can be found in the annex Excel file “Annex_Data_Norway.xls”.

9.1 Methodological remarks

The employment calculations for Norway followed the methodological approach outlined in the guidelines with the following exceptions:

- Domestic output of PV wafers and cells was directly estimated from data on production in physical units (IEA 2010a and IEA 2011a) and cost data, instead of calculating the data from expenditures, imports and exports, as proposed in the guidelines (cf. guidelines, chapter 4.3.3, calculation steps 2 and 3).

9.2 Input data

The input data used for the calculations are documented in detail in the Excel file. The following data sources were used to generate the input data:

Table 9-1: Input data for Norway

Data type	Source
Capacities, generation and fuel input of RE facilities 2009: • Installed capacity • Net capacity increase • Electricity generation • Biomass fuel input	Green-X database, based on data from Eurostat combined with own assessments/modelling (based on RE-Shaping scenarios (see Resch et al. (2012)) for biomass in order to estimate detailed breakdowns by technology/feedstock
Specific costs 2009 • Specific installation costs • Specific O&M costs • Specific fuel costs	Green-X database (see also Resch et al. (2012))
Output of the RE industry by technology	IEA (2010a), IEA (2010b), IEA (2011a), IEA (2011b), UN Comtrade database
Cost structures • Shares of cost components • Allocation to industries according to the IO model	Own assumptions based on various techno-economic studies
Input-output table of Norway 2007	Download from Eurostat website (Eurostat 2011)
Industry specific employment data	Statistics Norway

9.3 Results

The following tables and figures contain an overview of the results for RE-E related employment in Norway. The results are distinguished by technology and life cycle phase and by direct, indirect and total employment related to renewable energy use.

In 2009 the Norwegian RE-E industry employed almost 11,000 persons. Hydro power (10,000 EP) accounts for the largest share of employed persons in the RE-E industry. Approximately 7,500 EP were indirectly related to RE-E use. They worked in upstream industries supplying the RE-E industry. Thus, in total over 18,000 employed persons (EP) were related to renewable energy use. Operation of RE facilities, especially of hydro power plants triggered more than half of total employed persons (10,000 EP respectively) Installation of new RE-E facilities (incl. exports) was responsible for more than 8,000 EP, while the relevance of biomass supply was neglectable.

Table 9-2: Direct employment in the Norwegian RE-E industry

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	0	0		0
Hydro power large (> 10 MW)	2,897	6,664		9,562
Hydro power small (<= 10 MW)	34	271		305
Solar thermal electricity	0	0		0
Photovoltaics	611	1		612
Wind - Offshore	0	0		0
Wind - Onshore	63	81		144
Biogas (incl. CHP)	0	12	0	12
Biomass small scale (incl. CHP)	0	20	15	35
Biomass large scale (incl. CHP)	0	52	26	78
Biomass co-firing (incl. CHP)	0	9	2	12
Biowaste (incl. CHP)	12	6	0	18
Total	**3,619**	**7,116**	**43**	**10,778**

Source: Calculation Rütter+Partner

Table 9-3: Indirect RE-related employment in Norway

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	0	0		0
Hydro power large (> 10 MW)	3,303	2,590		5,893
Hydro power small (<= 10 MW)	34	132		166
Solar thermal electricity	0	0		0
Photovoltaics	1,314	1		1,314
Wind - Offshore	0	0		0
Wind - Onshore	56	33		89
Biogas (incl. CHP)	0	5	0	5
Biomass small scale (incl. CHP)	0	5	7	12
Biomass large scale (incl. CHP)	0	7	12	19
Biomass co-firing (incl. CHP)	0	1	2	3
Biowaste (incl. CHP)	11	1	0	12
Total	**4,719**	**2,774**	**20**	**7,513**

Source: Calculation Rütter+Partner

Table 9-4: Total RE-related employment in Norway

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	0	0	0	0
Hydro power large (> 10 MW)	6,201	9,254	0	15,455
Hydro power small (<= 10 MW)	68	403	0	471
Solar thermal electricity	0	0	0	0
Photovoltaics	1,925	1	0	1,926
Wind - Offshore	0	0	0	0
Wind - Onshore	119	114	0	233
Biogas (incl. CHP)	0	17	0	17
Biomass small scale (incl. CHP)	1	26	21	48
Biomass large scale (incl. CHP)	1	59	38	98
Biomass co-firing (incl. CHP)	0	10	4	14
Biowaste (incl. CHP)	23	7	0	30

Total	**8,338**	**9,890**	**63**	**18,291**

Source: Calculation Rütter+Partner

Figure 9-1: Direct employment in the RE-E industry by technology

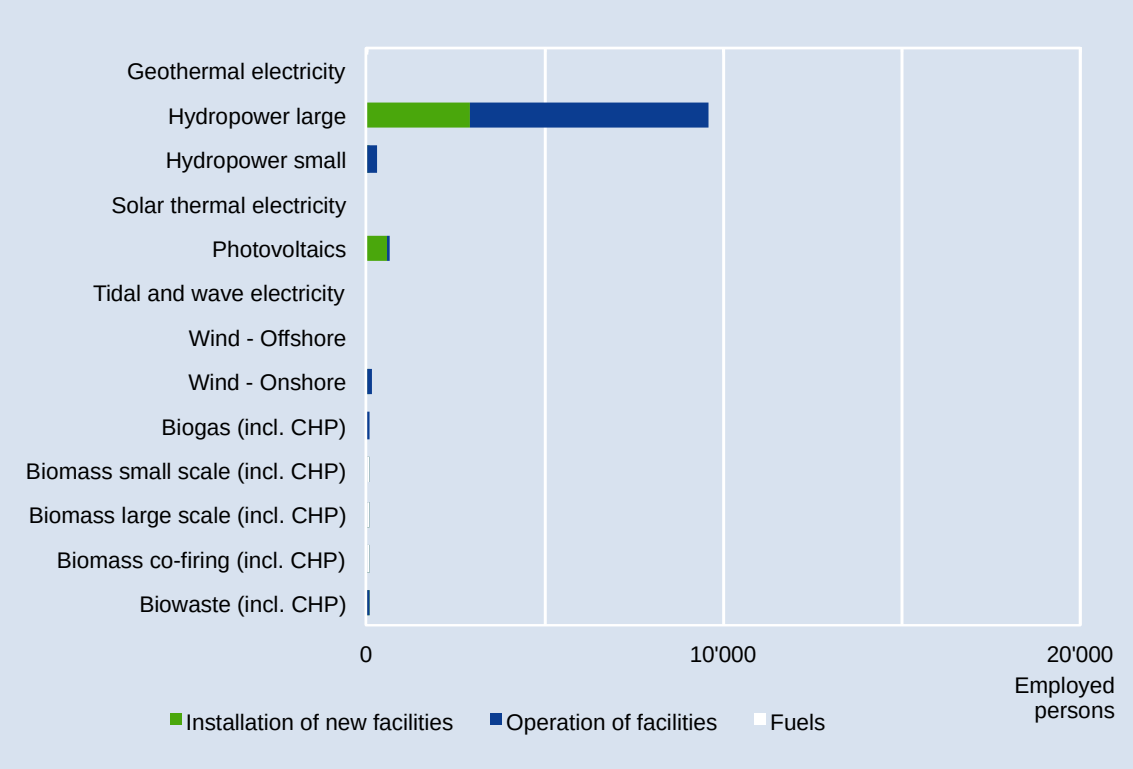


Figure 9-2: Total employment in the RE-E industry and upstream industries by life cycle phase

9.4 Conclusions

The application of the guidelines was feasible for Norway. Imports and exports in the PV subsector could be identified, but exports in the hydro power field may be underestimated, given the large relevance of this technology. Here additional research could improve the accuracy of the results. Furthermore employment related to operation of hydro power plants could be cross-checked by directly surveying the operating companies.

10 United Kingdom

This chapter contains a brief overview of methodological remarks, input data and results of the calculations for the United Kingdom. Detailed input data and results can be found in the annex Excel file “Annex_Data_United_Kingdom.xls”.

10.1 Methodological remarks

The employment calculations for the United Kingdom followed the methodological approach outlined in the guidelines with the following exceptions:

- Domestic output of PV modules was directly estimated from data on production in physical units (IEA 2010 and IEA 2011) and cost data, instead of calculating the data from expenditures, imports and exports, as proposed in the guidelines (cf. guidelines, chapter 4.3.3, calculation steps 2 and 3).

10.2 Input data

The input data used for the calculations are documented in detail in the Excel file. The following data sources were used to generate the input data:

Table 10-1: Input data for United Kingdom

Data type	Source
Capacities, generation and fuel input of RE facilities 2009: • Installed capacity • Net capacity increase • Electricity generation • Biomass fuel input	Green-X database, based on data from Eurostat combined with own assessments/modelling (based on RE-Shaping scenarios (see Resch et al. (2012)) for biomass in order to estimate detailed breakdowns by technology/feedstock
Specific costs 2009 • Specific installation costs • Specific O&M costs • Specific fuel costs	Green-X database (see also Resch et al. (2012))
Output of the RE industry by technology	IEA (2010a), IEA (2010b), IEA (2011a), IEA (2011b), Cocchi et al. (2011), Junginger et al. (2011), UN Comtrade database (for hydro turbines)
Cost structures • Shares of cost components • Allocation to industries according to the IO model	Own assumptions based on various techno-economic studies
Input-output table of United Kingdom 2005	Download from Eurostat website (Eurostat 2011)
Industry specific employment data	KLEMS database; Download from www.euklems.net

10.3 Results

The following tables and figures contain an overview of the results for RE-E related employment in the United Kingdom. The results are distinguished by technology and life cycle phase and by direct, indirect and total employment related to renewable energy use.

In 2009 the British RE-E industry employed approximately 16,000 persons. Wind energy (6,700 EP), small scale biomass (2,900 EP) and biogas (2,700 EP) are the most important technology fields. Approximately 11,000 EP were indirectly related to RE-E use. They worked in upstream industries supplying the RE-E industry. Thus, in total more than 27,000 employed persons were related to renewable energy use. Installation of new RE-E facilities triggered the major share of total employed persons (18,000 EP) 5,500 EP can be related to operation of RE-E facilities, and 3,400 EP to the supply of biomass fuels.

Table 10-2: Direct employment in the British RE-E industry

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. export)	Total
	EP	EP	EP	EP
Geothermal electricity	0	0	0	0
Hydro power large (> 10 MW)	403	532	0	935
Hydro power small (<= 10 MW)	219	95	0	314
Solar thermal electricity	0	0	0	0
Photovoltaics	849	5	0	853
Tidal and wave electricity	0	0	0	0
Wind - Offshore	1,225	485	0	1,710
Wind - Onshore	3,881	1,156	0	5,036
Biogas (incl. CHP)	1,723	763	181	2,667
Biomass small scale (incl. CHP)	1,158	369	1,403	2,930
Biomass large scale (incl. CHP)	343	152	292	786
Biomass co-firing (incl. CHP)	73	360	305	738
Biowaste (incl. CHP)	101	82	0	182
Total	**9,972**	**3,999**	**2,181**	**16,152**

Source: Calculation Rütter+Partner

Table 10-3: Indirect RE-related employment in United Kingdom

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. ex-port)	Total
	EP	EP	EP	EP
Geothermal electricity	0	0	0	0
Hydro power large (> 10 MW)	366	230	0	596
Hydro power small (<= 10 MW)	199	47	0	246
Solar thermal electricity	0	0	0	0
Photovoltaics	1,152	4	0	1,156
Wind - Offshore	992	198	0	1,190
Wind - Onshore	2,971	511	0	3,482
Biogas (incl. CHP)	1,247	324	100	1,671
Biomass small scale (incl. CHP)	958	101	786	1,845
Biomass large scale (incl. CHP)	283	23	168	475
Biomass co-firing (incl. CHP)	66	35	164	265
Biowaste (incl. CHP)	87	14	0	101
Total	**8,322**	**1,486**	**1,218**	**11,027**

Source: Calculation Rütter+Partner

Table 10-4: Total RE-related employment in United Kingdom

RE technologies	Installation of new facilities (incl. export)	Operation of facilities	Fuel supply (incl. ex-port)	Total
	EP	EP	EP	EP
Geothermal electricity	0	0	0	0
Hydro power large (> 10 MW)	769	762	0	1,531
Hydro power small (<= 10 MW)	418	142	0	560
Solar thermal electricity	0	0	0	0
Photovoltaics	2,001	8	0	2,009
Wind - Offshore	2,216	683	0	2,900
Wind - Onshore	6,852	1,666	0	8,518
Biogas (incl. CHP)	2,970	1,086	281	4,337
Biomass small scale (incl. CHP)	2,116	470	2,189	4,776
Biomass large scale (incl. CHP)	626	176	460	1,261
Biomass co-firing (incl. CHP)	139	395	469	1,003
Biowaste (incl. CHP)	187	96	0	283

Total	**18,295**	**5,485**	**3,399**	**27,179**

Source: Calculation Rütter+Partner

Figure 10-1: Direct employment in the RE-E industry by technology

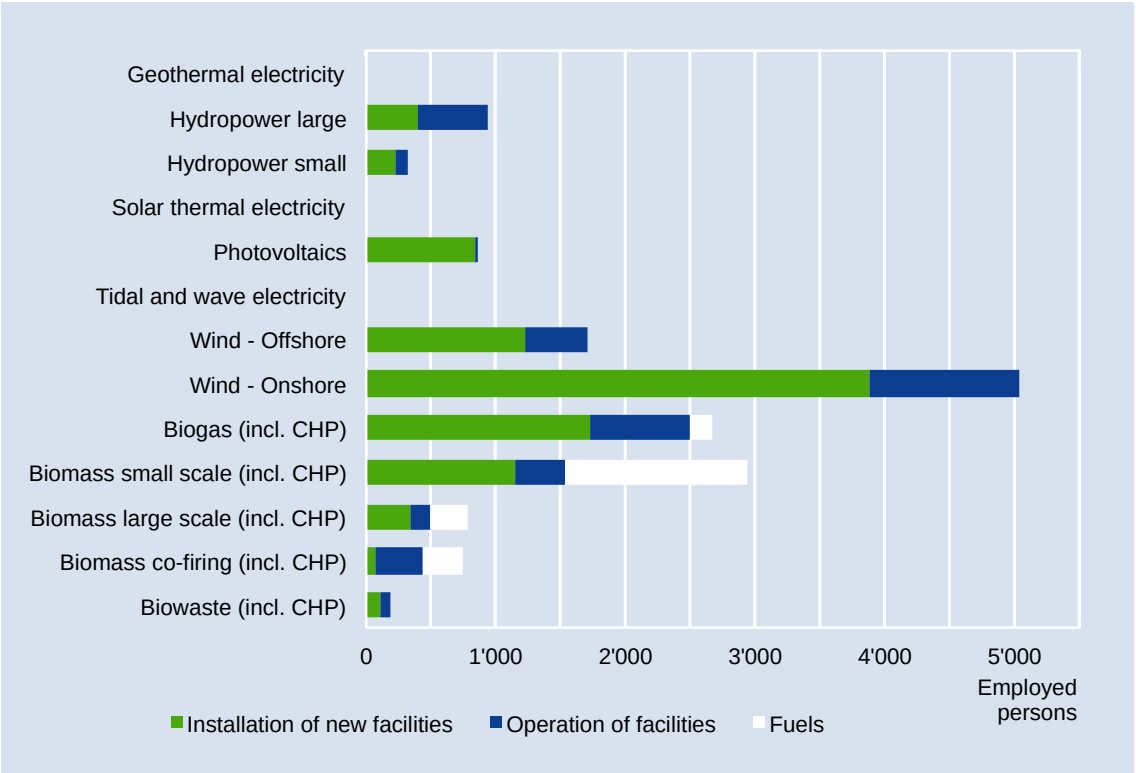
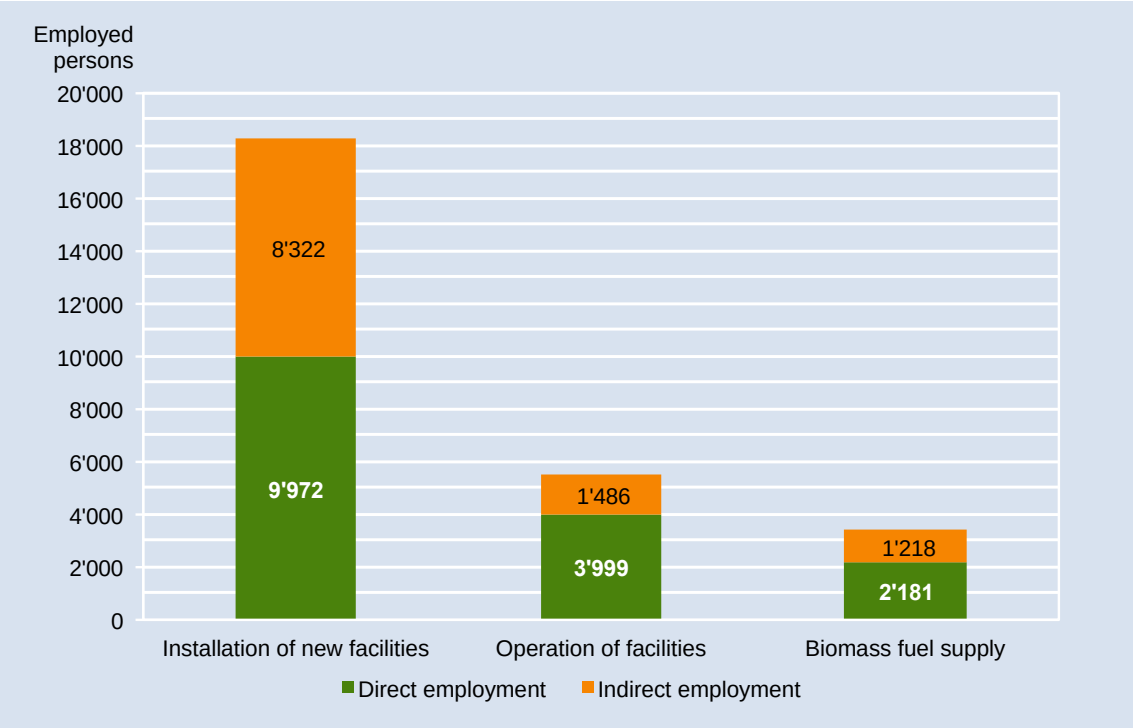


Figure 10-2: Total employment in the RE-E industry and upstream industries by life cycle phase



10.4 Conclusions

The application of the guidelines was feasible for the United Kingdom. The accuracy of the results could be improved by additional research on imports and exports, that would probably require an enterprise survey.

A recent study, that uses a completely different approach, estimates the total RE related employment (including indirect employment) in the United Kingdom at almost 100,000 persons in the year 2010/2011, a figure that is much larger than the result of this study. An explanation of this difference would require an in-depth comparison of the methodological approaches, the input data and assumptions. The difference in results is probably due to a mix of the following factors:

- Renewable energy use for heat and biofuel generation is also included, whereas this study is restricted to electricity generation from renewable sources.
- Different reference years; deployment of offshore wind power plants and especially of PV facilities soared in the UK after 2009.
- Different methodological approaches: the REA study only contains a brief characteriation of the method. The analysis is mainly based on an evaluation of business registers and case studies. This approach raises questions as to how companies active in the RE field were identified, how double-counting was avoided or how the

share of RE in turnover, exports and employment were estimated without surveying the companies. Therefore the system boundaries of the RE industry are probably different from those defined in this study. These methodological differences will probably influence the results.

11 Tunisia

Author: Ulrike Lehr (GWS)

11.1 Acknowledgements

The following is an excerpt from the final report on “Renewable energy and energy efficiency in Tunisia – employment, qualification and economic effects - past, present, future” commissioned by GIZ on behalf of ANME (Agence Nationale pour la Maîtrise de l'Energie, Tunis). The German Gesellschaft für Wirtschaftliche Strukturforschung (GWS), Osnabrück, Germany led this project and Alcor, Tunis, Tunisia, a consultancy worked as a sub-contractor.

11.2 Methodological approach

The analysis of employment effects from an increase in renewable energy and energy efficiency in a developing country/emerging economy has not been treated in the literature until now. Studies and results can be found either for larger units, for instance for certain world regions such as Africa, the Middle East, Latin America, Asia; or for much smaller units with the analysis of single projects. The latter can be found on rural electrification projects in Africa or India, but neither result can be easily transferred to estimate the effects of RE deployment and energy efficiency measures in Tunisia.

The methodology follows the approach suggested in the EMPLOY guidelines, i.e. an adjusted Input-Output (I/O) Analysis, with two important differences:

1. We have been modeling projections, i.e. future scenarios of RE deployment. For past years two important factors forced us to deviate from the recommended structure:
    a. Very few data are available on investment and RE-deployment in the past (in Tunisia),
    b. In the past, very little RE-technologies have been produced in Tunisia except for solar water heaters. Employment stems from installation and services. Total employment since 2005 in RE and energy efficiency has been calculated as 3503, plus roughly 2500 indirect jobs.
2. We directly use I/O *vectors* for the RE technologies from a study on the German RE-industry (Lehr et al. 2012 and BMU 2011) and use Tunisian I/O *tables* for second round and higher order effects. This means, we consider RE-technology

manufacturing as a new economic sector. Since this sector is fairly young, we assume that the survey based I/O vectors hold true in each country in the world.

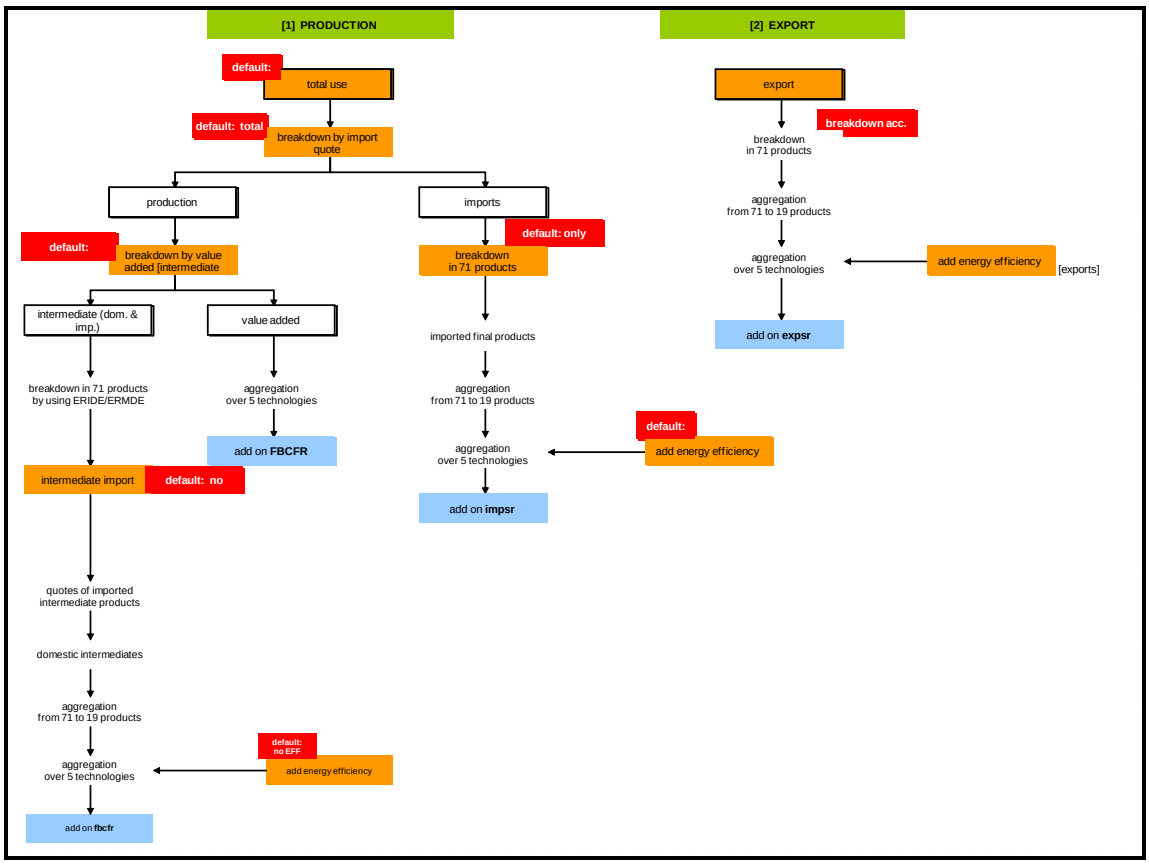
We apply the RE-technology-specific I/O vectors to model intermediary production caused by the additional demand for RE-systems and by operation and maintenance. For the calculation of indirect employment, labor-intensities from Tunisian statistics are used and the calculation of second round effects is based on Tunisian I/O tables. Local employment crucially depends on the share of imported goods and services and local production. These shares are taken into consideration along the whole value chain. They change over time; local production can replace imports as industrial development takes place.

The results of these steps provide estimates of indirect employment. Indirect employment can grow faster in Tunisia than direct employment in production of RE-systems at the beginning, because it can be directly developed from existing production structures, while a new fabrication site for windmills or for PV systems takes longer to build. For those technologies which are produced locally and installed locally or exported, however, direct employment has to be added. Direct employment can be derived from international RE-specific labor intensities, because the Tunisian industry can be as innovative and productive as its international competitors.

Learning curves for RE-technologies are embedded in the scenarios; investment per MW installed follows the respective learning curve per technology. Exports increase over time as the industry develops. Import shares decline over time as more and more industrial integration takes place.

The following data was readily available: I/O Tables (19 sectors) for Tunisia exist for 2004-2008; I/O Tables for RE-Technologies (71 economic sectors) exist for 2007, both being adjusted for future development, and the scenarios (capacities installed, investment, and electricity generation) have been developed in parallel and in close cooperation with our work.

11.3 Model structure



11.4 Input data

The following input data were used for the calculations:

Table 11-1: Input data for Tunisia

Data type	Source
Capacities, generation and fuel input of RE facilities 2012 - 2030: • Installed capacity • Net capacity increase • Electricity generation	• The Tunisian Solar Plan (PST), on energy efficiency and renewable energy in electricity and heat • “Renewable energy production in Tunisia, perspectives and opportunities until 2030 (Production d’électricité renouvelable en Tunisie - Perspectives et opportunités a l’Horizon 2030) GIZ/ANME, October 2010 • The strategic study on the energy mix for the electricity production in Tunisia, part 5” Models and scenarios”, Wuppertal Institute and Alcor, January 2012
Efficiency	• Plan Bleu (2008) • Own Calculation

Data type	Source
Investment in • New capacities • O&M • Efficiency	• The strategic study on the energy mix for the electricity production in Tunisia, part 5" Models and scenarios", Wuppertal Institute and Alcor, January 2012 • Plan Bleu (2008) • Own Calculation
Turnover of the RE industry by technology	Calculated from: Investment – import + export
Cost structures • Shares of cost components • Allocation to industries according to the IO model	From Lehr et al. 2011, 2012
Input-output table of Tunisia 2004-2008	Download from Tunisian National Institute of Statistics (INS, http://www.ins.nat.tn/)
Industry specific employment data • Employment per unit of output • Compensation per employee	Download from Tunisian National Institute of Statistics (INS, http://www.ins.nat.tn/)

Remarks:

- Tunisia plans to install wind turbines (1570 MW), PV (1930 MW), CSP (595 MW) for electricity generation, solar water heaters (700 MW) in the residential heat sector and 50 MW biogas until 2030.
- Assumptions on imports of complete systems and/or components and/or intermediary goods are crucial for the calculation of employment from renewable energy in developing countries/ emerging economies
- Installation and operation and maintenance lead to local employment early in the process.
- Permanent employment is created in operation and maintenance. In production of RE-systems, it depends on industrial integration and export opportunities, because otherwise employment is found in installation and parallels the building time of RE projects.
- Because one may expect newly rained experts and engineers in RE-production to have higher wage demands, the local wage structure has to be adapted to new industries.

11.5 Results

The following table contains an overview of the main results for RE (and Energy Efficiency) related employment in Tunisia by technology. It should be noted that assumptions on imports are conservative and sensitivities for higher integration rates of the

local industries are given in the full study. Also, exports have only been assumed for PV and Solar Water Heaters. The largest existing local industry in the RE-sector currently is solar water heaters (7 companies, 1,100 micro-enterprises, very good support program PROSOL). Per 100 million dinar spent, employment is the highest for residential efficiency measures such as insulation, efficient lamps and efficient household appliances, followed by solar water heaters, PV and wind. Under conservative assumption on imports, maximal employment (current structure improving gradually) could reach 10,473 jobs in 2021. If integration is raised and imports are lowered to a general average of 10%, maximal employment yields 24,729 jobs by 2018[3]. This shows how crucial the assumptions on imports are.

Table 11-2: Total RE-employment in Tunisia from the scenarios until 2030

	Renewable Energy - Electricity		Renewable Energy - Heat		Efficiency	
	2020	2030	2020	2030	2020	2030
Solar thermal electricity	2,077	2,966				
Photovoltaics	2,342	1,395				
Wind	1,561	2,120				
Efficiency: residential, industry and CHP					1,468	1,003
Solar water heater			2,077	2,966		
Total	**5,980**	**6,481**	**2,077**	**2,966**	**1,468**	**1,003**

11.6 Conclusions

The study on Tunisia shows that it is possible to analyze the effects on employment with a simple model for a developing country which has already an industrial sector. Though data are not consistently available on everything one might wish for, the discussion with local experts and stakeholders leads to an improved understanding of all quantities involved, i.e. import shares, productivity of labor, investment and wages. On the other hand, stake holders and decision makers profit from sensitivity analyses on several assumptions (especially assumptions on local content and RE-technology costs), because the effects of regulation and support e.g. of the industry can be easily shown.

[3] The integration rate influences the year with maximal employment. If local integration is high and no exports are assumed then production follows the investment paths very closely and peak employment occurs a little earlier than in the more conservative case at peak investment in 2018.

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