Headlines

The renewable energy industry is one of Europe's fastest growing sectors, as Member States encourage renewables deployment as an alternative, indigenous energy source with low environmental impacts. Policy makers now recognise that there are also additional economic benefits from renewables, especially in terms of the potential for employment creation and the development of a strong export industry.

This report summarises the findings from an EU-wide study into the impacts of renewable energy on employment in Europe to 2020. Key findings are as follows:

- **Energy produced from renewable sources is predicted to increase by a factor of about 2.4, from a base of 440 TWh in 1995 to 1,066 TWh by 2020. The modelling predicts increases in the capacity and output of all the renewable energy technologies studied, and in all Member States. These predictions also represent an increase in the overall proportion of final energy consumption in the EU provided by renewables[1] from 4.3% in 1995 to 8.2% by 2020.**

- **The modelling predictions estimate that this increase in energy provided from renewable sources can result in the creation of over 900,000 new jobs by 2020. 385,000 jobs are predicted to be created by 2020 from provision of renewable energy, and a further 515,000 jobs from biomass fuel production. This increase takes account of the direct, indirect and subsidy effects on employment, and jobs displaced in conventional energy technologies.**

- **Jobs gains are greatest from biomass technologies - both in the biomass energy industry and in fuel supply - however all technologies show long-term net job creation.**

- **Renewable energy technologies are in general more labour intensive than conventional energy technologies, in delivering the same amount of energy output.**

- **Jobs displaced as a result of subsidies to support renewable energy deployment are significantly less than corresponding job gains (both direct and indirect impacts) elsewhere in the economy.**

- **Job gains are greatest in the agriculture and manufacturing industrial sectors. The conventional energy supply industry is predicted to lose less than 2% of its work force by 2020 as a consequence of the shift to a greater use of energy from renewable sources.**

- **All technologies generate a net increase in jobs during the construction phase. For some technologies however there are net employment losses during the operational phase.**

- **Employment creation occurs in all Member States. Germany, France and Italy have the greatest absolute employment increases, whilst Denmark, Greece and Austria achieve the highest proportional increase relative to the size of their labour force.**

The results from the study will be of practical interest to many different groups, including policy makers, the renewable energy industry, regional and local authorities, investors, and will help to raise general awareness about the employment benefits from renewable energy technologies.

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[1] Excluding large hydro, geothermal, wave and tidal energy which were not included in the analysis.

Introduction

The rationale for the promotion of renewable energy technologies in the EU has focused around their potential contribution to energy security and the environment. Increasingly, however, there is a realisation that the widespread deployment of renewable energy technologies has the potential to offer additional benefits, such as improved industrial competitiveness and the development of a strong export industry, regional development and the creation of employment, especially in more remote areas. Agricultural regions in particular can benefit from stimulation of biomass industries to halt the decline in jobs, by encouraging a switch from traditional food crop production to non-food biomass production.

The European Commission in its White Paper and Action Plan on Renewable Energy Sources in 1997 proposed an objective to double the contribution of renewable energy in Europe by 2010, to 12% of gross inland consumption. The Campaign for Take-Off, launched in 1999, presents detailed priorities for initiatives to achieve this objective. The rationale for the Action Plan is driven not only from the environmental dimension, but also recognises the important economic, employment and social benefits that an increase in renewable energy use can bring.

A number of studies have looked at the impact of renewable energy on patterns of employment - these have generally investigated the effects of renewables either at the individual technology level, or in a specific region or country. Most studies have generally focused on the direct employment benefits from renewable energy; i.e. they considered jobs at the plant level, and/or in manufacturing and associated industries. However, such studies have not generally identified the implications on employment from a subsequent decrease in energy used from conventional sources; nor have they considered the economic impacts of the (sometimes considerable) levels of subsidy provided to renewables on the rest of the economy.

There is therefore a need to provide quantitative information to policy makers involved with renewable energy and interested in its impact on the wider economy - for example, what kind of impacts occur, in terms of jobs/GWh output or jobs/MW installed, as a result of investment in renewable energy? Renewable energy is now recognised as an important mainstream industry, and as such it must therefore compete with other sectors for public and private investment. A detailed understanding of the economic benefits provided from renewable energy is important for decision-makers in national, regional and local planning.

To this end, a study was carried out during 1998-9, to evaluate and quantify the employment and economic benefits of renewable energy in the EU. The study, funded by the European Commission through the ALTENER programme, was initiated by EUFORES and carried out by a consortium of organisations led by ECOTEC Research & Consulting Ltd.

The Challenge

The study set out to answer the question:

"Will an investment in renewables lead to more jobs and economic growth?"

A complete analysis of employment impacts from renewable energy needs to take account of the jobs created both directly and indirectly as more renewable plant are manufactured, installed and operated. It should also consider the jobs displaced in conventional (fossil or nuclear) energy plant, or jobs lost because of subsidies provided to renewables that could otherwise fund employment in other sectors of the economy.

This type of analysis had not been carried out before at the EU level. One of the principal objectives of the study was therefore to develop a methodology that could calculate the economic and employment impacts of investment in new renewable energy technologies. This methodology could then be combined with an existing energy model predicting future penetration levels of renewables in the EU, to determine the impacts of an increase in renewable energy on employment.

The Approach

Methodology development

The methodology developed during the study takes a two-stage approach to calculating the employment effects from renewable energy:

- ***Stage 1: Projecting the future energy market, and the market share of renewable energy to 2020***. This modelling uses the ***SAFIRE*** [2] ***energy model*** to predict the levels of market penetration for the various renewable energy technologies, and the resulting displacement of conventional energy technologies. Any gains in employment or economic development achieved through an increase in renewable energy will be offset by corresponding changes - and in particular losses - in the conventional energy industries as energy supplied from these industries is displaced by energy from renewables.
- ***Stage 2: Estimating the economic and employment impact of the market changes.*** An input-output model (termed the ***RIOT model*** - *Renewables enhanced Input-Output Tables*) was developed for the study, to calculate employment impacts. This in turn is based on the calculation of production functions that represent the value of inputs (including employment) from the various industrial sectors of the economy needed to produce a unit of energy, for different energy technologies (both renewable and conventional).

[2] SAFIRE (Strategic Assessment Framework for Rational Use of Energy) is an established model, which analyses the impact of different modes of energy consumption, the introduction and spread of energy technologies, and energy policies on a number of indicators. It was used as the basis for the development of the TERES and TERES II modelling projects - TERES II formed the basis of the development of the targets presented in the EC's White Paper on Renewable Energy Sources.

The outputs from the RIOT model are presented in terms of ***net impacts***, i.e. taking account of employment displaced in conventional energy technologies. The analysis separates out direct, indirect and subsidy impacts:

- ***Direct impacts*** are defined as effects within the energy industry (for the renewable and conventional power and heat technologies) or in the agriculture industry (for the renewable fuel technologies)
- ***Indirect effects*** are impacts elsewhere in the economy induced by changes in the purchasing activities of the renewable and conventional energy technologies.
- ***Subsidy*** impacts arise when Government or price subsidies artificially support the renewable energy technology. As a result consumers have less to spend elsewhere in the economy.

Combining these two models, the study approach is able to predict, for a specific policy scenario, the subsequent employment and economic impacts. These can be expressed as the ratios of net additional employment per unit of capacity, for different renewable technologies.

Employment effects are measured in ***Full Time Equivalents (FTEs)****. The number of FTE working in the economy is calculated from adding full-time workers to part-time and seasonal workers weighting the latter two according to how many hours a year they work. The definition of a full time worker is usually someone that works more than 30 hours a week all year round.*

The RIOT analysis relates only to domestic employment in the 15 Member States generated as a consequence of new *domestic* renewable energy plant or biomass fuel supply. Any additional employment created as a consequence of exports is not included. In addition, domestic employment in the manufacturing of renewable energy plant is modified to take account wherever possible of imports of technologies. However, the subsequent employment benefits generated as a result of export sales within the EU have not been included in the results presented here. To do this would require a detailed knowledge of the patterns of trade between EU countries, and in particular the relative contributions of each country to total EU export (i.e. non-domestic) sales of renewable energy goods and services. This level of trade information was not readily available for many of the renewable energy technologies studied.

Policy scenario

The policy scenario used for the study was based on the 'best practice' scenario from TERES II, which takes account of measures and policies in support of renewable energy development in all the Member States. The SAFIRE model's data inputs were then reviewed and updated to reflect changes in individual country policies, technology costs etc., since TERES II was completed.

The base year for the study was 1995. Three time periods were considered for the study, 2005, 2010 and 2020, with the following investment scenario for the three time periods:

- **Short term:** During the first time period, up to 2005, it is considered that renewable energy will still require investment support. Renewables continue to be supported by similar renewable energy programmes to those that are implemented throughout Europe today. These provide a range of subsidies from direct capital subsidies through to fixed rate income per kWh for the output of renewable energy.

- **Medium term:** During the second time period, from 2005 to 2010, a European wide carbon tax or equivalent tax is implemented. The level of taxation is determined at a national level to reflect the costs of pollution and climate change and internalise them in the price of energy. It is assumed that a minimum European level for the tax will be set. However, the implementation will be determined by an extension of national policies already implemented in the area of environmental taxation.
- **Long term:** In the third time period, to 2020, convergence of renewable energy prices and conventional energy prices occurs. This is due to the combination of policies of government support, up to 2005 and internalisation of external costs, up to 2010. Thus by 2020, no new subsidies are predicted from the SAFIRE model, however there are still residual subsidy effects evident as a result of long term government support programmes.

Data collection

To support the methodological approach, all project partners carried out a comprehensive programme of data collection.

Firstly, information was collected to update the SAFIRE model's input tables for each of the EU15 Member States. These updates incorporated changes and developments in national policies on energy and agriculture (subsidies, taxes, price support mechanisms, etc.), revised technology costs, and any national plans or targets proposed for renewable energy penetration levels.

Secondly, the RIOT methodology uses a comprehensive set of production functions for each of the energy technologies in each of the 15 Member States. Data was collected on employment, and spending on goods and services, for renewable and conventional energy installations in the Member States. Secondary data was also collected on the energy market, prices and subsidies relating to renewable energy in each Member State.

These production functions were completed for key country / technology combinations where the technology is (or is expected to) make a significant impact in terms of energy penetration. For the remaining technologies in each country, data from an appropriate production function developed for another country were used. All data compiled related to either the construction and installation (C&I) or the operation and maintenance (O&M) phase of the plant. Similar datasets were also compiled for the appropriate conventional energy technologies - combined heat and power, power generation, and heat.

Technologies and biomass fuels studied:

The renewable energy technologies and biomass fuels included in the study are described as follows:

Wind energy - electricity generated from wind turbines. Most wind turbines are built on land (**onshore**), but there is increasing interest in exploiting **offshore** wind energy.

Solar energy - can be harnessed using **photovoltaic** (**PV**) panels, which generate electricity directly. **Solar thermal** collectors are used for heating. In the future, an increasing amount of electricity may also be generated from solar thermal sources (**solar thermal electricity**).

Biomass - can be used to produce heat, electricity or **biofuels** for use in vehicles, through **combustion**, **gasification** or **anaerobic digestion** of a range of **fuels**, including **forestry residues**, **agricultural wastes** and **energy crops**, and solid and liquid industrial and municipal wastes.

Small-scale hydro electricity (<10 MW) is produced by the natural flow of water through turbines installed in small river courses.

Large-scale hydro, wave, tidal and geothermal were excluded from the study, as was passive solar.

Production functions for three principal forms of conventional (fossil or nuclear) energy technologies were also compiled: **Conventional CHP; Conventional power generation; Conventional heating.**

Most of the graphs and tables in this report present the results separately for each of the renewable energy technologies studied, and where appropriate for the different biomass fuels. However, where appropriate data are combined for the following technologies:

Solar thermal = solar thermal heat + photovoltaic + solar thermal electric
Wind = onshore wind + offshore wind
Biomass = all biomass energy transformation technologies
Biomass fuels = all biomass fuels, i.e. energy crops + forestry residues + agricultural wastes

Results - renewable energy to 2020

- **The SAFIRE model predicts an increase in energy produced from renewable sources by a factor of about 2.4, from a base of 440 TWh in 1995 to 1,066 TWh by 2020, for the specified investment and subsidy scenario.**

The energy predictions provided by the SAFIRE model are presented in **Figure 1** and **Table 1**. These show the predicted capacity in GW and energy production in TWh, for each of the renewable energy technologies.

- **The SAFIRE model predicts increases in the capacity and output of all the renewable energy technologies studied.**

The largest overall increase comes from biomass sources, especially from biomass combustion and anaerobic digestion of liquid wastes, providing electricity, heat and co-generation outputs. Total biomass capacity is predicted to increase from 180 GW in 1995 to 876 GW by 2020. Most of this increase occurs in the biomass combustion technology, however the model also predicts 102 TWh generated from liquid biofuels by 2020 (equivalent to about 10,400 million litres).

The proportion of renewable energy provided from biomass sources declines, from 90% of the total output in 1995 to 82% by 2020. Much of this is due to the rapid increase in wind energy capacity, which is predicted to expand 20-fold by 2020, to 50,000 MW. The total installed capacity of photovoltaic cells in the EU is predicted to increase 100 times by 2010 and nearly 300 times by 2020, to 14 GW. The newly emerging technologies offshore wind and biomass gasification are predicted to increase in capacity and output, particularly during the period 2010 to 2020. These increases are very dependent on the level of support given through national policies, particularly subsidy support in the short term in countries such as Denmark (offshore wind) and the Netherlands (photovoltaics).

- **The SAFIRE outputs show an increase in energy produced from renewable sources in all Member States.**

Figure 2 and **Table 2** show the predicted renewable energy capacities and outputs for each of the 15 Member States over the 25 year period of the modelling study.

All Member States show an increase in renewable energy capacity and output, with increases in output between 1995 to 2020 of between 1.4-8. Germany, Italy and France show the greatest total increase in new renewable energy production, with an additional 167 TWh predicted for Germany. The Netherlands and the UK are predicted to increase their renewable energy production by 8 and 6.8 times, to 42 and 58 TWh respectively. Member States such as Spain, Austria, Finland and Sweden, which in 1995 were already generating a high proportion of their total energy from renewable sources, also show increases in renewable energy generation of up to 44 TWh by 2020.

Figure 1: SAFIRE predictions of capacity and output from renewable energy technologies to 2020, for each renewable energy technology

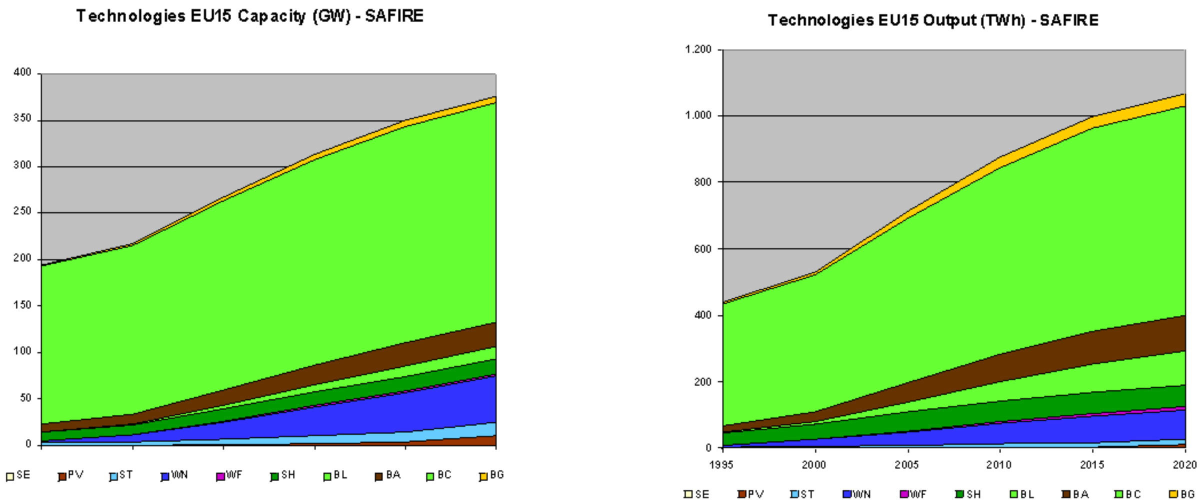


Figure 2: SAFIRE predictions of capacity and output from renewable energy technologies to 2020, for each Member State

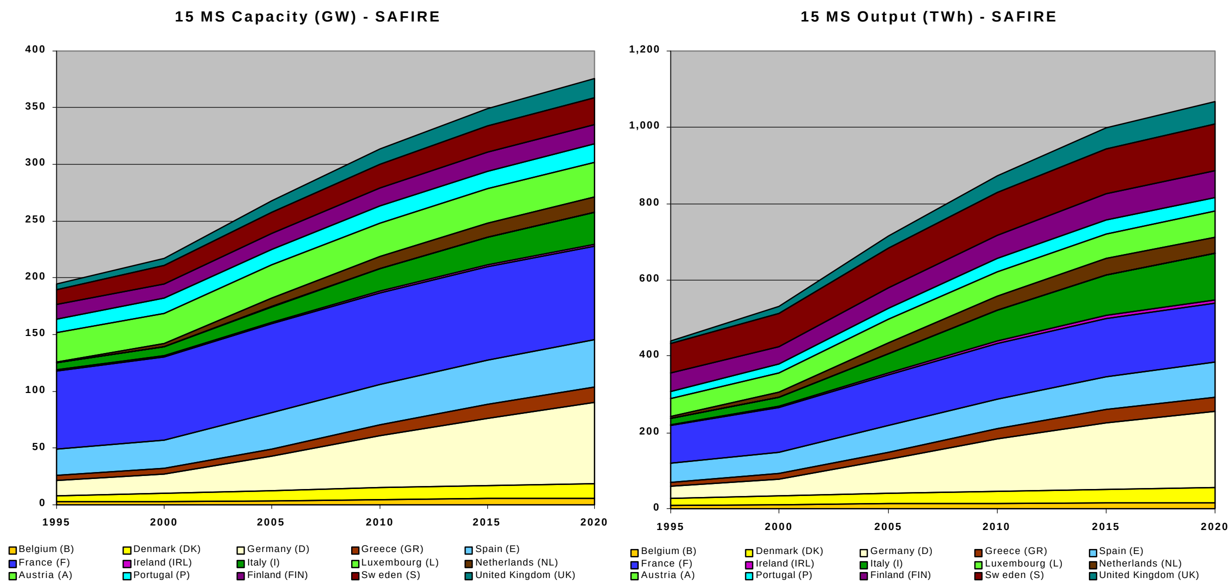


Table 1: Predicted capacity and output of each renewable technology to 2020

	1995	2000	2005	2010	2015	2020
Capacity GW						
Solar thermal electricity	0.00	0.09	0.18	0.20	0.20	0.20
PV electricity	0.04	0.34	0.82	2.15	3.42	10.43
Solar thermal heat	2.56	3.18	5.59	8.01	10.92	13.97
Onshore Wind	2.48	7.80	18.60	31.15	42.49	50.07
Offshore Wind	0.00	0.14	1.02	1.31	2.00	2.30
Small Hydro	9.35	10.99	13.37	14.64	15.48	15.87
Biomass liquid (GW eq.)	0.15	0.75	3.88	7.68	11.23	13.42
Biomass anaerobic	8.12	10.19	16.08	21.58	24.66	26.77
Biomass combustion	170.09	181.58	204.27	221.28	232.97	236.33
Biomass gasification	1.64	1.86	3.92	5.38	6.15	6.36
Total	*194.43*	*216.91*	*267.73*	*313.37*	*349.52*	*375.73*
Output TWh						
Solar thermal electricity	0.00	0.03	0.07	0.08	0.08	0.08
PV electricity	0.04	0.31	0.87	2.30	3.70	10.14
Solar thermal heat	3.15	3.87	6.84	9.68	13.02	16.32
Onshore Wind	3.55	22.21	39.84	62.07	79.39	88.96
Offshore Wind	0.00	0.54	4.23	5.41	8.29	9.56
Small Hydro	38.78	46.19	56.78	60.77	63.42	65.14
Biomass liquid	1.21	5.93	30.00	58.40	85.53	102.14
Biomass anaerobic	19.43	30.01	57.15	82.94	97.32	106.92
Biomass combustion	367.51	412.76	496.33	562.90	611.22	630.61
Biomass gasification	6.56	8.14	20.95	30.20	35.03	36.37
Total	*440.24*	*529.99*	*713.06*	*874.74*	*997.00*	*1066.24*

Table 2: Predicted capacity and output for each Member State to 2020

	1995	2000	2005	2010	2015	2020
Capacity GW						
Belgium (B)	2.50	2.94	3.71	4.72	5.37	5.79
Denmark (DK)	5.37	7.11	8.68	10.02	11.40	13.12
Germany (D)	13.34	16.60	30.07	45.74	59.48	71.47
Greece (GR)	4.74	5.24	6.79	9.66	11.94	13.61
Spain (E)	23.24	25.56	32.14	35.76	39.29	41.98
France (F)	68.71	72.79	78.12	80.83	82.11	81.62
Ireland (IRL)	0.71	0.84	1.18	1.70	2.06	2.17
Italy (I)	6.26	8.00	13.73	19.30	24.31	27.96
Luxembourg (L)	0.04	0.09	0.14	0.18	0.19	0.19
Netherlands (NL)	1.16	3.22	7.72	10.61	11.97	13.16
Austria (A)	25.66	26.68	28.93	30.11	30.65	30.96
Portugal (P)	11.97	12.92	14.05	14.61	15.15	15.73
Finland (FIN)	13.33	12.97	14.40	15.78	17.04	17.51
Sweden (S)	12.68	15.51	18.44	21.19	22.69	24.07
United Kingdom (UK)	4.70	6.44	9.64	13.16	15.87	16.40
Total:	*194.43*	*216.91*	*267.73*	*313.37*	*349.52*	*375.73*
Output TWh						
Belgium (B)	8.27	9.87	12.08	14.20	15.56	16.35
Denmark (DK)	18.16	23.90	28.21	30.87	34.79	39.42
Germany (D)	30.97	44.51	89.64	137.50	175.60	198.09
Greece (GR)	12.07	13.73	17.53	26.43	33.07	36.98
Spain (E)	49.46	56.32	69.63	76.93	85.20	92.92
France (F)	99.96	116.92	133.62	147.93	154.94	154.53
Ireland (IRL)	1.89	2.38	4.00	6.48	8.27	8.93
Italy (I)	16.50	23.39	51.73	80.09	105.96	122.14
Luxembourg (L)	0.13	0.28	0.50	0.65	0.70	0.71
Netherlands (NL)	5.25	13.20	29.05	37.08	40.73	42.47
Austria (A)	46.33	50.70	59.95	64.03	65.89	66.75
Portugal (P)	20.27	23.79	30.06	32.77	35.07	36.95
Finland (FIN)	45.57	44.80	53.15	61.59	68.82	71.13
Sweden (S)	76.98	89.61	101.92	111.73	116.58	121.20
United Kingdom (UK)	8.43	16.59	31.97	46.45	55.83	57.67
Total:	*440.24*	*529.99*	*713.06*	*874.74*	*997.00*	*1,066.24*

- **These predictions also represent an increase in the overall proportion of final energy consumption in the EU provided by renewables (excluding large hydro, geothermal, wave and tidal energy which were not included in this study) from 4.3% in 1995 to 8.2% by 2020.**

Total energy demand in the EU is rising over the period of the study, therefore it is important to assess the relative contribution made by renewable energy towards total energy demand. **Table 3** presents the contribution of the renewable energy predicted through the SAFIRE modelling with the predicted total demand for energy in the EU, to 2020, as given by the European Commission's *Energy to 2020* study[3].

Total final energy demand is predicted to rise by 25% by 2020, but SAFIRE predicts that an increasing proportion of this demand will be met from renewable energy sources.

Table 3: The contribution of SAFIRE's predictions of renewable energy output towards total final energy demand in the EU

	1995	**2005**	**2010**	**2020**
Total final energy demand[1] (TWh)	10,350	11,375	11,950	12,950
Renewable energy output[2] (TWh)	440[3]	713	875	1,066
Proportion from renewable sources (%)	**4.3**	**6.3**	**7.3**	**8.2**

[1] From European Energy to 2020.
[2] SAFIRE model - excluding large hydro, geothermal, wave and tidal energy
[3] EUROSTAT data

Results - employment from renewables

- **The overall impact on employment from the predicted increase in renewable energy penetration is a net increase in jobs throughout the EU. This increase takes account of the direct, indirect and subsidy effects on employment, and jobs displaced in conventional energy technologies.**

Figure 3 shows the net employment predicted to be created as a consequence of the increase in energy generated from renewable sources. Data relating to the Figure are given in **Table 4.** The overall number of net additional jobs predicted to be created from the 1995 base year by 2020 is 385,000 (full time equivalents, FTE) jobs. In addition, a further 515,000 jobs are predicted to be created as a consequence of investment in biomass fuel production - from agricultural and forestry residues, and from energy crops. The total number of jobs predicted to be created by 2020 from renewable energy technologies together with biomass fuel provision is therefore 900,500.

[3] Energy in Europe: European Energy to 2020. European Commission, 1996.

Figure 3: Impact on employment
(new net FTE employment relative to base in 1995)

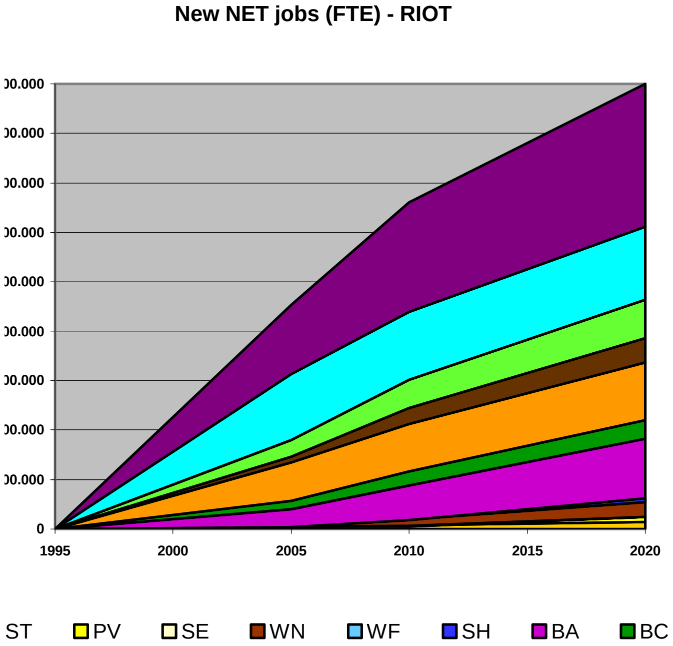


Table 4: Impact on employment
(data for Figure 3)

Year:	**2005**	**2010**	**2020**
Solar thermal heat	4,590	7,390	14,311
PV	479	-1,769	10,231
Solar thermal electric	593	649	621
Wind onshore	8,690	20,822	35,211
Wind offshore	530	-7,968	-6,584
Small hydro	-11,391	-995	7,977
Bio anaerobic	37,223	70,168	120,285
Bio combustion	15,640	27,582	37,271
Bio gasification	78,524	96,026	117,151
Liquid biofuels	10,900	32,369	48,709
Energy crops	33,527	56,472	79,223
Forest residues	133,291	139,421	147,170
Agricultural waste	140,823	220,645	288,971
Total	453,418	660,812	900,546
Total excluding Fuels	145,777	244,274	385,182
Total Fuels	*307,641*	*46,538*	*515,364*

(Fuels = Energy crops + forest residues + agricultural waste)

- **Jobs gains are greatest from biomass technologies - both in the biomass energy industry and in fuel supply - however all technologies show long-term net job creation.**

The vast majority of employment is created in biomass technologies, together with biomass fuel provision. By 2020, biomass use for power, heat or biofuels is predicted from SAFIRE to have the potential to create 323,000 jobs, together with the further 515,000 jobs through provision of fuel as energy crops, forestry or agricultural wastes. Note that the analysis has assumed that expansion of biological fuel sources occurs *without* displacing employment in conventional agriculture and forestry[4].

Other technologies generate more modest levels of employment, with onshore wind the greatest number at 35,000 by 2020. Solar photovoltaics and small hydro both show job losses in the early years as a consequence of larger levels of subsidy, but both show net gains in employment by 2020. These lower levels of employment are a consequence of their lower penetration predicted compared with biomass technologies, as well as their lower overall FTE/MW employment ratio. Offshore wind has a negative impact on employment to 2020, mainly because of the higher levels of subsidy still received by this technology.

- **Renewable energy technologies are in general more labour intensive than conventional energy technologies, in delivering the same amount of energy output.**

The production functions compiled for individual renewable and conventional energy technologies give an indication of the relative employment levels for the different technologies at the individual

[4] The rationale for this is that there is still widespread overproduction of many agricultural products due to price subsidies from consumers and export subsidies from the CAP even though significant areas of land are in set-aside. The political reality of how an increase in energy crop production can be brought about within the framework of CAP and international trade agreements has not been considered within this study.

plant level, for both construction and installation (C&I) and operation and maintenance (O&M). Employment data for the O&M of biomass fuel provision were also compiled.

Table 5 gives production functions for all technologies and fuels (including conventional technologies as a range of values), weighted to reflect the relative contribution of each production function towards total EU capacity or output from the technology, calculated using the SAFIRE capacity and output data.

Table 5: Production functions weighted averages, for direct employment in C&I and O&M
(excludes solar thermal electricity)

Year:	**1995**	**2005**	**2010**	**2020**	**Range**
Construction and installation : FTE/MEURO					
Solar thermal heat	4.70	6.31	6.40	6.51	
Solar photovoltaic	5.94	3.53	6.97	5.38	
Wind offshore	7.64	7.79	7.48	6.71	
Wind onshore	5.57	4.64	6.06	6.07	
Hydro small scale	4.84	5.12	5.17	5.21	
Biomass liquid	6.08	6.08	6.08	6.08	
Biomass anaerobic	4.09	7.33	7.99	8.31	
Biomass combustion	4.15	4.29	4.41	4.52	
Biomass gasification	6.26	6.17	6.11	5.93	
Fuel production energy crops	11.05	11.05	11.05	11.05	
Fuel production forest residues	-	-	-	-	
Fuel production agricultural wastes	-	-	-	-	
Conventional CHP					2.3 - 5.7
Conventional power					4.2 - 13.0
Conventional heating					3.5 - 15.9
Operation and maintenance : FTE/GWh					
Solar thermal heat	0.26	0.27	0.26	0.25	
Solar photovoltaic	0.22	0.54	0.44	0.40	
Wind offshore	0.22	0.21	0.22	0.22	
Wind onshore	0.15	0.15	0.14	0.14	
Hydro small scale	0.08	0.08	0.09	0.09	
Biomass liquid	0.86	0.86	0.86	0.86	
Biomass anaerobic	0.19	0.22	0.24	0.24	
Biomass combustion	0.08	0.08	0.08	0.08	
Biomass gasification	0.09	0.09	0.09	0.10	
Fuel production energy crops	0.42	0.42	0.42	0.42	
Fuel production forest residues	0.10	0.10	0.10	0.10	
Fuel production agric. wastes	0.36	0.36	0.36	0.36	
Conventional CHP					0.02 - 0.06
Conventional power					0.01 - 0.1
Conventional heating					0.01 - 0.06

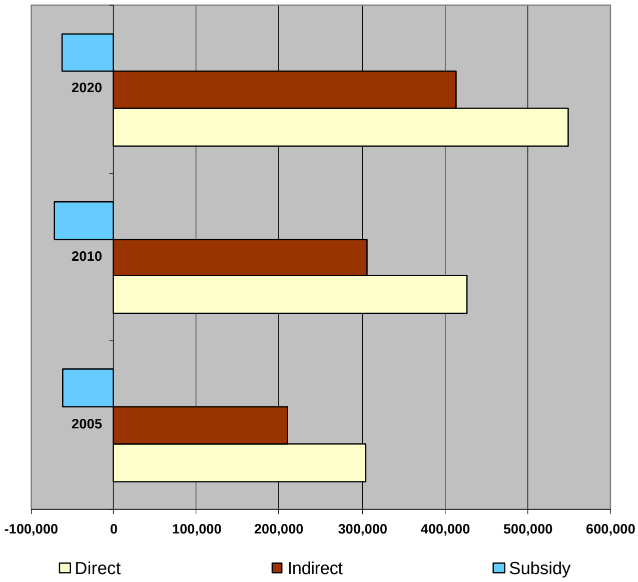
- **Jobs displaced as a result of subsidies to support renewable energy deployment are significantly less than corresponding job gains (both direct and indirect impacts) elsewhere in the economy.**

To an extent, and more so in the earlier years, subsidies are required to enable renewables to compete in the market with conventional energy sources. However, even when allowance is made for jobs that would have been created from alternate deployment of these subsidies (consumers buying other goods, Governments investing in alternative public services) renewables were still found to generate *net* jobs relative to conventional energy sources they displace.

Figure 4 show the RIOT methodology's predictions of direct, indirect and subsidy impacts of investment in renewables on employment to 2020. The largest employment increases arise from direct employment impacts, i.e. jobs in C&I or O&M at the renewable energy plant, which increase from 305,000 new jobs by 2005 to 549,000 by 2020. Indirect employment, principally jobs in manufacturing, also increases, from 209,000 new jobs by 2005 to 413,000 by 2020.

The greatest number of jobs displaced through subsidies occurs by 2010, where about 72,000 jobs are predicted to be displaced in other sectors of the economy. However, by 2020 these job losses have declined somewhat to 62,000, reflecting the steady decline in the amount of new subsidy made available to renewables.

Figure 4: Direct, indirect and subsidy impacts on employment (new net FTE employment relative to base in 1995)



- **Job gains are greatest in the agriculture and manufacturing industrial sectors. The conventional energy supply industry is predicted to lose less than 2% of its work force by 2020 as a consequence of the shift to a greater use of energy from renewable sources.**

Table 6 shows the RIOT predictions of the impacts of investment on employment in the major industrial sectors in the EU. From a base level of the total EU workforce in 1995 of about 147 million, the input-output analysis shows that the majority of job gains or losses occur in only a few sectors, particularly in agriculture, the energy supply industry, and various manufacturing sectors (abbreviated as *Agric*, *Fuel* and *AgMach/MetProd* respectively in the table). By 2020, the analysis shows a 7% increase in the number of people employed in the agriculture sector, engaged in the production, harvesting and supply of biomass fuels. By contrast, the conventional energy supply industry loses less than 2% of its work force by 2020 as a consequence of the shift to a greater use of energy from renewable sources.

The RIOT analysis also defines a separate "Renewable energy manufacturing" sector (*RET* in the table), which in 1995 was estimated to comprise about 38,000 jobs. By 2020 this sector is predicted to expand to nearly 194,000 jobs. These jobs were adjusted (reduced) for each Member State and each technology to take account of imports; however there is no associated increase to this sector if the Member State has a significant export industry to other Member States. As a consequence, the number of jobs estimated in domestic renewable energy manufacturing should be viewed as an under-estimate, especially for countries with a well-established export industry.

Table 6: Impacts on employment in the major industrial sectors (new net FTE employment relative to base in 1995)

Industrial sectors:	**1995 (base)**	**2005**	**2010**	**2020**
Agric	7,663,157	288,453	407,421	512,874
Fuel	2,071,698	-21,188	-30,485	-34,444
RET	38,555	92,610	135,890	193,572
Metals	1,218,483	4,569	5,944	7,721
Miner	1,363,741	510	1,460	2,898
Chem	1,787,736	8,771	15,347	23,318
MetProd	2,826,240	19,151	22,285	26,436
AgMach	3,124,353	22,049	32,173	43,393
OffMach	738,776	84	196	401
ElecGood	3,001,134	10,384	14,849	24,399
TranspEq	2,857,927	8,557	12,640	17,167
Food	4,330,754	701	1,865	3,611
Textile	3,484,848	-788	-229	730
Paper	2,355,824	783	1,540	2,698
Plast	1,302,986	979	1,594	2,388
OthMan	3,283,655	323	1,383	3,238
Constr	9,807,506	5,231	9,055	14,979
Distrib	22,132,257	7,330	15,422	26,411
Cater	6,587,631	-58	408	1,707
LandTran	3,888,948	-2,139	-552	3,874
WaterTran	592,627	-157	128	470
OthTran	2,064,931	2,278	3,995	5,785
Communic	2,067,455	1,454	2,206	3,110
BankIns	4,702,649	10,119	15,064	20,579
OthMrk	25,402,640	8,250	14,359	22,497
NonMkt	28,730,936	-14,838	-23,146	-29,270
Total Industry	147,427,447	453,418	660,812	900,546

- **All technologies generate a net increase in jobs during the C&I phase. For some technologies however there are net employment losses during the O&M phase.**

The solar technologies (photovoltaic and solar thermal) and wind (on- and off-shore) in particular generate net positive employment from C&I (see **Table 7**). However, many renewable technologies, such as hydro, only require low levels of maintenance, hence their net employment from O&M can be negative. This is particularly apparent for employment predictions to 2005 and 2010 where additional jobs are lost from subsidies.

In contrast, a large amount of labour is needed to operate a biomass plant, and to collect and deliver the biomass fuel to the plant, hence the FTE in O&M for both of these operations are highly positive, for the short, medium and long term scenario predictions.

Table 7: Employment created in C&I and in O&M (new net FTE employment relative to base in 1995)

	FTE C&I			FTE O&M			Total FTE (C&I + O&M)		
	2005	**2010**	**2020**	**2005**	**2010**	**2020**	**2005**	**2010**	**2020**
Solar thermal	2,645	4,681	9,628	2,538	3,357	5,304	5,183	8,039	14,932
Solar PV	1,134	1,671	11,105	-655	-3,441	-874	479	-1,769	10,231
Wind	11,925	17,983	21,315	-2,705	-5,129	7,312	9,220	12,855	28,627
Small Hydro	699	1,501	2,248	-12,091	-2,496	5,728	-11,391	-995	7,977
Biomass	2,687	4,703	7,107	139,600	221,441	316,309	142,287	226,145	323,415
Biomass Fuels *(O&M only)*				307,641	416,538	515,364	307,641	416,538	515,364
Total	*19,090*	*30,541*	*51,404*	*434,328*	*630,271*	*849,142*	*453,418*	*660,812*	*900,546*

- **Employment creation occurs in all Member States. Germany, France and Italy have the greatest absolute employment increases, whilst Denmark, Greece and Austria achieve the highest proportional increase relative to the size of their labour force.**

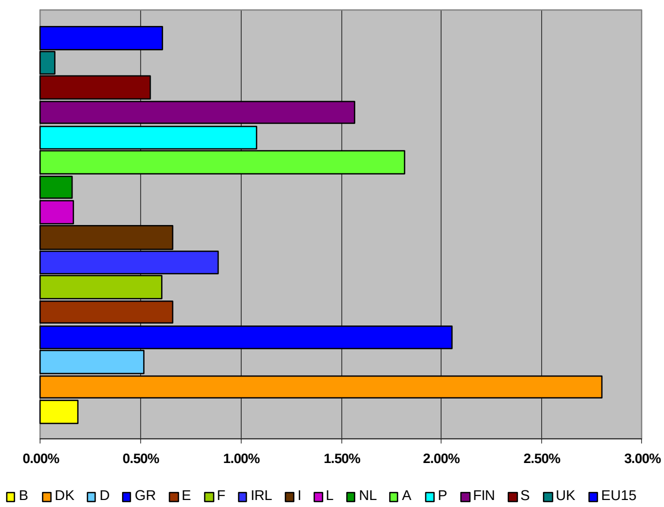
The total employment creation predicted by the RIOT model for each of the 15 Member States is shown in **Table 8**. Overall, around 20% of the EU's predicted employment creation from new renewable energy plant will come from Germany, and a further 15% from France. Italy will also contribute significantly by 2020.

Employment creation in Denmark from renewables is predicted to be nearly 3% of the country's total labour force by 2020 (**Figure 5**). Greece, Austria, Finland and Portugal all have predicted job creation levels higher than 1% of their total labour force, compared with the EU-wide average value of 0.6% of the labour force.

Table 8: Employment creation in the 15 Member States (new net FTE employment relative to base in 1995)

Year:	2005	2010	2020
Belgium (B)	4,040	4,605	6,936
Denmark (DK)	58,758	64,546	73,539
Germany (D)	81,282	134,618	183,759
Greece (GR)	17,311	46,385	83,470
Spain (E)	37,389	44,971	84,397
France (F)	87,018	126,832	135,164
Ireland (IRL)	4,446	7,981	11,184
Italy (I)	21,405	66,201	132,077
Luxembourg (L)	353	353	353
Netherlands (NL)	13,306	5,901	8,464
Austria (A)	55,746	59,980	62,182
Portugal (P)	26,778	38,116	47,473
Finland (FIN)	20,695	26,071	30,592
Sweden (S)	15,437	19,098	22,583
United Kingdom (UK)	9,453	15,155	18,373
Total:	453,418	660,812	900,546

Figure 5: Contribution of renewables towards total employment by 2020 (% of total labour force)



Next Steps

This study has enabled an assessment to be made of the overall impacts of renewables on employment in Europe. The approach was based on a sound understanding of the policy and technical factors influencing the likely development of renewable energy into the next century, combined with the compilation of a comprehensive data set of energy production functions. Overall, the results have shown that the development of renewable energy of the order calculated will generate net employment benefits, with some 385,000 net jobs generated, and an additional 515,000 jobs generated in the provision of biomass fuel supply, as a consequence of the levels of penetration predicted to 2020.

The results occur as a consequence of the higher labour intensity of renewable energy technologies compared with conventional energy technologies; the reduction in imports and a higher multiplier and the utilisation of currently inefficiently used resources for biomass production.

The study has provided a robust methodology that has been peer reviewed, for use with other policy scenarios, and as a basis for further examination of the economic benefits from investment in renewable energy. This methodology begins the process of redefining statistical analyses and data procedures, necessary to measure the renewable energy industry as a mainstream component of the EU economy.

The study provides information about the employment created as a result of investment in renewable energy technologies, and will be of practical interest to many different groups, including:

- **Policy-makers and other decision-makers** - who need to understand the relationship between investment in renewable energy and employment;
- **The energy industry** - the study provides comparative data on employment created per unit of energy output;
- **Regional and local authorities** - since new renewable energy developments make a significant contribution to the local economy;
- **Investors in new energy technologies** - as the renewable energy market expands both in the EU and world-wide;
- The **general public** - to raise awareness about the wider benefits of increased deployment of renewable energy technologies.

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