DETAILED TABLES

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Renewable energy sources statistics in the European Union

Data 1989-1998

8

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The project was co-ordinated by the Centre for Renewable Energy Sources (GREECE) and the Institute for the Diversification and Energy Saving (SPAIN) while the following national authorities or specialised institutes were responsible for the collection of national statistics.

Belgium	B	Institut Wallon
Denmark	DK	Danish Energy Agency
Germany	D	Statistisches Bundesamt
Greece	EL	Centre for Renewable Energy Sources
Spain	E	Instituto para la Diversificación y Ahorro de la Energia
France	FR	Observatoire de l' Energie CEREN
Ireland	IRL	The Irish Energy Centre
Italy	I	ENEA (Italian National Agency for New Technology, Energy and Environment)
Luxembourg	L	Agence de l'Energie
Netherlands	NL	Centraal Bureau voor de Statistiek
Austria	A	Austrian Central Statistical Office, Technical University of Vienna
Portugal	P	Ministério da Indústria e Energia
Finland	FIN	Statistics Finland
Sweden	S	Statistics Sweden
United Kingdom	UK	Energy Technology Support Unit / AEA Technology plc
Iceland	IC	National Energy Authority
Norway	N	Statistics Norway

Abbreviations

CAP	Common Agricultural Policy
CHP	Combined Heat and Power
EU	European Union
MSW	Municipal Solid Waste
NCV	Net Calorific Value
PV	Photovoltaic
RES	Renewable Energy Sources
WECs	Wind Energy Converters
kJ	Kilojoule
MJ	Megajoule
TJ	Terajoule
ktoe	Thousand tonnes of oil equivalent
Mtoe	Million tonnes of oil equivalent
kW_p	Kilowatt peak
MW	Megawatt
MW_{th}	Megawatt thermal
MW_e	Megawatt electric
MWh	Megawatt-hour
GW	Gigawatt
GWh	Gigawatt-hour
TWh	Terawatt-hour

Summary

Any country wishing to exploit its renewable energy resources needs statistics to define a coherent, realistic policy and to determine the effectiveness of any policy measures to encourage uptake of the various renewable energy technologies. In the late 1980´s, Member States and the Commission undertook a systematic approach in collecting necessary statistics as:

- an aid to policy and planning;
- a guide to R&D programmes, highlighting shortcomings in the deployment of certain technologies;
- a tool to determine and monitor the effectiveness of national and EU policies.

This work has allowed evaluation of the effectiveness of a variety of measures and policies implemented to assist the uptake of new and renewable technologies.

Eurostat has been instrumental in setting up a harmonised system for the collection of relevant statistics. It operated intensively within the European Statistical System in defining user needs, developing necessary collection methods, establishing a harmonised accountancy system and collecting necessary statistics. Since there is a large number of technologies allowing the exploitation of renewable resources, a stepwise procedure was followed over a long period, identifying the weak areas where special efforts and resources were needed, and amending the methodology and results following the experience gained both by the Member States and by Eurostat.

The project succeeded in:

- developing a standard methodology across the EU;
- establishing a system for the regular collection of statistics;
- allowing both the Commission and the Member States to monitor the effectiveness of the policies pursued in a quantitative manner.

This report presents the situation on renewable energy sources in the European Union and in each Member State over the period 1989-98. Detailed statistics are presented for all new and renewable technologies and their respective field(s) of application, which are either commercially viable or approaching economic viability.

In summary, in 1998 and for EU-15 we may state that for new and renewable energy sources:

- primary production was 85.5 Mtoe representing 11.4% of total primary energy production;
- the contribution to the overall gross inland consumption was 6.0%;
- electricity generation was 356 TWh, representing 14.3% of total electricity generation;
- heat production was 44.3 Mtoe.

This project has benefited from activities and parallel surveys initiated by Eurostat (energy consumption in households, combined heat and power generation etc.), from specific surveys implemented by Member States on an ad-hoc basis and financial support from the ALTENER programme. In future, data collection will continue with special efforts being made to improve the quality of certain field(s) of application, while also taking new policy initiatives into account.

PART I – DEVELOPMENT OF STATISTICS ON EU RENEWABLE ENERGY SOURCES

1. Technologies / Applications

While there is a limited number of Renewable Energy Sources (RES), there is a large number of technologies allowing the exploitation of these sources, most of which are still at the research/development stage or have not yet reached commercial maturity. The survey, however, covers only the technologies that are either economically viable or approaching economic viability, because these are the technologies that either contribute significantly to the overall energy balance at present, or could do so in the near future.

Taking into account the dispersed nature of RES production and consumption, identifying the major field(s) of application of each technology allows surveys to be focused on the major producers/consumers of RES so that data collection will be realised in a cost-effective manner. Applications of minor contributions such as off-grid operation of hydropower plants and Wind Energy Converters (WECs), or small-scale applications of photovoltaic systems have not been included in the methodology. In cases where such data were available at low cost however, they were included in the statistics. It should be noted that the current trend of national programmes is to encourage grid-connected plants, and for this reason the present system is limited to these.

Finally, although there is no consensus on whether heat pumps, and in particular those driven by electricity, should be included in the technologies allowing the exploitation of a renewable energy source, we have also considered them in the methodology for reasons of completeness.

2. Statistics Methodology

The methodology established by Eurostat for RES statistics had as an objective the definition of the set of RES statistics necessary to allow RES market penetration to be monitored, as well as an evaluation of the RES contribution to the security/diversification of supplies in the Member States and the European Union.

The RES technologies which are commercially mature, together with their major field(s) of application, are defined. For each of these applications, a set of statistics is determined which will allow an assessment of the political objectives described previously.

On the basis of the subsidiarity principle, the actual methodology to be followed for statistics collection is left to the discretion of the Member States, as this methodology depends strongly upon the existing national system of energy statistics in general, as well as on RES priorities and deployment within the various Member States.

The data collection methodology serves rather to determine complementary actions to be adopted as part of existing surveys in order to allow the collection of statistics in a cost-effective way, as well as to identify various authorities, professional associations etc. which could supply relevant statistics. The problems encountered in collecting the statistics for RES are outlined, along with recommendations for overcoming them, drafting questionnaires, evaluating and improving the quality and coverage of RES statistics, as well as proposals for strengthening the links between the information holders and the surveying body.

The methodology used for the collection of statistics in the Member States is also included in this publication, and describes the technologies and their applications for which data were collected. Full details are given in Part III (Data Collection Methodology) of this report.

3. Energy Balance Sheets - Accountancy System

Evaluating the contribution of the individual RES to the overall energy balance of a Member State or of the European Union, as well as assessing the positive impact of RES on the security/diversification of supplies, necessitates the establishment of an accountancy system for the RES. Having a single accountancy system in all Member States allows comparable harmonised statistics and indicators to be determined at European Union level.

While the existing Eurostat methodology on energy balances, as published in "Principles and Methods of Energy Balance Sheets", covers transformation and final energy consumption for the RES, it is necessary to complement it by defining the primary energy production for the different RES considered here. It must be stressed that the accountancy system for RES described below is compatible with the basic principles already used by Eurostat in drafting the annual energy balance sheets for the other energy sources. Primary energy production is defined below for the different renewable energy sources/technologies:

Hydropower, wind energy, solar photovoltaic: Primary energy production (TJ) is the gross electricity generation assuming 3 600 kJ/kWh.

Solar energy (flat plate collectors): Primary energy production (TJ) is the heat available to the heat transfer medium, i.e. the incident solar energy less the optical and collector losses.

Ambient energy: Primary energy production (TJ) is the heat removed from the environment, i.e. the useful heat, plus the energy consumed by the prime mover.

Geothermal energy: Primary energy production (TJ) is the difference between the enthalpy of the fluid produced in the production borehole and that of the fluid eventually disposed of (re-injection borehole).

Biomass/wastes: In the case of Municipal Solid Waste (MSW), wood/wood waste, and other solid waste, primary energy production (TJ) is the heat produced after combustion and corresponds to the net calorific value (NCV) of the fuel. In the case of anaerobic digestion of wet wastes, primary energy production (TJ) corresponds to the heat content (NCV) of the biogases produced, including the gases consumed in the installation for the fermentation processes but excluding flared gases. Primary production (TJ) in the case of biofuels corresponds to the heat content (NCV) of the fuel.

PART II – RES STATISTICS IN THE EUROPEAN UNION

1. Overview

Based on the established methodology, data on renewable energy sources have been collected on an annual basis since 1989 via the specific surveys foreseen under the project.

The collected information is often combined with information obtained from other surveys, such as the ‘Energy Consumption in Households’ survey. When the quality of data was not satisfactory, specialised surveys were organised in the Member States, e.g. the surveys on wood consumption in households in Germany and Belgium. It should be noted that most Member States had little or no experience of collecting renewable energy statistics during the early years of this project. The experience acquired during the first data collection exercises gave the Member States considerable know-how in monitoring the renewable energy market. This know-how is clearly reflected in the quality of data collected during the last phase of the project and also in the renewable energy data reported in the annual EUROSTAT/IEA/ECE Electricity & Heat and Solid Fuels questionnaires. Slight readjustments were also necessary in a few cases, where data for previous years were inaccurately estimated.

This report presents the major results and conclusions on the deployment of renewable energy sources across the European Union.

Renewable Energy Statistics in the EU-15

- KEY FIGURES -

				Increase per period		
	1989	**1993**	**1998**	**89-93**	**93-98**	**89-98**
Total RES Primary Energy Production (Ktoe)	**65,351**	**72,908**	**85,488**	**12%**	**17%**	**31%**
WIND	46	203	976	343%	380%	2027%
SOLAR	146	222	354	52%	60%	143%
HYDRO	21,975	25,126	26,482	14%	5%	21%
GEOTHERMAL	2,215	2,614	3,014	18%	15%	36%
BIOMASS	40,969	44,743	54,661	9%	22%	33%
Total RES Electricity Generation (GWh)	**275,497**	**317,816**	**355,716**	**15%**	**12%**	**29%**

2. Primary Energy Production

Primary energy production of renewable energy sources in the European Union (EU-15) in 1989 was 65.3 Mtoe, representing 9.1% of overall primary energy production. The increase to 85.5 Mtoe over the period 1989-98, resulted in a higher contribution to primary production (11.4% in 1998). However, the importance of RES in the various Member States varies considerably depending upon their energy policies, the existence of fossil fuel reserves, and in particular upon specific measures taken to promote renewable energy sources at national and international level. In Luxembourg and Portugal, renewable energy sources are almost the only indigenous sources available and constituted 100% of the total primary production in 1998. In Austria, renewable energies contribute 70.8% to primary energy production because of large hydro and biomass/waste resources. The contribution of renewable energy sources to primary energy production is also important in Finland (54.5%), Sweden (45.6%), Italy (38.7%), Spain (22.2%), France (14.2%) and Greece (13.5%) but it is below the EU average contribution in the UK (0.8%) and the Netherlands (2.3%), both Member States having few hydro and/or extensive fossil fuel reserves.

EU-15, Primary Energy Production in 1998

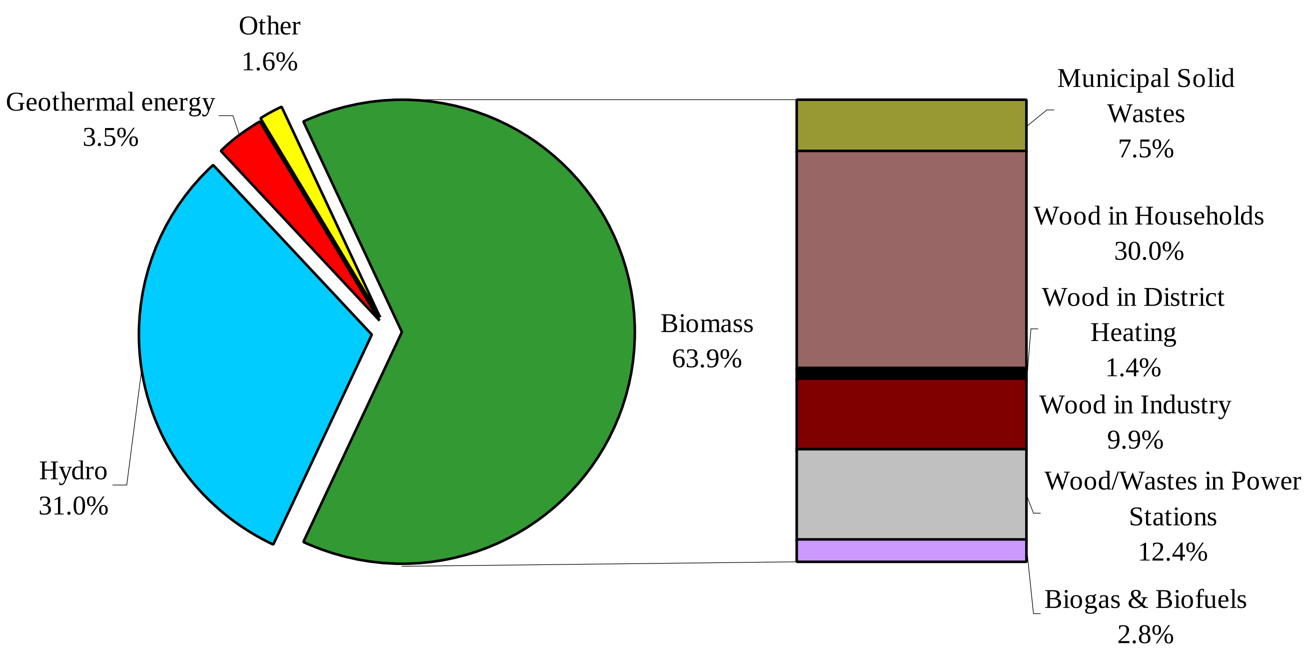


Table 1: Primary energy production from RES in EU-15

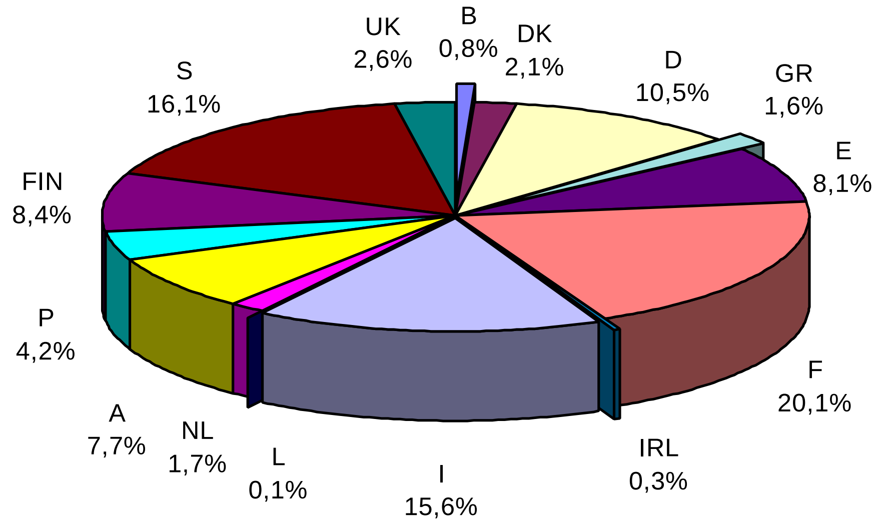
Year	Primary energy production from RES (ktoe)	Total primary production (ktoe)	Total inland consumption (ktoe)	Contribution of RES to total primary production %	Contribution of RES to total inland consumption %
1989	65 351	720 745	1 310 430	9.1	5.0
1990	66 219	701 236	1 314 192	9.4	5.0
1991	69 072	705 930	1 344 466	9.8	5.1
1992	70 971	700 305	1 334 326	10.1	5.3
1993	72 908	707 994	1 333 951	10.3	5.5
1994	72 969	721 613	1 334 621	10.1	5.5
1995	73 885	736 267	1 362 611	10.0	5.4
1996	76 236	761 778	1 411 075	10.0	5.4
1997	82 522	759 647	1 409 540	10.9	5.9
1998	85 488	750 931	1 435 331	11.4	6.0

Finally, the application of the substitution principle shows that if the electricity generated from hydropower, wind and photovoltaic systems had been produced from a conventional power station (where 220 toe of primary energy are required to produce 1 GWh), renewable energy in 1998 in the European Union (EU-15) would have contributed 16.2% to total primary energy production.

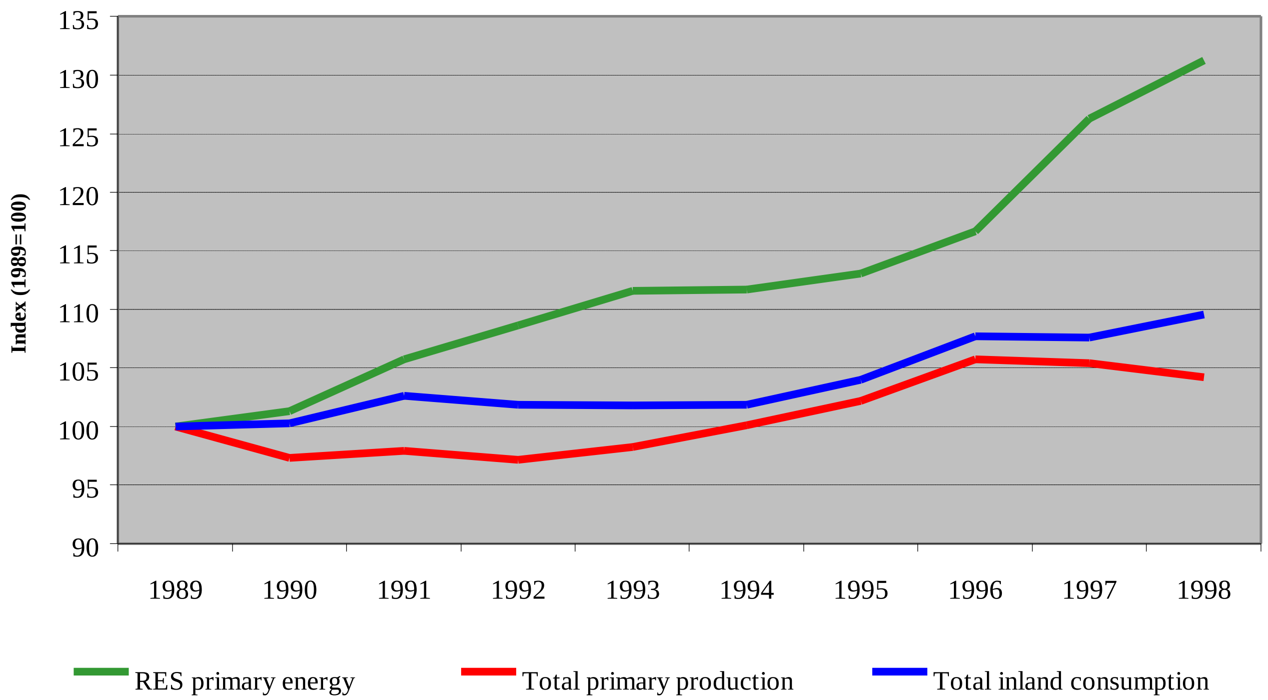
Table 2: Primary energy production from RES in EU-15
Using the substitution principle: 220 toe/GWh

Year	Primary energy production from RES (ktoe)	Total primary production (ktoe)	Total inland consumption (ktoe)	Contribution of RES to total primary production %	Contribution of RES to total inland consumption %
1989	99 676	755 070	1 344 755	13.2	7.4
1990	101 647	736 663	1 349 619	13.8	7.5
1991	105 600	742 458	1 380 994	14.2	7.6
1992	109 796	739 130	1 373 151	14.9	8.0
1993	112 391	747 477	1 373 434	15.0	8.2
1994	112 991	761 635	1 374 643	14.8	8.2
1995	113 459	775 841	1 402 185	14.6	8.1
1996	115 722	801 264	1 450 561	14.4	8.0
1997	123 665	800 789	1 450 683	15.4	8.5
1998	128 296	793 740	1 478 140	16.2	8.7

Member States Contribution to EU-15 RES Primary Energy Production in 1998



Primary Energy Evolution in EU-15, 1989-1998



3. Inland Consumption

Renewable energy sources accounted for 5.0% of the total inland consumption in the European Union (EU-15) in 1989. This percentage was increased to 6.0% in 1998. In the European Union, hydro and biomass/wastes are the major renewable energy sources while geothermal, solar and wind energy make a smaller contribution. The use of biomass/waste is predominantly in the form of firewood consumption in households, although wood waste burned in industry and municipal solid waste incineration contribute significantly. The Member States where renewable sources supplied a significant part of the total inland consumption were Sweden (28.7%), Austria (22.8%), Finland (21.5%) and Portugal (15.9%). The contribution to the total inland consumption was also relatively high in Denmark (8.4%), Italy (7.7%), France (6.9%), Spain (6.3%) and Greece (5.0%).

Table 3: RES Contribution in 1998

Country	To Total Primary Production %	To Total Inland Consumption %	To Total Electricity Generation %
B	6.0	1.3	1.3
DK	8.8	8.4	10.4
D	6.8	2.6	4.8
GR	13.5	5.0	8.2
E	22.2	6.3	18.9
FR	14.2	6.9	13.0
IRL	10.2	1.9	5.6
I	38.7	7.7	18.1
L	100.0	1.6	13.8
NL	2.3	1.9	4.3
A	70.8	22.8	70.4
P	100.0	15.9	36.5
FIN	54.5	21.5	32.2
S	45.6	28.7	48.9
UK	0.8	1.0	2.5
EU-15	**11.4**	**6.0**	**14.3**

4. Electricity Generation

In 1998, electricity generation in the European Union (EU-15) from renewable energy sources was 356 TWh, representing 14.3% of the total electricity generation and coming essentially from hydropower plants (308.0 TWh in 1998). Looking at electricity generation from biomass/wastes (32.0 TWh in 1998), municipal solid wastes (11.3 TWh) account for 35.5% of the total electricity from biomass, and wood/wood waste and agricultural solid wastes burned in power stations (16.7 TWh) for 52.2%, with the remainder being generated from biogas. In 1989, 534 GWh were generated from wind turbines whose total installed capacity was 354 MW, while in 1998, 11 354 GWh were generated from an installed capacity of 6 219 MW. The Member States making the major contribution of RES to total electricity generation were Austria (70.45%), Sweden (48.9%), Portugal (36.5%), Finland (32.2%), Spain (18.9%) and Italy (18.1%).

EU-15, Percentage Contribution of each Source to the Total RES Electricity in 1998

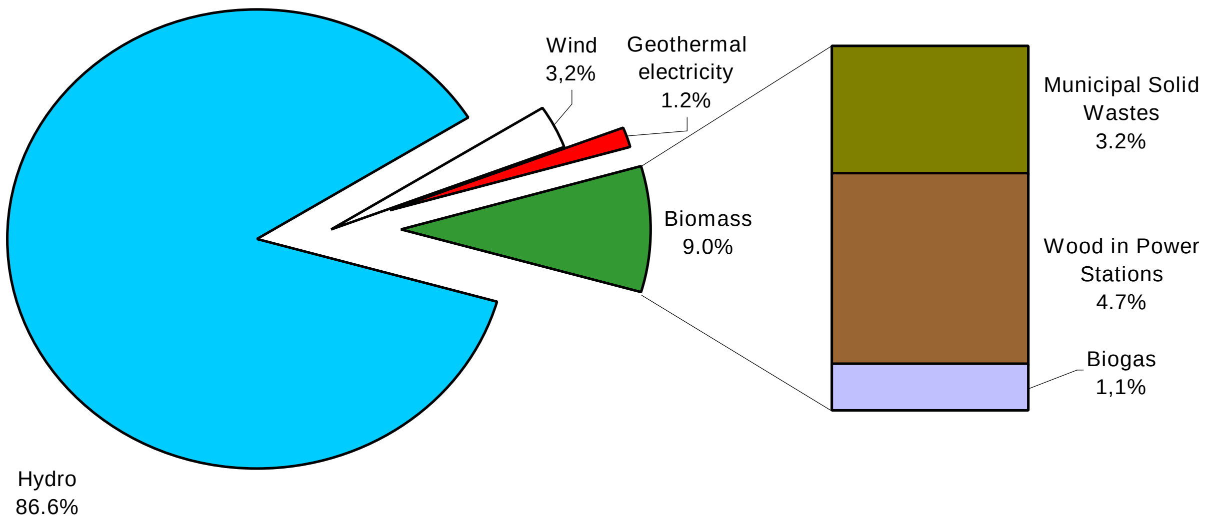
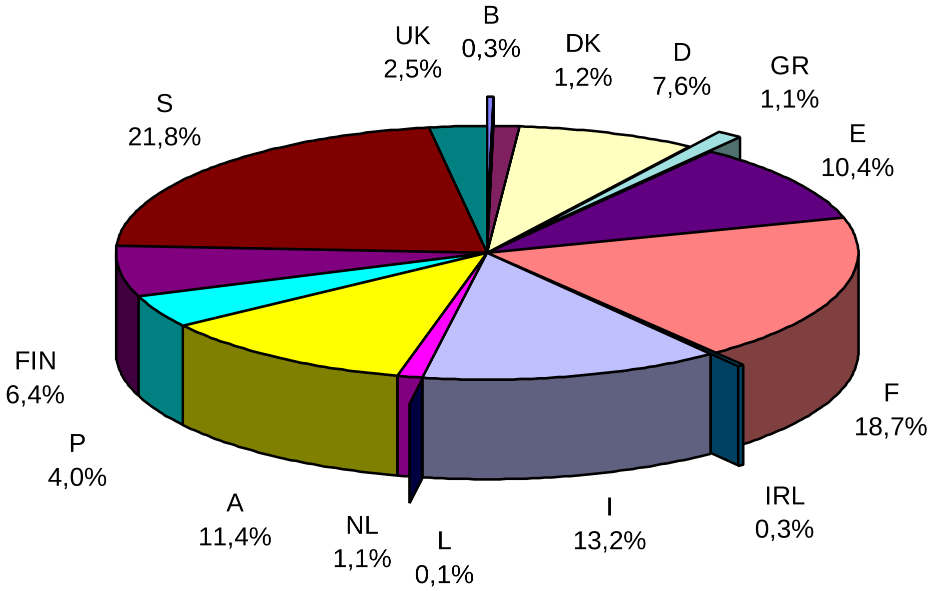


Table 4: Electricity Generation from RES in EU-15			
Year	Electricity Generation from RES (GWh)	Total Electricity Generation (GWh)	Contribution of RES to Total Electricity Generation %
1989	275 497	2 020 494	13.6
1990	283 884	2 061 877	13.8
1991	292 723	2 228 793	13.1
1992	311 262	2 231 881	13.9
1993	317 816	2 231 694	14.2
1994	323 689	2 269 158	14.3
1995	322 148	2 327 195	13.8
1996	325 910	2 411 029	13.5
1997	339 315	2 426 436	14.0
1998	355 716	2 493 331	14.3

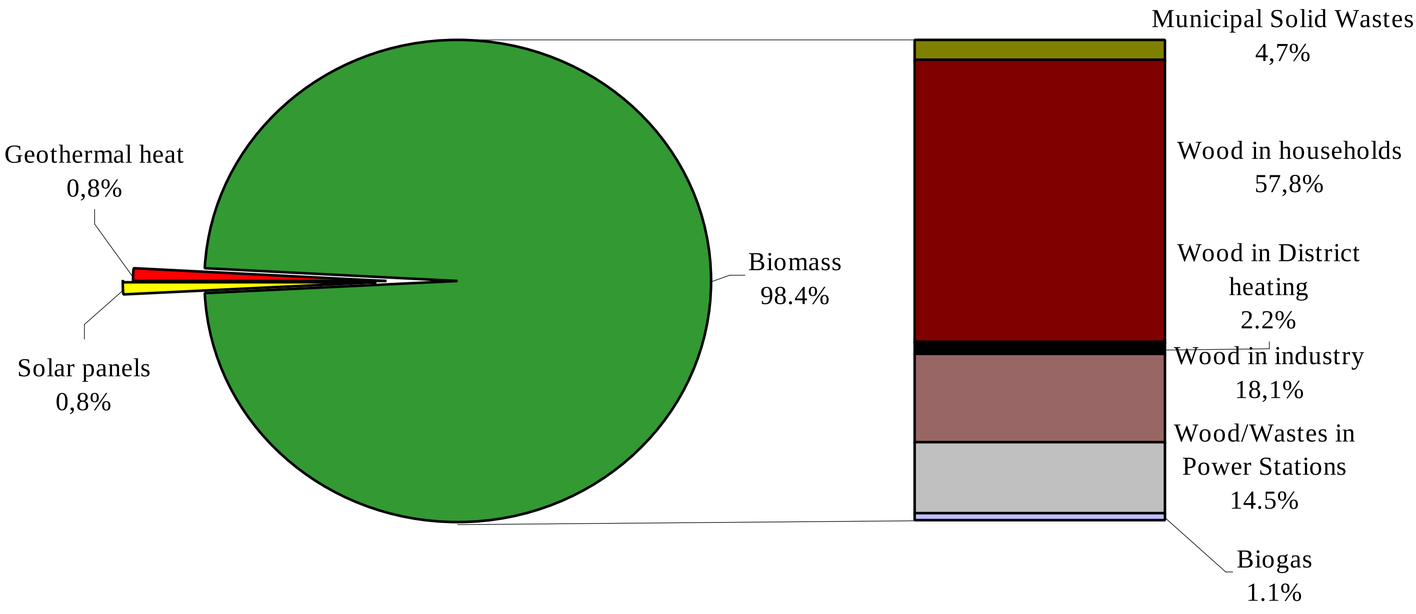
Member States Contribution to EU-15 RES Electricity Generation in 1998



5. Heat Production

Heat production in the European Union (EU-15) from renewable energy sources has increased by 22.4% from 36.2 Mtoe in 1989 to 44.3 Mtoe in 1998. Biomass/wastes accounted for 98.4% of total RES heat production. Firewood consumption for domestic heating (25.6 Mtoe) and combustion of wood waste in industry (8.0 Mtoe) for on-site steam/heat production are the main applications.

EU-15, Heat Production in 1998



6. The Impact Of Each Resource

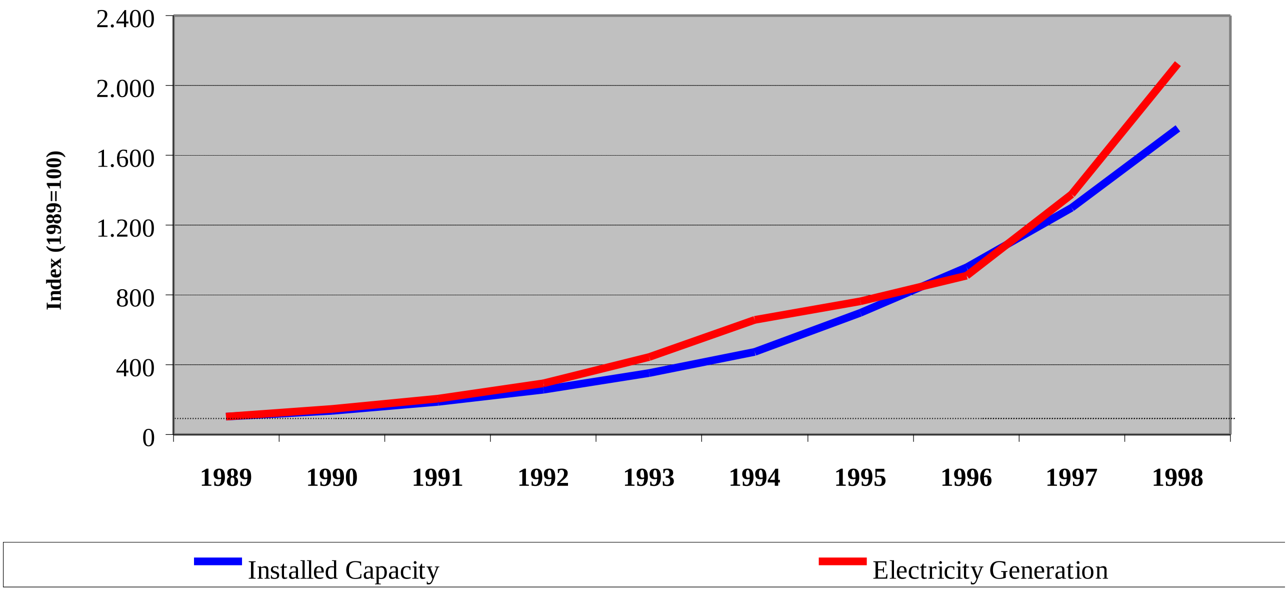
6.1 Wind

In 1998, the installed capacity of wind energy converters in EU-15 was 6 219 MW, generating 11354 GWh of electricity (976 ktoe). Since 1989, installed capacity has increased by a factor of 18 while electricity generation has risen by a factor of almost twenty-one.

The 43% of this capacity is installed in Germany (2 672 MW) and 23% in Denmark (1 443 MW). In Portugal, Austria, Germany, Sweden, Ireland, Spain, France, UK, Italy and Greece the installed capacity has attained higher expansion rates than the EU average in the period 1989-98.

In 1998, 4 593 GWh of electricity were generated in Germany, 2 779 GWh in Denmark and 1 437 GWh in Spain.

Wind Energy Trend in EU-15, 1989-1998



6.2 Hydropower

Hydropower is the second largest renewable energy source in EU-15 in terms of primary energy production, accounting for 31.0% (26 482 ktoe) of total RES energy production in 1998. By the end of 1998, installed capacity was 98 432 MW, showing an increase of 13.8% over the reference period. It must be stressed that the potential of large-scale plants in the European Union has already been exploited.

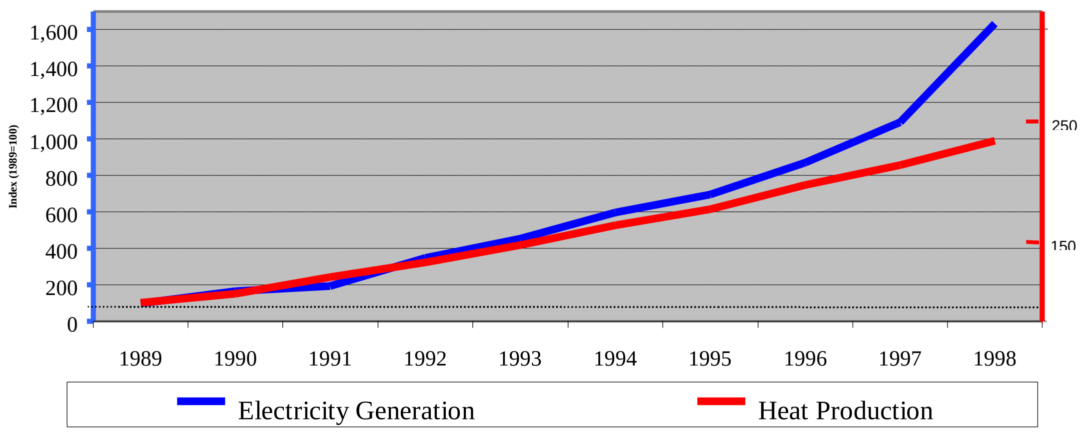
Table 5: Hydropower in EU-15			
Year	Installed Capacity (MWe)	Primary energy production (ktoe)	Electricity generation (GWh)
1989	86 453	21 975	255 583
1990	87 066	22 661	263 557
1991	86 881	23 339	271 451
1992	87 300	24 774	288 133
1993	87 991	25 126	292 225
1994	91 580	25 374	295 114
1995	91 941	25 036	291 179
1996	95 049	24 912	289 743
1997	93 533	25 760	299 606
1998	98 432	26 482	308 005

6.3 Solar energy

In 1998, the total installed surface of solar collectors in EU-15 was 9 037 200 square metres. Primary energy production was 348 ktoe, i.e. 0.4% of total EU-15 RES primary energy. Production has doubled over the reference period. About 28% of the total surface area of installed solar collectors in EU-15 was located in Germany, 26.3% in Greece and 20.8% in Austria while the shares to the total heat production are 34.2%, 22.9% and 15.7% for Greece, Germany and Austria respectively.

Installed capacity of photovoltaic (PV) panels in EU-15 in 1998 was 79 749 kWp, which means an increase of eighteen times the 1989 capacity of 4 422 kWp. Electricity generation has risen by a factor of sixteen from 1989 (4 GWh) to 1998 (61 GWh). Primary energy from PV panels was 5.3 ktoe in 1998. Significant reductions in cost due to the use of cheaper materials, together with promotion policies in some Member States, have resulted in significant development of PV panels mainly in small-scale stand-alone applications. Germany had the largest PV capacity in EU-15 in 1998 with 49435 kWp followed by Italy with a capacity of 17 680 kWp.

Solar Energy Evolution in EU-15, 1989-1998



6.4 Geothermal Energy

In EU-15, electricity production and installed capacity of geothermal power plants in 1998 were 4295 GWh and 604 MWe respectively, i.e. an increase of 35.3% in generation and 13.9% in capacity since 1989. Primary production from *geothermal electricity* was 2 654 ktoe in 1998, which represented 3.1% of total RES primary energy in EU-15. Electricity generation is almost exclusively confined to Italy (4 214 GWh) due to the high enthalpy geothermal resources while minor contributions were made by Portugal (58 GWh).

In contrast to the use of geothermal heat for electricity generation, the direct end-use of low enthalpy geothermal heat is more widely spread across the European Union and serves mainly in district heating and agriculture. Direct end-use heat production in EU-15 was 15 106 TJ in 1998. The main contributing Member States in 1998 are Italy with 8 916 TJ and France with 4 913 TJ.

6.5 Biomass / Wastes

Biomass/Wastes are the most important renewable energy sources in EU-15.

Biomass/wastes contributed 2 288 644 TJ of primary energy production in EU-15 in 1998, representing 63.9% of total RES energy production. They are mainly used to produce heat, the electricity generation being 32 000 GWh in 1998 and the heat production 1 826 070 TJ in 1998.

France is the Member State with the highest primary energy production from biomass/wastes, and accounts for 21% of total biomass/wastes energy production in EU-15, while the Member State with the most electricity generated from biomass/wastes is Finland with 7 528 GWh in 1998.

Table 6: Biomass/Wastes in EU-15

Year	Primary energy production (ktoe)	Electricity generation (GWh)	Heat Production (ktoe)
1989	40 969	16 202	35 745
1990	41 118	16 295	35 892
1991	43 264	16 970	37 851
1992	43 480	18 092	36 874
1993	44 743	19 537	37 901
1994	44 556	21 609	37 030
1995	45 716	23 386	37 446
1996	47 884	27 463	38 651
1997	53 001	28 366	43 031
1998	54 661	32 000	43 613

Municipal Solid Waste incineration

Incineration is the method used most frequently to recover energy from wastes disposed of by households, industry and the tertiary sector.

In 1998, primary energy production was 268 249 TJ, i.e. an increase of 60% since 1989. This represented about 11.7% of the total primary energy production from biomass/wastes. Significant production took place in France (24.3%), Germany (20.9%), the Netherlands (15.5%) and Denmark (10.2%), while data for Greece, Portugal and Ireland were not available.

In Europe, electricity generation from MSW was 11 350 GWh in 1998, i.e. an increase of 135% since 1989. It represented 35.5% of total electricity generation from biomass/wastes. Most Member States favour using municipal solid waste for electricity generation, but MSW are also used for heat production in the cases of France (25 394 TJ), Germany (22 556 TJ), Denmark (17 710 TJ), and Sweden (14 301 TJ).

Wood/ Wood Wastes / Other Solid Wastes

The combustion of firewood and forestry/agricultural solid wastes is the major RES technology in EU-15, accounting for 83.8% of total primary energy production from biomass/wastes and 53.4% of the total RES energy production (1 918 517 TJ in 1998). The production of steam and heat in industry and households are the main applications of this fuel source while use for electricity generation is rather limited (16 711 GWh in 1998). The principal fuels used are firewood and wood waste (wood chips, bark etc.), while there are minor contributions from black liquor, straw and other agricultural wastes.

Firewood consumption in households, 1 072 459 TJ in 1998, increased by 20.3% since 1989. France (318 623 TJ), Italy (226 800 TJ), Germany (159 729 TJ) and Spain (83 373 TJ) show significant levels of firewood consumption for domestic heating.

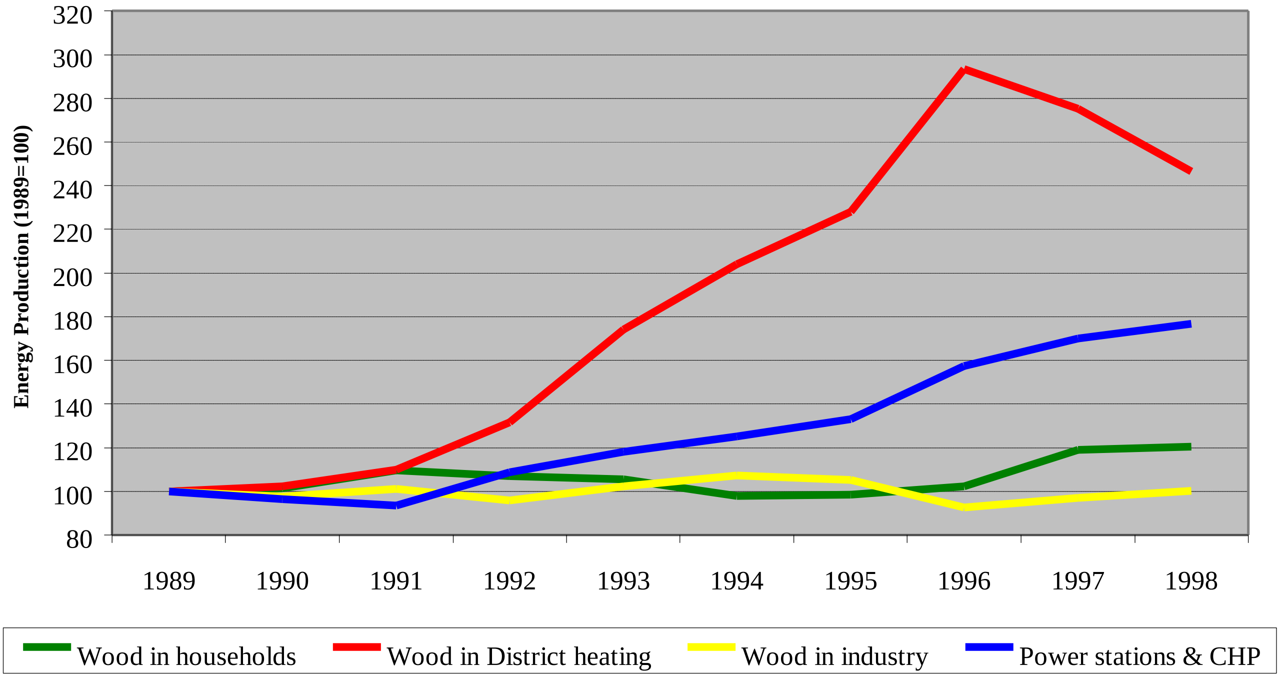
> It should be noted here that accurate statistics on firewood consumption can only be obtained with surveys. Such surveys have been carried out recently in Germany and Italy and showed that the actual firewood consumption was much higher than previously estimated. A punctual upward correction of firewood statistics was made for 1997 and 1998 data.

> The consumption of forestry/agricultural waste in industry for heat production in EU-15 was 353 015 TJ in 1998 (an increase of 0.2% since 1989), mainly in Sweden (28.9%), France (14.9%), Portugal (14.1%), Italy (11.8%) and Spain (10.7%).

The consumption of forestry/agricultural waste, including black liquor, in power stations in EU-15 was 443 606 TJ in 1998, i.e. a 76.7% increase since 1989. Electricity generation was 16 711 GWh and took place mainly in Finland (44.8%), Sweden (15.4%) and France (10.4%). The heat produced was 268806 TJ; and was either used on-site by the industrial auto-producers or supplied to the district heating network.

In addition, 49 436 TJ of forestry/agricultural wastes was consumed for district heating mainly in Sweden (57%).

Trend of Wood/Wood Wastes/Other Solid Wastes in EU-15, 1989-1998



Biofuels

Primary energy production from liquid biofuels in EU-15 has increased significantly and attained 18920 TJ in 1998. France (57.7%), Germany (21.1%), Italy (18%) and Austria (3.1%) were the only contributors.

Biogas

The anaerobic fermentation of organic wastes is a practice that has been rapidly expanding in EU-15. Whereas it is an activity that takes place mainly for environmental reasons, energy recovery is a welcomed by-product. In EU-15, biogas energy production was 82 958 TJ in 1998, mainly from landfill gas (47.9%) and sewage sludge gas (42.7%). Electricity generation from biogas in EU-15 was 3 939 GWh in 1998, mainly from landfill gas (72.9%). Heat production from biogas in EU-15 was 20903 TJ in 1998, 61.2% from sewage sludge gas.

In 1998, primary energy production from landfill gas was 39 728 TJ (eight times that of 1989) and took place mainly in the UK (42.2%), Germany (23%) and Italy (14.5%). This technology is not yet applied in Luxembourg and Portugal and was applied for first time in Ireland in 1996, with 400 TJ of energy production and in Greece in 1998. Electricity generation using this source in EU-15 was 2 871 GWh in 1998. Electricity was mainly generated in the UK (41.1%), Germany (26.1%) and Italy (16.7%).

In 1998, primary energy production from sewage sludge was 35 444 TJ and took place mainly in Germany (44.2%) and UK (21.7%). This technology is not applied in Portugal. Electricity generation using this source in EU-15 has decreased from 915 GWh in 1989 to 780 GWh in 1998. Electricity was mainly generated in the UK (49.4%), the Netherlands (14.1%) and Spain (13.3%).

Eleven Member States practised energy recovery from farm slurries in 1998. Primary energy production from farm slurries in EU-15 was 2 241 TJ in 1998 and took place mainly in Denmark (54.5%). Electricity generation using this source in the EU was 155 GWh in 1998, mainly in Denmark and Germany.

In 1998, primary energy production from the agro-food industry was 5 545 TJ and took place mainly in France (48.3%), the Netherlands (14.9%) and Spain (12.8%). This technology is not yet applied in Luxembourg and the UK. Electricity generation using this source in EU-15 was 133 GWh in 1998. Electricity was mainly generated in France (60.3%) and Germany (15.9%). In Denmark, Greece, Portugal, Ireland and Sweden there was no or very little electricity generation from this source.

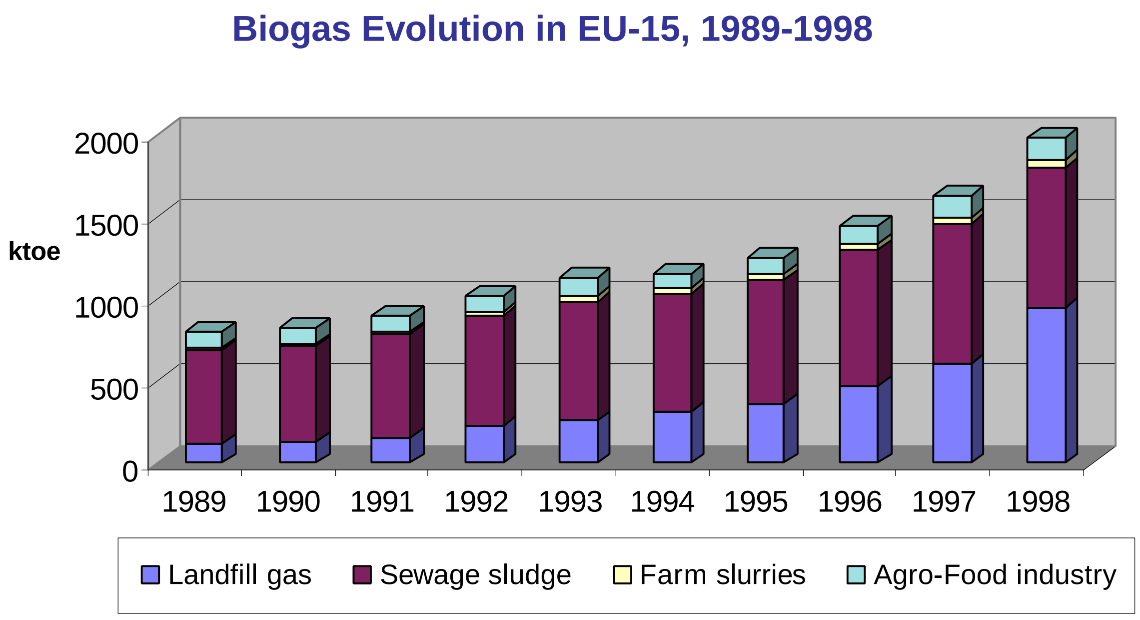
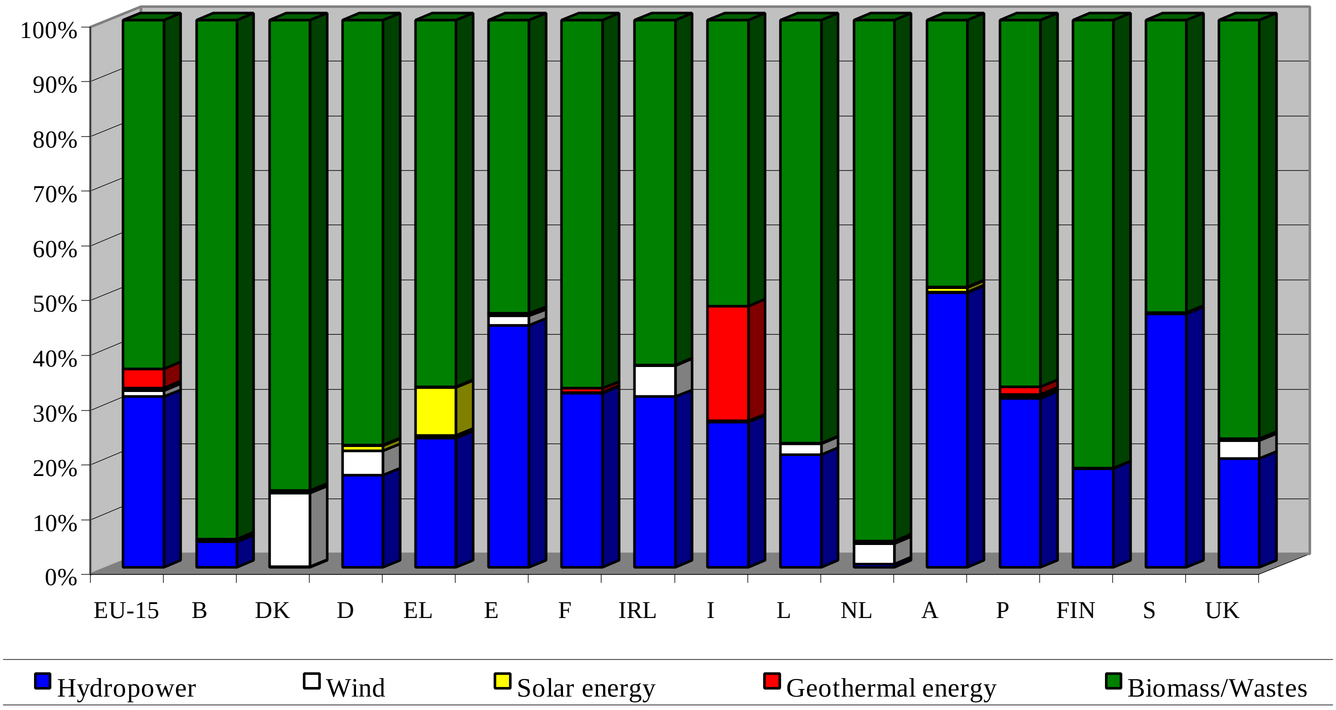


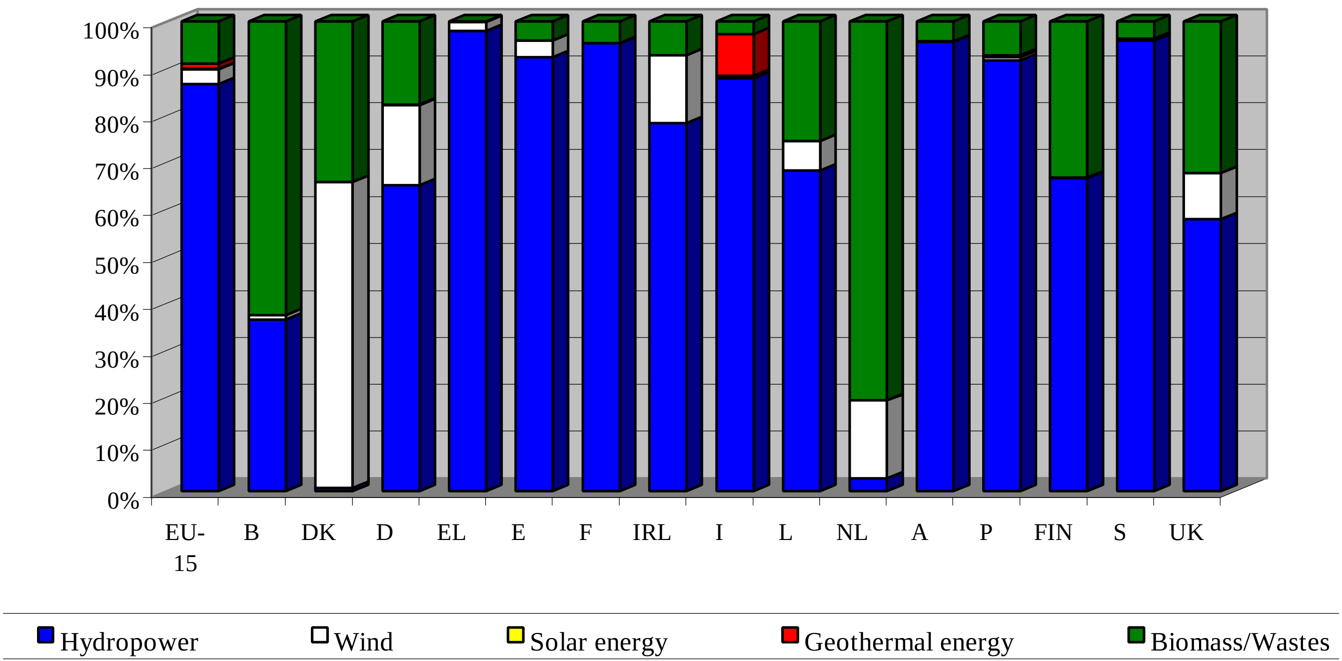
Table 7: The contributions made by various RES to the Total Primary Energy Production in 1989 and 1998

Renewable Energy Application	Collectors surface ($1000m^2$)		Installed Capacity (MW)		Electricity generation (GWh)		Primary energy production (ktoe)	
YEAR	1989	1998	1989	1998	1989	1998	1989	1998
Hydro all plants			86 453	98 432	255 583	308 005	21 975	26 482
Hydro -1 MW								
Hydro 1-10 MW								
Hydro 10+ MW								
Wind energy			354	6 219	534	11 355	46	976
Solar panels	3 198	9 037					146	349
Photovoltaic panels			4	80	4	61	0.3	5
Geothermal electricity			530	604	3 175	4295	1 881	2 654
Geothermal heat							335	361
Municipal Solid Wastes					4 834	11 350	3 997	6 407
Wood/wood wastes, agricultural wastes:								
In households							21 286	25 614
In district heating							479	1 181
In industry							8 415	8 431
In power stations					10 173	16 711	5 997	10 595
Biofuels							1	452
Landfill gas					203	2 871	117	949
Sewage sludge					915	780	574	847
Farm slurries					4	155	11	54
Agro-Food industry					73	133	92	132

Primary Energy Production by Technology in 1998



Electricity Generation by Technology in 1998



7. Norway

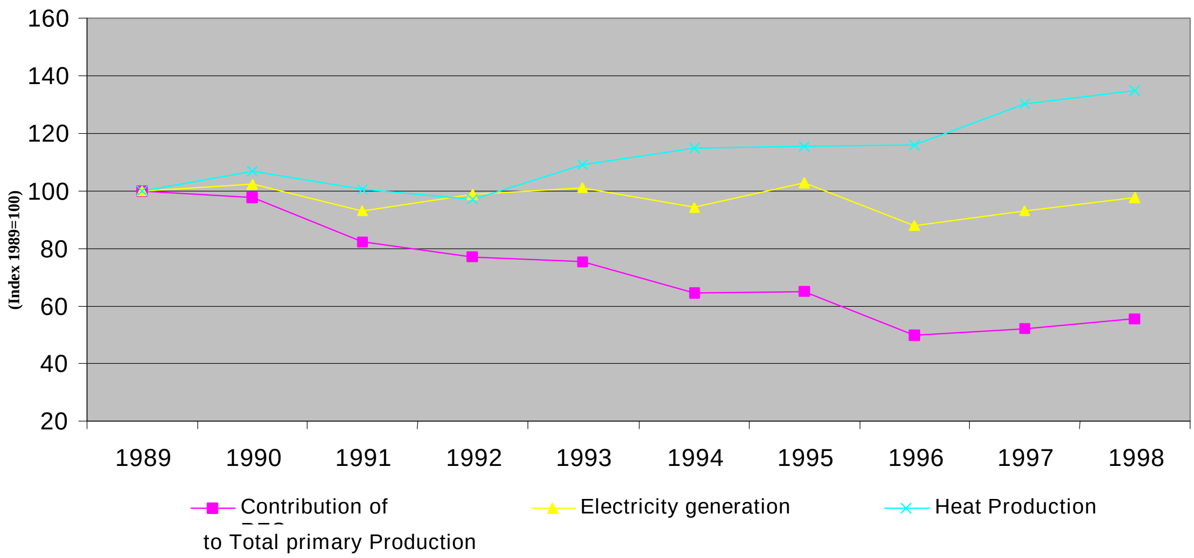
In 1998, primary energy production form renewable energy sources in Norway was 10 993 ktoe. This represented 5.3% of the country's total primary energy production and 43.2% of the total inland consumption. Almost all electricity generation in Norway is obtained from renewable energy sources. In 1998, 115 670 GWh were generated, representing 99.6% of total electricity generation.

Hydropower is the main renewable energy source in Norway representing 90.2% of the renewable primary energy production and 99.7% of electricity generation from renewables in 1998. Biomass/Wastes are also important accounting for 9.7% of the renewable primary energy production and almost 100% of heat production.

In 1998, consumption of wood represented 86% (47% in households and 39% in industry) of primary production from biomass/wastes. Municipal solid wastes (9% of primary energy production of biomass/wastes) and wood/wastes burned in power stations (82% of electricity generated from biomass/wastes) were also important contributors to the biomass/wastes total.

Due to the importance of hydro in Norway, the percentage contribution of renewables is subject to variations depending on the rainfall conditions.

Significant variations in Norway, 1989-1998



8. Iceland

In 1998, primary energy production form renewable energy sources in Iceland was 1 529 ktoe. This represented 87.8% of the country's total primary energy production and 58.2% of the total inland consumption. Almost all electricity generation in Iceland is obtained from renewable energy sources. In 1998, 6 273 GWh were generated, representing 99.9% of total electricity generation.

In terms of primary energy production, geothermal energy is the main renewable energy source, representing 68.3% of the renewable primary energy production, while it accounts for 10.5% of electricity generation from renewables in 1998.

On the other hand, hydropower is the main source for electricity production accounting for 89.5% of electricity generation from renewable energy sources.

The capacity for electricity production from geothermal energy was 140.1 MW in 1998 (213% increase comparing to 1989) while the electricity production in 1998 was 655.9 GWh (155% increase).

Concerning hydro-power plants, their capacity was 951.5 MW in 1998 (752 MW in 1989) while the electricity production was 5617 GWh, a 33% increase since 1989.

PART III – DATA COLLECTION METHODOLOGY

1. RES – Technologies / Applications

While there is a limited number of Renewable Energy Sources (RES), there is a large number of technologies allowing the exploitation of these sources, most of which are still at the research/development stage or have not yet reached commercial maturity. This survey will cover only the technologies, which are economically viable or approaching economic viability because these are the technologies which contribute or could contribute significantly to the overall energy balance in the near future. Table II.1 summarises the sources and technologies to be taken into account on the basis of the criteria mentioned above. A short description and evaluation of different sources and technologies is presented in Annex 1.

It should be noted that some technologies and in particular solar panels, ethanol production from sugar/starch crops and diesel production from vegetable oil crops have been included in the present survey because of the targets set by the ALTENER programme, which necessitate a close monitoring of these technologies although their present deployment would not justify it.

Although there is no consensus on whether heat pumps, and in particular electricity-driven ones, should be included under the technologies allowing the exploitation of a renewable energy source, for reasons of completeness we have also considered them here.

Table II.1 identifies the major field(s) of application of each technology. Taking into account the dispersed nature of RES production and consumption, identifying the major field(s) of application of each technology allows surveys to be focused on the major producers/consumers of RES so that data collection will be realised in a cost-effective way. Applications of minor contribution like off-grid operation of hydroplants, WECs or small-scale applications of photovoltaic systems have not been included. It should be noted that on the basis of national programmes, the emphasis is now on encouraging grid-connected plants and for this reason the present system is limited to these ones.

Parts I and II of the present report summarising statistics for the EU and the Member States on Renewable Energy Sources have basically followed the same structure and definitions for the sources, technologies and fields of application as shown in Table II.1. Ambient Energy statistics have not been included, however, because they were unavailable for certain Member States.

RENEWABLE ENERGY SOURCES TECHNOLOGIES AND APPLICATIONS
Table II.1

RES	TECHNOLOGY-APPLICATIONS
HYDRO-POWER	**1. HYDRO-ELECTRIC POWER STATIONS** 1.1 Electricity generation from grid-connected large-scale(>10 MW) hydroplants 1.2 Electricity generation from grid-connected small-scale (1 MW to 10 MW) hydroplants 1.3 Elecricity generation from grid-connected mini (<1 MW) hydroplants
WIND ENERGY	**1. WIND ENERGY CONVERTERS (WECs)** 1.1 Electricity generation from grid-connected WECs
ACTIVE SOLAR	**1. FLAT PLATE COLLECTORS** 1.1 Seasonal swimming pool heating, domestic hot water **2. SOLAR PHOTOVOLTAIC PLANTS** 2.1 Electricity generation from grid-connected plants
GEOTHERMAL ENERGY	**1. GEOTHERMAL POWER PLANTS** 1.1 Electricity generation from grid-connected plants **2. GEOTHERMAL HEAT PLANTS** 2.1 District heating, heat in agriculture

RES	TECHNOLOGY-APPLICATIONS
AMBIENT ENERGY	**1.HEAT PUMPS** 1.1 Space heating, domestic hot water, heating of swimming pools, industrial low-temperature heat
BIOMASS / WASTES	**1. DIRECT COMBUSTION** **1.1 Municipal solid waste** 1.1.1 Electricity and/or heat production by grid-connected incinerators or district heating plants **1.2 Wood crops/ wood waste/ other solid waste** 1.2.1 Heat production burning firewood in households 1.2.2 Heat production in district heating plants 1.2.3 Heat production (exclusively) for on-site use in industry 1.2.4 Electricity generation by the public supply and autoproducers 1.2.4.1 Electricity generation in grid-connected power plants 1.2.4.2 Electricity and heat production in grid-connected CHP plants **2. ANAEROBIC FERMENTATION** **2.1 Wastes in landfill** **2.2 Sewage sludge** **2.3 Animal slurries** **2.4 Agro-food industry wastes** Production of landfill gas, sludge gas, farm gas or industrial biogas for heat and/or electricity generation **3. BIOFUEL PRODUCTION** **3.1 Sugar/starch crops** 3.1.1 Ethanol production as fuel additive/substitute **3.2 Vegetable oil crops** 3.2.1 Production of diesel-oil substitutes

2. Renewable Energy Sources Statistics

The European Union and the Member States (to a different extent) have established a number of policy measures promoting the penetration of RES because of their positive impact on the environment, on the security and diversification of supplies and the positive effects on industrial activity (especially on small and medium enterprises) while the positive impact on employment in rural areas due to the CAP reform was recognised recently. An information system on RES should comprise a comprehensive set of statistics which would allow an evaluation of the impact of the European Union and national policy measures so that not only the overall positive impact on the diversification/security of supplies will be assessed but the penetration of individual technologies/applications will be monitored so that additional measures in various fields like technology development, removal of administrative/legal barriers etc. may be taken to enhance their future penetration. It is obvious that such a system must be a harmonised one and it must assure continuity over time so that comparability of the different indicators among Member States and over time can be guaranteed.

It must, however, be recognised that RES are utilised over wide areas and often outside formal structures so that it is usually difficult to establish a regular flow of information in a cost-effective way. It was therefore decided to create a minimum set of statistics which would allow an evaluation of the attainment of the political objectives described above.

These statistics comprise basically technological indicators. While this information should normally be available from the producers/users or other specialised professional associations, occasionally it is necessary to supplement basic information by experts' estimates for various technical factors in order to make available required statistics. Economic indicators (capital cost, energy production cost) are not included in these statistics because they are greatly affected by local conditions and such indicators should therefore be the objective of specialised studies.

Table II.2 presents the statistics to be collected for the different applications. It has been decided to desegregate at the level of application for the different RES technologies not only because of the refinement of collected information but mainly because the quality of information for the different applications of the same technology will be different, varying from that of a census of existing installations to an estimated aggregate value on the basis of statistics on equipment. Since the cost of statistics collection will be different for the various applications while their relative importance and/or potential for further development may be restricted due to limitations on resources or other considerations, establishing a continuous monitoring system might be achieved in a cost-effective way by differentiating the frequency of data collection for the different applications of the same technology.

Table II.2. STATISTICS FOR RES APPLICATIONS

A. HYDRO-POWER

APPLICATION:	1.1	Electricity generation from grid-connected large-scale (>10 MW) hydroplants

- Number of plants .....
- Installed capacity ..... MW
- Gross/net electricity generation ...... MWh/..... MWh

APPLICATION:	1.2	Electricity generation from grid-connected small-scale (1 MW to 10 MW) hydroplants

- Number of plants .....
- Installed capacity ..... MW
- Gross/net electricity generation ...... MWh / ..... MWh

APPLICATION:	1.3	Electricity generation from grid-connected mini (<1 MW) hydroplants

- Number of plants .....
- Installed capacity ..... MW
- Gross/net electricity generation ...... MWh / ..... MWh

B. WIND ENERGY

APPLICATION:	1.1	Electricity generation from grid-connected wind energy converters

- Number of plants (WECs) .....
- Installed capacity ..... MW
- Gross/net electricity generation ...... MWh / ..... MWh

C. SOLAR ENERGY

APPLICATION: 1.1 Seasonal swimming pool heating, domestic hot water

- Area of collector surface ..... m^2
- Production of heat ..... TJ
    - of which for domestic hot water ..... TJ

APPLICATION: 2.1 Electricity generation from grid-connected PV plants

- Number of installations .....
- Peak capacity
    - crystalline solar cell panels ..... kWp
    - thin film panels .... kWp
- Gross/net electricity generation .... kWh / ..... kWh

D. GEOTHERMAL ENERGY

APPLICATION: 1.1 Electricity generation from grid-connected plants

- Number of installations .....
- Installed capacity ..... MW
- Heat input ..... TJ
- Gross/net electricity generation ..... MWh / ..... MWh

APPLICATION: 2.1 District heating plants, heat for agricultural uses

- Number of installations .....
- Installed capacity ..... MW_{th}
- Heat production ..... TJ
    - of which for agricultural uses ..... TJ

E. AMBIENT ENERGY

APPLICATION:	**1.1**	Heat pumps for space heating, heating of swimming pools, industrial low temperature heat, domestic hot water

- Installed capacity ..... MW
- Heat production ..... TJ
  - of which: for industrial uses ..... TJ
    for domestic use ..... TJ

F. BIOAMASS / WASTES

APPLICATION:	**1.1.1**	Electricity and/or heat production by grid-connected incinerators or district heating plants incinerating municipal solid waste

- Number of installations .....
- Installed capacity ..... MWe ..... MW_{th}
- Incinerated MSW .... tonne ..... TJ
- Gross/net electricity generation ..... MWh ..... MWh
- Production of heat (CHP, district heating plants) ..... TJ

APPLICATION:	**1.2.1**	Heat production by burning firewood in households

- consumption of firewood ..... tonne ..... TJ

APPLICATION:	**1.2.2**	Heat production in district heating plants burning wood/wood waste/other solid waste

- Number of plants .....
- Installed capacity ..... MW_{th}
- Consumption of wood/wood waste/other solid waste .....tonne ..... TJ
  - Production of heat ..... TJ

APPLICATION:	1.2.3	Heat production (exclusively) for on-site use in industry burning wood/wood waste/ other solid waste

- Number of plants .....
- Installed capacity ..... MW_{th}
- Consumption of wood/wood waste/other solid waste ... tonne ..... TJ

APPLICATION:	1.2.4	Electricity generation by the public supply and autoproducers

APPLICATION:	1.2.4.1	Electricity generation in grid-connected power plants (public supply, autoproducers) burning wood/wood waste/other solid waste

- Number of plants .....
- Installed capacity ..... MWe
- Consumption of wood/wood waste/other solid waste ... tonne ..... TJ
- Gross/net electricity generation ..... MWh ..... MWh

APPLICATION:	1.2.4.2	Electricity and heat production in grid-connected CHP plants (public supply, autoproducers) burning wood/wood waste/other solid waste

- Number of plants .....
- Installed capacity ..... MWe ..... MW_{th}
- Consumption of wood/wood waste/other solid waste ... tonne ..... TJ
- Gross/net electricity generation ..... MWh ..... MWh
- Production of heat (CHP plants) ..... TJ
    - of which sales to third party ..... TJ

APPLICATION: 2.1 Production of biogas from organic materials in landfill

- Gas production ..... TJ
- Gross/net electricity generation ..... MWh / ..... MWh
- Production of heat ..... TJ

APPLICATION: 2.2 Production of biogas from sewage sludge

- Gas production ..... TJ
- Gas auto-consumption for fermentation ..... TJ
- Sales of gas ..... TJ
- Gross/net electricity generation ..... MWh / ..... MWh
- Production of heat ..... TJ

APPLICATION: 2.3 Production of biogas from farm slurries

- Gas production ..... TJ
- Gas auto consumption for fermentation ..... TJ
- Sales of gas ..... TJ
- Gross/net electricity generation ..... MWh / ..... MWh
- Production of heat ..... TJ

APPLICATION: 2.4 Production of biogas from agro-food industry effluents

- Gas production ..... TJ
- Gas auto consumption for fermentation ..... TJ
- Sales of gas ..... TJ
- Gross/net electricity generation ..... MWh /..... MWh
- Production of heat ..... TJ

APPLICATION:	3.1	Ethanol production as fuel additive/ substitute

-	Number of installations		.....
-	Capacity		.....tonne/y
-	Production		..... tonne
-	Imports/Exports	... tonne.	.... tonne
-	Stock variation		... tonne

APPLICATION:	3.2	Diester production as diesel substitute

-	Number of installations		.....
-	Capacity		..... tonne/y
-	Production		..... tonne
-	Imports/Exports	..... tonne	..... tonne
-	Stock variation		..... tonne

3. Energy Balance Sheet

Evaluating the contribution of the individual renewable energy sources to the overall energy balance of a Member State or of the European Union, as well as assessing the RES positive impact on the security/diversification of supplies, necessitates the establishment of an accountancy system for the RES. Having a single accountancy system in all Member States allows comparable harmonised statistics and indicators to be determined at European Union level.

While the existing Eurostat methodology on energy balances, published in "Principles and Methods of Energy Balance Sheets", covers transformation and final energy consumption for the RES, it is necessary to complement it by defining the primary energy production for the different RES considered here. It must be stressed that the accountancy system for RES described below is compatible with the basic principles already used by Eurostat for the other sources in drafting the annual energy balance sheets. For the different renewable energy sources/technologies, the primary energy production is defined below:

- **Hydropower, wind energy, solar photovoltaic**

  Primary energy production (TJ) is the gross electricity generation assuming 3 600 kJ/kWh.

- **Solar energy (flat plate collectors)**

  Primary energy production (TJ) is the heat available to the heat transfer medium i.e. the incident solar energy less optical and collectors' losses.

- **Ambient energy**

  Primary energy production (TJ) is the heat removed from the environment which corresponds to the useful heat, subtracting the energy of the prime mover.

- **Geothermal energy**

  Primary energy production (TJ) is the enthalpy difference between the fluid produced in the production borehole and of the fluid eventually disposed of (re-injection borehole).

- **Biomass/wastes**

  In the case of MSW and wood/wood waste/other solid waste, primary energy production (TJ) represents the heat produced after combustion (corresponding to the NCV of the fuel). In the case of anaerobic digestion of wet wastes, primary energy production (TJ) corresponds to the heat content (NCV) of the biogases produced, including the gases consumed in the installation for the fermentation processes but excluding flared gases. Primary production (TJ) in the case of biofuels corresponds to the heat content (NCV) of the fuel.

4. Collection Methodology

4.1

Renewable energy sources are particularly suitable for regional or local applications. This scattered nature of RES applications, often outside formal structures, poses major problems in collecting RES statistics in a cost-effective way.

The data collection methodology to be applied by the Member States depends on the level of RES development, national priorities, existing general infrastructure of statistics (surveys on industry, households etc.) and the specific infrastructure related to RES (public/private institutions, professional associations) among the Member States. On the basis of the current national situation, alternative methods may be applied which will allow the collection of necessary statistics.

This proposal should therefore be viewed as a recommendation rather than as a rigid methodology to be applied by Member States. It is not intended to advocate new surveys to be realised by the Member States. It rather serves to identify complementary actions to be taken by Member States in slightly modifying existing surveys which would allow the collection of necessary statistics in a cost-effective way as well as identifying appropriate bodies which monitor the market evolution so having the disposing necessary statistics.

It is also noted that, often because of the small size of the applications, there is a complete lack of an accountancy system kept by the user/producer or that the existing accountancy system is not adequate in supplying the required information. In these cases, easy to collect variables and evaluated parameters may be used to allow the collection of necessary statistics. It should be noted that these evaluated parameters, based on experts' opinion, are country-specific and more or less constant over time, needing a revision only when the matter is examined more deeply.

For these reasons, it is recommended that each Member State decides on the most suitable "Collection Methodology" to be followed, creating a team of experts with high technical/technological sensibility and sufficient independence to proceed with necessary estimates, elaborations and evaluations. The present recommendation should serve as a basic tool for "estimating" necessary statistics or identifying complementary actions needed in existing surveys to allow an efficient, cost-effective data collection system.

With reference to the statistics for RES applications, described in Table II.2, the data collection methodology is described below.

A. HYDROPOWER

APPLICATION 1.1, 1.2, 1.3

The current system of energy statistics allows the collection of necessary data. Statistics are furnished by utilities, grid operators or electricity distribution companies. It must however be noted that official statistics for electricity generation quite often use a lower installed capacity threshold. In such cases, the missing part of electricity generation may be estimated by:

$$E_H = P_H * LF$$

where E_H = hydroelectricity generation (MWh)

P_H = total installed capacity below the threshold (MW)

LF = load factor, average number of hours of operation per year.

The load factor may be estimated on the basis of plants of higher size where information on both capacity and electricity generation is available. Since this contribution will be rather small, country average figures may be used.

B. WIND ENERGY

APPLICATION 1.1

This case is similar to the previous point on hydropower. It should be noted that for estimating the electricity generation from the WECs below the survey threshold, the load factor may be further refined by considering different ranges in installed capacities of WECs and regions in the country to account for wind speed variation over the country and variation in the technical characteristics of WECs of different sizes.

C. SOLAR ENERGY

APPLICATION 1.1

The heat production by flat plate collectors may be estimated by:

$$E_S = S * I_m * \varepsilon$$

Where E_S = heat production (TJ)

S = total surface of installed collectors (m^2)

I_m = average solar insolation ($MJ/m^2/year$)

ε = efficiency factor.

Although solar insolation is a site-specific factor, a country average value may be considered. The efficiency factor, ε, takes into account optical and collectors' losses in the installation. Methods of determining the total surface of installed collectors, S, are described in Annex 2.

It should be noted that the useful heat is lower than the heat production mainly because of the intermittent use of collectors' heat, especially in secondary dwellings. Such considerations, being highly subjective, have been excluded.

APPLICATION 2.1

This case is similar to the one described for hydropower.

D. GEOTHERMAL ENERGY

APPLICATION 1.1

The current system of energy statistics allows the collection of necessary statistics for grid-connected electricity generation by geothermal plants. Information is furnished by utilities, plant operators etc. Heat input, if not directly measured, may be estimated on the basis of plant efficiency and actual electricity generation.

APPLICATION 2.1

Statistics on district heating plants using geothermal energy may be collected directly from plant operators.
Geothermal heat used in greenhouse applications, usually not readily available, may be estimated on the basis of the technical characteristics of the installations by:

$$E_G = W * h_i * T$$

where
E_G = heat production (TJ)
W = well delivery (kg/h)
h_i = enthalpy difference between production/re-injection borehole (kJ/kg)
T = hours of operation per year (h)

In this case, technical information available from competent national authorities, professional associations and/or agricultural/farms organisations may be used.

E. AMBIENT ENERGY

APPLICATION 1.1

Since heat pumps are used widely without providing direct information on heat production, it could be estimated on the basis of installed capacity by

$$E_{HP} = P * COP * LF$$

where
E_{HP} = heat produced (TJ)
P = installed capacity (MW)
COP = coefficient of performance
LF = load factor, average number of hours of operation per year

The installed capacity, P, may be determined using the methodology outlined in Annex 2. The coefficient of performance, COP, is a characteristic of the heat pumps depending on the size of individual machines. Values towards the upper size should be used since it is mainly the large machines which will determine heat production. The load factor, LF, depends on the sector where heat pumps are installed.

In general, professional associations have a complete picture of the market in the various Member States (installed capacity per type, size and sector of application) which would normally allow better estimates of both COP and LF than the methodology outlined in Annex 2.
It must be noted that the primary energy production corresponding to the heat removed from the environment may be estimated by

$$E = P * (COP-1) * LF$$

F. BIOMASS/WASTES

APPLICATION 1.1.1, 1.2.2, 1.2.4

These applications are characterised by a limited number of plants (district heating or power plants) and are easy to recognise. For this reason, the necessary statistics may be collected directly from plant operators.

The present system of energy statistics surveys these installations collecting information on fuel consumption, electricity and heat production and on equipment. It would be necessary to modify the questionnaires used proceeding to necessary desegregation, which will allow the statistics required for these applications to be determined.

APPLICATION 1.2.1

Firewood combustion in households is an important component of RES in various Member States. Since the traded part of firewood is roughly a third of the total wood consumption in households, it is apparent that the total consumption can only be determined by an actual survey.

The survey on "Energy Consumption in Households" to be established by Eurostat on a regular basis, should allow the determination of relevant statistics. Since this RES application has rather limited possibilities for further expansion in the European Union, a low frequency survey is considered adequate.

APPLICATION 1.2.3

The consumption of biomass/wastes in industry may be determined by adapting appropriately the questionnaires used in surveying energy consumption in the manufacturing industry and in particular in the wood/paper primary and secondary industries.

APPLICATION 2.1, 2.2

Statistics on heat/electricity production by landfill gas and sewage sludge treatment plants may be obtained from plant operators while gas production may be estimated using nominal efficiency values for electricity/heat generation of the allations. In the case of sewage plants, the gas consumption for the fermentation may be estimated, if not directly available, by:

$$I_{eq} * M_{pc} * H_m$$

where I_{eq} = inhabitants served by installation
M_{pc} = annual quantity of wet wastes per capita (kg/y)
H_m = heat needed to ensure the fermentation process per kg of wet waste

APPLICATION 2.3

In the case of large-scale plants serving a number of farms, good quality statistics may be provided directly by operators.

In the case of small-scale individual digestors used in farms, statistics may be estimated on the basis of livestock size and type served and the theoretical gas production per livestock head.

APPLICATION 2.4

Surveys on energy consumption in industry, adapted appropriately, could serve to provide necessary statistics.

APPLICATION 3.1, 3.2

Statistics from relevant plants complemented by external trade statistics should provide necessary information.

4.2

There are two main methods of collection of statistics about renewable energy sources that can be applied:

- questionnaires are sent out to organisations or to individual project managers requesting statistical information on each project;
- or, where such an approach is inappropriate, an expert in the technology can provide an estimate.

4.2.1 Questionnaires

Projects from renewable energy sources represent a very wide spectrum in terms of size, management, project expertise, etc. Therefore for any questionnaire to be effective, it needs to be tailored towards the types of people or organisations who are likely to be responding to it. This will encourage a high number of returns, also a high quality of the information supplied.

Thus for small projects where there is likely to be little expertise with energy statistics and no previous requirements to provide such information, any questionnaire needs to be straightforward and have all data requested explained clearly.

For larger projects, especially those with a regular requirement to provide statistical returns, questionnaires hold fewer problems.

Much information may already be available from within existing national or technological surveys, and it is important to link data collection from renewable energy applications into these routine data collection systems where possible. Minor additions to existing surveys could provide all of the information needed for this current survey. This approach has two advantages:

- it saves on duplication of requests for information from project managers
- it ensures that data collected from projects are consistent throughout all surveys and uses.

4.2.2 Estimates

In cases where it is inappropriate to collect information from individual projects, estimates can be derived instead for the contribution of that application. In such cases, the estimate should be derived by an expert in the field, and ratified by consensus from other national experts. These estimates should also be updated regularly.

4.3

If the projects are to be surveyed in a separate RES survey, then the letter accompanying the questionnaire form may provide general background information to the project manager, to give information on:

- where the contact was obtained from;
- what the information collected will be used for; and
- to stress the confidentiality of the data to be collected (where appropriate).

4.4

It is essential that all relevant data are collected, in particular:

- where energy is used within the process and is not actually measured, e.g., with sludge digestors;
- with waste, the calorific value of the waste in each plant is needed, since this can vary considerably especially between different waste streams;
- input of fuels should be in specific units, especially for small projects, e.g. as tonnes, litres etc., and the calorific value should also be asked;

- where RES are used in conjunction with conventional fuels, information on all energy inputs to the plant needs to be collected, so that the appropriate scaling can then be carried out to apportion the energy supplied from the renewable source.

4.5

The quality of data provided from each project can vary considerably:

- **Good** : comprehensive information held
- **Basic** : minimal information held
- **Poor** : the existence of the project is known but no further details are held

Certain technology areas will yield only limited data on the first year of surveying. In such cases, it is important to assess the reasons for the poor success rate, and to target such "blackspots" in following years to establish a gradual improvement in the quality of information on these areas.

One method of improving the quality of information provided by project managers is to provide them with a questionnaire form pre-printed with information already held on the project, which can then be modified and updated as appropriate.

It is also important to obtain ratification of the results obtained from each application. This can be done by establishing a system of ratification of the results by national experts. This also raises the awareness of the survey and its results with these national experts, and can be useful for obtaining feedback and improvements to the survey results in future years.

Statistics covering a given application can be of varying degrees of completeness:

- **complete** : information is available on all known projects

  Complete information is generally known on grid-connected projects, also for technologies where there are few large installations, which are required to provide national energy statistical returns.

- **incomplete** : information is only available on a limited number of projects

  This is the case for many of the technologies where installations are small, non grid-connected, or are not required to provide national energy statistical returns.
  Improving the degree of completeness can be achieved through close liaison with national experts in the technology area, or through contacts with equipment manufacturers of industrial associations.

4.6

Some of the smaller technologies may not appreciate the importance of supplying energy statistics. In such instances, it can be useful to raise the profile of the statistics so that managers can see more relevance to the information that they provide. Some useful methods are:

- contact with national experts;
- publicity and contact with national associations, manufacturers, etc.;
- feedback of the information provided, e.g. through the use of statistical publications, news sheets, technical articles, conferences etc.

4.7

The survey frequency for the different applications may be variable, taking into account factors like cost, relative importance of the application, prospects and potential of the specific application, etc. It is apparent that while it will be necessary for some applications (e.g. WECs) to collect statistics on an annual basis, less frequent surveys may be planned for other applications (e.g. firewood consumption in households) intermediate annual results being based on estimates where this is the case.

ANNEX I – RENEWABLE ENERGY TECHNOLOGIES AND APPLICATIONS: REVIEW

1. Hydropower

Hydroelectric plants of the reservoir, run-of-river or diverted-flow type are part of a well-established technology for converting the potential and kinetic energy of water into electricity. Pumped storage hydroplants are excluded from this survey because they are not considered as plants exploiting a RES.

Major sites for large-scale (>10 MW) hydroplants have already been exploited in the European Union. It is rather the mini (<1 MW) and small-scale (1 MW to 10 MW) applications which present major potential for further deployment in the European Union. It must be noted that off-grid operation is excluded from further consideration in this survey because of the minor importance of this application for the European Union.

2. Tidal / Wave Energy

With the exception of the tidal power station at La Rance in France (240 MW) commissioned in 1966, the high capital cost of both tidal and wave plants is rather prohibiting the future deployment of these types of plants. Therefore, both tidal and wave energy are not considered in the present survey with the exception of the existing plant.

3. Wind Energy

Wind energy converters (WECs) comprising a wind turbine and an electric generator for electricity generation represent the main technology developed for the exploitation of wind energy. The most common application in the European Union is the grid-connected operation of WECs of a rated output in the range of 250-500 kW. Smaller turbines may be also used for decentralised, stand-alone operation but these applications are not considered here because of their small overall impact.

4. Solar Energy

Flat Plate Collectors
Glazed, flat plate collectors mainly of the thermosyphon type are a well-established technology of domestic water heating or for the seasonal heating of swimming pools.

Solar Photovoltaics
Solar panels for the direct conversion of solar energy into electricity (photoelectric effect) have limited prospects for grid-connected electricity generation in the short term. However, they have a wide range of small-scale stand-alone applications like space applications and telecommunications/signalling at remote sites.

These applications are not considered here because of their extremely small contribution.

Other technologies
A number of solar thermal-electric technologies have been developed for electricity production which are still at a research/development stage. Passive solar for the direct heating, cooling and lighting of dwellings or other buildings is not included in this survey because the definition of an accountancy system would look arbitrary.

5. Geothermal Energy

Geothermal energy is being exploited at suitable sites where both a heat source and sufficient fluids are available at an accessible depth via a production borehole

- for electricity generation (geothermal power plant) using dry steam or high enthalpy brine after flashing

- for direct use (geothermal heat plant) in district heating or for agricultural use

  Hot dry rock technology, not being applied yet, is not considered under the present survey.

6. Ambient Energy

The heat pump is the device used to extract low-grade heat from the environment (e.g. ground/surface water, soil or outdoor air) and transfer it as higher temperature heat, using external power. Heat pumps used in industry for waste heat recovery should not be included under the present RES project.

7. Biomass / Wastes Energy

This RES covers organic, non-fossil material of biological origin which may be used for energy production. It comprises both purpose-grown energy crops and wastes[1]. A number of mature technologies is available today for exploiting biomass/wastes but their maturity depends on the physical-chemical characteristics of the source material. The different types of biomass/wastes along with the corresponding technologies are listed below.

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[1] Note that the term "wastes" used in this methodology covers both clean by-products of human activities as well as wastes requiring special measures during combustion for the protection of environment.

Energy crops
Rapidly growing plant material which may be used for energy purposes is classified under wood crops, oil crops and sugar/starch crops.

- Wood crops cover perennial lignocellulocic crops (like poplar, willow, etc.) suitable for direct combustion;

- Oil crops cover oleaginous plants (like sunflower, rape etc.) for vegetable oil extraction with further conversion into a diesel substitute;

- Sugar/starch crops, allowing the production of ethanol by the fermentation of glucose derived from sugar bearing plants (like sugar cane) or starchy materials after hydrolysis.

Energy crops and in particular the last two cases present a high potential for short-term expansion, taking into account CAP reform, since fallow land may be used for energy purposes.

Wastes
Wastes cover the residues produced by various human activities and they may be classified into solid, wet and gaseous wastes. Combustion is the preferred technology for solid wastes while wet organic wastes are converted into biogas by anaerobic fermentation. Gaseous wastes and in particular landfill gas may be exploited directly. Other technologies like gasification, pyrolysis and liquefaction are beyond the scope of this survey because they are not at present considered commercially mature technologies.

The wastes may be classified as follows:

- Municipal solid waste covers wastes produced by households, industry and the tertiary sector, incinerated at specific installations.

- Wood/wood waste covers a multitude of woody materials generated by an industrial process and in particular by the wood/paper industry or provided directly by forestry and agriculture, like:

    (a) firewood, traditional fuel from forests, fields etc. 20 cm or more long;

    (b) wood chips produced from thinning and clear cuts in forestry;

    (c) wood waste and bark, industrial waste products like sawdust, shavings and chips. Black liquor obtained in the process of paper pulp manufacture is also included.

- Other solid waste covers mainly straw as well as rice husks, nut shells, olive pressing waste, crushed grape dregs, poultry litter etc. An exhaustive list is not presented for these wastes, as the impact of those not listed is rather limited. It must be noted that wastes of fossil origin (like tyres, solvents etc.) are not included. However these should be included in the overall energy balance sheet as a separate category.

- Wet organic wastes cover the following types treated by digestion producing a methane rich biogas which may be used for heat and/or electricity production.

(a) SEWAGE SLUDGE

Anaerobic fermentation of sewage sludge is a common practice in various Member States at specifically designed sewage treatment works, usually for environmental reasons.

(b) ANIMAL SLURRIES

Highly polluting slurries produced by livestock may be treated both on and off-farm producing biogas.

(c) AGRO-FOOD INDUSTRY WASTES

Wastes in abattoirs, breweries and other agro-food industries may be digested anaerobically.

(d) LANDFILL GAS

Landfill gas, a methane rich biogas formed by the digestion of landfilled wastes, is exploited in various Member States for energy production for safety and environmental reasons.

ANNEX II – STATISTICS ON EQUIPMENT

1. Statistics On Equipment

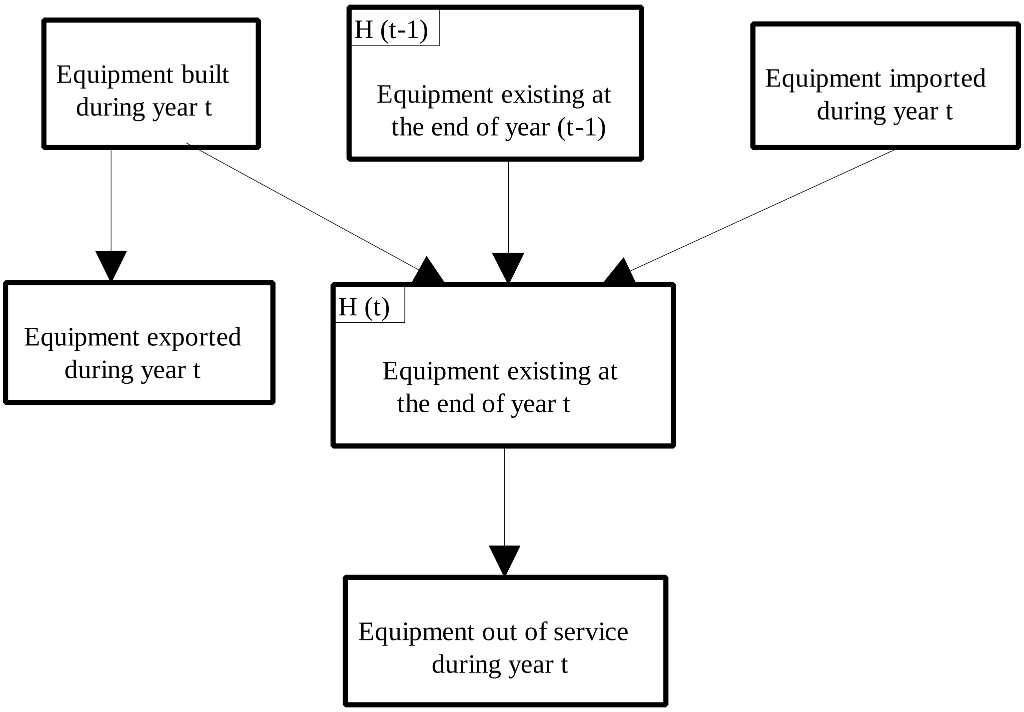
1. Equipment characteristics (installed capacities) for the major RES applications are compiled directly by a survey of RES producers/users.

2. Table II.3 describes an indirect method of determining the installed capacity of heat pumps and the surface of installed solar collectors at the end of a reference year. The extent to which such a method may be used depends on the availability of historical data concerning both production and external trade. Assuming a typical lifetime, information on equipment dismantled during the year may not be necessary. It should, however, be recognised that European Union requirements (PRODCOM, CN) do not provide necessary information either because the physical units are not suitable (heat pumps) or because the products cannot be identified (solar collectors). The outlined methodology can therefore be used to the extent that national nomenclatures can provide necessary details.

3. Professional associations, having used similar methods as outlined above, may have available the necessary statistics along with additional details such as type, size and use. In such a case, relevant information may be used to estimate necessary equipment characteristics.

4. It must be emphasised that aggregated statistics on equipment are used in both cases (heat pumps, solar collectors) to estimate primary energy production since there is no direct measurement of the latter since these types of equipment are used in a dispersed manner at small sizes.

TABLE II.3. EQUIPMENT STATISTICS



SOURCES OF INFORMATION

Built :	- Manufacturers/Association of Manufacturing Industries
Imported :	- Foreign Trade Statistics - Assembling Industries/Association of Assembling Industries
Exported :	- Foreign Trade Statistics - Association of Manufacturing Industries
Out of service :	- Assembling Industries/Association of Assembling Industries